THE ROLE OF EFFORT IN THE RECOVERY OF ARM FUNCTION FOLLOWING A STROKE

By

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ABSTRACT

The role of effort in the recovery of arm function following a stroke.

by

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Stroke patients often report an increased sense of effort when using their paretic limb. Currently there is little research investigating this phenomenon and the implications that it could have for recovery. This study was an exploratory piece of work which combined quantitative and qualitative methods to investigate the role of effort in the recovery of arm function following a stroke. For the study, a new piece of equipment was designed called the assessment of perceived stiffness to provide a measure of effort that was less open to subjective bias than previous studies. In this new approach, stroke patients were asked to subjectively match the force of the grip strength being exerted by the impaired and unimpaired hand and then measures of the actual force being applied were taken using a dynamometer that was attached to the equipment. An interview schedule was also designed to examine stroke participants' experiences of effort and compare them with the performance on the assessment of perceived stiffness. Seventeen participants were recruited for the study and were divided into three groups namely, a stroke participant group, an age-matched control group and a young control group.

The stroke participants' performance on the assessment of perceived stiffness was compared with that of the two control groups. The stroke participants' perception of perceived stiffness was then compared with their reports of increased effort in everyday
life when they performed a movement task with their recovering arm. Furthermore, the research investigated whether stroke participants make a distinction between physical effort and mental effort.

The results from the stroke sample showed that there were differences in their perception of stiffness compared to the control groups. The stroke participants' performance suggests that they were perceiving a greater stiffness on their paretic side when exhibiting the same amount of force on both sides. The results from the interview data demonstrated that the stroke participants who perceive increased stiffness on their paretic side report greater effort in everyday life. Individual differences were demonstrated when stroke participants were asked if they made a distinction between physical effort and mental effort.

The results confirm the findings of previous studies and add weight to earlier research that an increased sense of effort is reported during recovery of arm function. Furthermore, this study highlights the need for additional research to investigate this area. The clinical implications of the results and areas for future research are discussed in detail.
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“My arm and leg seemed to me enormous burdens which I could only lift with the greatest effort”. (Mach, 1906, p175).
1 INTRODUCTION
1.1 Nature and prevalence of stroke disease

Stroke is a relatively common condition which is characterised by rapidly developing signs of cerebral dysfunction, having a vascular basis and lasting more than 24 hours (Churchill, 1993). A stroke typically involves a sudden loss of movement on one side of the body often resulting in the loss of use of an arm and leg or the control of facial muscles. Recovery is often incomplete. As well as the physical impairment of movement, a number of different functions can be affected including sensation, perception of the body and of one’s environment, communication and continence. In addition to the physical disability, emotional reactions can include depression, feelings of isolation and frustration. Mood changes are also frequent. Furthermore, cognitive difficulties can result, affecting memory and attention. The patterns of dysfunction vary considerably with unique problems being created for each client. Research suggests that about a third of patients die in the early weeks following a stroke (Wade, 1994), and a substantial number of survivors are left with limitations in aspects such as mobility, self-care, social interaction and employment (Churchill, 1993; Wade, 1994).

Stroke disease is a major cause of adult disability throughout the developed world, consequently, strokes present a substantial healthcare cost. Estimates have suggested that approximately 5% of the National Health Service budget in Britain is thus consumed (Isard and Forbes, 1992), much of which is due to the cost of caring for inpatients.

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1 Wade (1994) estimates the British incidence of first and recurrent stroke as 2.4 per thousand per year.
Rehabilitation interventions that can aid recovery and reduce long-term disability would have a major impact on both the individual and the cost of care resulting from the disease.

1.2 Recovery of arm function following a stroke

1.2.1 How is arm function defined?

While many functions can be affected following a stroke one common impairment that causes great distress to the individual is the loss of arm function. The definition of arm function is a complex area as definitions of movement of the arm often incorporate descriptions of the arm, hand and shoulder. While other explanations include descriptions of a clients' ability to coordinate their limb to lift objects or perform everyday tasks. However, a clear understanding of arm function is the ability to move the arm and hand and to be able to use them to perform everyday tasks.

Many of the skilled tasks that we perform on a daily basis without much thought depend upon normal arm function. Loss of “automaticity” when performing tasks with the upper limb has been reported by patients in the literature, as a factor that causes much distress (Doolittle, 1992; Parry, 1997). The impact of the loss of arm function can have a huge psychological effect on a patient's well being (Kelly and Field, 1996; Parry, 1997). Patients may be unable to carry out simple everyday self-care tasks or be able to
participate in their hobbies, therefore hampering their independence and often precipitating a withdrawal from social situations.

The full story on movement is a difficult and incomplete one with many competing factors affecting the recovery of arm function. Following a stroke there is often paresis of the limb leading to an inability to move the affected part. However, higher level control problems can also play a part leading to problems of poor coordination and difficulty performing complex actions.

1.2.2 Literature highlighting the poor prognosis for arm function

The literature on long-term recovery of arm function following a stroke makes depressing reading (Adams et al., 1953; Joshi et al., 1974). In each of these early studies, both authors reported specifically on the percentage of patients with functional recovery of the upper limb, finding it to be 4% and 5% respectively. Further literature examining the long-term recovery of arm function suggests that 40% of all stroke survivors had impaired function in their affected arm at three months post stroke and that only 20% had entirely normal function (Parker et al., 1986). There is much consensus within the literature that recovery of arm movement is concentrated in the early months and that there is a plateau after six months (Bard and Hirschberg, 1965; Carroll, 1965; Fugl-Meyer et al., 1975; Skilbeck et al., 1983; Wade et al., 1983). More optimistically the research also highlights that it is possible to find individuals who show later improvement
and progress which may continue for months or even years following their stroke (Bard and Hirschberg, 1965; Carroll, 1965; Fugl-Meyer et al., 1975; Wade et al., 1983).

In 1982, Gowland reported that,

"The poor prognosis for the arm suggests that further studies aimed at elucidating and improving the recovery potential of the arm are required" (p83).

Despite this, while recovery during the acute phase of stroke is relatively well understood in terms of a range of physiological mechanisms (Sofroniew, 1993), longer term recovery is still less well understood. There is a great need to elucidate the longer-term mechanisms of recovery that could be used to facilitate further treatment and aid recovery of arm function.

1.3 The rehabilitation process

Many of those who suffer disabilities secondary to a stroke encounter healthcare rehabilitation services (Ashburn et al. 1993). Following a stroke both the clients and their families look to the rehabilitation process as the main treatment that will restore their independence. Recovery is clearly seen as a central aim of the rehabilitation process and clients express high hopes that the treatment will improve their functioning. This view of rehabilitation is the ideal and what rehabilitation professionals would hope to provide.
However, despite the advances in diagnostics, medications, and rehabilitation techniques, outcome for an individual patient remains difficult to predict.

1.3.1 Emphasis on the importance of physiotherapy in rehabilitation

Physiotherapists are generally regarded as “experts on the body” (Thornquist, 1994). Within specialist stroke rehabilitation units physiotherapy is regarded by many stroke survivors and carers as the most important form of treatment which they receive, with physiotherapists being given credit by patients for their recovery (Gold, 1983; Kaufman, 1988; Pound et al., 1994a). Clients frequently express the view that if they had only had more physiotherapy, then their level of functioning would have increased. Decisions regarding the best treatment for each client are complex. Physical rehabilitation professionals are often left with vexing concerns over whom to treat first and who will benefit most from therapy. These beneficial and distributive arguments in physical therapy are partly dictated by policy and resource restraints, however, they also result from a lack of objective criteria on which physical therapists can base their decisions.

