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Measurement of walking capacity after stroke in the Soweto community

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CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This review provides a description of stroke with particular reference to the diagnosis of stroke and the resulting body structure and function changes that contribute to limitation of walking ability. Typical characteristics of the altered walking pattern associated with hemiplegia after stroke are described, specifically walking speed and endurance. The rationale for the selection of the following outcome measures: level of activity (Barthel Index), self paced gait speed (ten-metre walk test), functional walking tests (2 minute and 6 minute walk test) and heart rate as a measure of exercise intensity are also described.

2.2 DEFINITION OF STROKE

Stroke is a word used to describe a cerebrovascular haemorrhage, embolus or thrombosis which results in damage to neuronal tissue (Stroke Working Group 2000). Stroke has been defined according to the WHO definition of "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or leading to death, with no apparent cause other than vascular origin" (WHO MONICA 1988). In terms of diagnosis, stroke should be suspected whenever a patient has any of the five major warning symptoms listed:

- Weakness or numbness of the face or an arm or leg on one or both sides of the body.
- Sudden blurred or decreased vision in one or both eyes. Sudden onset of double vision
- Difficulty speaking or understanding.
- Dizziness, loss of balance or any unexplained fall or unsteady gait
- Headache (usually severe and abrupt in onset) or unexplained changes in the pattern of headaches (Stroke Therapy Clinical Guideline 2000).

Diagnosis is determined by integrating clinical findings with specific investigations. These are chest X-ray, CT scan (best method to distinguish between haemorrhage and infarct), ECG, and blood tests, INR, FBC, U&E, glucose levels and arterial blood gases – if hypoxia is suspected (Stroke Therapy Clinical Guideline 2000).

2.3 IMPACT OF STROKE ON THE INDIVIDUAL

The WHO International Classification of Functioning Disability and Health (WHO 2001) provides a framework of health outcomes in terms of body, person and social function and also a framework for research. It is used here to describe the impact of stroke on the individual. There are typical changes to body structure and functioning associated with stroke. These are motor weakness, decreased motor coordination and dexterity, altered muscle tone, decreased sensation, changes in vision, cognitive and behavioural changes. The distribution of impairments depends on the area of the brain affected i.e. on the area of the brain supplied by the specific branch of the carotid arteries (anterior system) or the vertebral arteries (posterior system). The most common presenting signs of motor impairment associated with a lesion in the middle cerebral artery are contralateral weakness and loss of dexterity. Typically the face, arm and leg are affected with the leg being less affected. If the anterior cerebral artery is affected the leg impairments are more marked. When the lesion is in the posterior system, weakness and loss of coordination are the chief presenting signs. The motor impairments along with changes in sensation and vision commonly result in the difficulties in standing and walking experienced by the stroke victim.

At the activities and participation level basic activities of daily living (eating dressing, toileting, walking) are included as well as more sophisticated skills to allow the person to participate optimally in their own environment and social setting. This, as a simple example, includes the abilities to plan a visit to the shops, the walking endurance, speed of walking to cross a road safely, manage uneven surfaces and crowded pavements and the cognitive skills to be able to communicate and manage financial transactions.

Within the ICF model, outcomes may be measured at the different levels i.e. body functioning, activities or participation. Assessment of stroke outcomes is complex as change continues over months and the rate and extent of change may vary between the different levels of the ICF (Duncan et al 2000). The extent and timing of recovery are known to relate to the initial severity of the stroke (Jorgensen et al 1995a).

There are many measures of impairment and activity. According to Duncan et al (2000) in their systematic review of outcome measures in acute trials fourteen different measures of impairment were used and eleven measures of activity. The BI was the most commonly selected measure of activity. It is known to have significant ceiling effects. Data on functional recovery in the study by Kalra et al (2005) suggested that there was a hierarchy in which activities improved and that patients needed to achieve basic ADL skills before progressing to higher levels of function. Pedersen et al (1997) and Kalra et al (2005) recommend use of the Frenchay Activities Index (FAI) in addition to the BI. Duncan et al (2000) recommends that measures that assess a higher level of activity (i.e. instrumental or extended ADL) and mobility may be more sensitive to differences between groups.

The study by Wade and Hewer (1987) confirmed the initial BI as an important prognostic factor for both recovery and for survival. In a study by Kalra et al (2005) factors that predispose to high risk of death or institutionalization were patients with initial BI <5 (using the BI 0-20 scale) and incontinence. This was seen in the domiciliary care strategy group and the stroke team group. In their study the most important predictor of outcome in the home care group was the BI on admission (Kalra et al 2005).

