Walking Performance in People with Stroke

[Loopvaardigheid bij mensen met een CVA]

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“ONDERGETEKENDE

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bevestigd hierbij dat de onderhavige verhandeling mag worden geraadpleegd en vrij mag worden gefotokopieerd. Bij het citeren moet steeds de titel en de auteur van de verhandeling worden vermeld.”

Voorwoord

Deze eindscriptie is geschreven ter afsluiting van de opleiding Fysiotherapiewetenschap. “Walking Performance in People with Stroke” was het thema van mijn afstudeerperiode. Binnen dit thema heb ik een literatuurstudie en een onderzoeksproject gedaan. In deze eindscriptie kunt u zowel de literatuurstudie als het onderzoeksproject bekijken. De beide artikelen zijn in de Engelse taal geschreven, alleen de samenvattingen zijn ook in de Nederlandse taal weergegeven.

In september 2006 ben ik aan de opleiding Fysiotherapiewetenschap begonnen om kennis te vergaren over het ontwikkelen, verspreiden en integreren van wetenschappelijke kennis. Tijdens deze studie heb ik ontzettend veel geleerd over wetenschappelijk onderzoek maar ook over mezelf als praktiserend fysiotherapeut en als persoon. Met de opgedane kennis hoop ik in de toekomst een bijdrage te kunnen leveren aan de professionalisering van de discipline fysiotherapie.

De afgelopen drie jaar waren heel leerzaam maar ook best heel zwaar. Daarom wil ik vanaf deze plaats in het bijzonder Sander heel erg bedanken voor zijn eindeloze steun en liefde. Hij heeft me alle vrijheid en tijd gegeven om me te richten op de studie, waarvoor ik hem zeer dankbaar ben. Ook Ingrid van de Port, mijn eerste begeleider, wil ik graag bedanken voor alle discussies, hulp en feedback om binnen een jaar het afstudeerproject tot een goed einde te brengen. Daarnaast wil ik Lotte Wevers bedanken, gezien het feit dat ik gebruik heb mogen maken van gegevens vanuit haar promotie onderzoek. De begeleiders van de opleiding wil ik bedanken voor al hun raad. Tot slot, wil ik mijn familie, vriend(innen) en collegae bedanken. Zij hebben de afgelopen drie jaar enorm met me meegeleefd en hebben me ontzettend gesteund.

Inger Borggreve-Timmermans

Inhoudsopgave

Factors Related to Comfortable Gait Speed in People with Stroke: A Narrative Review

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Abstract

Background and Purpose: Improving hemiplegic gait has a high priority in stroke rehabilitation. To optimize this rehabilitation it is important to get more insight into the factors that are related to hemiplegic gait and more specific to gait speed. The purpose of this review is to determine the factors which are related to comfortable gait speed in people with stroke.

Methods: A computerized search for studies was conducted in CINAHL, Cochrane, EMBASE and PubMed (until November 2008). The inclusion criteria were: (1) subjects with stroke, (2) comfortable or self-selected gait speed as outcome measure, (3) statistical data concerning the relationship between gait speed and other factors (excluding biomechanical factors) and (4) written in English, German or Dutch. Two independent reviewers extracted the data by using a standardized form and determined the methodological quality of the studies. The identified related factors were categorized in the Core Set “Stroke” of the International Classification of Functioning, disability and health (ICF).

Results: Twenty-five studies were included; 19 studies had a cross-sectional design and six studies a longitudinal design. A total of 57 factors have been studied having a relation with comfortable gait speed. The most striking factors which were significantly related to comfortable gait speed were strength measures of the paretic leg and the factors categorized in chapter D4 “Mobility”.

Conclusions: A large variety of factors are related to comfortable gait speed and many of these factors might be influenced in stroke rehabilitation.

Key Words: stroke, comfortable gait speed, review

Samenvatting

Achtergrond en doelstelling: Verbetering van de loopvaardigheid bij mensen met een CVA heeft een hoge prioriteit binnen CVA-revalidatie. Om deze revalidatie te optimaliseren is het belangrijk om inzicht te hebben in factoren die de loopvaardigheid beïnvloeden en meer specifiek die de loopsnelheid beïnvloeden. De doelstelling van dit literatuuronderzoek is het onderzoeken van de factoren die een relatie hebben met comfortabele loopsnelheid bij mensen met een CVA.

Methode: Een gecomputeriseerde zoektocht naar studies heeft plaatsgevonden in CINAHL, Cochrane, EMBASE, en PubMed (tot november 2008). De inclusiecriteria waren: (1) patiënten met een CVA, (2) comfortabele loopsnelheid als uitkomstmaat, (3) statistische data over de relatie aangeven tussen loopsnelheid en andere variabelen (met uitzondering van biomechanische factoren) en (4) geschreven in Engels, Duits of Nederlands. Twee onafhankelijke onderzoekers hebben bruikbare gegevens uit de artikelen gehaald met behulp van een gestandaardiseerd formulier en hebben de methodologische kwaliteit van de studies geanalyseerd. De onderzochte factoren werden gecategoriseerd in de Core Set “Beroerte” van de International Classification of Functioning, disability and health (ICF).

Resultaten: Vijfentwintig studies zijn geïncludeerd; 19 studies met een cross-sectioneel design en zes studies met een longitudinaal design. In totaal zijn 57 variabelen bestudeerd. De meest opvallende factoren, die een significante relatie vertonen met comfortabele loopsnelheid, zijn kracht van het hemiplegische been en de factoren die gecategoriseerd zijn in hoofdstuk D4 “Mobiliteit”.

Conclusie*:* Een grote variatie aan factoren hebben invloed op de comfortabele loopsnelheid en vele van deze factoren kunnen mogelijk worden beïnvloed in CVA-revalidatie.

Sleutelwoorden: CVA, comfortabele loopsnelheid, literatuurstudie

Introduction

According to the Dutch Heart Foundation, the number of people with stroke in The Netherlands is around 190.000.[1] Annually around 41.000 people suffer a first stroke and about 7.000 people a second stroke.[1] Stroke is a major cause of disability and handicap[1,2], leading to various limitations related to mood, speech, perception, cognition, gross and fine motor ability, capacity to carry out the basic and instrumental activities of daily living, and ambulation[3,4]. Disability in people with stroke is related to their quality of life[5] and is a strong predictor of mortality[6].

Walking is an important human activity which enables us to be productive and participative members of a community. After stroke, although the majority of patients leave rehabilitation with some level of independence walking, many have residual walking disabilities. According to the Copenhagen Stroke Study, by the end of rehabilitation still 22% of the people is unable to walk and 14% walks with assistance.[7] The comfortable gait speed of community-dwelling people with stroke has been reported to be around 0.5 m/s (range between 0.3 m/s and 0.8 m/s)[8-11]. In comparison, the reported gait speed of healthy older people is 1.3 m/s[12]. This reduction in gait speed can result in major limitations in community ambulation[10], because gait speed is a powerful discriminative measure of community ambulation[13]. Previously reported threshold gait speeds for community ambulation varied between 0.8 m/s and 1.2 m/s.[10,14,15] Therefore, improving hemiplegic gait has a high priority in stroke rehabilitation[12,16]. To restore this hemiplegic gait many different training programs have been developed, such as traditional neurological treatment approaches, programs for training sensorimotor function or influencing muscle tone, cardiovascular fitness and aerobic programs, methods for training mobility and mobility-related activities, biofeedback therapy, functional and neuromuscular electrical stimulation, orthotics and assistive devices, and intensity of exercise training.[17]

To optimize the rehabilitation of gait after stroke it is important to get more insight in the mechanisms behind the deterioration of walking ability. A great deal of research has been carried out to record and describe hemiplegic gait. Olney et al.[18] and Lamontagne et al.[19] reviewed the biomechanical patterns that characterize hemiplegic gait. Some characteristics

are a shorter stride length, a longer cycle duration, and asymmetries between the paretic and nonparetic leg.[18,19] In this review, factors (except biomechanical factors) are searched which are related to hemiplegic gait in people with stroke. More specifically, factors related to gait speed were searched, since gait speed is a useful tool to objectively monitor the progress in hemiplegic gait[20]. In addition, gait speed is a simple but highly reliable and responsive parameter of hemiplegic gait[20]. To summarize, the purpose of this review is to determine the factors which are related to comfortable gait speed in people with stroke, with the exception of biomechanical factors.

Materials and Methods

Study Identification

A computerized search for studies was conducted in CINAHL, Cochrane, EMBASE, and PubMed (until 18 November 2008). The search strategy contained the following MeSH- and textwords: stroke, cerebrovascular disorders, gait, walking, determin* or determinant, predictor, prognosis, correlat* or correlation, regress* or regression. The full search strategy is available on request from the corresponding author.

Study Selection

The studies included in the review were selected by one reviewer (IB) and the final inclusion or exclusion of the studies was performed by two reviewers (IB,IP). In case of disagreement, consensus was achieved after discussion. First, the title and abstract were screened to determine whether the study met the following inclusion criteria: (1) subjects are diagnosed with stroke, (2) comfortable or self-selected gait speed is one of the outcome measures, (3) the study incorporates statistical data concerning the relationship between gait speed and other factors (for example univariate and multivariate analyses) and (4) the study was written in English, German or Dutch. Studies that determine the relationship between gait speed and biomechanical factors were excluded. In this review *biomechanical factors* include: (1) gait cycle parameters (stride interval, step frequency, and ground reaction force[21]), (2) spatial parameters (step length, stride length, and step width[22]), (3) temporal parameters (step time, and stride time[22]) and (4) kinematic factors (linear and angular positions, their displacements

and the time derivatives, notably the linear and angular velocities and accelerations[19]). After screening the title and abstract, the full-text of the studies was screened to check whether the study met the inclusion and exclusion criteria. In addition, the reference lists of the selected studies were reviewed for relevant references.

In the following, comfortable gait speed is described as gait speed.

Data Extraction

A standardized form based on "The Renal Group Data Extraction Form"[23] was used for data extraction. The following data were extracted: (1) study design, (2) characteristics of study population, (3) outcome assessment and measurements, (4) validity and reliability of the measurements, (5) statistical analysis and (6) influence of the different factors on gait speed. The data were extracted individually by two reviewers (IB, MB). In case of disagreement, consensus was achieved after discussion.

Methodological Quality Assessment

The methodological quality of the included studies was measured by a modified checklist (Table 1).

Table 1: Modified Checklist for Methodological Quality

Item	Outcome strategy	Criteria
	To evaluate internal validity	
1.	Were the main outcome measures valid and reliable?	Positive, if the study tested the validity and the reliability of the measurements used or referred to other studies which had established the validity or reliability.
	To evaluate external validity	
2.	Were the relevant patient characteristics specified?	Positive, if age, type, localization as well as number of strokes are specified.
3.	Were the additional medical and paramedical interventions during observation described?	Positive, if information on medical and paramedical treatment is reported.
	To evaluate statistical validity	
4.	Was the relationship between dependent and independent variables statistically valid?	Positive, if the relationship between a dependent and an independent variable is tested for statistical significance.
5.	Was the sample size (n) adequate in relation to the number of determinants (K)?	Positive, if univariate ratio [n:K] exceeds [20:1] and if multivariate ratio [n:K] exceeds [10:1].
6.	Was there a control for multicolinearity?	Positive, if interaction between two or more independent variables is tested in the prediction model.
	To evaluate reporting	
7.	Are the main findings of the study clearly described?	Positive, if simple outcome data reported for all major findings so the reader can check the major analysis and conclusions.

This modified checklist was derived from the Methodological Quality list for prognostic studies developed by Kwakkel et al.[24] and the checklist for measuring study quality by Downs and Black[25].

Qualitative Analysis

The factors related to gait speed were categorized within the Core Set “Stroke” of the 'International Classification of Functioning, disability and health' (ICF)[26] by two independent reviewers (IB, IP). In case of disagreement, consensus was achieved after discussion. The relation between gait speed and the researched factors was described per chapter of the ICF Core Set “Stroke”. A distinction was made upon study design (cross-sectional and longitudinal studies) and upon statistical analyses (univariate and multivariate analyses). Strength of the univariate results were classified using Munro’s correlation descriptors (very high=.90-1.00, high=.70-.89, moderate=.50-.69, low=.26-.49 and very low=.00-.25)[27]. The multivariate results were classified as significant or non-significant contributors in explaining the variance of gait speed.

Results

Eligible Studies

The initial search strategy identified 233 citations. One hundred and seventy studies were excluded based on their title and/or abstract; the reasons for exclusion are presented in Figure 1. Reference tracking of the 63 remaining studies led to the inclusion of seven additional studies. Of the included studies, 43 studies did not meet the outcome measures and two studies did not include data concerning the relation to gait speed. A total of 25 studies was included (Figure 1).