1.4 Efficacy of physiotherapy

There is a growing demand throughout the health service for the efficacy of treatments to be investigated. With clients placing much faith in the effects of physiotherapy treatment
further research needs to investigate the nature of the effects. An increased understanding could also aid the development of techniques that are more effective.

The mechanisms by which improvement occurs following stroke are presently unknown, and therefore the reasons for the effectiveness of treatment designed to improve movement and function are also uncertain. It may be likely that some physical treatments which are directed towards the relearning of motor skills and take advantage of the brain’s plasticity could be more effective than a treatment that is primarily directed peripherally by means of exercises. This argument which is not a new one appears in the literature and has previously been hypothesized by Ayres (1972) commenting that,

"The demands of the environment greatly assist in the reorganisation of the brain after it is damaged" (p41).

There has been a development in recent years of research evaluating the effectiveness of physiotherapy (Ashburn et al., 1993; Langhorne et al., 1996). Despite patient and therapist’s strong beliefs about the efficacy of physiotherapy, the results from the literature have concluded, at best, that physiotherapy in stroke rehabilitation has only moderate effects on outcome. A substantial difficulty that the research has reported in attempting to assess the effectiveness of physical therapy is the limitations of standardized outcome measures which disguise the many facets and complexity of progress and recovery after stroke.
The changing emphasis in the health service for professionals to provide the most effective treatment for clients has lead to a growth in the research investigating treatment efficacy following a stroke and the conditions under which physiotherapy is most beneficial (Hesse et al., 1994; Langhorne et al, 1996; Richards et al., 1993; Sivenius et al., 1985; Smith et al., 1981; Smith et al., 1992; Stern et al., 1971; Sunderland et al., 1992; Wade et al., 1984; Wade et al., 1992; Wade and Langton-Hewer, 1989; Wagenaar and Meijer, 1991a; Wagenaar and Meijer, 1991b). Questions that researchers have addressed include assessing the benefits that expert rehabilitation care provides, examining the optimum time for physiotherapy to be given, investigating if the “intensity” of the treatment affects performance and who would benefit most?

1.4.1 The benefits of specialized stroke care

One of the most important developments in stroke research, in recent years is the evidence that strongly supports that specialized stroke care is beneficial. Research has indicated that organised (stroke unit) care focussed on a multidisciplinary team, which is expert in managing the rehabilitation process of patients after stroke can reduce both mortality and the need for institutional care (Langhorne et al., 1993; Langhorne et al., 1995; Wagenaar and Meijer, 1991a).

An extensive review of stroke rehabilitation including the differential effects between various forms of treatment is provided by Wagenaar and Meijer (1991a; 1991b).
This review will predominately address the early start of physiotherapy treatment and the intensity of treatment.

Within the literature a number of opinions concerning the value of treatment are encompassed from the positively inconclusive of Ernst (1990) who reported that,

"The evidence available today suggests that it does not matter which form of treatment is chosen and that any of the available approaches will improve the patient's functional status" (p1081).

Ernst based his findings on the literature with respect to the early start of intensive rehabilitation after stroke onset. In his review, he also reported that no relevant differences were to be found between the different forms of physiotherapy given to clients.

Other authors are more pessimistic about the benefits of rehabilitation treatments claiming that,

"Functional gains experienced by stroke patients are primarily attributable to spontaneous recovery" (Lind, 1982, p134).
Wade and Langton-Hewer (1989) in their review of the efficacy of rehabilitation methods came to a similar conclusion to that of Ernst (1990) namely that,

"Clinically relevant differences in efficacy are only incidentally found in intervention studies and when they do occur, they are often dubious and sometimes contradictory" (p242).

1.4.2 Early start of treatment

A key question that clients ask is whether their improvement could have been greater if they had received treatment earlier. There is literature that examines the effect that early intervention following a stroke has on functional outcome. Wade and Langton-Hewer (1989) commented that,

"Early attention from therapists may facilitate a more rapid return to independence in activities of daily living" (p. 243).

Other studies indicate that there is little difference between clients who receive physical therapy within two weeks following stroke and those who receive it following the initial two weeks (Andrews et al., 1982). Johnston and Keister (1984) in their study initially found a significant relation between onset of rehabilitation (the categories they used were within 2 weeks, 2 to 5 weeks or more than 5 weeks post stroke) and functional outcome.
However, the significant results became non-significant when the severity of the stroke deficit on admission was controlled for.

The complexity in this area is that there is a common clinical assumption that the earlier an intervention is instigated after an injury then the more effective it is likely to be (Miller, 1984). However, any effect could be an artifact of “spontaneous remission” which typically occurs at a greater rate in the period following an injury. This could lead the therapist to regard spontaneous recovery as a response to treatment. However, clinical opinion runs strongly in this direction, despite the lack of evidence to support the theory. Presently, no definite conclusions can be drawn with respect to the effects of the early start of treatment post stroke on functional recovery.

1.4.3 Intensity of therapy debate

In addition to research investigating the most beneficial time for physical therapy to be administered with stroke patients, another area that has promoted interest has been the amount of therapy that stroke patients receive. A number of studies have attempted to clarify whether an increase in physical therapy leads to better intrinsic recovery (Peacock et al., 1972; Richards et al., 1993; Sivenius et al., 1985; Smith et al., 1981; Stern et al., 1971; Wade et al., 1992). "Enhanced therapy" also has been investigated (Sunderland et al., 1992). This study compared orthodox physiotherapy with an enhanced therapy regime which increased the amount of treatment as well as using behavioural methods to
encourage motor learning. The results found a small but statistically significant recovery of strength, range and speed of movement in the “enhanced therapy” group. This effect did appear to be concentrated for clients who had demonstrated an initial milder impairment.

While no clear consensus is available some of the trials did report statistically significant improvements for motor impairment scores (Sivenius et al., 1985; Sunderland et al., 1992) and Activities of Daily Living (ADL) scores (Sivenius et al., 1985; Smith et al., 1981). Positive results have also been noted in studies where there were specified target outcomes such as vocational scores (Peacock, 1972); maintaining their ADL level (Smith et al., 1981); arm function tests (Sunderland et al., 1992) and walking speed (Wade et al., 1992). Despite these positive reviews, there is still inadequate information to allow professionals to make informed decisions about the best level of physical therapy input after a stroke. Furthermore, research is needed to discover the reasons for the improved recovery.

1.5 **Who receives physiotherapy?**

Decisions to provide an intensive in-patient rehabilitation program for a stroke patient can often be based on views as to whether a patient will benefit from such a program. Benefits are generally measured in terms of improved survival rate, reduced length of stay in hospital, the possibility of a more favourable discharge and improved functional
outcomes. These measures are themselves based on decisions regarding someone’s age or severity of stroke. At the same time costly programs with little or no rehabilitation effect are recognized as poor rehabilitation practice. Of greater benefit to rehabilitation practices would be a measure that would allow rehabilitation professionals to do more than use their clinical judgement to consider which clients would be expected to regain functional recovery of the hemiparetic arm. This type of information would allow professionals to determine the choice of rehabilitation program appropriate for a client’s expected outcomes.

Presently, physiotherapists are provided with clinical guidelines which are intended to help them assess a client’s rehabilitation potential, however it often appears that those treating stroke clients do not continuously base their rehabilitation treatments on scientific findings. This view has come to the attention of a number of authors within the physiotherapy literature. In a review of physical therapy, Klinteberg (1992) acknowledged that,

"Many treatment methods used by physical therapists rely heavily on clinical experience gathered over many years rather than on assessment" (p6).

