Knee posture during gait and global functioning post-stroke: a theoretical ICF framework using current measures in stroke rehabilitation.

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Implications for the rehabilitation

- Identification of abnormal knee posture in gait can indicate potential assessment and treatment priorities e.g. knee flexor strength is a major determinant of functioning in patients with abnormal knee posture and should be assessed;

- The identification of an abnormal knee posture post-stroke seems relevant for planning patient's long-term needs (e.g., amount of caregiver support);

- The interpretation of functional measures based on the ICF framework can enhance clinical-reasoning in rehabilitation post-stroke.

Abstract

PURPOSE:

To characterise the global functioning post-stroke in patients with normal knee posture (NKP) and abnormal knee posture (AKP) during loading-response.

METHODS:

35 people, 6 months post-stroke. with NKP and AKP were identified and assessed using clinical measures classified into the corresponding International Classification of Functioning, Disability and Health (ICF) domains: weight function (body mass index); muscle power (knee isometric strength); muscle tone (Modified Ashworth Scale); voluntary motor control (Leg sub-score of Fugl-Meyer scale); walking short distances (5-meter walk test; Timed-Up and Go test); walking on different surfaces (Functional Ambulation Categories); moving around (Falls Efficacy Scale); moving using equipment (walking aids) and global assessment of function (WHODAS II). Age, gender, marital status, current occupation and caregivers support characterised personal factors.

RESULTS:

Patients with AKP had significantly lower knee flexor strength, higher knee flexor and extensor spasticity, more difficulty in maintaining a standing position, walking short and long distances, used walking aids more often and needed more caregiver support. Restriction in activities and participation were correlated with knee flexor strength for AKP and with knee spasticity for NKP group.

CONCLUSIONS:

AKP restricts functioning and participation.

Introduction

Stroke is a major cause of disability worldwide that seriously affects walking ability[1, 2] and functional independence [3]. One of the most important walking impairments post-stroke is the reduced capacity to dynamically transfer body weight in the direction of the paretic lower limb [4]. The body weight transference occurs during the double stance period of walking, and includes two different phases: initial foot contact and the loading response [5]. During the loading response, the foot comes into full contact with the floor and body weight is fully transferred onto the stance limb. A normal knee posture is necessary to ensure an efficient loading-response mechanism and is therefore, a key determinant of walking ability [4]. Hence, regaining a normal knee posture (NKP) during gait is a primary target of stroke rehabilitation and depends on normal knee biomechanics during loading response [6, 7]. The knee is normally maintained in between 8 to 15 degrees of flexion during loading[8]. However, in patients with stroke, two abnormal knee postures are commonly seen: knee hypoflexion (flexion<8 degrees)[9-11] or knee hyperflexion (flexion > 15 degrees)[12].

Despite the potential importance of knee posture to walking ability, little is known about the relationship between knee posture, gait impairments and other measures of global functioning post-stroke [13]. The use of an internationally agreed approach to measuring function may enhance understanding of the relationship between kinematics and function and provide guidance for the assessment and management of people with impaired gait following stroke.

The International Classification of Functioning, Disability and Health (ICF) provides a multidimensional framework for assessing global functioning[14]. According to the ICF, clinical measures of functioning and disability can be classified into two primary levels of functioning:(i) impairments of body functions and structures (which define a significant loss or deviation of anatomy or physiology); and (ii) restrictions to activities and participation (which estimate the difficulties experienced by an individual in completing a given activity, life situation or role) [13, 15]. In addition, the ICF accounts for the influence of contextual factors, both environmental (social support, work, attitudes from others) and personal factors (race, gender, age, life style) on functioning [16]. This approach may facilitate understanding of the interactions between different functional components and is recommended to guide the comprehensive assessment and management of patients [14, 17]. The ICF framework might be used in people with stroke who have an abnormal knee posture (AKP) during loading stroke for several purposes, including: (i) identify the most important health components to be assessed in these patients; (ii) to characterize the contribution of AKP to global functioning and (iii) inform possible strategies for rehabilitation. The aim of this study was to characterise global functioning post-stroke in patients with normal and abnormal knee posture during loading-response, using current stroke rehabilitation measures to construct one ICF theoretical framework. This paper therefore sought to answer the following research questions:

- What are the functional abilities (body function, activity or participation and need for care) of people with stroke with i) normal and ii) abnormal knee posture during the loading phase?