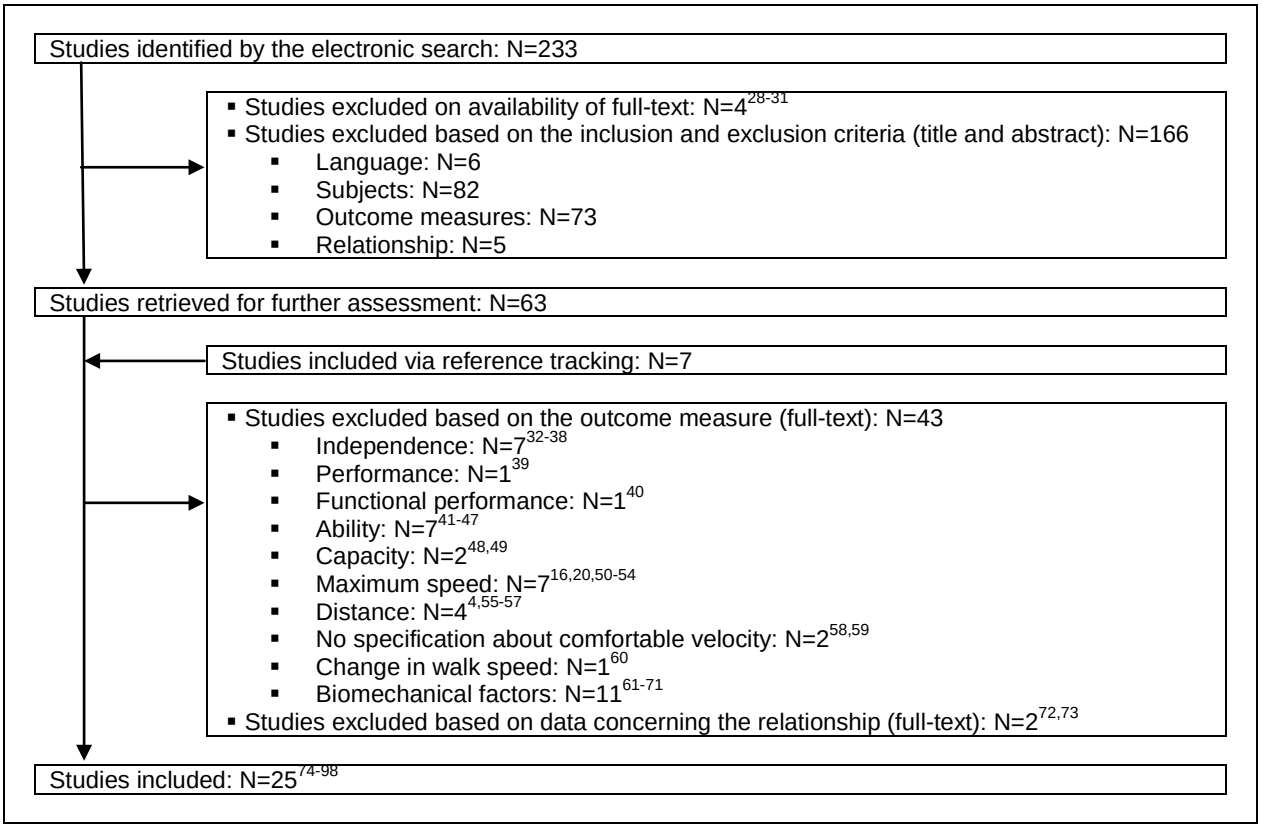

Figure 1: Flow-chart of the Study Selection

Study Characteristics

The studies were published between 1987 and 2007 and analyzed 943 subjects. The average age of the subjects was 64 years (range 18-95 years). The time since stroke onset and baseline measurement ranged from 6 days to 20.6 years. Table 2 shows the main characteristics of the subjects in the included studies. In 11 studies gait speed was measured with a timed walk test, namely: 5-meter[74], 8-meter[75,76], 30-foot[96] or 10-meter[82,85,86,88,93,94,97]. The other studies[77-81,83,84,87,89-92,95,98] used gait analyzer systems. Nineteen studies[75-79,81,82,84,86,87,89-91,93-98] had a cross-sectional study design and six studies had a longitudinal study design[74,80,83,85,88,92]. Of the longitudinal studies, one study[92] reported only cross-sectional results and one study reported the univariate results of cross-sectional data and the multivariate results of longitudinal data[74].

Methodological Quality

With regard to the internal validity, no study described both the validity and reliability of the measures that were used. The reliability of the main outcome measures were good to excellent in six studies[75,76,82,87,90,93].

Regarding the external validity, relevant patient characteristics were specified in six studies[74,77,84,87,88,91] and the additional medical and paramedical interventions were described in two studies[81,86]. In relation to the statistical validity, the relationship between dependent and independent variables was statistically valid in 24 studies[74,76-98]. The sample size was adequate in relation to the number of determinants regarding univariate analyses in 18 studies[74,80-85,87-94,96-98] and regarding multivariate analyses in four studies[74,88,90,97]. Multicolinearity was considered in two studies[74,88]. As far as the reporting, the main findings were clearly described in 22 studies[74,76,79-98]. An overview of the methodological quality of the studies is reported in Table 3.

Quantitative Analyses

In the studies, a total of 57 factors were studied having a relation with gait speed. Most of the factors could be categorized in the different chapters of the ICF Core Set “Stroke”. Time since stroke onset, hypertension and diabetes mellitus could not be categorized and therefore an additional chapter entitled “Other Factors” was added (Table 4).

Study Results

This result section is a description of the overall results per factor per chapter of the ICF Core Set “Stroke”. The detailed results, for example the measurements used, the time of measurements of the dependent and independent variables, the correlation coefficients of the univariate analyses and the independent variables, the significant variables and the squared multiple correlation coefficient of the multivariate analyses, are shown in Table 5 to 10.

Study Results - Body Functions (Table 5):

Chapter B1:

In one cross-sectional study[89], self-efficacy, cognition and depression were analyzed in a multivariate analysis. Only for self-efficacy a significant contribution in explaining the variance of gait speed was found after correcting for the other independent variables of the analysis.

In one longitudinal study[88], the grade of consciousness measured in an univariate analysis, showed a non-significant and low correlation with gait speed. In a longitudinal multivariate analysis[74], the level of cognition showed a significant contribution in explaining the variance of gait speed after correcting for the other independent variables of the analysis.

Chapter B2:

In longitudinal studies, spatial neglect[83], visual inattention[88], hemianopia[88], conjugate eye deviation[88] and body image and proprioception[88] were analyzed in univariate analyses. Visual inattention[88] showed a significant and moderate correlation with gait speed. Hemianopia[88] and body image and proprioception[88] showed a significant and low correlation and conjugate eye deviation[88] showed a significant and very low correlation with gait speed. Spatial neglect[83] was not significantly correlated with gait speed. No information about the strength of the correlation was reported. In two separate longitudinal multivariate analyses[74,83], spatial neglect showed no significant contribution in explaining the variance of gait speed after correcting for the other independent variables of the analyses.

Chapter B4:

In cross-sectional studies, VO_{2peak} [86,94,96], heart rate during maximal exertion[86], fractional utilization[94] and oxygen consumption[94] were analyzed in univariate analyses. Heart rate[86] and VO_{2peak} [86,96] showed both a significant and moderate correlation with gait speed. A third study[94], on the other hand, found a non-significant and low correlation for VO_{2peak}. This study[94] also found a non-significant and low correlation for fractional utilization and oxygen consumption.

Chapter B6:

In one longitudinal study[88], urinary incontinence was analyzed in an univariate analysis. Urinary incontinence showed a significant and low correlation with gait speed.

Chapter B7:

In cross-sectional studies, passive stiffness[90], joint position sense[90,91], isometric muscle torque[76,97], isometric strength[90,91], isometric force[75], isokinetic torque[84,87,92,95], isokinetic strength[81,82,89,96], isokinetic total work[84], isokinetic power[89], lower extremity strength[78], spasticity[76,81,84,90,95], lower extremity motor function[77-79,84,91,95], sensory function[79,84,95], lower limb physical impairments[81], and motor score[92] were analyzed in univariate analyses. First, significant correlations were found for the following. Lower limb impairments[81] showed a significant and high correlation with speed gait. The motor score of the paretic side[92], motor score of both sides in men[92], and lower extremity motor function[79,84,95] showed significant and moderate correlations with gait speed. Two other studies[78,91] only reported a significant correlation between lower extremity motor function and gait speed, without reporting the strength of these correlations. Spasticity of the knee[76] and ankle and foot[81] showed significant and low correlations with gait speed. Different isometric and isokinetic strength measures showed significant and low or moderate correlations with gait speed; these strength measures were: (1) isometric torque and strength of different hip, knee and ankle muscle groups of the paretic side[75,76,90,91,97], (2) isokinetic torque of hip flexors of the paretic side[67,84,87], knee flexors of the nonparetic side[87] and ankle plantarflexors of the nonparetic side[87], (3) isokinetic total work of the paretic hip flexors[84], knee extensors[84], ankle plantarflexors[84], (4) isokinetic strength of the paretic knee flexors[82], knee extensors[82,89],and ankle plantarflexors[81] and (5) combination of knee flexor and extensor strength of the paretic and nonparetic side[96]. Isokinetic power of the paretic knee extensors[89] was significantly correlated with gait speed; information about the strength of the correlation was not reported. Second, non-significant and very low or low correlations were found in relation with: (1) passive stiffness of the ankle plantarflexors[90], (2) knee position sense[91], (3) isokinetic torque of hip flexors of the nonparetic side[87], hip extensors of the paretic and nonparetic side[87], knee extensors of the nonparetic side[87] and ankle dorsiflexors of the paretic and nonparetic side[87] and (4) isokinetic strength of

knee flexors of the nonparetic side[82], knee extensors of the nonparetic side[82], ankle plantarflexors of the nonparetic side[81]. Motor score of both sides showed a non-significant and moderate correlation with gait speed in women[92]. Finally, conflicting results were found. Significant and non-significant correlations were found for: (1) ankle position sense[90,91], (2) isokinetic torque of knee flexors of the paretic side[87,92], knee extensors of the paretic side[84,87,92] and ankle plantarflexors of paretic side[84,87,95], (3) ankle plantarflexion spasticity[84,90,95] and (4) sensory function[79,84,95]. The relation between knee extensor force and gait speed was unclear; no description of the significance level was given.[75] Focusing on the cross-sectional multivariate analyses, nine studies[82,84,87,89-92,95,97] included isometric or isokinetic strength factors as independent variables in the analyses. When isometric or isokinetic factors of the paretic and nonparetic side were included, only factors related to the paretic side showed a significant contribution in explaining the variance of gait speed[87,89]. When entering more than one paretic factor, mostly one paretic factor showed a significant contribution in explaining the variance of gait speed[84,87,91]. Two studies[84,95] described only the hip flexors as significant contributors, a third study only the ankle plantarflexors[87] and a fourth study[91] knee extensors and ankle dorsiflexors as significant contributors in explaining the variance of gait speed after correcting for the other independent variables of the analysis. Besides the isometric and isokinetic strength factors, other factors of this chapter measured in multivariate analyses were passive stiffness[90], knee position sense[91], ankle position sense[90,91], ankle plantarflexor spasticity[84,90], sensory function[84,95], and lower extremity motor function[77,84,91,95]. Significant contributors of explaining the variance of gait speed were ankle position sense[90,91] and ankle plantarflexor spasticity[84,90]; non-significant contributors were passive stiffness of ankle plantarflexors[90] and knee position sense[91]; conflicting results were found for the significant contribution of sensory function[84,95] and lower extremity motor function[77,84,91,95] in explaining the variance of gait speed.

In longitudinal studies, lower extremity motor strength[85,88], upper extremity motor strength[88], lower extremity motor function[88], and producing locomotor rhythm[85] were analyzed in univariate analyses. Lower extremity strength measured by the Motricity Index[88], upper extremity strength[88], and lower extremity motor function[88] showed significant and moderate correlations with gait speed. Producing locomotor rhythm[85] showed a significant correlation;

no information about the strength of the correlation was reported. Lower extremity motor strength measured by the Scandinavian Stroke Scale[85] was not significantly correlated with gait speed: no information about the strength of the correlation was reported. In longitudinal multivariate analyses lower extremity motor strength[88] and locomotor rhythm[85] both showed a significant contribution in explaining the variance of gait speed after correcting for other variables of the analyses.

Study Results - Body Structures (Table 6):

Chapter S1:

In one cross-sectional study[82], type of stroke and side of brain damage were analyzed in multivariate analyses. Both factors showed no significant contribution in explaining the variance of gait speed after correcting for the other independent variables of the analyses.

In longitudinal studies, type of stroke[88] and side of brain damage[83,88] were analyzed in univariate analyses. Type of stroke[88] showed a significant and low correlation with gait speed. Side of brain damage[83,88] was not significantly correlated with gait speed. Neither variable showed a significant contribution in explaining the variance of gait speed after correcting for the other variables in longitudinal multivariate analyses[74,83,88].

Chapter S4:

In one longitudinal study[88], cardial co-morbidity or hyperlipidemy were analyzed in univariate analyses. Both factors showed non-significant and very low correlations with gait speed.

Chapter S7:

In one cross-sectional study[98], bone mineral density was analyzed in an univariate analysis. Paretic and nonparetic bone mineral density showed non-significant and very low correlations with gait speed.

Study Results - Activities and Participation (Table 7):

Chapter D4:

In cross-sectional studies, balance[79,81,92-96], gait distance[81,86,96], voluntary motor ability and basic mobility[74], walking ability[92], ambulatory activity[94] and functional assessment[79] were analyzed in univariate analyses. Balance showed significant and high correlations in three studies[81,92,93], significant and moderate correlations in three studies[79,95,96] and a significant and low correlation in one study[94]. In one study[92] only the women showed no significant correlation. Gait distance[81,86,96], voluntary motor ability and basic mobility[74], walking ability[92], ambulatory activity[94] and functional assessment[79] showed significant and high or moderate correlations with gait speed. In a cross-sectional multivariate analysis[95] balance showed no significant contribution in explaining the variance of gait speed after correcting for other variables of the analysis.

In longitudinal studies, trunk control[80,88], gait speed[83], functional assessment[88], and combined strength of upper and lower limb, balance, proprioception and cognitive functions[88] were analyzed in univariate analyses. Trunk control[80,88], functional assessment[88], and combined strength of upper and lower limb, balance, proprioception and cognitive functions[88] showed significant and moderate correlations with gait speed. Gait speed eight weeks after admission[83] showed a significant and high correlation with gait speed measured at admission to a rehabilitation centre. In different longitudinal multivariate analyses, the independent factors were gross manual dexterity of the paretic upper extremity[74], trunk control[74], balance[74], gait speed[74,83], voluntary motor ability and basic mobility[74], functional mobility[74], walking ability[92], walking function[85] and functional assessment[74]. Gross manual dexterity of the paretic upper extremity[74], balance[74], gait speed[74,83], voluntary motor ability and basic mobility[74] and functional mobility[74] showed a significant contribution in explaining the variance of gait speed after correcting for other variables of the analyses. Trunk control two weeks post-stroke was a significant contributor in explaining the variance of gait speed 26 weeks post-stroke after correcting for other variables of the analyses, but four weeks post-stroke no significant contribution was measured.[88] Walking function[85] showed no significant contribution in explaining the variance of gait speed after correcting for other variables of the analysis.

Chapter D7/8/9:

In one cross-sectional study[82], perceived participation was analyzed in an univariate analysis. This variable showed a significant and moderate correlation with gait speed.

Study Results - External factors (Table 8):

Chapter E1:

In cross-sectional studies[74,91], the use of devices was analyzed in multivariate analyses. This variable showed a significant contribution in explaining the variance of gait speed after correcting for the other factors of the analyses.

Chapter E3:

In one longitudinal study[88], social care (having a healthy partner who can take care of the patient) was analyzed in an univariate and a multivariate analysis. This variable showed a significant and low correlation with gait speed and was a significant contributor of explaining the variance of gait speed after correcting for other variables of the analyses.

Chapter E5:

In a longitudinal study[88], treatment type was analyzed in an univariate analysis. This variable showed a non-significant and very low correlation with gait speed.

Study Results - Personal factors (Table 9):

In cross-sectional studies, age[78,96], gender[96], race[96], percentage of body fat[96], lean mass of the paretic and nonparetic side[96] and body mass index[96] were analyzed in univariate analyses. Percentage of body fat[96] and lean mass of the paretic side[96] showed significant and low correlations with gait speed. Age[78,96], gender[96], race[96], lean mass of nonparetic side[96] and body mass index[96] showed non-significant and very low correlations with gait speed. In cross-sectional multivariate analyses, conflicting results about the significant contribution of age and gender in explaining the variance of gait speed was found.