In practice, time and effort are divided equally among all clients until discharge or until an individual’s performance has plateaued. Ernst (1990) in a broader and more scathing criticism on rehabilitation practices reported that rehabilitation professionals,
"have little awareness of the contents of the rehabilitation process itself or of physical therapy models" (p1082).

When rehabilitation therapists are asked to provide a prediction of a client's outcome, the decision is often an intuitive one based again on their clinical experience. This can be highlighted in the literature (Brocklehurst et al., 1978c; Garraway et al., 1980b). These studies reported that the provision of physiotherapy appears to be targeted on those clients with the greatest impairments, while occupational therapy is given more to the patients with "good prospects" of recovery. Further authors (Anderson, 1988) also reported that even among the "good prospects" little difference was noted in the ability to do things independently between those who received remedial therapy and those who did not. Resulting from this lack of specificity about the use of remedial therapy for clients with differing functional limitations it would seem appropriate to argue, as some have done (Brocklehurst et al., 1978c; Davies et al., 1989), for reconsidering the criteria for the selection of clients for remedial therapy.

The lack of systematic research evidence demonstrating that rehabilitation works or at least what rehabilitation professionals say that they are calling rehabilitation is the factor that has brought about change and improved functioning for a client, has lead many rehabilitation professionals to be skeptical about the rehabilitation process. While most do not believe that it is harmful, many question if it is doing any good or if it can actually provide improvements for some clients.
In our economically driven culture, the need to prove efficacy is at the forefront of Health Authorities’ agendas. Furthermore, with the government’s recent drive to built efficiency and accountability into healthcare it is increasingly seen as wasteful to deliver treatment to people who do not need it. It can also be potentially harmful if the treatments that are delivered are ineffective. This can happen if professionals are unaware of the evidence about what works best for whom, if outcomes for treatment are not assessed properly.

1.6 The influence of the Bobath philosophy on physiotherapy practice

Following a stroke, physiotherapy focuses mainly upon the restoration of movement. This is clear from contemporary texts on physiotherapy approaches in neurology (Bobath, 1990; Carr and Shepherd, 1987; Edwards, 1996; Lennon, 1996). Current approaches emphasise the re-education of "normal" movement, contrasting with earlier approaches which emphasised compensation for disability by focussing on the non-affected side.

Within the physiotherapy profession there are a number of strongly held beliefs regarding the best approach to improve function following a stroke. The techniques that have been developed exemplify the way in which many of the techniques used by physiotherapists have evolved. Initially, little was known about the nature of movement until four decades ago, and, previously exercises were based on the knowledge of musculoskeletal anatomy. Techniques have gradually been developed through applications of research in the basic
sciences, such as neurophysiology and physiology. Therapists then learned, that sensory, tactile, and proprioceptive stimulation can affect motor response.

Several of the early applications from the research took the form of specific approaches named after the clinician who developed them. Some of the methods of treatment are associated with Rood, Bobath, Brunnstrom, Knott and Voss (proprioceptive neuromuscular facilitation) and Ayres (sensory integration). These techniques were developed due to considerable use of research from other fields, but were based largely on clinical observations and impressions of the therapists who used them (Klinteberg, 1992).

The Bobath philosophy is the foremost treatment approach used in stroke rehabilitation treatment in Britain (Lennon, 1996). The Bobath treatment (Bobath, 1990) has undergone many changes from the time of its inception, but the underlying concept remains unchanged. This approach has evolved for patients with lesions of the upper motor neurone such as hemiplegia following a stroke and for children with cerebral palsy. A Bobathian therapist would identify the main problem which clients experience as that of,

"abnormal coordination of movement patterns combined with abnormal postural tonus"

(Bernstein, 1967, p62).
Problems related to the strength and activity of individual muscles and muscle groups are considered secondary to the coordination of their action. The central nervous system is seen to be functioning abnormally, i.e. with a lack of control of the muscle function. Muscles are seen as the tools of the nervous system and, therefore, the activity of individual muscles is secondary to that of their coordination in patterns of activity. The assessment and treatment of a patient’s motor patterns is the only way of leading directly to functional use.

One of the central elements of the Bobath approach is that treatment approaches should inhibit a patient’s abnormal patterns of movement because we cannot superimpose normal on abnormal patterns. Of particular importance, Bobath (1990) commented that,

"The movement that a patient performs with or without the therapist’s help should not be done with undue effort. Effort leads to an increase of spasticity and produces widespread associated reactions” (p60).

Bobath (1990) believed that a therapist’s job was to enable a patient to experience the normal sensations of functional movements which they had lost. She commented that,

"It was only through this feeling a normal movement with normal effort, which is minimal can the patient again learn how movement is done” (p68).
Therapists from the Bobath school (Bobath, 1990) discourage excessive effort which they believe increases spasticity, while therapists adopting a Movement Science perspective (Carr and Shepherd, 1987) may encourage the patient to exert effort to increase force generation to underactive muscles. It is important to acknowledge that these views are at the extreme end of the spectrum of opinion in the Bobathian school and the Movement Science school and many physiotherapists may adopt a practice somewhere in the middle.

1.6.1 Could effort be beneficial?

There is no consensus as to whether the exertion of effort to help regain movement is advantageous within the various physiotherapy schools. Anecdotal reports from the literature suggest that “effort” could be a necessary factor that is being overlooked in the process of recovery of arm function (Doolittle, 1992; Parry, 1997; Rode et al., 1996). Yet, surprisingly there is little research of this topic.

Little significance has been directed towards clients’ subjective accounts of the phenomenon of effort when discussing recovery of arm function. There is a need for research to investigate and explore if the phenomenon of “effort” could play an important role in the recovery process of arm function following stroke. There could be implications for rehabilitation practice that have not yet been investigated. The clinical value of such a question would be to know if rehabilitation professionals should
encourage stroke patients to put more or less effort into movement. Presently, clients could be being given the wrong information regarding the most beneficial approach to their recovery. Some authors (Rode et al., 1996) have also tentatively suggested that “effort” could be used as a prognostic factor in the recovery of arm function.

1.7 Prognostic indicators in stroke rehabilitation

Attempting to predict success or failure in the rehabilitation process is not a new concept in the area of brain injury (Ben-Yishay et al., 1970). In recent years considerable research efforts have been expended attempting to identify possible prognostic factors following stroke which would allow us to determine the best rehabilitation treatment for each client (Andrews et al., 1982; Feigenson et al., 1977; Gowland, 1982; Lincoln et al., 1989; Lincoln et al., 1990; Wade et al., 1983). The literature investigating the prognosis of recovery following a stroke has indicated that certain factors are associated with poor functional outcome including age, incontinence, perceptual abilities and cognitive function. Lincoln’s (1989) study identified a clear prognostic indicator when she and her colleagues reported that motor function was possibly the single most important determinant of physical function and independence of daily living.

Despite the effort invested in attempting to identify prognostic factors, accurately predicting outcomes for individual patients still remains difficult, particularly during the
first few weeks of recovery (Lincoln et al., 1990). Stroke remains an unexpected event from which physical recovery is unpredictable, often prolonged and usually incomplete.

1.8 Mechanisms of recovery after stroke

Recovery from a motor stroke is often observed although the morphological lesion that originally caused the deficit remains. There is much evidence in the literature detailing the different mechanisms which are hypothesized to be involved in the recovery process and its highly adaptive nature (Brodal, 1973; Fisher, 1992; Newman, 1972; Weiller, 1995). Clearer knowledge of the mechanisms that are responsible for the recovery of various functions are important if rehabilitation professionals are to achieve the best possible rehabilitation strategies for stroke patients.