-What is the relationship between knee posture during the loading phase and patient functioning?

Methods

Design and Ethics

An exploratory descriptive study was conducted in four hospitals (Hospital of Anadia, Ovar, Cantanhede and Tocha). The study received full approval from the ethics committee of each institution. .

Participants

People with stroke were included if they (i) had a first ischemic stroke within the previous 6 months; (ii) were able to walk at least 5 meters without a walking device but with human assistance, if required; (iii) had lower limb hemiparesis, identified by a sensory-motor impairment scoring <34 on the Fugl-Meyer); and (iv) had no previous history of other severe cardiovascular disease. People were excluded if they had (i) involvement of the brainstem or cerebellum, identified via computed tomography and (ii) a score< 27 in the Mini-Mental State Examination, indicative of cognitive impairment[19].

Potentially eligible participants were identified and approached by the physiotherapists in each hospital. Those who expressed an interest were contacted by the researcher and an appointment was scheduled. Detailed written information about the study was provided and written informed consent obtained. Thirty-five people fulfilled the inclusion criteria and all agreed to participate in the study.

Data collection

The following clinical measures, which are commonly used to assess patients and/or predict stroke recovery [20-29] were employed to describe and compare global functioning in participants with normal and abnormal knee posture: Isometric muscle strength (knee extensors, knee flexors)[20], Modified Ashworth Scale[21], Leg sub-score of Fugl Meyer [22], structure of brain affected, 5-meter Walk at self-selected speed, 5-meter Walk at fast speed, Timed Up and Go test [23], Functional Ambulatory Category [24], Falls Efficacy Scale [25], Use of walking aid [27] and World Health Organization Disability Assessment Schedule[28] and Body Mass Index (BMI) [29]. Each clinical measure was then linked to the relevant ICF categories (body functions and structures and activities and participation using corresponding ICF codes published by Ustun et al. [29] and Mudge et al. [13]). Relevant personal factors were also collected from the participant's clinical files. The list of clinical measures and personal factors used within each domain are presented in Figure 1.

[Figure 1]

Health Condition: knee posture during gait in people with stroke.

Clinical diagnosis

The side of hemiparesis and time post-stroke when patients began to walk (even with some physical assistance) were collected from medical notes. These are two good predictors of functioning post-stroke [30] and relevant for general stroke diagnosis.

Determining abnormal knee posture during gait

An 8 meter walkway was mapped out in a hospital corridor with tape, with markers placed at 0m, 1.5m, 4m, 6.5m, 8m. The first and last 1.5m were used for acceleration and deceleration. A two dimensional video camera (Sony HDR-PJ50VE, 640×360 pixels, 20Hz) was positioned perpendicular to the corridor at the 4m mark. Each participant was videoed in the sagittal plane whilst walking at a self-selected comfortable speed. Reflective markers were placed on the head of the fifth metatarsal, posterior heel, lateral malleolus of the ankle, lateral epicondyle of the femur and greater trochanter of the hip [31]. The video recording was manually checked and the last frame before the non-affected foot lifted off the floor was selected as a standardised reference frame of the loading-response [32].