In longitudinal studies, age[83,88], gender[88], heredity[88] and smoking[88] were analyzed in univariate analyses. Age[83,88] and gender[88] showed significant and low correlations with gait

speed. Heredity[88] and smoking[88] showed non-significant and very low correlations with gait speed. In longitudinal multivariate analyses, two[74,83] studies found a significant contribution of age in explaining the variance of gait speed correcting for other variables in the analyses. On the other hand, another longitudinal study[85] found no significant contribution.

Study Results - Other factors (Table 10):
In a cross-sectional study[82], time since onset of stroke was analyzed in a multivariate analysis. This variable showed no significant contribution in explaining the variance of gait speed after correcting for other for variables in the analysis.
In longitudinal studies, time since stroke onset[83], hypertension[88] and diabetes[88] were analyzed in univariate analyses. Time since stroke onset[83] was not significantly correlated with gait speed; no information about the strength of the correlation was reported. Hypertension[88] and diabetes[88] showed non-significant and very low correlations with gait speed. In longitudinal multivariate analyses[83], time since onset of stroke showed no significant contribution in explaining the variance of gait speed after correcting for other variables in the analysis.

Discussion

To summarize, the purpose of this review is to determine the factors (except biomechanical factors) which are related to comfortable gait speed in people with stroke. Twenty-five studies were included, and these studies measured 57 factors having a relation with comfortable gait speed. The identified studied factors are categorized within the chapters of the ICF Core Set “Stroke”.

In chapter B1, striking is the presence of significant and non-significant contributions of the level of cognition in explaining the variance of gait speed. Comparing both studies, differences can be identified. One difference is the study design, which leads to the conclusion that the level of cognition is not significantly related to gait speed in a cross-sectional study design, but the level of cognition might be a predictor of the development of gait speed during stroke rehabilitation. Another difference is the different kind of independent

factors which were used in the multiple regression analyses. The level of cognition is only a significant contributor in an analysis with age, gender, type and side of lesion and perceptual neglect and not in the analysis with knee extensor power/strength, self-efficacy and gender. To summarize, the studied mental factors in this review show less relation to gait speed.

In chapter B2, different factors are studied concerning visual problems. According to Jones et al.[99] stroke can cause various visual problems including gaze palsies, visual field defects, diplopia, reduced vision, ptosis, pupillary and eye movement disorders and cortical blindness. The authors also reported that visual problems in people with stroke are associated with problems relating to activities of daily living (ADL), falls and rehabilitation[99]. Studies in healthy people with visual deficits concluded: first, that visual fields are associated with mobility performance, measured by percentage of preferred gait speed[100], and second that visual functions are important factors in orientation and mobility performance in particular mobility errors, gait speed and percentage of gait speed[101]. These findings are conforming the results of this review, namely that visual function is significantly related to gait speed.

In chapter B4, VO_{2peak} and heart rate during maximal exertion are significantly related to gait speed. When people with stroke walk with a higher speed, the VO_{2peak} and heart rate will increase, such as in healthy people. In addition, the mean of the VO_{2peak} in people with stroke is shown to be roughly half of age-matched healthy individuals.[102] The impact of this low cardiovascular function on functioning after stroke is an increase of energy cost during activities of daily live such as walking, which can lead to a reduced physical activity.[102] This reduction of physical activity can lead to a further decrease of cardiovascular function, leading to a vicious circle[103]. During this vicious circle, the cardiovascular function and the gait speed in people with stroke might decrease.

Strength measures are the most frequently determined factors in chapter B7. According to this review lower limb muscle strength measures of the paretic side are related to gait speed, and strength measures of the non-paretic side were not. A review of Bohannon et al.[104] conformed these results. They found significant correlations (.56-.85) between the strength of the paretic lower limb muscles and gait performance measured as comfortable and maximal

gait speed, gait distance and gait independence. Regarding correlations between the strength of the non-paretic lower limb muscles and gait performance, conflicting results were found.[104] Another striking point regarding strength measures, when entering these factors in a multivariate analyses, they always show a significant contribution in explaining the variance of gait speed. To summarize, strength measures are strongly related to gait speed.

The factors belonging to the chapters S1, S4 an S7 are, generally speaking, hardly related to gait speed. Although these factors are hardly related to gait speed, it is recommendable that physiotherapist take notice of these factors and anticipate on these. For example, the side of brain damage can represent other kind of impairments leading to another approach of the physiotherapist and cardial co-morbidity can be a contra-indication for some types of training programs.

In chapter D4, some items are striking. First, balance is measured with functional mobility tests in all studies[79,81,92-96]. Significant and low, moderate or high relations are found. This finding is conformed in other studies[13,105] in which balance is related with mobility (defined as moving by changing body position or location or by transferring from one place to another). Therefore, measuring balance by functional mobility tests, as is frequently done in clinical practice, seems valuable in stroke rehabilitation. Second, different tasks of mobility are measured. According to Sturnieks et al.[105] mobility tasks are influenced by multiple physiological and psychological processes, including vision, peripheral sensation, reaction time, balance, strength and anxiety.[105] Prospective studies have shown that mobility decline is associated with increasing age, reduced levels of physical activity, higher body mass index, slower gait velocity, reduced leg strength, female gender, symptoms of distal symmetrical neuropathy, depressive symptoms and cognitive impairments[106-108]. These findings confirmed the results of this review; mobility is significantly related to gait speed.

The use of devices and social care, belonging to the “External Factors”, are related to gait speed. A properly adjusted orthoses in people with deviations of normal gait increases gait speed compared with the gait speed of people without an orthoses.[109] On the other hand,

Kuan et al.[110] reported the effects of cane use on the hemiplegic gait in patients with stroke, and they found that walking with a cane showed a significantly increased stride period, stride length, and affected side step length, as well as decreased cadence and step width. Regarding to gait speed, no significant change was found between patients with or without a cane. The relation between gait speed and social care is likely a psycho-social stimulation to physical activity.

In the chapter “Personal Factors”, different factors are studied. Age and gender, both showed non-significant cross-sectional univariate correlations and significant longitudinal univariate correlations with gait speed. The non-significant cross-sectional relation between age and gait speed can be explained by the fact that the relationship shows a curvilinear decline with a critical age of 62 years[111]. The significant longitudinal relation between age and gait speed might lead to the conclusion that younger people recover faster in regard to gait speed during stroke rehabilitation compared with older people. Regarding to gender, the male subjects were advantaged with respect to the female subjects in relation to gait speed[88]. Probably, the male subjects recover faster compared with female subjects in regard to gait speed during stroke rehabilitation. Although, age and gender cannot be influenced, physicians or physiotherapists might need to anticipate on these negative factors during rehabilitation.

More generally, it might be recommended that physiotherapists measure the factors which are significantly related to gait speed, especially the factors found in the longitudinal studies. These factors can be helpful in de the decision-making process of clinical reasoning (as clinical prediction rules) to optimize the rehabilitation program for the individual patient. The Guideline “Stroke” of The Dutch Society of Physical Therapy (KNGF)[112] included an intake-form, seven basic measurements and eighteen recommended measurements. These measurements match the mobility milestones of patients during their recovery period. The identified factors which are significantly related to gait speed are represented in the guideline, with exception of the visual function. Measuring the visual function do not belong to the profession of physiotherapists, however taking notice of this function can be valuable in designing the rehabilitation program.

The factors which are significantly related to gait speed and which can be influenced by physiotherapists can function as a focus for a physical training program to improve walking after stroke. Results of another review[17] show that physical training programs seem to be effective if they are task-oriented. Therefore, arranging a training program with a focus on walking with a mix of exercises regarding cardiovascular fitness, strength, balance, trunk control and ambulatory activities might be recommended. During this physical training program physiotherapists must be aware of the possible negative consequences of the factors which they cannot influence such as age, gender and social care. The physiotherapists must anticipate on these, for example by giving information to the patients or by increasing the trainings intensity or by suggesting walking aids or safety measures.

Some limitations need to be taken in consideration when comparing the results of the included studies in this review. One important limitation is the fact that the included studies used different outcome measures to describe factors such as gait speed, strength, spasticity, balance, motor function and functional assessment. Also different protocols were used, for example different body positions, different velocity angles and different instructions. In addition, comparability of the results will also be influenced by the fact that the studies did not use the same independent variables in the multiple regression analyses. The results only count for the specific regression analysis and a restriction about generalization is important[113]. Interpretation of the results should be done with care since some of the included studies showed disadvantages regarding the methodological quality. Some studies used different kinds of measurements which are not being known as valid or reliable. Therefore, is it unknown, whether these measurements determine what they intended to or if these measurements can be conceptualized as reproducibility or dependability.[113] Regarding the external validity the included studies contain subjects with different patient characteristics. The most important difference is the time since stroke onset of the subjects. It is debatable whether subjects with acute, subacute and chronic stroke are comparable with each other. However, the influence of the stage of stroke on the relationship between the different factors is unknown. Also the use of assistance or devices was not equal in all subjects. The use of an assistive device was permitted in some studies while in other studies it was prohibited.

Regarding the statistical validity of the studies, the sample size is frequently not adequate in relation to the number of determinants, so the statistical power of these results is low[113]. Furthermore, checking multicolinearity has only been done in two studies[74,88]. Therefore it is unknown whether the particular regression coefficient represents the importance of a single variable after having accounted for the effect of all other factors in the equation.[113] Finally, the main findings of some studies were not clearly described.

This review gives an overview of the relation of different factors with gait speed. There are a lot of factors significantly related with gait speed. For designing an optimal physical training for people with stroke, it is necessary to evaluate the impact of these factors on gait speed. More studies with multivariate regression analyses are needed to give that insight. Especially, longitudinal studies will be valuable to determine important prognostic factors which are related to gait speed. Another point of attention is the chosen outcome measures. Different outcome measures are used for measuring the same conceptual variable. This can cause confusion; therefore uniformity concerning the use of outcome measures is practical for the physiotherapists and needed for general statements. Guidelines can be helpful for getting this uniformity in clinical practice and research.

Summary

Comfortable gait speed in people with stroke is significantly related to various factors which are categorized in all segments of the ICF Core Set “Stroke”. The identified factors which can be influenced by physiotherapists can function as a focus for physical training programs for improving gait speed. The identified factors which cannot be influenced by physiotherapist can be used to anticipate on by physiotherapist during physical training programs to optimize rehabilitation after stroke.

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Table 2: Main Characteristics of the Subjects of the 25 Studies

Studies:	Number of subjects:			Age (in years): (mean ± SD (range))	Time since stroke onset: (mean ± SD (range))	Type of stroke:			Localization of stroke:			Use of assistance during walking trial:	Comfortable gait speed (in m/s): (mean ± SD (range))
	all	♂	♀			IS	HS	US	left	right	bi		
Ahmed et al. 2003	63	39	24	67 ± 14 (25-95)	8 ± 3 days (3-14)	59	4		30	31	2	Not described	0.55 ± 0.38 (0-1.33)
Bohannon et al. 1989	12	6	6	64.4 ± 14.1 (33-78)	36.4 ± 10.7 days (17-54)	Not described			Not described			Not described	0.26 ± 0.287 (0.05-1.02)
Bohannon et al. 1990	17	11	6	59.0 ± 11.4 (33.0-84.0)	51.0 ± 41.8 days (15.0-198.0)	Not described			7	10		Not described	Test 1: 0.336 ± 0.329 Test 2: 0.377 ± 0.305
Chen et al. 2003	35	17	18	Group 1: 59.4 ± 14.1 Group 2: 63.1 ± 11.2	6 mos	17	18	0	17	18		walk 20m without walking aids	Group 1: 15.1 ± 11.7 %BH/s Group 2: 30.2 ± 11.7 %BH/s
Quervain et al. 1996	18	12	6	59 (34-76)	Not described	18			6	12		2 harness, 14 four pint or straight cane, 6 AFO	0.08 - 1.05
Dettmann et al. 1987	15	15	0	64 (46–87)	2 yrs (1 mos to 11 yrs)	Not described			7	8		without usual walking aids or orthoses	0.473 ± 0.297
Duarte et al. 2002	28	?	?	64.5 ±13.1	15.33 ± 6 days	24	4		16	12		with technical devices and/or standby supervision	0.38 ± 0.57
Eng et al. 2002	25	17	8	62.6 ± 8.5 (50-82)	4.4 ± 3.0 yrs (1-11)	12	11	2	13	12		10 cane, 9 AFO	0.80 ± 0.26
Flansbjer et al. 2006	50	38	12	♂: 59.7 (46–72) ♀: 58.5 (50-66)	17.9 mos (6–46)	37	13		30	20		with their AFO and their assistive device	0.94 ± 0.28 (0.36-0.53)
Goldie et al.1999	42	20	22	median 66 (IQR 50-76)	Median 31 days (IQR 23-39)	Not described			19	23		no physical assistance, but with closer supervision, no aids or orthoses	0.45 ± 0.02
Hsu et al. 2003	26	19	7	54.2 (30–69)	10.3 mos (1–43)	13	13		12	14		without any orthoses or aids	0.62 ±0.21
Katz et al. 2005	44	22	22	65 ±11	15 days	Not described			Not described			using any assistance device needed	0.45 ± 0.16
Kelly et al. 2003	17	13	4	median 66 (IQR 48-73)	median 30 days (IQR 19-39)	13	4		Not described			7 need or physical or device assistance	median 0.71 (IQR 0.55-0.96)
Kim et al. 2003	20	14	6	61.2 ± 8.4 (52-82)	4.0 ±2.6 yrs (4.5-10.0)	9	7	4	9	11		7 cane, 13 no mobility aid	0.45 ± 0.25 (0.20-1.10)
Kwakkel et al. 2004	101	40	61	65.9 ± 10.6	7-14 days	101			41	60		Not described	0.03 ± 0.12
LeBrasseur et al. 2006	31	23	8	66.2 ± 1.5	17.5 ± 1.2 mos	31			Not described			with or without an assistive device	0.68 ± 0.06

Table 2 (Continued):