Measurement of participation are only now being developed for individuals after stroke. There is also great debate regarding the construct of "quality of life" and many of the measures deemed to assess the quality of life are also measuring activities or emotion (Duncan et al 2000).

2.4 WALKING AFTER STROKE

Recovery of walking is a priority goal for most patients with stroke (Goldie et al 1996) as walking increases their functional independence (Jorgensen et al 1995b). Muscle weakness, loss of motor control and soft tissue contracture are major contributors to walking dysfunction after stroke (Carr and Shepherd 2003). According to Wade and Hewer (1987) in unselected patients with stroke, >80% are able to walk independently six months after the event. It has been recommended that gait velocity be used for measuring outcome during rehabilitation when patients are able to walk independently (Wade et al 1987; Wade 1992). Wade et al (1987) measured walking recovery in sixty subjects over the first three months after stroke. Twenty three percent had no significant loss of walking speed and 25% were immobile. Of the 50% who regained independent walking 15% recovered normal walking speed and 13% used a walking aid.

Functional walking performance also however depends on one’s level of fitness. Therefore in evaluating functional gait one must take into consideration secondary cardiovascular and musculoskeletal consequences of disuse and physical inactivity. According to Carr and Shepherd (2003) impairments post stroke frequently impose excessive energy cost (effort) during walking, limiting the type and duration of activities. Stroke patients, particularly those of advanced age, are often unable to maintain their most efficient gait speed comfortably for more than a very short distance, indicating that muscle weakness, elevated energy demands and poor endurance further compromise walking ability (Olney et al 1986). Stroke patients may self–select a speed that requires the least

energy (Grimby 1983) and may not have the capacity to increase this without increasing energy demands beyond their capacity (Holden et al 1986).
Several studies of (non stroke) older individuals show positive effects of muscle strengthening exercises and aerobic exercises in preventing falls, increasing walking speed and aerobic capacity (Fiatarone et al 1990; Krebs et al 1998).

A study by Hale et al (1999) indicated that a group of black stroke patients in Soweto who were able to walk felt the need for improved walking ability, as they were scared of falling.

2.5 WALKING SPEED

Given the high energy cost of walking in the presence of muscle weakness, loss of coordination and secondary musculoskeletal changes it is not surprising that the most consistent research finding is that individuals following stroke walk more slowly than their age matched healthy counterparts (von Schroeder et al 1995). Walking speed is an important element in gait analysis as changes in speed are accompanied by changes in every aspect of walking e.g. walking pattern, stride length, cadence and duration of double support phase (Olney and Richards 1996). There is also evidence that gait velocity is an appropriate measure for documenting recovery of walking after stroke (Goldie et al 1996). Their study showed that gait velocity discriminated the effect of stroke and the change during rehabilitation.

Large differences have been shown between stroke patients for gait velocity during rehabilitation. Research by Friedman (1990) found a more than three fold difference during rehabilitation between patients who were initially immobile or mobile after the seventh day after stroke. An earlier study by Friedman et al (1988), showed that substantially fewer patients required long term institutional care if they could walk faster than 9m/min. This indicated that a level of gait velocity could distinguish between those who require long term care and those who were more mobile and more independent. According to Carr and Shepherd

(2003) walking velocity may be the most important objective measure of functional ability. It is simple to administer and is easily understood and accepted by patients. Almost all other gait measures are speed dependent (Andriacci et al 1977), for example as speed increases so does the extent of hip extension and amount of push-off.

Normal walking speed in healthy people has been reported to range between 1.14 – 1.69 m/s (Murray et al 1970; Bradstater et al 1983)

2.6 WALKING ENDURANCE

Endurance has been defined as the time limit of a person's ability to sustain a particular level of effort (McArdle et al 1996).Traditionally the emphasis in stroke rehabilitation has been on improving task- related abilities through balance training and motor learning (Carr and Shepherd 1998) and until recently little emphasis has been placed on endurance training. However, stroke patients are known to have low endurance to exercise which may decline further after discharge from formal rehabilitation (King et al 1989).

Low endurance may compound the increased energy cost of movement associated with residual hemiparesis and may contribute to poor rehabilitation outcomes (Duncan and Badke 1987). According to Potempa et al (1995) cardiovascular responses to exercise testing after stroke include lowered peak exercise responses, reduced oxidative capacity of paretic muscles and decreased endurance. Carr and Shepherd (2003) concluded that reduced functional capacity after stroke is therefore likely to be due to in varying extents, a reduction in the number of motor units recruitable during dynamic exercise, reduced oxidative capacity of weak muscles and low endurance. In some individuals this is compounded by the presence of co-morbid coronary artery disease and physical inactivity.