Static images of each of these reference frames were captured and printed. Two physiotherapists, who had been trained to analyse these images, independently classified the posture of the stance knee in this frame as being 1) normal (8-15 degrees of flexion); 2) hyperflexed (>15 degrees of flexion) or 3) hypoflexed (<8 degrees of flexion) [32]. The inter-rater agreement was calculated using the Intra-Class Correlation Coefficient (ICC $_{2,k}$) using standard classifications: ICC scores>0.4 = poor agreement; ICC between 0.4 and 0.7 = fair to substantial agreement; ICC>0.7 = high agreement [33]. Any disagreements were resolved by discussion with a third independent physiotherapist. Patients allocated to category 1 were considered participants with "NKP" and subjects allocated to categories 2 and 3 were considered participants with “AKP". This observational method for gait analysis has been considered a low cost, simple and adequate measurement tool, particularly when undertaken by well-trained therapists [34].

Body Functions and Structures

The following components of body function and structure, which were potentially relevant to knee posture during gait were measured as described below.

s110, structure of brain. Computed tomography scans were classified according to the Bamford et al. [35] classification which defines stroke sub-types according to the region of cerebral infarction.

b530, weight maintenance function. BMI, an estimate of body fat based on height and weight, is an anthropometric predictor for walking recovery post-stroke [29].

b730, muscle power function. Maximal isometric muscle strength, a reliable measure of lower limb strength in people with stroke [20], was assessed in knee flexors and extensors of the paretic lower limb. Values were collected using a hand held dynamometer (Microfet, Hoogan Health Industries, Draper, UT USA) following break-test standard procedures, i.e., the examiner applied resistance to knee flexors (knee maintained in 90º flexion), then to the knee extensors (knee maintained in 90º extension) while the participant was seated [36-39].Three trials, which lasted 6 seconds each, were performed for each muscle group with 30 to 60-seconds interval between each trial [40].

b735, muscle tone. The Modified Ashworth Scale (MAS) a reliable measure of lower limb muscle tone after stroke [21] was used to assess knee flexor and extensor muscle tone of the paretic lower limb. This scale consists of a 6-point rating scale of increasing muscle tone between 0 (“no increase in tone”) and 5 (“limb rigid in flexion or extension”)[21].

b750, motor reflex functions and b760, control of voluntary movement. The leg sub-score of the Fugl-Meyer scale (FM) was used to assess motor reflex functions and control of voluntary movement. This scale is a feasible and efficient clinical method for measuring sensory-motor stroke recovery [22]. The leg sub-score is a numerical scoring system for measurement of reflexes, joint range of motion, coordination and speed. Each item is scored on a 3-point ordinal scale with a maximum score of 34 [41].

Activities and Participation

The following activity and participation measures, which were considered potentially related to knee posture during loading-response, were performed:

d450, walking short distances. The 5-meter walk and the Timed-Up and Go-Test (TUG) were used to asses this category. Self-selected and fast walking speed were assessed using the 5-meter walk test (5mWT) [42] performed following standard procedures [23]. Patients walked three trials at their comfortable speed, with a 5-minute interval between each trial and then repeated the same procedures at their fastest speed. The TUG reliably assesses the ability to perform sequential motor tasks involving walking and turning [43] by measuring the time needed to stand from an arm chair, walk 3 meters, turn, return and sit down [44]. Participants performed three trials with a 5-minute interval between each trial.

*d5502, walking on different surfaces (level/uneven/slopes).*The Functional Ambulation Category (FAC) is a valid and reliable functional walking test that evaluates ambulation ability in people with stroke [24] using a 6-point scale to determine the amount of human support needed when walking on different surfaces, regardless of whether or not they use a personal assistive device [24]. Patients can be rated on the following conditions: cannot walk or needs help from 2 or more people (score 0);

needs firm continuous support from 1 person who helps with weight bearing and balance (score 1); needs continuous or intermittent support of one person to help with balance and coordination (score 2); requires supervision or stand-by help from one person but not physical contact (score 3); can walk independently on level ground, but requires help on stairs, slopes or uneven surfaces (grade 4); can walk independently anywhere (score 5). Participants classified with score 5 were considered as having no impairment in ambulation.

d455, moving around. The Falls Efficacy Scale (FES) [45]which measures fear of falling while performing common daily activities, was included to assess this domain. The FES, a valid and reliable measure of self-perceived balance in people with stroke [25, 26], is a 10-item self-report questionnaire describing common daily activities, each rated from 1 (no fear of falling) to 10 (fear of falling).

d465, moving around using equipment. Patients were classified into two categories, considering their ability for walking indoors: “needs walking aid” or “doesn´t need walking aid”. For data analysis, patients were assigned a 0 (doesn´t need walking aid) or a 1 (need a walking aid), in a binary scale.