Studies:	Number of subjects:			Age (in years): (mean ± SD (range))	Time since stroke onset: (mean ± SD (range))	Type of stroke:			Localization of stroke:			Use of assistance during walking trial:	Comfortable gait speed (in m/s): (mean ± SD (range))
	all	♂	♀			IS	HS	US	left	right	bi		
Lin et al. 2005	21	15	6	65.2 ± 9.1 (51–79)	63.2 ± 55.5 mos (18–247)	12	9		13	8		11 none, 1 regular cane, 9 quadricane	Not described
Lin et al. 2006	68	52	16	61.69 ± 13.97	3.91 ± 5.87 yrs	Not described			26	42		without gait aids	0.65 ± 0.32 (0.04 -1.49)
Lindmark et al. 1995	34	22	12	♂: median 74 (IQR 49-82) ♀: median 72 (IQR 63-82)	3 mos	Not described			16	16	2	able to walk on their own	Men: 0.81 ± 0.21 Women: 0.72 ± 0.22
Liston et al. 1996	20	15	5	64.0 ± 8.5	46.3 mos (6 mos to 17 yrs)	Not described			10	10		Not described	Test 1:0.611 Test 2: 0.627 Test 3: 0.632
Michael et al. 2003	50	28	22	65 (45 -84)	10.3 mos (6-166)	50			Not described			Not described	0.42 ± 0.20 (0.09-1.03)
Nadeau et al. 1999	16	12	4	47.9±15.6 (18-73)	43.9 ± 36.5 mos (2-105)	8	5	3	4	12		Not described	0.76 ± 0.27 (0.41-1.50)
Patterson et al. 2007	74	43	31	64 ±10 (42-84)	48 ± 59 mos	Not described			Not described			39 AFO, 38 single point cane, 17 quad cane, 6 walker	0.51 ± 0.26 (0.13-1.17)
Pohl et al. 2002	83	44	39	70.3 ± 9.8 (50-90)	78.6 ± 27.4 days (36-145)	Not described			38	45		57 use assistive device, 26 no assistive device, 15 AFO	0.632 ± 0.259 (0.15-1.19)
Worthen et al. 2005	33	29	4	65 ± 8 (46-81)	45.9 ± 29.1 mos (12-121)	Not described			15	18		8 straight or quad cane, 8 AFO, 2 foot splint, no personal assistance	0.79 ± 0.34 (0.23-1.34)

All: number of all subjects, ♂: number of male subjects, ♀: number of female subjects
SD: Standard Deviation
IS: Ischemic Stroke, HS: Hemorrhagic Stroke, US: unknown
yrs: years, mos: months
%BH/s: percentage body height per second
AFO: ankle-foot orthoses

Table 3: Methodological Quality of the 25 Studies

Studies	Internal validity	External validity		Statistical validity				Reporting
	Item 1 Validity & Reliability	Item 2 Patient characteristics	Item 3 Interventions	Item 4 Variables statistically valid	Item 5 [n:K] Univariate ratio	Item 5 [n:K] Multivariate ratio	Item 6 Control for multicolinearity	Item 7 Main findings
Ahmed et al. 2003	X	+	-	+	+	+	+	+
Bohannon et al. 1989	X	-	-	-	-	n.a.	n.a.	-
Bohannon et al. 1990	X	-	-	+	-	n.a.	n.a.	+
Chen et al. 2003	-	+	-	+	n.a.	-	-	-
Quervain et al. 1996	-	-	-	+	-	n.a.	n.a.	-
Dettmann et al. 1987	X	-	-	+	-	n.a.	n.a.	+
Duarte et al. 2002	X	-	-	+	+	n.a.	n.a.	+
Eng et al. 2002	X	-	+	+	+	n.a.	n.a.	+
Flansbjer et al. 2006	X	-	-	+	+	-	-	+
Goldie et al.1999	-	-	-	+	+	-	-	+
Hsu et al. 2003	X	+	-	+	+	-	-	+
Katz et al. 2005	X	-	-	+	+	-	-	+
Kelly et al. 2003	-	-	+	+	-	n.a.	n.a.	+
Kim et al. 2003	X	+	-	+	+	-	-	+
Kwakkel et al. 2004	X	+	-	+	+	+	+	+
LeBrasseur et al. 2006	X	-	-	+	+	-	-	+
Lin et al. 2005	X	+	-	+	+	-	-	+
Lin et al. 2006	X	-	-	+	+	+	-	+
Lindmark et al. 1995	X	-	-	+	+	-	-	+
Liston et al. 1996	X	-	-	+	+	n.a.	n.a.	+
Michael et al. 2003	X	-	-	+	+	n.a.	n.a.	+
Nadeau et al. 1999	X	-	-	+	-	-	-	+
Patterson et al. 2007	-	-	-	+	+	n.a.	n.a.	+
Pohl et al. 2002	-	-	-	+	+	+	-	+
Worthen et al. 2005	X	-	-	+	+	n.a.	n.a.	+

X: some outcomes are described
+: positive, -: negative, n.a.: not applicable

Table 4: Factors Categorized in the ICF Core Set "Stroke"

Chapter	Name of chapters	Factors	
	Belonging to "Body Function"		
B1.	Mental functions	▪ Grade of consciousness ▪ Self-efficacy ▪ Cognition ▪ Depression	
B2.	Sensory functions and pain	▪ Spatial neglect ▪ Visual inattention ▪ Hemianopia ▪ Conjugate eye deviation ▪ Body image and proprioception	
B4.	Functions of the cardiovascular, haemological, immunological and respiratory system	▪ VO_{2peak} ▪ Heart rate ▪ Fractional utilization ▪ Oxygen consumption	
B6.	Genitourinary and reproductive functions	▪ Urinary incontinence	
B7.	Neuromusculoskeletal and movement related functions	▪ Passive stiffness (ankle) ▪ Joint position sense (JPS) (knee, ankle) ▪ Isometric torque + strength + force ▪ Isokinetic torque + strength + total work + power ▪ Lower and upper extremity motor strength ▪ Spasticity (knee, leg & foot, ankle)	▪ Lower extremity motor function ▪ Sensory function ▪ Produce locomotor rhythm ▪ Lower limb physical impairments Motor score (sub scores: both legs and paretic leg)
	Belonging to "Body Structures"		
S1.	Structures of the nervous system	▪ Type of stroke ▪ Side of brain damage	
S4.	Structures of the cardiovascular, haemological, immunological and respiratory system	▪ Cardial co-morbidity ▪ Hyperlipidemy	
S7.	Structures related to movement	▪ Bone mineral density	

Table 4 (Continued):

Chapter	Name of chapters	Factors	
	Belonging to "Activities and Participation"		
D4.	Mobility	▪ Unilateral gross dexterity ▪ Trunk control ▪ Balance ▪ Gait distance ▪ Gait speed ▪ Voluntary motor ability and basic mobility (sub scores: total, upper and lower extremity, basic mobility) ▪ Functional mobility	▪ Walking ability ▪ Walking function ▪ Ambulatory activity ▪ Functional assessment ▪ Combined strength of upper and lower limb, balance, proprioception and cognitive functions
D7./D8./D9.	Interpersonal interactions and relationships + Major life areas + Community, social and civic life	▪ Perceived participation	
	Belonging to "External Factors"		
E1.	Products and technology	▪ Use of devices	
E3.	Support and relationships	▪ Social care	
E5.	Services, systems and polices	▪ Treatment type	
	Belonging to "Personal Factors"	▪ Age ▪ Gender ▪ Race ▪ Body mass index ▪ Percentage body fat ▪ Lean mass ▪ Heredity ▪ Smoking	
	Belonging to the additional chapter "Others"	▪ Time since onset of stroke ▪ Hypertension ▪ Diabetes Mellitus	

Table 5: The Univariate and Multivariate Results of the Factors Categorized in "Body Functions"

B1. Mental functions

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Grade of consciousness	**IV:** Coma Glasgow Scale **DP:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .13	No[88]
Self-efficacy	**IV:** Ewart Self-Efficacy Scale **DV:** Ultrasonic gait speed monitor	**IV:** 17.5 ± 1.2 mos **DV:** Idem	No	Model 1: IVs: gender, cognition, depression, self-efficacy and knee extensor strength (P+NP) **Significant IVs:** knee extensor strength (P) + self-efficacy + gender Partial R^2 = .10 self-efficacy R^2 = .71 knee extensor strength (P)+ self-efficacy + gender Model 2: IVs: gender, cognition, depression, self-efficacy and knee extensor power (P+NP) **Significant IVs:** knee extensor power (P) + self-efficacy + gender Partial R^2 = .11 self-efficacy R^2 = .70 knee extensor power (P) + self-efficacy + gender[89]
Cognition	**IV:** Mini-Mental State Examination **DV:** Ultrasonic gait speed monitor	**IV:** 17.5 ± 1.2 mos **DV:** Idem	No	Model 1: IVs: gender, cognition, depression, self-efficacy and knee extensor strength (P+NP) **Significant IVs:** knee extensor strength (P) + self-efficacy + gender Cognition shows no significant contribution[89] Model 2: IVs: gender, cognition, depression, self-efficacy and knee extensor power (P+NP) **Significant IVs:** knee extensor power (P) + self-efficacy + gender Cognition shows no significant contribution[89]
	IV:- **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: age, gender, type of lesion, side of lesion, level of cognition and perceptual neglect **Significant IVs:** age + level of cognition R^2 = .30 age + cognition[74]
Depression	**IV:** Geriatric Depression Scale **DV:** Ultrasonic gait speed monitor	**IV:** 17.5 ± 1.2 mos **DV:** Idem	No	Model 1: IVs: gender, cognition, depression, self-efficacy and knee extensor strength (P+NP) **Significant IVs:** knee extensor strength (P) + self-efficacy + gender Depression shows no significant contribution Model 2: IVs: gender, cognition, depression, self-efficacy and knee extensor power (P+NP) **Significant IVs:** knee extensor power (P) + self-efficacy + gender Depression shows no significant contribution[89,89]

B2. Sensory functions and pain

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Spatial neglect	**IV:**- **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days(37-124)	No	IVs: age, gender, type of lesion, side of lesion, level of cognition and perceptual neglect **Significant IVs:** age + level of cognition Neglect shows no significant contribution[74]
	IV: Shape Cancellation Task **DV:** Clinical Stride Analyzer	**IV:** median 31 days (IQR 23-39) **DV:** median 86 days (IQR 79-95)	p>.05	IVs: age, time since onset of stroke, side of brain damage, spatial neglect and gait speed **Significant IVs:** initial gait speed + age Spatial neglect shows no significant contribution[83]
Visual inattention	**IV:** line-bisection task + letter-cancellation task **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.52**	No[88]
Hemianopia	**IV:** 2 grades: yes/no **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.28**	No[88]
Conjugate eye deviation	**IV:** 2 grades: yes/no **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.24*	No[88]
Body image & proprioception	**IV:** Thumb Find Test **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.40**	No[88]

B4. Functions of the cardiovascular, haemological, immunological and respiratory system

VO_{2peak}	**IV:** Cycle ergometer test (ag) **DV:** Timed 10-meter	**IV:** median 30 days (IQR 19-39) **DV:** Idem	R = .73*	No[86]
	IV: Treadmill test **DV:** Timed 10-meter	**IV:** 10.3 mos (6-166) **DV:** Idem	r = .290	No[94]
	IV: Treadmill test **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .54***	No[96]
Heart rate	**IV:** Exercise stress test **DV:** Timed 10-meter	**IV:** median 30 days (IQR 19-39) **DV:** Idem	R = .55*	No[86]
Fractional utilization	**IV:** Treadmill test **DV:** Timed 10-meter	**IV:** 10.3 mos (6-166) **DV:** Idem	r = -.163	No[94]
Oxygen consumption	**IV:** Treadmill test **DV:** Timed 10-meter	**IV:** 10.3 mos (6-166) **DV:** Idem	R = .207	No[94]

B6. Genitourinary and reproductive functions

Urine incontinence	**IV:** 2 grades: yes/no **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.27**	No[88]

B7. Neuromusculoskeletal and movement related functions

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Passive stiffness of ankle plantarflexors	**IV:** Electronic goniometer **DV:** GAITRite system (bw)	**IV:** 3.91 ± 5.87 yrs **DV:** Idem	r = -.16	IVs: ankle plantarflexor strength (P), ankle dorsiflexor strength (P), spasticity index of ankle plantarflexors, passive stiffness of plantarflexors and ankle JPS **Significant IVs:** ankle dorsiflexors strength (P) + spasticity index of ankle plantarflexors + ankle JPS Passive stiffness of plantarflexors shows no significant contribution[90]
Knee joint position sense (JPS)	**IV:** Computerized 2-inclinometer system **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	r = -.075	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age, use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS Knee JPS shows no significant contribution R^2 = .96 all the independent variables together[91]
Ankle joint position sense (JPS)	**IV:** Computerized 2-inclinometer system **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	r = -.021	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age, use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS R^2 = .96 all the independent variables together[91]
	IV: Electronic goniometer **DV:** GAITRite system (bw)	**IV:** 3.91 ± 5.87 yrs **DV:** Idem	r = -.27*	IVs: ankle plantarflexor strength (P), ankle dorsiflexor strength (P), spasticity of ankle plantarflexors, passive stiffness of plantarflexors and ankle JPS **Significant IVs:** ankle dorsiflexors strength (P) + spasticity index of ankle plantarflexors + ankle JPS R^2 = .30 dorsiflexors strength (P) R^2 = .45 dorsiflexors strength (P) + ankle JPS R^2 = .50 dorsiflexors strength (P) + ankle JPS + spasticity of ankle plantarflexors[90]
Isometric hip flexion strength	**IV:** Power Track II dynamometer (bw) **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	Paretic: r = .663**	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age + use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS R^2 = .96 all the independent variables together[91]
Isometric knee extension torque	**IV:** Cybex II isokinetic dynamometer **DV:** Timed 8-meter	**IV:** 51.0 ± 41.8 days (15.0-198.0) **DV:** Idem	Paretic: r = .539* – r = .605*	No[76]