In both research and clinical practice however there is some evidence that workload, exercise time and sensorimotor function can improve with intense exercise and aerobic training (Potempa et al 1995; Teixeira-Salmela et al 1999).
A small study by Silver and colleagues (2000) showed that an aerobic treadmill training programme, three times a week for three months, resulted in a decrease in the overall time to perform the "Get up and Go Test" and an increase in the gait velocity and cadence. Exercise was individualized and increased to 40 minutes training at approximately 60-70% of maximum heart rate reserve.

In terms of exercise prescription Carr and Shepherd (2003) recommend that as a general health precaution it is advisable that older adults have a general medical check prior to starting a moderately vigorous exercise and fitness programme. This should also occur after stroke. The contraindications to exercise training appear to be few, even in the very old (Mazzeo et al 1998 as reported in Carr and Shepherd 2003). Endurance can be tested specifically for walking by the six minute walking test (6MWT), in which the distance walked in six minutes is measured (Sciurba and Slivka 1998).

2.7 SOWETO – AN URBAN BLACK COMMUNITY

Soweto, an acronym for South Western Township, was established in 1904. It stretches across a vast area 20 kilometres south west of Johannesburg. Soweto is the most populous black urban residential area in the country, with Census 2001 putting its population at 896 995 (Census 2001).
(http://www.safrica.info/plan_tripholiday.cities/soweto.htm)
Around 1936 many black South Africans had been evicted from farms and were determined not to live in the overcrowded Reserves. They moved to the cities many settling around Orlando (part of Soweto).To resolve the squatter issue the Government moved people into the massive low cost housing estates which collectively became known as Soweto (Stadler 1979). From its early days Soweto has had problems of poor housing and overcrowding. Generally infrastructure has been inadequate and there has been an ongoing high rate of

unemployment. As in many other black townships in South Africa many of the dwellings are constructed of corrugated iron.

The apartheid government paid minimal attention to providing basic services in Soweto. It is only since the advent of a democratic government that, electricity and water and sanitation supplies have been provided and upgraded to more of the residents. Clinics and shopping centres have also been built.

(http://www.safrica.info/plan_trip/holiday/cities/soweto.htm)

Many of the roads are not tarred and houses are only identified by plot number though some of the streets are named." A typical address might be "Mr A Dube, Plot 10578, Chiawelo. Relatively few of the townships that make up Soweto have telephone connections so that though in recent years the arrival of cellular telephones has improved communication it remains relatively poor. The inadequate health infrastructure in these communities combined with mass unemployment (29.5% in 2002, the Economist, 2004) and poverty (Human Development Index 68.4% in 2002, the Economist, 2004) result in rehabilitation services being inaccessible (Hale and Wallner 1996). Patients are generally unable to return for out-patient therapy after discharge from Chris Hani Baragwanath Hospital due to poverty or lack of transport (Schneider et al 1994 as cited in Hale and Wallner 1996). Most Sowetan residents rely on the local minibus taxi service as their only means of transport. Financial problems and the lack of accompanying care-givers are often constraints to the use of taxis (Hale and Eales 1998).

Chris Hani Baragwanath Hospital is a 2865 bed acute-care hospital situated in Soweto. In 2004 there were 133 556 general admissions to the hospital. Patients only stay until they are medically stable and are then discharged home. The brief hospital stay, the shortage of therapists and large numbers of patients mean that only minimal rehabilitation services can be offered in the acute phase (Hale and Eales 1998).

2.8 THE BARTHEL INDEX

Several instruments for the assessment of functioning and disability have been developed. In clinical trials the most widely used are the BI and the Modified Rankin Scale (MRS) (Roberts and Counsell 1998). These scales are sensitive measures of stroke severity and show high interrater reliability (D' Olhaberriague et al 1996). In addition they can be assessed via telephone or proxy interview.

The BI of activities of daily living (ADL) was introduced by Dorothea Barthel in 1955 to follow progress in self-care and mobility skills during in-patient rehabilitation and to indicate the amount of nursing care needed (Mahoney and Barthel 1965). The scale assesses 15 items related to self-care and mobility. Activities of daily living account for 33 points, bowel and bladder control 20 points and ambulation activities, including the ability to walk and to negotiate stairs, 47 points. (Mahoney and Barthel 1965).

It is an empirically derived ordinal scale with proven inter observer and test-retest reliability and validity which measures the patient's functional ability without family and social functioning distorting the outcome. The BI has been found to be reliable and repeatable in skilled and unskilled hands (Collin et al 1988; Shah et al 1989; Wade 1992).