Global Assessment of Function. The World Health Organisation Disability Assessment Schedule 2.0 (WHODAS 2.0) is a multidimensional instrument that is conceptually based on the ICF and captures 6 major life domains: (1) cognition, (2) mobility, (3) self-care, (4) getting along with people, (5) life activities and (6) participation [28]. A 5-point Likert scale is used to grade the difficulty experienced by the participant while performing activities into each domain: 1-none; 2-mild; 3- moderate; 4-severe; 5-extremely or cannot do. The following WHODAS domains were excluded in this study: (1) Cognition, as cognitive impairment had been screened previously by the Mini-Mental State Examination; (5) Life activities, questions about work and/or school attendance (d5.5-d5.8) and (6) Participation, questions about human rights and emotional functions were considered irrelevant to be scored as all patients had not returned to work/education at 6 months post-stroke.

The corresponding ICF categories in each WHODAS´ domain included were:

(2) Mobility Domain (5 questions): (2.1) d4154, maintaining a standing position; (2.2) d4104, standing; (2.3) d460, moving around within the home (moving by means other than walking, e.g. climbing); (2.4)

d4602, moving around outside the home and other buildings (less than 1 km); (2.5) d501, walking long distances;

(3)Self-care Domain (4 questions): (3.1) d5101, washing whole body; (3.2) d540, dressing; (3.3) d550, eating; (3.4) d510-d650, multiple self-care and domestic life tasks;

(4) Getting along Domain (5 questions): (4.1) d730, relating to strangers; (4.2) d750, informal relationships with friends; (4.3) d760, family relationships and d770, intimate relationships and d750, informal social relationships; (4.4) d7500 informal relationships with friends and d720, forming relationships; (4.5) d7702, sexual relationships.

(5) Life activities Domain (4 questions from a total of 8 included): (5.1) d6, domestic life; (5.2-5.4) d640, doing housework; d210, undertaking a single task; d220, undertaking a multiple task.

(6) Participation Domain (5 questions): (6.1) d910, community life; (6.2) d9, community, social and civic life; (6.6) d870, personal economic resources;(6.8) d920, recreation and leisure items were considered in this study.

Personal factors

Socio-demographic data (age, gender, marital status, current occupation, formal and informal caregiver support) were collected as personal factors.

Data Analysis

Patients were stratified into two groups according to the physiotherapist's categorisation of knee posture in the loading-response: normal (NKP) or abnormal (AKP). The inter-rater agreement for this categorisation was measured using Cohen´s kappa statistics. The following benchmarks were used for interpreting kappa [46]: < 0- poor agreement; 0.0 – 0.20, means slight agreement; 0.21 – 0.40, means fair agreement; 0.41 – 0.60, moderate agreement; 0.61 – 0.80, substantial agreement; 0.81 – 1.00, almost perfect agreement.

Descriptive statistics were used to characterise both groups and describe global functioning according to the main categories in the ICF framework. Where three trials had been performed (muscle strength, 5-meter walk test and TUG) the mean of these trials was calculated. To assess significant differences between the NKP and AKP groups, Mann-Whitney tests were used for ordinal data and Chi-Square tests for categorical data. From this analysis, discriminant ICF categories between groups were identified. These discriminant categories were then entered into a logistic regression model to determine any linear associations between body functions and structures, activities and participation and personal factors in each group. This would contribute to understand interactions between knee posture and functionality. Data analyses were performed using the Statistical Package for Social Sciences (SPSS, Version 19). A significance level of 0.05 was used for all statistical tests.