	IV: Cybex 6000 Dynamometer **DV:** Timed 10-meter	**IV:** 78.6 ± 27.4 days (36-145) **DV:** Idem	No	Model 1: IVs: age, gender, rate of knee extensor torque (P) and knee extensor peak torque (P) **Significant IVs:** unclear R^2 =.12 age + gender + rate of knee extensor torque (P) + knee extensor peak torque (P) R^2 = .12 age + rate of knee extensor torque (P) + knee extensor peak torque (P) R^2 = .06 gender + rate of knee extensor torque (P) + knee extensor peak torque (P) R^2 = .06 rate of knee extensor torque (P) + knee extensor peak torque (P) Model 2: IVs: age, gender, rate of knee extensor torque (NP) and knee extensor peak torque (NP) **Significant IVs:** unclear R^2 = .10 age + rate of knee extensor torque (NP) and knee extensor peak torque (NP) R^2 = .10 age + rate of knee extensor torque (NP) and knee extensor peak torque (NP) R^2 = .08 gender + rate of knee extensor torque (NP) and knee extensor peak torque (NP) R^2 = .07 rate of rate of knee extensor torque (NP) and knee extensor peak torque (NP)[97]
Isometric knee extension strength	**IV:** Power Track II dynamometer (bw) **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	P: r = .436*	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age + use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS R^2 = .96 all the independent variables together[91]
Isometric knee extension force	**IV:** hand held dynamometer **DV:** Timed 8-meter	**IV:** 36.4 ± 10.7 days (17-54) **DV:** Idem	P: r = .702 p=? NP: r = .545 p=?	No[75]
Isometric ankle plantarflexion strength	**IV:** Power Track II dynamometer (bw) **DV:** GAITRite system (bw)	**IV:** 3.91 ± 5.87 yrs **DV:** Idem	P: r = .58**	IVs: ankle plantarflexor strength (P), ankle dorsiflexor strength (P), spasticity index of ankle plantarflexors, passive stiffness of plantarflexors and ankle JPS **Significant IVs:** ankle dorsiflexors strength (P) + spasticity index of ankle plantarflexors + ankle JPS Ankle plantarflexor strength (P) shows no significant contribution [90]
Isometric ankle dorsiflexion strength	**IV:** Power Track II dynamometer (bw) **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	P: r = .645**	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age + use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS R^2 = .96 all the independent variables together[91]
	IV: Power Track II dynamometer (bw) **DV:** GAITRite system (bw)	**IV:** 3.91 ± 5.87 yrs **DV:** Idem	P: r = .67**	IVs: ankle plantarflexor strength (P), ankle dorsiflexor strength (P), spasticity index of ankle plantarflexors, passive stiffness of plantarflexors and ankle JPS **Significant IVs:** ankle dorsiflexors strength (P) + spasticity index of ankle plantarflexors + ankle JPS R^2 = .30 dorsiflexors strength (P) R^2 = .45 dorsiflexors strength (P) + ankle JPS R^2 = .50 dorsiflexors strength (P) + ankle JPS + spasticity of ankle plantarflexors[90]

Isokinetic hip flexors torque	**IV:** Cybex 6000 dynamometer (at 30°/s) (bw) **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	P: r = .49*	No[84]
	IV: Kin-Com dynamometer (at 60°/s) (bw) **DV:** Infrared-emitting diodes	**IV:** 4.0 ± 2.6 yrs (4.5-10.0) **DV:** Idem	P: r = .574** NP: r = .380	IVs: torque of hip flexors (P), knee flexors (P), ankle plantarflexors (P), knee flexors (NP) and ankle plantarflexors (NP) **Significant IV:** torque of ankle plantarflexors (P) Hip flexor torque (P) shows no significant contribution[87]
	IV: Biodex dynamometer (at 30°/s) (bw) **DV:** Videographic data	**IV:** 43.9 ± 36.5 mos (2-105) **DV:** Idem	P: r = .827***	IVs: lower extremity motor function, sensory function, balance, ankle plantarflexion spasticity, hip flexor torque (P)and plantarflexor torque (P) **Significant IV:** hip flexor torque (P) R^2 = .685 hip flexor torque (P)[95]
Isokinetic hip flexor total work	**IV:** Cybex 6000 dynamometer at 30°/s) (bw) **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	P: r = .57**	IVs: total work of hip flexor (P), knee extensor (P) and ankle plantarflexor (P), lower extremity motor function, sensory function (P), ankle plantarflexor spasticity **Significant IVs:** total work of hip flexors (P) + ankle plantarflexor spasticity + sensory function (P) R^2 = .32 total work of hip flexors (P)[84]
Isokinetic hip extensor torque	**IV:** Kin-Com dynamometer (at 60°/s) (bw) **DV:** Infrared-emitting diodes	**IV:** 4.0 ± 2.6 yrs (4.5-10.0) **DV:** Idem	P: r = .351 NP: r = .346	No[87]
Isokinetic knee flexor torque	**IV:** Kin-Com dynamometer (at 60°/s N=14, 30°/s N=6) (bw) **DV:** Infrared-emitting diodes	**IV:** 4.0 ± 2.6 yrs (4.5-10.0) **DV:** Idem	P: r = .555* NP: r = .615**	IVs: torque of hip flexors (P), knee flexors (P), ankle plantarflexors (P), knee flexors (NP) and ankle plantarflexors (NP) **Significant IV:** torque of ankle plantarflexors (P) Knee flexor torque of (P + NP) shows both no significant contribution[87]
	IV: Cybex II dynamometer (at 90°/s) **DV:** Photocells	**IV:** 3 mos **DV:** Idem	P: Men: r = .43* P: Women: r = .52	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
	IV: Cybex II dynamometer (at 12°/s) **DV:** Photocells	**IV:** 3 mos **DV:** Idem	P: Men: r = .63** P: Women: r = .72*	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
Isokinetic knee flexor strength	**IV:** Biodex Multi-Joint System II dynamometer (at 60°/s) **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	P: r = .61** NP: r = .09	IVs: knee flexor strength (P + NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee flexor strength (P +NP) R^2 = .37 knee flexor strength (P) R^2 = .42 knee flexor strength (P +NP)[82]
Isokinetic knee extensor torque	**IV:** Cybex 6000 dynamometer (at 90°/s) (bw) **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	P: r = .52**	No[84]
	IV: Kin-Com dynamometer (at 60°/s N=14, 30°/s N=6) (bw) **DV:** Infrared-emitting diodes	**IV:** 4.0 ± 2.6 yrs (4.5-10.0) **DV:** Idem	P: r = .408 NP: r = .331	IVs: torque of hip flexors (P), knee flexors (P), ankle plantarflexors (P), knee flexors (NP) and ankle plantarflexors (NP) **Significant IV:** torque of ankle plantarflexors (P) Knee extensor torque (P + NP) shows both no significant contribution[87]

	IV: Cybex II dynamometer (at 90°/s) **DV:** Photocells	**IV:** 3 mos **DV:** Idem	P: Men: r = .53* P: Women: r = .21	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
	IV: Cybex II dynamometer (at 12°/s) **DV:** Photocells	**IV:** 3 mos **DV:** Idem	P: Man: r = .43 P: Women: r = .69*	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
Isokinetic knee extensor strength	**IV:** Biodex Multi-Joint System II dynamometer (at 60°/s) **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	P: r = .61** NP: r = .12	IVs: knee extensor strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee extensor strength (P+NP) R^2 = .37 knee extension strength (P) R^2 = .46 knee extension strength (P+NP)[82]
	IV: Computer-interfaced pneumatic resistance machines **DV:** Ultrasonic gait speed monitor	**IV:** 17,5 ± 1,2 mos **DV:** Idem	*	IVs: gender, cognition, depression, self-efficacy and knee extensor strength (P+NP) **Significant IVs:** unclear Partial R^2 = .13 knee extensor strength (P) R^2 = .71 knee extensor strength (P) + self-efficacy + gender[89]
Isokinetic knee extension power	**IV:** Computer-interfaced pneumatic resistance machines **DV:** Ultrasonic gait speed monitor	**IV:** 17,5 ± 1,2 mos **DV:** Idem	*	IVs: gender, cognition, depression, self-efficacy and knee extensor power (P+NP) **Significant IVs:** unclear Partial R^2 = .21 knee extensor power (P) R^2 = .70 knee extensor power (P) + self-efficacy + gender[89]
Knee flexor combined with knee extensor strength	**IV:** Isokinetic dynamometry trough a range of 20-70 degrees across speeds 30°/s,90°/s,120°/s **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	P: r = .60*** NP: r=.38*	No[96]
Isokinetic ankle plantairflexion torque	**IV:** Cybex 6000 dynamometer (at 30°/s) (bw) **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	P: r =.42*	No[84]
	IV: Kin-Com dynamometer (at 60°/s N=2, 30°/s N=18) (bw) **DV:** Infrared-emitting diodes	**IV:** 4.0 ± 2.6 yrs (4.5-10.0) **DV:** Idem	P: r = .845** NP: r = .486*	IVs: torque of hip flexors (P), knee flexors (P), ankle plantarflexors (P), knee flexors (NP) and ankle plantarflexors (NP) **Significant IV:** torque of ankle plantarflexors (P) Torque of ankle plantarflexor (NP) shows no significant contribution. R^2= .715 ankle plantarflexor torque (P)[87]
	IV: Biodex dynamometer system (at 30°/s) (bw) **DV:** Videographic data	**IV:** 43.9 ± 36.5 mo (2-105) **DV:** Idem	P: r = .337	IVs: lower extremity motor function, sensory function, balance, ankle plantarflexion spasticity, hip flexor torque (P) and plantarflexor torque (P) **Significant IV:** hip flexor torque (P) Ankle plantarflexor torque (P)shows no significant contribution[95]

Isokinetic ankle plantarflexor total work	**IV:** Cybex 6000 dynamometer (at 30°/s) (bw) **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	P: r = .39*	IVs: total work of hip flexor (P), knee extensor (P) and ankle plantarflexor (P), lower extremity motor function, sensory function (P), ankle plantarflexor spasticity **Significant IVs:** total work of hip flexors (P)+ ankle plantarflexor spasticity + sensory function (P) Total work of ankle plantarflexor (P) shows no significant contribution[84]
Isokinetic ankle plantairflexion strength	**IV:** Kin-Com dynamometer (at 30°/s) (bw) **DV:** Infrared-emitting diodes (ll)	**IV:** 4.4 ± 3.0 yrs (1-11) **DV:** Idem	P: r = .537** NP: r = -.232	No[81]
Isokinetic ankle dorsiflexion torque	**IV:** Kin-Com dynamometer (at 60°/s N=2, 30°/s N=18) (bw) **DV:** Infrared-emitting diodes	**IV:** 4.0 ± 2.6 yrs (4.5-10.0) **DV:** Idem	P: r = .329 NP: r = .294	IVs: torque of hip flexors (P), knee flexors (P), ankle plantarflexors (P), knee flexors (NP) and ankle plantarflexors (NP) **Significant IV:** torque of ankle plantarflexors (P) Ankle dorsiflexor torque (P+NP) shows both no significant contribution[87]
Lower extremity motor strength	**IV:** Motricity Index **DV:** Vicon motion analysis system	**IV + DV:** cross-sectional	"associated"	No[78]
	IV: Motricity Index **DV:** Timed 10-meter	**IV:** 2 wks (+ 10 wks) **DV:** 26 wks	r = .67**	IVs: lower extremity motor strength, social care and trunk control **Significant IVs:** lower extremity motor strength + social care + trunk control After 2 wks: R^2= .37 lower extremity motor strength After 2 wks: R^2= .46 lower extremity motor strength + social care After 2 wks: R^2= .49 lower extremity motor strength + social care + trunk control After 10 wks: R^2 = .62 lower extremity motor strength + social care[88]
	IV: Scandinavian Stroke Scale **DV:** Timed 10-meter	**IV:** 15 days **DV:** 3 mo	Not significant	IVs: produce locomotor rhythm with and without resistance, age, lower extremity motor strength and walking function **Significant IVs:** locomotor rhythm with and without resistance Lower extremity strength shows no significant contribution[85]
Upper extremity motor strength	**IV:** Motricity Index **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .67**	No[88]
Spasticity Knee extension spasticity	**IV:** Cybex II isokinetic dynamometer **DV:** Timed 8-meter	**IV:** 51.0 ± 41.8 days (15.0 -198.0) **DV:** Idem	r = -.189 - r = -.267	No[76]
Leg and foot spasticity	**IV:** Ashworth Scale **DV:** Infrared-emitting diodes (ll)	**IV:** 4.4 ± 3.0 yrs (1-11) **DV:** Idem	r = -.452*	No[81]
Ankle plantarflexion spasticity	**IV:** Modified Ashworth Scale **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mo (1–43) **DV:** Idem	r = -.47*	IVs: total work of hip flexor (P), knee extensor (P) and ankle plantarflexor (P), lower extremity motor function, sensory function (P) and ankle plantarflexor spasticity. **Significant IVs:** total work of hip flexors (P) + ankle plantarflexor spasticity + sensory function (P) R^2 = .51 total work of hip flexor (P) + spasticity R^2 = .57 total work of hip flexor (P) + spasticity + sensory function[84]

	IV: electromyography-lengthening slope (mv) **DV:** GAITRite system (bw)	**IV:** 3.91 ± 5.87 yrs **DV:** Idem	r = -.46**	IVs: ankle plantarflexor strength (P), ankle dorsiflexor strength (P), spasticity index of ankle plantarflexors, passive stiffness of plantarflexors and ankle JPS **Significant IVs:** ankle dorsiflexors strength (P) + spasticity index of ankle plantarflexors + ankle JPS R^2 = .30 dorsiflexors strength (P) R^2 = .45 dorsiflexors strength (P) + ankle JPS R^2 = .50 dorsiflexors strength (P) + ankle JPS + spasticity of ankle plantarflexors[90]
	IV: spasticity scale proposed by Levin and Hui-Chan **DV:** Videographic data	**IV:** 43.9 ± 36.5 mos (2-105) **DV:** Idem	r = -.009	IVs: lower extremity motor function, sensory function, balance, ankle plantarflexion spasticity, hip flexor torque (P) and plantarflexor torque (P) **Significant IV:** hip flexor torque (P) Ankle plantarflexion spasticity shows no significant contribution[95]
Lower extremity motor function	**IV:** Fugl-Meyer Assessment **DV:** Vicon motion analysis system	**IV + DV:** cross-sectional	"associated with"	No[78]
	IV: Fugl-Meyer Assessment **DV:** Interrupted lightphotography	**IV:** 2 yrs (1 mos - 11 yrs) **DV:** Idem	r = .66**	No[79]
	IV: Fugl-Meyer Assessment **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	r = .54**	IVs: total work of hip flexor (P), knee extensor (P) and ankle plantarflexor (P), lower extremity motor function, sensory function (P) and ankle plantarflexor spasticity **Significant IVs:** total work of hip flexors (P) + ankle plantarflexor spasticity + sensory function (P) Lower extremity motor function shows no significant contribution[84]
	IV: Fugl-Meyer Assessment **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	significant	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age + use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS Lower extremity motor function shows no significant contribution. R^2 =0.96 all the independent variables together[91]
	IV: Fugl-Meyer Assessment **DV:** Videographic data	**IV:** 43.9 ± 36.5 mos (2-105) **DV:** Idem	r = .613**	IVs: lower extremity motor function, sensory function, balance, ankle plantarflexion spasticity, hip flexor torque (P) and plantarflexor torque (P) **Significant IV:** hip flexor torque (P) Lower extremity motor function shows no significant contribution[95]
	IV: Brunnstrom recovery stages **DV:** Vicon motion analysis system (bh)	**IV:** 6 mo **DV:** Idem	No	IVs: lower extremity motor function of proximal and distal part (P), age and gender **Significant IVs:** lower extremity motor function of proximal part + age Adjusted R^2 = .374 lower extremity motor function of proximal part + age[77]
	IV: Brunnstrom Fugl-Meyer Assessment **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .61**	No[88]
Sensory function	**IV:** Fugl-Meyer Assessment **DV:** Interrupted light photography	**IV:** 2 yrs (1 mos - 11 yrs) **DV:** Idem	Not significant	No[79]
	IV: Fugl-Meyer Assessment **DV:** GAITMatII gait acquisition and analysis system	**IV:** 10.3 mos (1–43) **DV:** Idem	r = .40*	IVs: total work of hip flexor (P), knee extensor (P) and ankle plantarflexor (P), lower extremity motor function, sensory function (P) and ankle plantarflexor spasticity **Significant IVs:** total work of hip flexors (P) + ankle plantarflexor spasticity + sensory function (P) R^2 = .57 total work hip flexor (P) + spasticity + sensory function (P)[84]