The BI is simple and easy to score, but it's disadvantages are insensitivity and a pronounced floor and ceiling effect (Wade 1992). It also lacks assessment of cognition or communication. However Wade and Hewer (1987) considers that, of many ADL scales, the B I is probably the "best buy". The BI has been used on clients with stroke, spinal cord injuries, other neurological conditions, burns, cardiac problems and amputations (Cole et al 1994). As an example of the use of the BI in countries with different social and cultural backgrounds, a study by Nazzal et al (2001) found the modified BI is simple, convenient and efficient and could be used in Arab countries.

Wilkinson et al (1997) concluded that the place of the BI as the standard outcome measure for populations of stroke patients is still justified for long term follow up, and may be a proxy for different outcome measures intended for the assessment of other domains. It can be used clinically, to monitor changes in function and for research. The lack of consistency in defining cut-off points for favourable or unfavourable results has been shown to hinder the interpretation of results and comparisons across trials (Duncan et al 2000). Granger et al (1979) have suggested that a score of 60 on the BI corresponds to the shift from dependence to assisted independence. Forty or below indicates severe dependence and 20 and below reflects total dependence. In the same study, a score of 85 was found to correspond to independence with minimal assistance. Sulter et al (1999) also reported that a score of < 85 corresponded to a level at which subjects reported needing help with activities of daily living.

Gait recovery was documented in a group of 804 stroke patients in the Copenhagen Stroke Study using the walking sub-score of the BI (Jorgensen et al 1995b). However it is recognized that such a coarse scale may fail to differentiate between patients who can walk independently but still have a substantial deficit in comparison to normal subjects and may fail to detect continuing improvement in walking status (Goldie et al 1996).

2.9 THE TEN-METRE WALK TEST

The use of timed walking tests as a measure of gait performance is not a new idea. Many studies carried out with a variety of patient groups describe some similar form of timed walking test. Though the distance used seems to vary, emphasis seems to be placed on the use of a distance of ten metres (Wade et al 1987; Ada et al 1990). Ten metres is probably the minimum functionally significant distance in the recovery of functional walking (Watson 2002). Wade et al (1987) first described and documented the specific use of a ten-metre walking test to monitor recovery of gait following stroke. This involved timing how long it

takes for subjects to walk ten metres from a standing start, moving at their usual speed using their usual walking aids (Wade et al 1987).

Inter-rater and test-retest reliability were found to be good though a specific operational procedure for the test was not given. The ten-metre timed walk has been described as a simple, reliable and valid measure of walking ability (Wade 1992; Rossier and Wade 2001). It is sometimes described as the measurement of the walking velocity over the middle ten metres of a fourteen metre walkway to avoid the effects of acceleration and deceleration (Whittle 1991 as cited in Watson 2002; Carr and Shepherd 2003). Watson (2002) however refined the test as a measure of the time taken for subjects to cover a distance of ten metres from a standing start, when walking at their usual speed. An argument for timing from a standing start is that it could be more representative of the normal situation (Watson 2002). A practical example of this would be walking across a road.

2.10 THE SIX MINUTE WALK TEST

The six minute walk test (6MWT) is a test of functional exercise performance which simply involves measuring the distance a patient can walk on a level course in the specified period of time. It is a submaximal measure used to determine functional capacity in individuals with compromised ability. Functional capacity has been defined as the extent to which a person can increase exercise intensities and maintain those increased levels (Brookes et al 1996 as cited in Eng et al 2002). Therefore functional walking tests differ from the standard self paced walking test (e.g. over ten metres) in their requirement for sustained walking activity over extended periods of time (Eng et al 2002) This tool is increasingly applied to many disease categories to assess functional status and to assess outcome following intervention. Eales and Stewart (1996) used the 6MWT as one of the measures to evaluate the exercise capacity of three groups of hypertensive patients within South Africa. The groups were from three different socio-economic settings: a tertiary care hospital; an urban community based

clinic; and a rural clinic. The results of the 6MWT for the three groups were 433 metres, 354 metres and 346 metres respectively. Functional walk tests have been used to evaluate training programmes because they require the individual to sustain a submaximal intensity at an intensity and duration that might better reflect activities of daily living in the population (Eng et al 2002). Advantages of this test include its minimal technical requirements, ease of execution by even severely debilitated patients, good reproducibility and correlation with maximal exercise testing and functional status questionnaires. Disadvantages include the lack of detailed physiologic data obtained relative to maximal cardiopulmonary exercise testing and the lack of standardization in methodology (Sciurba and Slivka 1998). Methodological differences which frequently prevent reliable comparison between research studies include: the number of practice walks, the intensity of encouragement and the characteristics of the walking track (Sciurba and Slivka 1998).