A number of mechanisms have been proposed for recovery following a stroke. Consensus within the literature reports that recovery of brain function after a stroke is complex and is likely to be influenced by many factors. The principal theories of recovery that have been proposed can be categorized into three main groups (Miller, 1984). These are “artifact theories”, “anatomical reorganisation”, and “functional adaptation”. It is important to note that each of these explanations are not mutually exclusive and that recovery may occur, incorporating elements from more than one of the categories.
1.8.1 Artifact theories

The artifact theories broadly involve two components in the recovery of brain damage. The first component is that they propose that the initial lesion will destroy tissue with the loss of all or some of the functioning that the tissue is responsible for. This primary deficit is likely to be permanent, however if any recovery occurs here then it is not explained by this group of theories.

In addition to the damage that the primary insult causes, temporary disturbances in the physiological functioning of other parts of the brain which are not directly affected by the primary insult can be noted. This damage can result in secondary behavioural impairments. As the temporary disruption resolves then the secondary deficits recover. “Artifact theories” attempt to explain the occurrence and resolution of these secondary deficits. A number of physiological changes, for example oedema, can follow a brain injury and these could give some temporary disruption of functioning with a consequent appearance of later recovery (Schoenfeld and Hamilton, 1977).

The notion of diaschisis (von Monakow, 1914; Pribram, 1969 translated version) is the most frequently referred to of all the artifact explanations of recovery. In this theory, von Monakow’s basic principle was that when a lesion occurs in a particular part of the brain then a form of shock could occur elsewhere. Von Monakow suggested that the parts of the brain that are susceptible to this effect can be adjacent to the site or the primary insult
or in distinct parts that are linked in some way to the area of the primary deficit. Von Monakow never adequately explained the exact nature of diaschisis. While commonly it is only a temporary phenomenon with subsequent recovery, the original formulation also postulated a form of permanent diaschisis. This would account for deficits that could not be attributed to the primary damage but which failed to show a recovery.

A further theory from the artifact group was proposed by LeVere (1980). LeVere suggests that an early consequence of damage is to cause a shift in control of the behaviour to undamaged neural systems.

1.8.2 Anatomical Reorganisation

The second broad group of theories is that of anatomical reorganisation which suggests that when damage occurs to one part of the brain then recovery can take place by means of other parts of the brain taking over the functions which that particular area would normally have done (Bach-y-Rita, 1981a). This theory proposes that each function will be picked up again once the initial effects of the shock of the injury dissipate with some loss of overall efficiency.
1.8.3 Functional Adaptation

The function adaptation approach to recovery does not propose a specific model but attempts to explain recovery in terms of the patient's reattainment of functions. The general belief is that the patient may be able to relearn a specific task that has been affected by neural damage. Luria et al., (1969) reported the application of remedial work with a number of clinical problems.

1.8.4 Further associated variables in recovery

While each of the theories that have been outlined can provide an explanation to account in part for some of the recovery that occurs following a brain injury none of the theories is able to provide a full explanation for the recovery process. It is acknowledged that several other factors may play an important role in recovery including an individual client's motivation to improve. However, it is not easy to try and disentangle whether a lack of motivation is a consequence of the damage that a client has received that is hampering recovery or if it is a feature of their premorbid personality. Further variables have been identified that may play an important part recovery include IQ level, premorbid education level, motivation and presence of emotional problems (Ben-Yishay et al., 1970c; Golden, 1978; Oddy and Humphrey; 1980).
1.9 Developments in brain imaging techniques and links to motor recovery

The mechanisms involved in the recovery of stroke are presently difficult to predict however, the literature on recovery is continuing to advance with the development of sophisticated brain-imaging techniques. It is hoped that brain-imaging work could provide many answers to recovery of motor function and help to discover the various ways in which the brain can compensate for the functional effects of damage in the motor cortex.

The refinement of new non-invasive functional imaging such as positron emission tomography (PET) and magnetic resonance imaging (MRI) has lead to a re-emergence of interest in directly studying brain functions. Researchers have already experienced some success in investigating simple cognitive processes by studying functional localization by varying task demands and observing subsequent shifts in primary sites of brain activity (Corbetta et al., 1991).

The development of these technique has lead researchers to investigate the reorganisation of the human motor system after a stroke (Weiller, 1995). In PET, a small dose of “positron-labelled” material is injected into the bloodstream. Detectors are then used to determine the rate of uptake of the positron-emitting agent in the brain during the task that is performed. PET allows measurements of regional cerebral blood flow (rCBF) changes that are elicited by stimulation or activation of neurological or behavioural
functions. It is therefore possible to identify the area of a client's brain that is activated during the performance of a motor task (Colebatch et al., 1990; Fox et al., 1985; Roland et al., 1980; Roland et al., 1982).

1.9.1 Evidence from positron emission tomography of motor recovery following a stroke

The advancement in technology has provided researchers with the ability to study the changes that occur in the human brain after injury. This is an important step as previous literature reported that while many patients are left with profound disabilities following a stroke, it is common for some individuals to show variable functional improvement leading to "near complete recovery" (Brodal, 1973; Fisher, 1992; Kerr, 1975; Rosner, 1974; Sheikh et al., 1983; Skilbeck et al., 1983; Smith et al., 1985; Twitchwell, 1951). The extent of recovery and its time course have formerly proved difficult to predict but despite this a number of experimental and clinical explanations have been proposed. Fisher (1992) reviewed a number of mechanisms of recovery commenting that a number are mostly theoretical. These included recovery from reversible ischemic damage to neurons, the assumption of function by the neighboring cortex, the induction of synaptic sprouting, subcellular plasticity and regeneration of neurons. Fisher (1992) noted that recovery from hemiparesis is part of a broader picture involving the reorganisation of neural activity.
Weiller (1995) investigating the reorganisation of the human motor system after stroke by measuring changes in the regional cerebral blood flow during a specified task with PET. Weiller's study reported on three previously known PET activation studies on recovery from motor stroke (Chollet et al., 1991; Weiller et al., 1992; Weiller et al., 1993). Chollet et al., (1991) compared the pattern of regional cerebral blood flow (rCBF) increases in the brain during movement of the recovered hand with the increases during movement of the "unaffected" hand. Weiller et al., (1992) studied the pattern of activation elicited by movement of the recovered as well as the contralateral hand in stroke patients and in age-matched controls. In the last study (Weiller et al., 1993) compared rCBF changes in single patients with the mean reference values from a group of healthy volunteers.

Following a detailed review of each of these studies Weiller et al., (1995) reported that there is considerable scope for "functional plasticity" in the adult human brain. He reported that recovery of the motor function after infarcts in the internal capsules is associated with a complex redistribution of rCBF including changes in both the damaged and undamaged areas. The pattern of reorganisation that takes place differed for each individual, depending on the site of the primary lesion. Weiller and his colleagues believed that substitution of functions in homologous brain regions of the undamaged hemisphere may occur in some patients, redistribution of activity within a widespread network of parallel-acting multiple motor areas and pathways constitutes the central mechanism in motor recovery. Weiller's results are also in line with other literature (Rijnjtes et al., 1994).
However, Weiller (1995) concluded that for motor recovery the,

"Redistribution of activity within the framework of a modality-specific network rather than any more radical substitution of function may be the dominant principle underlying recovery" (p289).