	IV: Fugl-Meyer Assessment **DV:** Videographic data	**IV:** 43.9 ± 36.5 mos (2-105) **DV:** Idem	r = .139	IVs: lower extremity motor function, sensory function, balance, ankle plantarflexion spasticity, paretic hip flexor torque and paretic plantarflexor torque **Significant IV:** paretic hip flexor torque Sensory function shows no significant contribution[95]
Produce locomotor rhythm	**IV:** Cycling test **DV:** Timed 10-meter	**IV:** 15 days **DV:** 3 mo	significant	IVs: produce locomotor rhythm with and without resistance, age, lower extremity motor strength and walking function **Significant IVs:** produce locomotor rhythm with and without resistance R^2= .40 cycle at constant rhythm + cycle at constant rhythm against 10W[85]
Lower limb physical impairments	**IV:** Chedoke-Mc Master impairment score **DV:** Infrared-emitting diodes (ll)	**IV:** 4,4 ± 3.0 yrs (1-11) **DV:** Idem	r = .757**	No[81]
Motor score (P+NP)	**IV:** BL Motor Assessment Chart **DV:** Photocells	**IV:** 3 mos **DV:** Idem	Men: r = .66** Women: r = .50	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
Motor score (P)	**IV:** BL Motor Assessment Chart **DV:** Photocells	**IV:** 3 mos **DV:** Idem	Men: r = .57** Women: r =.62*	No[92]

IV: Independent Variable, IVs: independent variables, DV: dependent variable
*: p<0.05, **: p<0.01, ***: p<0.001
r: Spearman or Pearson's correlation coefficient, R: regression coefficient
wks: weeks, mos: months, yrs: years
P: paretic side, NP: non-paretic side
ag: normalized to age, bh: normalized to body height, bw: normalized to body weight, ll: normalized to leg length, mv: normalized to maximum value

Table 6: The Univariate and Multivariate Results of the Factors Categorized in "Body Structures"

S1. Structures of the nervous system

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Type of stroke	**IV:** - **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	No	Model 1: IVs: knee extension strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee extensor strength (N+NP) Type of stroke shows no significant contribution. Model 2: IVs: knee flexion strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee flexor strength (N+NP) Type of stroke shows no significant contribution[82]
	IV: 3 grades (0=LACI,1=PACI,2=TACI) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.43**	No[88]
	IV:- **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: age, gender, type of lesion, side of lesion, level of cognition and perceptual neglect **Significant IVs:**: age + level of cognition Type of stroke showed no statistic significant contribution[74]
Side of brain damage	**IV:** 2 grades (left/right) **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	No	Model 1: IVs: knee extension strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee extensor strength (N+NP) Side of weakness shows no significant contribution. Model 2: IVs: knee flexion strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee flexor strength (N+NP) Side of weakness shows no significant contribution[82]
	IV: 2 grades (left/right) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.13	No[88]
	IV: - **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: age, gender, type of lesion, side of lesion, level of cognition and perceptual neglect **Significant IVs:** age + level of cognition Side of brain damage showed no statistic significant contribution[74]
	IV: 2 grades (left/right) **DV:** Clinical Stride Analyzer	**IV:** median 31 days (IQR 23-39) **DV:** median 86 days (IQR 79-95)	p>.05	IVs: age, time since onset of stroke, side of brain damage, spatial neglect and gait speed **Significant IVs:** initial gait speed + age Side of brain damage shows no significant contribution[83]

S4. Structures of the cardiovascular, haemological, immunological and respiratory system

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Cardial co-morbidity	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.04	No[88]
Hyperlipidemy	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.15	No[88]

S7. Structures related to movement

Bone mineral density	**IV:** Dual-energy X-ray absorptiometry **DV:** GAITRite system	**IV:** 45.9 ± 29.1 mos (12-121) **DV:** Idem	P: r = .178 NP: r = .191	No[98]

IV: Independent Variable, IVs: independent variables, DV: dependent variable
*: p<0.05, **: p<0.01, ***: p<0.001
r: Spearman or Pearson's correlation coefficient, R: regression coefficient
wks: weeks, mos: months, yrs: years
P: paretic side, NP: non-paretic side

Table 7: The Univariate and Multivariate Results of the Factors Categorized in "Activities and Participation"

D4. Mobility

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Unilateral gross manual dexterity	**IV:** Box and Block test **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: unilateral gross manual dexterity (adjusted for age and level of cognition) **Significant IVs:** unilateral gross manual dexterity (adjusted for age and level of cognition) R^2= .44 unilateral gross manual dexterity (adjusted for age and level of cognition)[74]
Trunk control	**IV:** Trunk Control Test **DV:** computerized photography	**IV:** admission rehabilitation unit 15.33 ± 6 days **DV:** discharge 19.2± 7.6 days later than admission	r = -.644 *	No[80]
	IV: Trunk Control Test **DV:** Timed 10-meter	**IV:** 2 wks + 4 wks **DV:** 26 wks	r = .53**	IVs: lower extremity motor strength, social care and trunk control **Significant IVs:** lower extremity motor strength + social care + trunk control After 2 wks: R^2= .49 lower extremity motor strength + social care + trunk control After the fourth week trunk control showed no significant contribution[88]
Balance	**IV:** Berg Balance Scale **DV:** Timed 10-meter	**IV:** 10.3 mos (6-166) **DV:** Idem	r = .377*	No[94]
	IV: Berg Balance Scale **DV:** Infrared-emitting diodes (ll)	**IV:** 4.4 ± 3.0 yrs (1-11) **DV:** Idem	r = .784**	No[81]
	IV: Berg Balance Scale **DV:** Timed 10-meter	**IV:** 46.3 mos (6 mos - 17 yrs) **DV:** Idem	r = .813**	No[93]
	IV: Berg Balance Scale **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .64***	No[96]
	IV: Fugl-Meyer Assessment **DV:** Interrupted light photography	**IV:** 2 yrs (1 mos to 11 yrs) **DV:** Idem	r= .61*	No[79]
	IV: Fugl-Meyer Assessment **DV:** Videographic data	**IV:** 43.9 ± 36.5 mos (2-105) **DV:** Idem	r = .507*	IVs: lower extremity motor function, sensory function, balance, ankle plantarflexion spasticity, hip flexor torque (P) and plantarflexor torque (P) **Significant IV:** hip flexor torque (P) Balance shows no significant contribution [95]
	IV: BL Motor Assessment Score **DV:** Photocells	**IV:** 3 mos **DV:** Idem	Men: r = .78*** Woman: r = .31	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
	IV: Berg Balance Scale **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: balance (adjusted for age and level of cognition) **Significant IVs:** balance (adjusted for age and level of cognition) R^2 = .62 balance (adjusted for age and level of cognition) [74]
Gait distance	**IV:** 6 MWT (ll) **DV:** Infrared-emitting diodes (ll)	**IV:** 4,4 ± 3.0 yrs (1-11) **DV:** Idem	r = .920**	No[81]
	IV: 6 MWT **DV:** Timed 10-meter	**IV:** median 30 days (IQR 19-39) **DV:** Idem	R = .91*	No[86]

	IV: 6 MWT **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .88***	No[96]
	IV: 12 MWT **DV:** Infrared-emitting diodes (II)	**IV:** 4.4 ± 3.0 yrs (1-11) **DV:** Idem	r = .914**	No[81]
Gait speed	**IV:** Timed 5-meter **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: gait speed (adjusted for age and level of cognition) **Significant IVs:** gait speed (adjusted for age and level of cognition) R^2 = .60 gait speed (adjusted for age and level of cognition)[74]
	IV: Clinical Stride Analyzer **DV:** Clinical Stride Analyzer	**IV:** median 31 days (IQR 23-39) **DV:** median 86 days (IQR 79-95)	r = .79*	IVs: age, time since onset of stroke, side of brain damage, spatial neglect and gait speed **Significant IVs:** initial gait speed + age R^2 = .62 initial gait speed R^2 = .66 initial gait speed + age[83]
Voluntary motor ability and basic mobility	**IV:** Stroke Rehabilitation Assessment of Movement **DV:** Timed 5-meter	**IV:** T0: 8 ± 3 days (3-14) T1: 29± 5 days (19-50) T2: 85 ± 17 days (37-124) **DV:** Idem	T0: r = .74*** T1: r = .62*** T2: r = .73***	IVs: level of cognition and voluntary motor ability (adjusted for age and level of cognition) **Significant IVs:** voluntary motor ability (adjusted for age and level of cognition) R^2 = .61 level of cognition and voluntary motor ability (adjusted for age and level of cognition)[74]
Voluntary motor ability and basic mobility of the upper extremity	**IV:** Stroke Rehabilitation Assessment of Movement **DV:** Timed 5-meter	**IV:** T0: 8 ± 3 days (3-14) T1: 29 ± 5 days (19-50) T2: 85 ± 17 days (37-124) **DV:** Idem	T0: r = .56*** T1: r = .53*** T2: r = .64***	No[74]
Voluntary motor ability and basic mobility of the lower extremity	**IV:** Stroke Rehabilitation Assessment of Movement **DV:** Timed 5-meter	**IV:** T0: 8 ± 3 days (3-14) T1: 29± 5 days (19-50) T2: 85 ± 17 days (37-124) **DV:** Idem	T0: r = .74*** T1: r = .55*** T2: r = .65***	No[74]
Basic mobility	**IV:** Stroke Rehabilitation Assessment of Movement **DV:** Timed 5-meter	**IV:** T0: 8 ± 3 days (3-14) T1: 29± 5 days (19-50) T2: 85 ± 17 days (37-124) **DV:** Idem	T0:r = .83*** T1: r = .65*** T2: r = .76***	No[74]
Functional mobility	**IV:** Timed Up and Go Test **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: functional mobility (adjusted for age and level of cognition) **Significant IVs:** functional mobility (adjusted for age and level of cognition) R^2 = 0.60 functional mobility + age + level of cognition[74]
Walking ability	**IV:** BL Motor Assessment Chart **DV:** Photocells	**IV:** 3 mos **DV:** Idem	Men: r = .63** Women: r= .74**	IVs: knee extensor torque (P), knee flexor torque (P), total motor score (P+NP), balance and walking ability (for the whole group) **Significant IVs:** unclear R value was above .65[92]
Walking function	**IV:** Scandinavian Stroke Scale **DV:** Timed 10-meter	**IV:** 15 days **DV:** 3 mo	No	IVs: produce locomotor rhythm with and without resistance, age, lower extremity motor strength and walking function **Significant IVs:** produce locomotor rhythm with and without resistance Walking function shows no statistic significant contribution[85]
Ambulatory activity	**IV:** Steps activity monitor **DV:** Timed 10-meter	**IV:** 10.3 mos (6-166) **DV:** Idem	r = .554**	No[94]
Functional	**IV:** Fugl-Meyer Assessment **DV:** Interrupted light photography	**IV:** 2 yrs (1 mos - 11 yrs) **DV:** Idem	r = .64*	No[79]

assessment	**IV:** Barthel-Index **DV:** Interrupted light photography	**IV:** 2 yrs (1 mos - 11 yrs) **DV:** Idem	r = .76 **	No[79]
	IV: Barthel-Index **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: self-care, continence and mobility (adjusted for age and level of cognition) **Significant IVs:** self-care, continence, mobility (adjusted for age and level of cognition) R^2 = .56 self-care, continence and mobility (adjusted for age and level of cognition)[74]
	IV: Barthel Index **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .62**	No[88]
Strength upper & lower limb, balance, proprioception and cognitive functions	**IV:** Orpington Prognostic Scale **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.58**	No[88]
D7. Interpersonal interactions and relationships + D8. Major life areas + D9. Community, social and civic life				
Perceived participation	**IV:** Stroke Impact Scale **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	r = .57**	No[82]

IV: Independent Variable, IVs: independent variables, DV: dependent variable
*: p<0.05, **: p<0.01, ***: p<0.001
r: Spearman or Pearson's correlation coefficient, R: regression coefficient
wks: weeks, mos: months, yrs: years
P: paretic side, NP: non-paretic side
ll: normalized to leg length

Table 8: The Univariate and Multivariate Results of the Factors Categorized in "External Factors"

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
E1. Products and technology				
Use of devices	**IV:** - **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	No	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age + use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors +ankle JPS R^2 = .96 all the independent variables together[91]
E3. Support and relationships				
Social care	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .36*	IVs: lower extremity motor strength, social care and trunk control **Significant IVs:** lower extremity motor strength + social care + trunk control After 2 wks: R^2= .37 lower extremity motor strength After 2 wks: R^2= .46 lower extremity motor strength + social care After 2 wks: R^2= .49 lower extremity motor strength + social care + trunk control After 10 wks: R^2 = .62 lower extremity motor strength + social care[88]
E5. Services, systems and polices				
Treatment type	**IV:** 3 grades (0:airsplint, 1: arm training, 2: leg training) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .25	No[88]

IV: Independent Variable, IVs: independent variables, DV: dependent variable
*: p<0.05, **: p<0.01, ***: p<0.001
r: Spearman or Pearson's correlation coefficient, R: regression coefficient
wks: weeks, mos: months, yrs: years
P: paretic side, NP: non-paretic side
ag: normalized to age, bh: normalized to body height, bw: normalized to body weight, ll: normalized to leg length, mv: normalized to maximum value

Table 9: The Univariate and Multivariate Results of the Factors Categorized in "Personal Factors"