Results

Thirty five patients with stroke (mean age 69.3±11.2 years; 22 males) participated in this study. Three outliers (1 male, 2 female) were identified and removed from further analyses.

Fifteen (46.8%) participants were allocated to the AKP group and seventeen (53.1%) to the NKP group. The inter-rater agreement for the categoristation of knee posture was moderate (k=0.50).

Knee posture during loading-response and clinical diagnosis

Clinical diagnosis is characterised in Table 1. During loading-response 73.3% (n=11) of the AKP group presented a pattern of knee hypoflexion and 26.7% (n=4) a pattern of knee hyperflexion. No significant differences for time post-stroke when participants began to walk or the side of hemiparesis were seen between AKP and NKP groups (Table 1).

[Table 1]

Body functions and structures

Those in the AKP group had significantly lower knee flexors strength (b730) (5.26±2.78 vs 7.35±2.78 Kgf; p=0.044) and significantly higher spasticity (b735) for the knee extensors (0.73±1.22 vs 0.06±0.242; p=0.033) and knee flexors (0.93±1.28 vs 0.12±0.332; p=0.029). No significant differences were found for BMI (p=0.737), motor reflexes or control of voluntary movement (p=0.089). No significant differences were seen between groups for stroke sub-types (s110). (p=0.803). The frequency and extent of impairments of body functions and structures in the AKP and NKP groups are presented in Table 2.

[Table 2]

Activities and participation

Significant differences between groups were found in the categories of: walking short distances (d450.0); moving around (d455); walking on different surfaces (d550.2); and moving around using equipment (d465). Compared with the AKP group, the NKP group showed significantly better performance in all of the clinical measures related to mobility such as 5MWT at self-speed (0.30±0.15 m/s vs 0.44±0.23 m/s, p=0.040) and fast-speed (0.50±0.32 m/s vs 0.84±0.33 m/s, p=0.016) and TUG (28.6±18.66 s. vs 16.16±10.75 s., p=0.024). Participants in the AKP group showed statistically significant higher fear of falling during daily task performance (FES, 46.20±24.25 vs 25.12±2.6, p = 0.011), had worse mean scores for walking on different surfaces (FAC, 3.33±1.29 vs 4.24±1.03, p=0.040) and were more likely to need a walking aid (11% vs 5%, p=0.013).

Participants in the AKP group also found maintaining a standing position (d4154 - 2.80±1.15 vs 1.82±0.95, p=0.014), moving around within the home (d460 - 2.27±1.10 vs 1.41±0.71, p=0.012) and walking long distances (d501; 4.20±0.90 vs 2.65±1.41, p=0.002), significantly more difficult. “Staying by yourself for a few days” and "Doing most important household tasks well" were also significantly more difficult for participants in AKP group (3.80±0.86 vs 2.71±1.05; p=0.004 and 4.53±0.74 vs 3.71±1.31; p= 0.05).

No significant differences were found across groups in the following ICF domains: (i) life activities, (d6, domestic life, d640, doing housework, d210, undertaking a single task, d220, undertaking a multiple task); (ii) getting along with people (d730, relating with strangers, d7500, informal relationships, d760, family relationships, d770, intimate relationships, d720, forming relationships, d7702, sexual relationships) and (iii) participation (d910, community life; d9 community, social and civic life; b152, emotional functions; d870, personal economic resources; d920, recreation and leisure).

Results of the frequency and extent of problems in the clinical measures assessing activity and participation domains in the AKP and NKP groups are presented in table 3.

[Table 3]

Personal Factors

Participants´ characteristics were generally similar in both AKP and NKP groups, regarding age (71.01±10.95 vs 69.80±9.75, p=0.496) and gender (66.7% vs 70.6% male, p=0.811). Most participants in both groups were married and retired. The need for caregiver support was significantly different between groups (p=0.002). In the AKP group all participants needed caregiver support for daily living activities and about 73% (n=11) of these needed a formal caregiver. In the NKP group, approximately 50% (n=8) also needed some caregiver support for daily living activities performance (Table 4).