1.10 Effort – is an important clinical topic being ignored?

Stroke patients often report an increased sense of effort when using their paretic limb. Currently there are no methods of assessing effort and the implications for recovery or response to rehabilitation therapy are unknown. A further difficulty is that there is much vagueness around the concept of effort and uncertainty over what exerting greater effort might entail. This exploratory study proposes that there are two distinct processes that might be involved when a patient reports increased effort. This study also proposes that there is a distinction between physical effort and mental effort. A definition of physical effort and mental effort as understood in this study are provided below. The roles that they may play in the recovery process are also discussed.

Physical Effort

Physical effort is the actual physical act of putting force into a task (therefore having a sense of force output).
There is strong evidence (Jones, 1986; Enoka and Stuart, 1992) that in motor control we sense the force applied when lifting a weight, in terms of the intensity of central motor outflow. Proprioceptive feedback is used to signal force onset and movement but appears to have little influence on perception of force (Gandevia and McCloskey, 1978). When asked to match the weight of objects lifted with either hand, patients with pure motor stroke tend to overestimate the weight on the hemiparetic side (Gandevia and McCloskey, 1978). This is consistent with having a preserved sense of motor outflow but having damage to efferent pathways which means that they produce less than the expected force output. These patients therefore achieve the desired output by excessive generation of motor outflow and this may correspond to the sensation of increased effort.

**Mental Effort**

Mental effort is the focussing of attention on a task.

A recurring element in patients' descriptions of increased effort is that there is a need for conscious thought about actions which were formerly automatic. This might indicate as Weiller (1995) suggested that cognitive resources are being deployed to allow functional reorganisation of the sensorimotor system. There is as yet no direct evidence of this but an increased role of cognition in motor control is suggested by studies showing that patients with traumatic brain damage show a decrease in skilled motor control if they attempt concurrent mental tasks (Guerts and Mulder, 1994). For the patient with impaired...
arm function, the compensatory cognitive process might involve focussing attention on selective aspects of the sense of movement, or activating a new form of motor representation which might be experienced as a mental image of desired action.

Distinguishing between strength and effort for the purpose of this study

Within this complex area, it is important to distinguish between effort and strength. Strength is taken to be directly observable as the maximum force which can be applied whereas effort relates to perception of difficulty when less than maximum force is required.

1.10.1 Anecdotal evidence from the literature of the phenomenon of effort

"My arm and leg seemed to me enormous burdens which I could only lift with the greatest effort" (Mach, 1906, p175).

Stroke patients often report an increased sense of effort when using their paretic arm (Brodal, 1973, Doolittle, 1992; Head, 1918; Parry, 1997). Yet, surprisingly this is an area where little research literature both in stroke rehabilitation and the neuropsychology field can be found. The majority of the research into recovery from stroke is quantitative in nature with much of the emphasis attempting to develop clinical measures to assess whether people can or can't do something. Furthermore, there is little evidence in the
literature to suggest that rehabilitation professionals consider that clients' subjective experiences during recovery could have a potential predictive value in helping recovery. Clients' reports of their experiences of recovery which may be sought by individual rehabilitation therapists have not been seen as a priority for researchers. However, the potential value of stroke participants' experiences has yet to be uncovered and could prompt further development in stroke treatment.

1.10.2 A possible link between sensation of effort and recovery of arm function

Some self-observations have appeared, where clients reported subjective accounts of their own feelings of "effort" following an upper limb hemiparesis (Brodal, 1973; Mach, 1906). It should be noted that Brodal's report was based on his own experience following an acute left-sided hemiparesis. While the observations that he recounted are not unique, their having been described by a professor of anatomy allowed him to raise a number of interesting points, with view to his expert knowledge.

In the accounts of Mach (1906) and Brodal (1973) each noted that during the initial period following the stroke the paralysis was total, and they felt no sensation, when they attempted to move their paretic limb. Later, when the recovery had progressed and the paralysis was less dense each reported that when they attempted to move they had the sensation that "the hand or foot was held down by heavy weights". Brodal (1973) described his own sensation as, "some kind of mental energy".

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Further evidence of this phenomenon in the literature comes from Gandevia (1982) who reported two similar cases in which a clear sensation of effort was noted from the beginning of the motor recovery. In addition, a single case study by Rode and his colleagues (1996) observed that the sensation of effort, which their client reported, and motor recovery appeared to be closely associated in their time course. Doolittle (1992) in her paper exploring the experience of stroke patients’ recovery following lacunar stroke also provided a number of vivid descriptions from clients about their experience of recovery. She commented that in the first few weeks following stroke clients reported that,

"The affected limbs were extremely heavy and cumbersome .....they talked to their limbs, and they concentrated very deliberately on getting and making movement" (p122).

Doolittle (1992) also noted that the clients consistently reported that following the stroke "automaticity" was lost and that "purposeful effort was required for movement" (p122).

Furthermore, she reported that,

"mind-over-matter effortful striving was beneficial in the first months following a stroke .....extreme effort was effective in propelling individuals through rehabilitation. The reward for effortful control of the body was visible progress" (p122).
Other reports that support the need to further investigating the role that “effort” plays in the recovery of arm function comes from the qualitative study of Parry (1997). Using in-depth semi-structured interviews Parry investigated the factors which both stroke patients and their physiotherapists believed influenced the recovery of the upper limb. During the interviews, Parry was struck by the frequency with which participants would comment on the amount of effort that they had to put into movement of their affected arm since their stroke. She also reported that clients would question how much of their recovery could have been influenced by the amount of effort that they put into movement.

1.10.3 The distinction between effort and strength

Patients who have experienced weakness following a stroke often complain of a “heaviness” in their limbs and the effort that it takes to move them rather than an awareness of diminished strength. This was illustrated from the letters of Samuel Johnson who took as evidence of his recovery from a “paralytick stroke” that,

"This day I watered the garden, and did not find the watering pots more heavy than they have hitherto been...." (Letters 850, 855, 1783, published 1952 cited in Gandevia and McCloskey, 1977).

This quote highlights the importance of distinguishing between effort and strength. The distinction between them is that the concept of strength is directly observable and is the
maximum force that is exerted. While effort relates to the perception of difficulty, when less than the maximum force is required. There is evidence that for patients who have experienced a pure motor stroke that perception of increased physical effort may be directly related to the degree of weakness (Gandevia and McCloskey, 1977).

1.10.4 Rode's study — "Inverse relationship between sensation of effort and muscular force during recovery from pure motor hemiplegia: A single-case study".

Rode and his colleagues (1996), in the only clinical experiment identified from an extensive literature search, attempted to provide evidence to support a link between an increased sense of effort and recovery of arm function. Rode's study will be discussed in detail, as it was a key influence on the thinking of this study and its development.

Rode and his colleagues (1996) investigated the relationship between sensation of effort and the muscular force that occurs during the initial stages of recovery following motor hemiparesis. Rode et al. (1996) conducted a single-case experiment with a client who had suffered a right, pure motor hemiplegia and complained of a striking sensation of effort when he performed an arm movement task. Rode considered the effort as mental effort and defined this mental effort as, "a subject's consciousness of his command to his muscle". The study followed the course of a client's recovery over a four-month period during which time it was qualitatively observed that the initial execution of movements on the paretic side required an important "effort of concentration" which the client spontaneously reported. The sensation of effort appeared most pronounced when the
client was required to perform a handgrip task. While performing this handgrip task the 
client also complained of an increase in heart rate and transient breathlessness.

In their study, Rode and his colleagues used a procedure known as the contralateral-limb 
matching task which was the innovation of McCloskey et al., (1974) and had previously 
been used in other studies by Gandevia and McCloskey (1977). Previous studies using 
this method had demonstrated that in paretic patients weights were perceived as heavier 
when lifted by the weakened side, supporting the hypothesis that objects feel heavier 
when an increased command to the muscles is required. Rode attempted to rate the 
subject’s sensations according to the subject’s perception of the heaviness of different 
weights as a measure of their muscular effort. The idea was that the subject would choose 
increasing weights with one arm until the heaviness perceived with that arm matches the 
reference weight lifted by the other arm.