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Age	**IV:**- **DV:** Timed 10-meter	**IV:** 78.6 ± 27.4 days (36-145) **DV:** Idem	No	Model 1: IVs: age, gender, rate of knee extensor torque (P) and knee extensor peak torque (P) **Significant IVs:** unclear R^2 = .12 age + gender + rate of knee extensor torque (P) + knee extensor peak torque (P) R^2 = .12 age + rate of knee extensor torque (P) + knee extensor peak torque (P) Model 2: IVs: age, gender, rate of knee extensor torque (NP) and knee extensor peak torque (NP) **Significant IVs:** unclear R^2 = .10 age + gender + rate of knee extensor torque (NP) and knee extensor peak torque (NP) R^2 = .10 age + rate of knee extensor torque (NP) and knee extensor peak torque (NP)[97]
	IV:- **DV:** Vicon motion analysis system (bh)	**IV:** 6 mos **DV:** Idem	No details	IVs: lower extremity motor function of proximal and distal part of paretic side, age and gender **Significant IVs:** lower extremity motor function of proximal part + age Adjusted R^2 = .374 lower extremity motor function of proximal part + age[77]
	IV:- **DV:** Vicon motion analysis system	**IV + DV:** cross-sectional	p>.05	No[78]
	IV: - **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	No	Model 1: IVs: knee extension strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee extensor strength (P+NP) Age shows no significant contribution Model 2: IVs: knee flexion strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee flexor strength (N+NP) Age shows no significant contribution[82]
	IV: grades (<49yrs, 50-59, 60-69, etc.) **DV:** Clinical Stride Analyzer	**IV:** median 31 days (IQR 23-39) **DV:** median 86 days (IQR 79-95)	r = -.32*	IVs: age, time since onset of stroke, side of brain damage, spatial neglect and gait speed **Significant IVs:** initial gait speed + age R^2 = .10 age R^2 = .66 initial gait speed + age [83]
	IV: - **DV:** Timed 10-meter	**IV:** 15 days **DV:** 3 mo	No	IVs: produce locomotor rhythm with and without resistance, age, lower extremity motor **Significant IVs:** produce locomotor rhythm with and without resistance Age shows no statistic significant contribution[85]
	IV:- **DV:** Timed 30-foot	**IV:** 48 ± 59 mo **DV:** Idem	r = .17	No[96]

	IV: - **DV:** Vicon motion analysis system (bh)	**IV:** 63.2 ± 55.5 mos (18–247) **DV:** Idem	No	IVs: age, use of assistive device, lower extremity motor function, strength of bilateral hip flexor, knee extensors and ankle dorsiflexors and knee and ankle JPS **Significant IVs:** age + use of assistive device + lower extremity motor function + strength of knee extensors and ankle dorsiflexors + ankle JPS R^2 = .96 all the independent variables together [91]
	IV:- **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: age, gender, type of lesion, side of lesion, level of cognition and perceptual neglect **Significant IVs:** age +level of cognition R^2 = .30 age + cognition[74]
	IV:- **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.31**	No[88]
Gender	**IV:** 2 grades (men/women) **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .12	No[96]
	IV: 2 grades (men/women) **DV:** Vicon motion analysis system (bh)	**IV:** 6 mos **DV:** Idem	No details	IVs: lower extremity motor function of proximal and distal part (P), age and gender **Significant IVs:** lower extremity motor function of proximal part (P) + age Gender shows no significant contribution[77]
	IV: 2 grades (men/women) **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	No	Model 1: IVs: knee extension strength (N+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee extensor strength (N+NP) Gender shows no significant contribution Model 2: IVs: knee flexion strength (N+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee flexor strength (N+NP) Gender shows no significant contribution[82]
	IV: 2 grades (men/women) **DV:** Timed 10-meter	**IV:** 78.6 ± 27.4 days (36-145) **DV:** Idem	No	Model 1: IVs: age, gender, rate of knee extensor torque (P) and knee extensor peak torque (P) **Significant IVs:** unclear R^2 = .12 age + gender + rate of knee extensor torque (P) + knee extensor peak torque (P) R^2 = .06 gender + rate of knee extensor torque (P) + knee extensor peak torque (P) Model 2: IVs: age, gender, rate of knee extensor torque (NP) and knee extensor peak torque (NP) **Significant IVs:** unclear R^2 = .10 age + gender + rate of knee extensor torque (NP) and knee extensor peak torque (NP) R^2 = .08 gender + rate of knee extensor torque (NP) and knee extensor peak torque (NP)[97]

	IV: 2 grades (men/women) **DV:** Ultrasonic gait speed monitor	**IV:** 17.5 ± 1.2 mos **DV:** Idem	No	Model 1: IVs: gender, cognition, depression, self-efficacy and knee extensor strength (P+NP) **Significant IVs:** unclear Partial R^2 = .08 gender R^2 = .71 knee extensor strength (P) + self-efficacy + gender Model 2: IVs: gender, cognition, depression, self-efficacy and knee extensor power (P+NP) **Significant IVs:** unclear Partial R^2 = 0.06 gender R^2 = 0.70 knee extensor power (P) + self-efficacy + gender[89]
	IV: 2 grades (men/women) **DV:** Timed 5-meter	**IV:** 8 ± 3 days (3-14) **DV:** 85 ± 17 days (37-124)	No	IVs: age, gender, type of lesion, side of lesion, level of cognition, and perceptual neglect **Significant IVs:** age +level of cognition Gender shows no significant contribution[74]
	IV: 2 grades (men/women) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .35**	No[88]
Race	**IV:**- **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .23	No[96]
Percentage body fat	**IV:** X-ray absorptiometry scan **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .26*	No[96]
Body mass index	**IV:** X-ray absorptiometry scan **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	r = .13	No[96]
Lean mass	**IV:** X-ray absorptiometry scan **DV:** Timed 30-foot	**IV:** 48 ± 59 mos **DV:** Idem	P: r = .25* NP: r = .24	No[96]
Heredity	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = -.15	No[88]
Smoking	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .17	No[88]

IV: Independent Variable, IVs: independent variables, DV: dependent variable
*: p<0.05, **: p<0.01, ***: p<0.001
r: Spearman or Pearson's correlation coefficient, R: regression coefficient
wks: weeks, mos: months, yrs: years
P: paretic side, NP: non-paretic side
bh: normalized to body height

Table 10: The Univariate and Multivariate Results of the Factors Categorized in Additional Chapter "Others"

Factors	Measurement	Time of measurement (mean ± SD (range))	Univariate analyses	Multivariate analyses
Time since onset of stroke	**IV:** - **DV:** Timed 10-meter	**IV:** 17.9 mos (6–46) **DV:** Idem	No	Model 1: IVs: knee extension strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee extensor strength (N+NP) Time since onset of stroke shows no significant contribution Model 2: IVs: knee flexion strength (P+NP) (combined with either age, gender, time since onset of stroke, type of stroke or side of weakness) **Significant IVs:** knee flexor strength (P+NP) Time since onset of stroke shows no significant contribution[82]
	IV:2 grades (<31 days, > 31 days) **DV:** Clinical Stride Analyzer	**IV:** median 31 days (IQR 23-39) **DV:** median 86 days (IQR 79-95)	p>.05	IVs: age, time since onset of stroke, side of brain damage, spatial neglect and gait speed **Significant IVs:** initial gait speed + age Time since onset of stroke shows no significant contribution [83]
Hypertension	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .04	No[88]
Diabetes mellitus	**IV:** 2 grades (yes/no) **DV:** Timed 10-meter	**IV:** 2 wks **DV:** 26 wks	r = .17	No[88]

IV: Independent Variable, IVs: independent variables, DV: dependent variable
*: p<0.05, **: p<0.01, ***: p<0.001
r: Spearman or Pearson's correlation coefficient, R: regression coefficient
wks: weeks, mos: months, yrs: years
P: paretic side, NP: non-paretic side

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Walking Performance and Post-Stroke Fatigue in People with Stroke

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Abstract

Background and Purpose: Many people with stroke suffer from post-stroke fatigue (PSF). PSF is a frequently overlooked sequel and usually receives little attention from healthcare professionals. In addition, PSF has been proven to be a negative factor for functional outcome. The purpose of this study is to investigate the relation between PSF and walking performance and to identify the impact of PSF on walking performance corrected for potential confounding variables.

Methods: Eighty stroke survivors were evaluated at the start of an outpatient rehabilitation program in nine rehabilitation centers in The Netherlands. Walking performance was quantified by walking distance (six-minute walk test), gait speed (5-meter walk test) and functional mobility (domain “Mobility” of the Stroke Impact Scale). The relation between PSF, measured by the Fatigue Severity Scale, and the three components of walking performance was studied by calculating correlation coefficients. Multiple regression analyses identified the impact of PSF on walking distance, gait speed and functional mobility corrected for age, gender, time since stroke onset, anxiety, depression, lower limb strength and balance.

Results: PSF was not significantly correlated with the three components of walking performance. A multiple linear regression analysis with walking distance and two multiple logistic regression analyses with gait speed and functional mobility showed no significant contribution of PSF in explaining the variance of the three components of walking performance.

Conclusion: PSF was not strongly related to walking performance in people with stroke at the start of an outpatient rehabilitation program.

Key Words: post-stroke fatigue, walking, rehabilitation, stroke

Samenvatting

Achtergrond en doelstelling: Veel mensen die een CVA hebben doorgemaakt, ondervinden vermoeidheidsklachten na het CVA. Deze vermoeidheid wordt frequent over het hoofd gezien en er wordt door professionals in de gezondheidszorg vaak te weinig aandacht aan gegeven. Echter, vermoeidheid blijkt een negatieve invloed te hebben op functionele uitkomsten. Het doel van deze studie is de relatie tussen vermoeidheid en loopvaardigheid te onderzoeken en de impact van vermoeidheid op loopvaardigheid gecorrigeerd voor mogelijke verstorende variabelen te bepalen.

Methode: Tachtig mensen zijn geëvalueerd bij de start van een poliklinisch CVA revalidatietraject in negen revalidatiecentra in Nederland. De loopvaardigheid is uitgedrukt in loopafstand (zes minuten looptest), loopsnelheid (vijf meter looptest) en functionele mobiliteit (domein “Mobiliteit van de Stroke Impact Scale). De relatie tussen vermoeidheid gemeten met de Fatigue Severity Scale en de drie componenten van loopvaardigheid zijn berekend middels correlatiecoëfficiënten. Multipele regressie analyses identificeren de impact van de vermoeidheid op loopafstand, loopsnelheid en functionele mobiliteit gecorrigeerd voor leeftijd, geslacht, tijdsduur vanaf ontstaan van het CVA, angst, depressie, kracht van de onderste extremiteit en balans.

Resultaten: Vermoeidheid correleerde niet significant met de drie componenten van loopvaardigheid. Een multipele lineaire regressie analyse met loopafstand en twee multipele logistische regressie analyses met loopsnelheid en functionele mobiliteit tonen een niet significante bijdrage van vermoeidheid in het verklaren van de variantie van de drie componenten van loopvaardigheid.

Conclusie: Vermoeidheid was niet sterk gerelateerd aan de loopvaardigheid bij mensen met een CVA bij de start van een poliklinisch revalidatietraject.

Sleutelwoorden: vermoeidheid, loopvaardigheid, revalidatie, CVA

Introduction

According to the Dutch Heart Foundation, the number of people with stroke in The Netherlands is around 190.000.[1] Annually around 41.000 people suffer a first stroke and about 7.000 people a second stroke.[1] Stroke is a major cause of disability and handicap[1;2], leading to various limitations related to mood, speech, perception, cognition, gross and fine motor ability, capacity to carry out the basic and instrumental activities of daily living, and ambulation[3;4]. According to the Copenhagen Stroke Study, by the end of rehabilitation still 22% of the people is unable to walk and 14% walks with assistance.[5] This reduction in walking ability can result in major limitations in community ambulation[6]. Therefore, walking has a high priority during stroke rehabilitation.[7;8]

A great deal of research has been carried out to determine factors which are related to the walking performance in people with stroke. Most of the factors which have been identified as being related with walking performance were physical factors. Strength of the paretic lower limb, balance and mobility have been indicated as important factors related to walking performance.[9-13] However, as described above, people with stroke often have to deal with psychosocial and emotional impairments and these might influence walking performance as well.

A frequently overlooked limitation in people with stroke is post-stroke fatigue (PSF)[14]. PSF often receives little attention from healthcare professionals, even though many patients suffer from fatigue after stroke.[15] The prevalence of PSF varies, depending on time since stroke onset, population types and subjects residence (hospital, rehabilitation centre, community); with estimated ranges between 38% and 68%[15-21]. The absence of a definition of PSF may also influence the reported prevalence, but PSF represents a complex of biological, psychosocial, and behavioral phenomena.[22] Several physical (physical fitness), mental (cognitive dysfunction), biographic (age and gender) and psychological (anxiety, depression and perception by the patient of having control over his health) post-stroke characteristics have been identified to contribute to PSF.[23;24] Although a great number of factors contributing to PSF have been identified, its underlying mechanisms remain elusive.[25] Nevertheless, PSF

often manifests as both mental and physical lack of energy, and many patients mention fatigue as one of the most difficult sequel to adjust.[15]

PSF, either mental and/or physical, often poses a barrier to daily activities and quality of life.[15-17;19;20] Regarding the daily activities, one study[19], that distinguishes activities of daily living (ADL) and instrumental activities of daily living (IADL), concluded that PSF was only significantly correlated with the more strenuous IADL activities. One can assume that these IADL activities will be influenced by walking performance and suggest that walking performance might be affected by PSF as well. Since walking performance is such an important, but with that also limiting outcome after stroke, it is relevant to investigate the relation between walking performance and PSF. Therefore, the first purpose of this study is to investigate the relation between PSF and walking performance in people with stroke. The second purpose is to identify the impact of PSF on walking performance corrected for potential confounding variables.

Materials and Methods

Design

This study was part of a large (ongoing) longitudinal multicentre randomized controlled trial; FIT Stroke Trial (Trial Register Number: NTR1534). Nine rehabilitation centers in The Netherlands participate in this trial and patients are followed from the start of outpatient rehabilitation in the rehabilitation centre until 6 months after the start. In the present (cross-sectional) study only the baseline data, collected at the start of outpatient rehabilitation, were used.

Subjects

Inclusion criteria were: (1) survivor of stroke, (2) age over 18 years, (3) discharged from inpatient rehabilitation, with an indication for physiotherapy during outpatient rehabilitation in the rehabilitation centre and (4) signed informed consent. Stroke was defined according to the World Health Organization (WHO)[26]. Reasons for exclusion from the study were: (1) cognitive impairments (Mini Mental State Examination <24 points), (2) subarachnoid hemorrhage, (3) communication problems (Utrecht's Communication Research <4 points) and (4) living >30

km from a rehabilitation centre. The FIT Stroke Trial was approved by the Medical Ethical Committee of the University Medical Centre Utrecht.