[Table 4]

Regression Analysis

For participants in the AKP group, knee flexor strength correlated significantly with performance in TUG (sec.) (r=-0.632; r^2=0.40; p=0.011), fast walking speed (m/s) (r=0.606; r^2=0.37; p=0.017) and FES (r=-0.532; r^2=0.28; p=0.041). Statistical significant associations between body functions and structures, activities and participation and personal factors, for patients with AKP are presented in Figure 2.

[Figure 2]

For participants in NKP group, knee extensor tone correlated significantly with performance in TUG (r=0.646; r^2=0.42; p=0.005), standing (r= 0.474; r^2=0.22; p=0.055) and walking long distances (r=0.575; r^2=0.12; p=0.016). High knee flexor tone correlated significantly with the need for caregiver support (r=0.454; r^2=0.21; p=0.067). Statistically significant associations between body functions and structures, activities and participation and personal factors, for patients with NKP are fully presented in Figure 3.

[Figure 3]

Discussion

This exploratory study identified AKP during the loading-response at 6 months post-stroke as a key indicator of impaired global functioning on the ICF. AKP assessed by experienced physiotherapists using a simple visual assessment was significantly associated with gait impairments such as walking speed, walking distances, ability to walk on different surfaces, the need for a walking aid, fear of falling and the need for a carer. Our study also identified impairments of knee flexor strength and increased tone in knee flexors and extensors as associated underlying impairments linked to these gait deficits. Visual identification of AKP can therefore act as a simple clinical indicator of the need to assess and, when appropriate, to treat, the body structure and activity related parameters identified in this study. This is important, given the negative impact on personal independence [3], risk of falls [29] and increased treatment and care costs [47] which appear to be linked to AKP.

The findings of this study suggest that knee flexor weakness and spasticity in flexors and extensors may contribute to abnormal knee posture in the loading-response. Previous literature, identified weakness of knee extensors as the cause of excessive knee flexion and increased extensor tone as the cause of excessive knee extension during loading-response [48-53]. Our results also confirm an association between extensor hypertonicity and AKP but none with knee extensor weakness. Moreover, our results indicate that impairments of knee flexor strength and tone are also associated with abnormal knee posture. There has been relatively little exploration of the importance of knee flexor weakness in post-stroke gait although recent studies have indicated isometric flexor weakness to be greater than that of the extensors in those with hemiparesis [54, 55]. There are logical reasons for the development of knee flexor weakness in patients with AKP. First, there is a tendency to develop selective weakness in short muscles after stroke [56]; this is likely to occur in people who walk on a hyperflexed knee. Alternatively, knee flexor weakness can be developed because of the lack of minimum concentric work [57, 58]; this is likely to be present in people who walked on a hypoflexed knee.

In people with AKP, restriction in activities and participation (moving around and walking short/long distances) were associated with impairment in knee flexor strength; for those with NKP, high knee extensor tone was associated with restrictions in standing, in walking short/ long distances and the need of more caregiver support). It appears therefore, that the global functioning of those with normal or abnormal knee posture is differentially affected by weakness or spasticity. Knee posture could be therefore a good potential parameter to help researchers and clinicians define appropriately tailored rehabilitation strategies post-stroke.