In the experiment, Rode explored the evolution of the participant’s sensations of effort, 
over a four-month period. Firstly, the participant was asked to realize a movement in their 
paretic arm, without resistance on their paretic side and to concentrate on the effort felt. 
The participant was then asked to carry out the same movement on the healthy side 
against resistance. The resistance was gradually increased by the investigator until the 
sensation of effort corresponding to that of the paretic arm was reached, using weights of 
increasing value.
From their results, Rode and his colleagues concluded that recovery of movement for the upper limb and effort sensation did not follow a linear trend over time. They reported that the motor recovery which they had measured, by power, at different joints on the paretic arm was initiated only after sensation of effort when attempting to move this joint had fully recovered. Furthermore, in their analysis they discovered significant steps and plateaus. In particular they noted that these steps tended to be clustered within a few days, consistent with critical periods in the recovery process. Rode noted that the sensation of effort which was experienced by this client fitted with those already mentioned in the literature (Brodal, 1973; Gandevia, 1982; Mach, 1906).

In their analysis, Rode and his colleagues observed the sensation of effort only appears with the earliest signs of motor recovery as measured by power at a given joint (grip movement, elbow movement, shoulder movement). They also demonstrated in their analysis that the client’s sensations of effort were consistent with crucial periods in their restoration period. The sensation of effort was observed during a limited period, during which time the motor power of the impaired arm remained weak but stable. This period they reported lasted for two months following the stroke. The motor efficiency measured by the motor power appeared only after the exaggerated effort sensation had disappeared. This pattern was observed for each of the three joints. Rode and his colleagues then hypothesised that there could be three different stages in the recovery process of their participant. They categorized these stages firstly into one of complete paralysis, during which time no sensation of effort or motor power were observable. The second stage
involved an exaggerated effort sensation, during which motor power remains weak and stable. Finally, motor power improves. In Rode’s study there was no report of the participant perceiving an increased sensation of effort after some motor recovery had returned.

Rode reported that the sensation of effort did not result from sensory abnormalities. In addition, he and his colleagues commented that capsular strokes (which was the type of stroke that their participant had experienced) are often reported in neurological settings yet, abnormal sensations are rarely reported by this group of patients. Rode concluded that sensory abnormalities could not account for the increased sensations of effort.

1.10.5 Problems with Rode’s study

Rode’s study was an attempt to design a clinical experiment to provide more than anecdotal evidence of the concept of mental effort. While the findings were interesting, there were a number of methodological problems with the piece of research. Firstly, in the study Rode used the contralateral limb-matching task. During the task the participant was not blindfolded therefore the results could be biased by contextual cues, such as the sight of the number or size of weights to be lifted, leading to this method not being as objective as Rode and his colleagues implied. Furthermore, Rode provided few real details of what he actually did, making it difficult to replicate the study or scrutinize the methodology. Similarly, the analysis of the data was unclear.
The results from Rode and his colleagues suggested that sensation of effort and recovery of arm function follow a linear pattern that occurs during a specific recovery period. They reported that a client's sensations of effort stopped once recovery has been completed. However, this view contradicts the reports of other authors (Doolittle, 1992; Parry, 1997). Doolittle reported that effort still occurs after recovery appears to have ended. Parry also commented that clients would report the phenomenon of increased effort months after their physiotherapy and apparent recovery had ended.

1.11 Further importance of this topic for stroke research

Stroke research usually falls within the traditional medical research model providing only a partial understanding of peoples' responses to illness and to the health care that they receive. Broadening of the research emphasis to encompass stroke patients' experiences may uncover important elements in the recovery process which traditional models of research overlook. The phenomenon of effort is unlikely to have been revealed using a traditional research model.

A review of the literature confirms that patients' perceptions of recovery from stroke has not been an issue of high priority that has been studied in depth by researchers in this field. Pound and colleagues (1994a) call for qualitative research which,
"might throw more light on.... their experience of recovery. We need to find out what it is that patients are searching for and, if appropriate, build on these aspects of care" (p71).

This need for greater emphasis in clients’ experiences has also been reported by other authors (Lewinter and Mikkelsen, 1995a, p8), who criticise the traditional medical research model commenting that,

"standardised scales that are a far cry from the reality that stroke patients have to face in community living”.

1.12 Possible connections of the effort literature to other areas of psychology

1.12.1 Links with the attention literature

Sustained attention has often been felt to be of central importance to patients during the rehabilitation process, with the belief that it is a crucial ability in the process of learning underlying recovery of motor skills and other functions. A number of authors provide evidence to support the view that sustained attention can predict recovery of function (Ben-Yishay et al., 1968; Blanc-Garin, 1994). Most recently, Robertson et al., (1997) examined the role of sustained attention in motor recovery after a stroke. This study identified that there was a significant relationship between sustained attention capacity at two months and the recovery of motor function at two years.
Within the effort literature a recurring element in patients’ descriptions of increased effort is that there is a need for conscious thought about actions which were automatic before the stroke (Doolittle, 1992; Parry, 1997). This might indicate, as suggested by Weiller (1995), that cognitive resources are being deployed to allow functional reorganisation of the sensorimotor system. Presently, there is no direct evidence to support this theory; however other literature shows that that an increased role of cognition in motor control in patients with traumatic brain damage show a decrease in skilled motor control if they attempt simultaneous mental tasks (Haggard and Cockburn, 1998). Concurrent cognitive activity has also been shown to impair walking after a stroke (Bowen, 1999).

Future research needs to examine the extent to which focussed attention might be linked to clients’ accounts of increased effort and the affect that that reduced attention might have on therapy.

1.12.2 Links to mental practice literature

Mental practice is an accepted procedure in the preparation of athletes (Suinn, 1984). This discussion will focus on visualisation of movement as this has been the main component investigated so far (Denis, 1985).

The paradigm in a number of studies of mental practice requires three conditions. Firstly, the subjects are tested on a given skill. Then they are randomly allocated to three groups.
One group does mental practice, one group carries out actual physical practice of the skill while the third group does not perform any training. The three groups are tested again during performance of the skill and any improvement is scored. Using this procedure, several studies have shown that mental practice produces significantly higher scores than the control conditions (MacBride and Rothstein, 1979; Twining, 1949). However, the studies also show that physical practice produces significantly higher scores than mental practice (Mendoza and Wichman, 1978). Other research has disputed that physical practice provides better performance scores than mental practice but still show that both produce higher gains than in the control group condition (Kohl and Roenker, 1980; Wrisberg and Ragsdale, 1979). The evidence appears to suggest that mental practice improves skilled motor performance. Furthermore, mental practice appears to be more efficient for skills that do not require a permanent sensory feedback information like athletics, diving and swimming which rely primarily on a so-called outflow processing (Decety and Mick, 1988).

A number of explanations have been advanced to explain why mental practice can improve motor skill learning. There is growing evidence that shows that mental imagery is related to movements underlying motor preparation and execution (Parsons, 1987). Several supporting arguments have arisen from experiments using cerebral functional mapping techniques, such as the mapping of the regional cerebral blood flow (rCBF). Using this method, a number of cortical motor areas have been shown to be activated during a mentally imagined sequence of movements. This pattern of activation is
strikingly similar to that observed during the actual execution of the same sequence of movement (Roland et al., 1980). The only difference that Roland and his colleague noted between the two situations was that the primary motor cortex was activated only if movements were actually executed. Decety and Ingvar (1990) also demonstrated similar findings. These findings suggest a commonality of neural structures responsible for mental imagery of movement and those responsible for programming actual movement.