Measures and Measurements

PSF was measured by the Fatigue Severity Scale (FSS)[27]. The FSS is a self-reporting questionnaire and consists of nine statements concerning the impact of fatigue on daily life scored on a 7-point Likert scale. The total score of the FSS is the mean of the nine items[27]. The higher the FSS score, the more impact PSF has on daily life. The average score of≥4 point indicates that subjects experience fatigue. The FSS has a good internal consistence (Cronbach's α=.89)[24] and it is a reliable instrument to assess and quantify fatigue[28].

Walking performance was quantified by walking distance, gait speed and functional mobility. Walking distance was measured during a six-minute walk test (6MWT)[29]. Subjects were instructed to "walk as far as possible during six minutes, without jogging or running and only stop unless needed to". The use of their assistive devices was allowed. The 6MWT shows a high reliability (ICC=0.973) in people with stroke.[30] Gait speed was measured by the five-meter walk test (5mWT). Subjects were instructed to "walk at comfortable speed" and the use of their assistive devices was allowed. The test was repeated three times, with a rest period of maximal two minutes in between. The mean time of the three measures was used for data-analyses. The 5mWT is highly reliable in people with stroke[31], and is the most responsive method of measuring gait speed after acute stroke[32]. Functional mobility was measured with the "Mobility" domain of the Stroke Impact Scale 3.0 (SIS)[33]. This domain consists of nine items about the capacity to move inside and outside the house scored on a 5-point Likert scale. The sum-score of the nine items reflects the functional mobility of the subject with a higher score indicating a better functional mobility. This domain shows a good validity and reliability[34]. Recently the Dutch version of the SIS 2.0 was examined on the psychometric properties, which was good and comparable with the English version.[35]

Potential confounding variables were age, gender, time since stroke onset, anxiety, depression, lower limb strength and balance. Age, gender and time since stroke onset were registered at the start of the outpatient rehabilitation. Anxiety and depression were measured

with the Hospital Anxiety and Depression Scale (HADS)[36]. The HADS consists of two subscales for anxiety and for depression, each consisting of seven items that are rated on a 4-point Likert scale. A higher score indicates more severe anxiety or depressive symptoms. The sum-scores of both subscales were used for further analyses. This scale showed to be valid and reliable.[37] Lower limb strength was measured by the lower extremity score of the Motricity Index (MI). An evaluation of three specific movements (hip, knee and ankle) was based on a weighted score using an ordinal 6-point scale. A higher score indicates a better maximal strength. The MI has a good reliability[38]. Balance was measured with the Timed Balance Test. This test evaluates the possibility to maintain five different standing positions for one minute on progressively diminishing support surface. One point is given when the standing position is maintained and a higher score indicates better balance. Validity and reliability have been demonstrated in people with stroke.[39]

Statistical Methods

All variables were examined by descriptive statistics. The normality of the data was checked graphically and with the Kolmogorov-Smirnov test. Depending on the normality of the data Pearson's Correlation Coefficients or Spearman Rank Correlation Coefficients were used to determine the relation between PSF and the three components of walking performance. The strength of the correlations were classified using Munro's correlation descriptors (very high=0.90-1.00, high=0.70-0.89, moderate=0.50-0.69, low=0.26-0.49 and very low=0.00-0.25)[40]. To identify the impact of PSF, multiple regression analyses by means of the enter-procedure were carried out. PSF, age, gender, time since stroke onset, anxiety, depression, lower limb strength and balance were the independent variables. The data were checked for the assumptions of regression analysis[41;42]. Normality of the data was checked as described before, linearity of the relationships were visualized with scatterplots, serial independence of errors was checked with the Durbin-Watson test (values <1 or >3 are cause for concern), multicolinearity was checked with the Variance Inflation Factor (VIF) (values >10 are cause for concern) and homoscedasticity was visualized with histograms and probability plots. All statistical analyses were performed with SPSS 17.0 (SPSS Inc, Chicago III) with a significance level of $p<.05$ (2-tailed).

Results

In total, 50 male and 30 female subjects were included in the study. Fifty-two subjects were classified as having PSF, 26 did not and from two subjects it was unknown. The subject characteristics and the outcome measures are presented in Table 1. During the 5mWT six subjects used a walking device: one a rollator, two a cane, and three a quadric-cane. Three of these six subjects also used an ankle-foot orthoses. Of the subjects who did not use walking devices, 21 subjects used an ankle-foot orthoses. During the 6MWT, 41 subjects did not use any kind of device and 39 used a walking device or orthoses.

Table 1: Patient Characteristics and Outcome Measures

Variable	n	Median (IQR)
Age, years	80	58 (51 - 65)
Gender (♂/ ♀)	50 / 30	
Time since stroke onset, weeks	80	12.5 (8 - 19)
Type of stroke (Ischemic Stroke/ Hemorrhagic Stroke/ Unknown)	57 / 20 / 3	
Hemiplegic side (Right / Left / No)	40 / 39 / 1	
First stroke (Yes/ No/ Unknown)	6 / 71 / 3	
PSF (Yes/ No/ Unknown)	52 / 26 / 2	
Co-morbidities (Cardial/ Vascular/ Respiratory/ Skeletal, muscle or skin/ Psychiatric)	23 / 33 / 14 / 28 / 25	
Walking distance (meters)	79	311 (235 - 411)
Gait speed (meters per second)	80	1.31 (1.03 - 1.64)
Functional mobility	80	39 (34 - 42)
PSF	78	4.67 (3.19 - 5.57)
Anxiety	79	3 (1 - 6)
Depression	79	4 (2 - 8)
Lower limb strength	80	75 (63 - 83)
Balance	80	3 (3 - 4)

IQR: InterQuartile Range

Analyses to check for normality showed that gait speed and functional mobility did not meet the assumptions for normality. Therefore, Spearman Rank Correlation Coefficients were used. PSF was not significantly correlated with walking distance (r=.079, p=.492), gait speed (r=.013, p=.911) and functional mobility (r=-.213, p=.061). On the contrary, PSF showed significant and low correlations with anxiety and depression (Table 2). The three components of walking performance showed significant and moderate to high relations with each other and significant and low or moderate correlations with time since stroke onset, lower limb strength and balance. Functional mobility also showed significant and low correlations with anxiety and depression.

Table 2: Spearman Rank Correlation Coefficients

	PSF	Walking distance	Gait speed	Functional mobility	Age	Gender	Time since stroke onset	Anxiety	Depression	Lower limb strength	Balance
PSF	1										
Walking distance	.079	1									
Gait speed	.013	-.831**	1								
Functional Mobility	-.213	.549**	-.629**	1							
Age	-.150	-.078	-.052	-.144	1						
Gender	-.020	.203	-.213	.143	.267*	1					
Time since stroke onset	-.075	-.490**	.502**	-.270*	-.116	-.219	1				
Anxiety	.396**	-.155	-.221	-.412**	-.007	-.168	.225*	1			
Depression	.286*	-.131	,.203	-.315**	-.155	-.100	.239*	.581**	1		
Lower limb strength	-.003	.479**	-.613**	.403**	-.048	.083	-.481**	-.337**	-.212	1	
Balance	.112	.525**	-.506*	.485**	-.120	-.040	-.308**	-.034	-.053	.353**	1

* : correlation significant at the 0.05 level (2-tailed). **: correlation is significant at the 0.01 level (2-tailed).

To determine the impact of PSF on walking performance; first, a linear regression analysis with walking distance as dependent variable was carried out. All independent variables were entered in the model because there was no concern for multicolinearity (VIF ranges from 1.177 to 1.839). The independent variables together explained 45.9% of the variance of walking distance (Table 3). Only, balance was significantly related to walking distance, where PSF showed no significant contribution. Second, a logistic regression analysis with gait speed was carried out. The data of gait speed were dichotomized with a cut-off score of 1.0 m/s. This cut-off score was arbitrarily chosen by means of reported thresholds for gait speed and community ambulation. These thresholds varied between 0.8 m/s and 1.2 m/s.[43-45] Seventy-eight subjects were included in the analysis, having a median score of 1.31 m/s; 61 of these subjects walked faster than 1.0 m/s. All independent variables were entered in the model, since multicolinearity was no concern (VIF ranges from 1.177 to 1.853). The independent variables together explained 49.1% of the variance of gait speed (Table 3). PSF showed no significant association with gait speed. Gender, lower limb strength and balance were significantly related to gait speed. Third, a logistic regression analysis with functional mobility as dependent variable was carried out. The data of functional mobility were dichotomized, based on the median score of 39 points of the SIS. Seventy-eight subjects were included in the analysis; 34 of these subjects had a poor functional mobility (range 9-38 points) and 44 subjects had a good functional mobility (range 39-45 points). The analysis showed no

multicolinearity (VIF ranges from 1.177 to 1.853) and therefore all the independent variables were entered in the model. The independent variables together explained 38.1% of the variance of functional mobility (Table 3). PSF showed no significant relation with functional mobility. Only, balance was significantly related to functional mobility.

Table 3: Multiple Regression Analyses

	Walking distance (Linear regression)		**Gait speed** (Logistic regression)				**Functional mobility** (Logistic regression)			
Variables	R^2	ß (SE)	R^2	Exp(B)	95% C.I. Exp(B) Lower	Upper	R^2	Exp(B)	95% C.I. Exp(B) Lower	Upper
All variables	.459		.491				. 381			
PSF		.101(.901)		1.026	.969	1.085		.974	.934	1.016
Age		-.097 (1.282)		.976	.902	1.055		.959	.903	1.018
Gender		.163 (26.749)		7.717*	1.231	48.385		.685	.200	2.345
Time since stroke onset		-.205 (1.819)		1.021	.895	1.165		.974	.896	1.059
Anxiety		-.044 (4.846)		.876	.653	1.085		.842	.672	1.056
Depression		-.019 (4.272)		1.073	.830	1.387		1.029	.850	1.247
Lower limb strength		.215 (.798)		.919**	.863	.979		1.028	.992	1.066
Balance		.397* (11,874)		.312**	.140	.737		1.955*	1.089	3.511

*: correlation significant at the 0.05 level (2-tailed). **: correlation is significant at the 0.01 level (2-tailed).
SE: Standard Error, R^2: squared multiple regression coefficient according to Nagelkerke

Discussion

The purpose of this study was to investigate the relation between PSF and walking performance in people with stroke and to identify the impact of PSF on walking performance corrected for potential confounding variables. The results show no significant relation between PSF and the three components of walking performance.

In this study, 67% of the included subjects experienced PSF in daily life. This score is high compared to the reported prevalence from 38% to 68% in previous studies[15-21]. This might be explained by the fact that the studied subjects were discharged from the rehabilitation centre to their homes and faced with a new situation with probably an increased demand in activities. Schepers et al.[24] concluded that the impact of PSF increased during the first year post-stroke, because the impact of PSF might become more relevant as patients try to resume their work and social activities, and the demands of daily life increase. In the first-phase post-stroke, PSF could be experienced as a “minor” problem compared to the other impairments and functional limitations.

PSF showed non-significant correlations with the three components of walking performance. Previous studies showed that PSF affects activities of daily living and especially the complex and energy-demanding ones[15;16;19]. However, in the present study we could not identify a relation between PSF and walking performance. Nevertheless, it is striking that functional mobility, the most complex component of walking performance chosen in this study, showed the biggest relation with PSF compared with the other two components. Despite the weak and non-significant relation, one might suggest that PSF has more influence on the more complex aspects of activities, as was shown in previous studies on outcome in IADL[15;16;19]. An important difference between previous studies[15;16;19] and the present one is the use of outcome measures to determine PSF. Two studies[15;16] did not use the FSS, and the study[19] that did use it, dichotomized the values which might have influenced the results. Also, the moment of measurement differs. The median score of the time since stroke onset in this study was 12.5 weeks compared with the other studies that measured the subjects with a range between 6 months and 3 years. Lastly, these results might be found because of the cross-sectional design of this study.

PSF showed a significant correlation with depression and anxiety. An association between PSF and post-stroke depression has been demonstrated in a number of previous studies[15;16;46;47]. There is a certain amount of overlap between PSF and post-stroke depression, partly because depression is often accompanied by PSF. On the other hand, a number of studies have shown that PSF can occur in the absence of depression[17;48;49]. The presence of PSF was shown to be independent of depression, but the impact of PSF on functional abilities was strongly influenced by depression.[17] Patients who experience PSF, as measured by the FSS, are impeded in their daily activities and responsibilities, which may create feelings of depression[50-52]. These conflicting results may be caused by the lack of definitions of post-stroke depression and PSF. The significant correlation between PSF and anxiety that is found in this study, also confirms previous studies[15;20].

PSF was no significant contributor in explaining the variance of walking distance, gait speed or functional mobility. As expected, the physical factors, lower limb strength and particularly balance were significantly related to walking performance. These findings confirm the results

of previous studies where physical factors like strength and balance were dominant variables in regression analyses[9;11;12]. From this study, we can conclude that the impact of PSF on the walking performance in people with stroke is a negligible factor in regard to physical factors.

Some limitations need to be taken in consideration when interpreting the results. One important limitation is the fact that definitions for walking performance and PSF are lacking. However, to cover different aspects of walking performance we studied three components. There were two reasons for choosing these three components. First, the Dutch Guideline "Stroke"[53] recommends measurement of walking distance and gait speed and they are mostly measured in general practice. Second, functional mobility represents a more functional dimension of walking performance related to activities of daily living. Because these three components of walking performance showed significant and moderate or high relations with each other it is debatable if all components measure different components. Regarding PSF, PSF has been defined in different ways. In this study, there was chosen to measure the impact of PSF on daily activities as measured by the FSS. The FSS is shown to be a valid and reliable instrument to determine fatigue in patients after stroke.

Since gait speed and functional mobility were non-normally distributed, data were dichotomized for the regression analysis. By limiting variation in the data; first, there is a loss of sensitivity of the data and second the data could be biased because of the arbitrary chosen cut-off score. Varying the cut-off score can significantly shift the percentage of individuals in the groups[54]. In addition, the independent factors chosen besides PSF have been chosen in an arbitrary way.

Although, in the present study PSF was not shown to be related to walking performance. PSF remains an important outcome after stroke which needs to be taken into account in both clinical practice as well as research. To understand the concept and effect of PSF more research is needed. A definition of PSF and an explanation of its underlying mechanisms and effects is desirable to be able to compare results and possibly treat PSF. In addition, the prognostic value of PSF on rehabilitation and (physical) outcome needs more attention by conducting longitudinal studies in large populations. In the mean time, physicians, but also

physiotherapists must be abreast of the fact that people with stroke can have PSF, quantify this and give people with stroke and their relatives information about the impact of PSF on activities of daily living.

Summary

PSF is not significantly related to the walking performance in people with stroke at the start of outpatient rehabilitation. The cross-sectional impact of PSF on the walking performance is negligible with regard to physical variables.

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