Our results demonstrated significantly different levels of spasticity and relationships to global functioning between those with AKP and NKP. In particular, knee extensor spasticity appeared to affect standing ability, gait speed and distance more in those with NKP. One previous study [59] confirmed that the knee extensor spasticity often developed after stroke as a compensation to allow weight bearing, with high extensor tone increasing stability but having consequent reduction in walking efficiency (such as speed). Thus, spasticity can be a compensatory strategy promoting functioning, albeit at reduced efficiency. However, a negative effect of knee flexor spasticity was observed in NKP patients´ dependence on caregivers for performing daily activities post-stroke. Which probably explained this association is that high spasticity of knee flexors may inhibit adequate voluntary activation of knee extensors, that is necessary to perform functional activities, such as walking, stair climbing, and sitting down [60, 61]. The relationship between knee flexor spasticity and carer dependency could provide therefore important societal and economic insights in the rehabilitation post-stroke.

No differences between groups (AKP, NKP) were detected in motor reflex and motor control using the Fugl-Meyer, yet, using the MAS, significantly higher spasticity was recorded for participants with IKP. This is a surprising result, given that spasticity is, by definition an abnormality of reflex activity. The MAS, although often used in clinical practice, does not reliably distinguish between the resistance to passive stretch caused by the tonic stretch reflex or by possible intrinsic changes to the viscoelastic properties of muscles [62]. Furthermore, post-stroke the increase in resistance to passive stretch tends to be only associated with viscoelastic muscle changes and not with neural components (tonic stretch reflex) [63]. Our findings further challenge the validity of the MAS as a measure of spasticity.

Although the need for caregiver support was associated with other ICF components in people with NKP, no significant correlations were found in people with AKP. This gap in our findings hinders the earlier identification of rehabilitation priorities in this group. As the functional dependence is a great social financial burden after stroke [47, 64, 65], future related studies should adopt other clinical measures (in addition to strength, spasticity etc.) to further explore other possible associations with the caregiver support requirement in people with AKP.

Our data showed at 6 months post stroke, all participants (independent of knee posture) had severe difficulties in participation in community, social and civic life. Although relationships between walking and reduced participation were identified in this study, it is clear that return to full and meaningful community integration requires more than a focus on physical functioning, confirming previous research [66, 67].

In summary, this study showed that: (i) impaired knee posture in loading-response is a very disabling impairment, associated with severe restrictions in patients' functioning; (ii) patients with AKP and NKP present different profiles using the ICF template, which might reflect different priorities and long-term treatment needs; (iii) the ICF framework is a useful instrument to report, critique and correlate stroke clinical measures using a standardised language.

Limitations and recommendations for future research

This study present potential limitations. Firstly, this is a cross-sectional descriptive study which can only determine associations rather than cause/effect relationships. Nevertheless, our study provided important clinical indicators suggesting differential patterns of functioning between those presenting with normal and abnormal knee posture during loading. These findings may guide the development of future related studies where gait intervention protocols are tailored to the underlying impairments. Moreover, this study had a relatively small sample size (n= 32). In future studies, larger samples would facilitate more detailed investigation of knee posture, for example, discriminating between participants with knee hyperextension and those with knee hyperflexion. Finally, the clinical measures currently used to assess spasticity (MAS) and motor control (Fugl-Meyer) did not allow distinction between changes in muscle visco-elastic properties or by reflex changes [68]. Measures which enable accurate distinction are needed for further studies.

Conclusions

A high percentage of patients presented with AKP in the first 6 months post-stroke. In general, patients with AKP presented with significantly more severe impairments in body functions (weakness of knee flexors; spasticity of knee flexors and extensors) activities and participation (walking short distances, moving around, walking in different surfaces, maintaining a standing position, getting out of home, needed a walking aid more frequently). Simple visual identification of abnormal knee posture during loading may therefore, be an important clinical indicator of reduced global functioning post-stroke prompting more detailed assessment from therapists.

Knee flexor strength and knee spasticity might be key determinants of activities and participation for patients with AKP and NKP respectively. Moreover, knee posture seems to be an important indicator of the amount of caregiver support needed post-stroke and could be used to anticipate patient´s needs.

The ICF framework proved to be a valuable tool to interpreting relationships between impairments of body structures, and restrictions in activity and participation, facilitating better clinical-reasoning in rehabilitation post-stroke.

Declaration of Interests

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