While there is strong evidence from sports psychology that sports training may benefit from the study of mental simulation of movement the clinical implications have yet to be thoroughly investigated, especially for motor rehabilitation. It has been hypothesised that systematic mental simulation of motor behaviour might be of particular value in facilitating motor recovery for individuals were physical practice is not possible (Decety and Ingvar, 1990). Jeannerod (1986) also proposed that mental simulation of movement could be of benefit during rehabilitation. During functional rehabilitation following a lesion two processes interact to maintain or restore affected function. The first process is “restitution” where the neural network has the tendency to recover itself. This process is the result of biochemical events and is relatively independent of the environment. The second process is “substitution” which suggests some functional adaptation of the defective but partially restored network. This process seems to depend strongly on external variables such as physical therapy.
Skilled motor performance is dependent on a number of cognitive processes. It is possible that imagery and mental practice may be related to these cognitive processes. However, presently this is far from clear. Further research to establish the precise nature of the sensations of effort may benefit from the use of mental simulation of movement.

1.13 Pilot work – Evolution and design of the study and design of the measures

The pilot work for this study was conducted over a six-month period. The pilot work was crucial to the whole project as it allowed the design of the experiment to evolve and highlighted the need for this study to be exploratory in nature. The ongoing pilot work also allowed procedures for the equipment to be tightened and tested out both with a healthy volunteer population and stroke patients. Furthermore, it provided an opportunity for discussion with the physiotherapy staff on the stroke unit and other rehabilitation professionals, who provided a number of valuable comments and practical ideas during this developmental stage.

1.13.1 The need for the study to be exploratory

Initially the research questions that were identified for this study were to investigate if “effort” could be used as a predictor of recovery of arm function following a stroke and if a measure of “effort” could be designed and used as a prognostic factor following a stroke. Additionally, the study wished to look at the effect that an attentional bias would
have on peoples’ reports of effort. In particular to explore if divided attention reduces paretic output and to investigate if the impact of divided attention is greatest for patients who report high effort. However, following an extensive literature search, it appeared that there was little information available about the phenomenon of effort. The understanding of this topic was at an embryonic stage in the research. Initially, basic questions still needed to be asked and answered. The study was therefore intended to be exploratory in nature and would attempt to establish if stroke patients’ reported an increased sense of effort during their recovery of arm function. The study also wished to investigate how common patients’ reports of increased effort were following recovery and what patient’s actually mean when they reported an “increased sense of effort”. Furthermore, whether patients distinguished between mental and physical effort and whether these concepts can be reliably measured?

1.13.2 Mixing methodologies

Scientists and practitioners in the field of health sciences believe that it is important to understand subjective symptoms and how these relate to objective findings. Therefore, further attempts to develop methods to quantify these subjective symptoms are needed (Borg, 1982).

The approach of marrying both quantitative and qualitative methods is well suited to this particular research question as it provides a more complete method of investigation.
Furthermore, the multidimensional character of patients' experiences after stroke indicated the suitability of qualitative methods as part of this study. This view has also been supported in the stroke research literature. Lewinter and Mikelsen (1995a) highlighted the importance of both subjectivity and objectivity in the rehabilitation process. They noted the importance that the client has as the principal source of knowledge about progress and the effects of treatment. However, they also note that few rehabilitation professionals would push this subjectivity to the extreme by denying that it was impossible to evaluate rehabilitation efforts and outcomes. Descriptive research has also highlighted how a client's recovery from stroke differs from the biomedical perspective and that the rehabilitation professionals may be missing much valuable information that could aid them in future treatment (Robertson and Boyle, 1984). Different research styles and alternative methodologies within stroke rehabilitation need to be encouraged as they could hold great potential for future development in the field.

1.13.3 Designing the assessment of perceived stiffness equipment

The pilot stage of this study allowed time and consideration for the designing of the equipment. In designing the equipment there was a question over whether to incorporate a measure of grip strength or wrist extension into the design. When the initial project idea was initiated, grip strength was decided upon, as this was a reliable measure that had been used in previous studies and was a relatively simple measure to look at with grip dynamometers. However, various concerns were raised from the physiotherapists about
the possibility of increasing stroke patients' spasticity. Following this, it was decided to try and design the equipment to incorporate wrist extension, as it would be less likely to increase spasticity with this measure. Subsequent attempts at making apparatus highlighted that this idea would need extensive pilot work as it was very difficult to accurately measure wrist extension e.g. wrist extension was likely to have needed sophisticated and sensitive equipment to measure it.

The pilot work then went back to the original idea of using grip strength and trying to design a piece of equipment suitable for the task. However, caution was to be taken to avoid increasing spasticity for stroke patients and as a safeguard the investigator learned some techniques to reduce spasticity if it occurred.

As previously mentioned this study intended to design a measure that was less open to subjective bias than the contralateral limb-matching method used by Rode and his colleagues (1996). An attempt was made to design a computer-simulated equivalent of the contralateral limb-matching task with an attentional component, however this original idea suffered from a number of problems and was felt to be too complex as this study intended to be an exploratory project.

Following a number of discussions with my supervisor and the physiotherapy staff the idea of incorporating grip strength into the equipment and asking clients to make a judgement when they felt that they were putting the same amount of effort into squeezing
two bars was decided on. This approach was felt to offer continuity of concept with Rode's method while allowing for some of the problems with his approach to be addressed.

1.13.4 Testing the equipment

The second phase of the pilot work involved trial runs of the equipment in order to gain comments from stroke patients and the physiotherapists and to complete any modifications to the equipment. This pilot stage was carried out with two in-patients and one physiotherapist at the Stroke Unit at Nottingham City Hospital. Following these sessions a number of modifications were made to the equipment. Firstly, it was decided to use a blindfold (as stroke participants found it very difficult to concentrate on keeping their eyes closed and giving full attention to concentrating on the task). Straps were also added to the equipment to stop the participants' hands from slipping and to ensure that all participants started in the same position. Furthermore, rather than moving the middle block (altering force) in a random fashion it was decided to have a scale marked on the equipment to make sure that each trial was conducted in exactly the same way. The physiotherapists commented that to reduce the possibility of spasticity then it would be a good idea to build in some procedure in the event that spasticity occurred.
1.13.5 Designing the interview schedule

The purpose of the third stage of the pilot work was to design the interview schedule. The interview schedule was designed in two parts. The first part attempted to gain information about the participant's experience and signs of recovery, while the second section was interested in the experience of mental and physical effort during recovery and in the longer term. The second section also attempted to incorporate some sort of scale to see if stroke participants were able to rate mental effort and physical effort and if they could distinguish between the two.

Attempts to devise a rating scale asking patients to rate effort were influenced by the work of Gunnar Borg (1982). Borg, a psychophysician at the University of Stockholm developed the “Borg Rating of Perceived Exertion”, used to judge effort. This is a fifteen point scale with verbal anchors progressing from six at the lowest level, or light; to twenty at the highest or very, very, hard level. This scale was originally developed for cardiac patients.

Following an initial design of an interview schedule, it was piloted with two stroke patients on the stroke unit at Nottingham City Hospital. The investigator completed the questionnaire with the stroke patients to gain an indication of the time that it took. The patients were encouraged to make comments about the wording of questions or any points which they felt were unclear. The interview schedule was also given to two of the
physiotherapists who work in stroke rehabilitation. Following comments from the patients and the physiotherapists on the stroke ward the interview schedule was amended. The changes involved making a number of questions more open-ended as some were felt to be leading. Furthermore, it was decided that it would be more helpful to the stroke participants to take them back to specific examples rather than to think of effort in general terms.