Practical guidelines for disability in the community have been described and can be directly compared to values derived from 6MW testing including the velocity needed to cross an intersection in the period allowed by the pedestrian signal light (1.32 m/sec) or the walking distance necessary to visit common community destinations (600 metres) (Sciurba and Slivka 1998).

Enright and Sherrill (1998) developed reference equations for the six-minute walk in healthy adults aged 40-80 years. These equations predict the distance a healthy person should walk in six minutes. The equations are gender specific and are based on the age, height and weight of subjects. Comparisons between actual distance walked and distance predicted by the equations allows the assessment of disability and potential handicap associated with poor walking endurance (Dean et al 2001).

2.10.1 The Two Minute Walk Test

The two minute walk test (2MWT) was validated by two studies as a similar measure of exercise tolerance as the 6MWT and the twelve minute walk test (12MWT) in patients with chronic respiratory disease (Butland et al 1982; Bernstein et al 1994). Both studies found strong correlations with distance walked in the respective times. A study by Connelly et al (1996) reported the interrater and intrarater reliability of the 2MWT to be good to high in frail elderly subjects.

A study investigating the validity and reliability of four mobility measures in patients presenting with neurologic impairment (Rossier and Wade 2001) found that all the following measures (Rivermead mobility index standard version and one with four levels of answer, ten metre walk test and 2MWT) could detect the expected difference between fast and slow walkers. They recognized that the scales measure different aspects of mobility with the ten metre walk test measuring short-duration speed and the 2MWT assessing endurance (which may be affected by such factors as arthritic pain and cardiovascular fitness). They suggest that the 2MWT may be the most relevant to patients. Rossier and Wade (2001) acknowledged that the 2MWT has not been used much in neurologically impaired patients, however this is changing (Moreland et al 2003)

2.11 MONITORING EXERCISE LEVEL DURING THE SIX MINUTE WALK TEST

One of the limitations of the functional walk test is that subjects can vary either or both the distance and the exertion Performance in this test depends not only on neuromuscular function and muscle strength but also on respiratory function, motivation and cardiovascular function (Eng et at 2001). A simple measure of heart rate (HR) gives an indication of intensity of exercise. It can be used to monitor level of exercise to ensure it is sufficiently vigorous and is a simple test of whether or not the patient's cardiovascular system is adapting to exercise (Carr and Shepherd 2003). There is general agreement that if the heart rate is measured within fifteen seconds of the conclusion of exercise that it will provide a valid indicator of intensity during exercise in normal individuals (Rothstein 1985)

Measures of oxygen use are cumbersome and not appropriate for measuring exercise intensity in the clinical environment; so measures of heart rate are more commonly used (Dawes et al 2003). The relationship of work rate to rate of oxygen consumption (VO_2) has been described as linear in individuals recovering from stroke (Macko et al 1997). The study by Dawes et al (2003) concluded that "the linear relationship between heart rate and VO_2 suggests that exercise intensity can validly be prescribed from heart rate in individuals with brain injury". They further noted "that people with brain injury often have reduced exercise capacity and peak heart rate" (Potempa et al 1995). Thus exercises prescribed at standard recommended intensities as a percentage of estimated maximum heart rate may work individuals at intensities close to peak heart rate" (Dawes et al 2003). Eales and Stewart's (1996) study of hypertensive patients reported a mean exercise intensity for all patients in all groups of 60% ±10.1% of age predicted maximum heart rate for the six minute walking test. A study by Eng et al (2002) demonstrated an exercise intensity of 63% ±9% of age-predicted maximal heart rate for the six minute walking test in individuals with stroke. They recommended that if the functional walk test is used to assess performance of an individual over time that both exertion (e.g. increase in HR) and distance be measured. Exercise HR is determined using a HR monitor.

Maximum age-predicted HR is calculated by subtracting the patient's age from 220.

Maximum age-predicted HR = 220 – age (McArdle et al 1996).

Exercise HR is calculated as a percentage of maximum age-predicted HR.

For example, a 50 year old subject maximum age-predicted HR = 220-50 (=180)

The 6MWT HR is 120b/m then the 6MWT HR is 67%.

2.12 SUMMARY

It is generally accepted that recovery of walking is a priority goal for most patients after stroke. Over the past twenty years much more emphasis has been placed on the importance of measuring the changes in patient's status. A measure of self-paced walking speed usually measured over ten-metres has become accepted as the standard measure of walking ability. However the importance of measuring endurance has been recognized more recently, with the aim of preparing patients to return to functional walking in the community. Endurance includes measurement of distance walked and exercise intensity reflected by changes in heart rate. Soweto is described, because of the important influence the environment has on the way individuals live and work.