Originally, a rating scale was included in the interview schedule. Following the pilot work it was decided not to include a rating scale as this was quite leading and confusing for participants. Participants were asked more generally if they could rate effort. A further dilemma that was highlighted in the pilot work was how to overcome the problem of asking clients to provide reports from memory. However, following a number of discussions with other professionals and reading of relevant literature it was felt that there was no real way to get round this inevitable difficulty.

1.13.6 Collecting the pilot data

Once the amendments had been made to the final design of the experiment, two participants were recruited to run through the procedures and familiarise the investigator with the equipment before conducting the experiment. These participants were recruited from undergraduate students (they were not paid to participate) and gave written
informed consent. The procedure was also conducted with one stroke participant on the stroke unit.

1.14 The present study

The proceeding literature review has discussed the recovery of arm function following a stroke and the need for greater treatment efficacy. The review also examined the literature on effort and discussed the possibility of a link between the phenomenon of effort and the recovery of arm function following a stroke. The literature demonstrates that the evidence to support the link between effort and recovery of arm function is far from clear. This is due to a number of reasons. Firstly, that research into the area of “sensation of effort” is problematic as the literature in this area is not well established and much of the clinical evidence is anecdotal. Furthermore, the area is conceptually difficult with a lack of clarity about what people actually mean when they report “having to put more effort in” or “having to think about it”. An added difficulty is whether the concept of “effort” can actually be measured. There has to date only been one published clinical study that has attempted to investigate the role that effort might play in the recovery of arm function (Rode et al., 1996).

A second difficulty in investigating this topic is partly due to the difficulties that are involved in attempting to conduct a piece of research within stroke rehabilitation which is often fraught with difficulties (Forer & Miller, 1980; Hewer, 1976). A major complaint of
the existing research into stroke rehabilitation is weak methodologies with the trials being poorly designed, lacking experimental and reliable assessment instruments. The heterogeneity of the stroke population has also been highlighted as a dominant factor jeopardizing research in this area (Basmajian and Gowland et al., 1987; Dombovy et al., 1986). A further difficulty of research into this field is the lack of agreement on the appropriate indicators of outcome.

It is apparent from the literature that stroke patients often report an increased sense of effort when using their paretic arm. Currently, there are no methods of assessing effort and there is little knowledge about the implications that the phenomenon of effort might have for recovery or for therapy. The purpose of the present study was to design a more objective way to investigate and possibly measure the concept of effort. In addition, it was attempted to see if effort occurred for all stroke patients during recovery of arm function as much of the anecdotal evidence suggested (Brodal, 1973; Doolittle 1992; Mach, 1906; Parry, 1997). More generally, the study also hoped to provide information to clarify what stoke patients meant when they spoke of “increased effort” and if they made a distinction between physical effort and mental effort.

Given the limitations of the lack of knowledge and the exploratory nature of this study it was not possible to build on an existing theory that would account for clients’ experiences. However, the literature had clearly identified that this was a suitable area for
investigation based on both the stroke rehabilitation literature and the anecdotal evidence.

The present study aims to test the following hypothesis.

**Hypothesis One**

Effort can be reliably measured using the newly designed assessment of perceived stiffness.

**Hypothesis Two**

The literature indicated that stroke patients anecdotally at least report an increased sense of effort when carrying out a movement task on their paretic side. Hypothesis two proposed that stroke participants would perceive increased stiffness on the paretic side.

**Hypothesis Three**

The third hypothesis proposed that stroke participants who perceive increased stiffness on their paretic side will report greater effort in everyday life.

The literature is unclear about what patients mean when they report putting increased effort into movement. Therefore, a second element of hypothesis three was extended to investigate what stroke patients mean when they report effort and whether they
distinguish between physical effort and mental effort. This would be done by using an interview schedule that was designed for the study.
2 METHODOLOGY
2.1 Design

In total, 17 participants took part in the study and were divided into three groups. These consisted of a stroke participant group (N=5), a healthy age-matched control group (N=6) and a young control group (N=6). The procedures and experimental tasks that each group was asked to complete differed slightly. The stroke participants completed the peg board task, grip strength measure, assessment of perceived stiffness task and the interview schedule concerning their experiences of recovery. The age-matched control group and the young controls completed the peg board task, grip strength measure and the assessment of perceived stiffness task.

This design allowed for the stroke participant's performance on the assessment of perceived stiffness to be compared with the performance of an age-matched control group. Furthermore, the design incorporated a young control group which was hoped to would provide a comparison with the age-matched control group in order to establish the ordinary range of performance on the assessment of perceived stiffness.
2.2 Participants

2.2.1 Ethical approval

The study was approved by Leicester University Ethics Research Committee (3.7.97) and Nottingham City Hospital Ethics committee (9.11.97). Participants were not informed of the exact hypotheses being tested but were told that the study was investigating patients' experiences of recovery of arm function. Additionally, all participants gave informed written consent. A copy of the written consent form that each participant was required to complete is provided in appendix four.

Before the study commenced, a letter was sent to the consultant in charge of the stroke unit for information and comment (a copy of this letter can be found in appendix one).

2.2.2 Stroke patients

The participants for this study were selected from the database of a stroke project that was being conducted at Queen's Medical Centre, Nottingham (details of this project are provided in the following section). There were several reasons for this, firstly ethical approval was granted on the basis that this work would be an extension of on-going work into recovery of arm function that was being conducted at the stroke unit of Nottingham City Hospital. The stroke unit was also keen to extend their body of exploratory work in
this new and under investigated area which also tied into my own interest in clients’
recovery of arm function following a stroke. Furthermore, the nature of this study meant
that it was important that the clients who were selected had relatively good recovery of
arm function in order that they could use the equipment. In addition, the stroke
participants needed to have good speech abilities and cognitive competence so that they
could complete the interview schedule about the role of effort in their recovery. Selection
from a database would provide preliminary information that would allow suitable
participants to be approached for this study. Recruitment of participants from the larger
research database facilitated assessment of potential participants on measures relevant to
these criteria.

Data from the arm section of the Rivermead Motor Assessment (Lincoln and Leadbitter,
1979) of 161 patients previously tested for the large study was examined to select clients
who demonstrated poor arm function at a one month assessment but who showed good
recovery of arm function by six months. The records of clients who were identified as
having met these criteria were screened further to ensure that they did not have severe
language or cognitive deficits. This was done using existing data from the Sheffield
Screening Test for Acquired Language Disorders (Syder et al., 1993) and the Rey-
Osterrieth Complex Figure Test (copy section)(Rey, 1941; Osterrieth, 1944). All the
participants had perfect scores on the Sheffield Screening Test for Acquired Language
Disorders (Syder et al., 1993), therefore displaying no receptive or expressive difficulties
on this screening assessment. The Rey-Osterrieth Complex Figure Test scores (Lezak,
1995, p569-578) were also obtained for the copy section of the task (the cut-off scores for this test are 33/36 for the age group of 60-69 and 32/36 for the age group of 70 years of age and older). All stroke participant’s scores were within the cut-off.

Stroke participants were excluded from this study if they had experienced a history of previous strokes, any previous neurological illness (e.g. Parkinson’s disease) or psychiatric history, and any other significant illness (e.g. cancer). Following this procedure, eleven participants were selected as being suitable for this study.

Before the participants were approached, a letter was sent to their general practitioner to ensure there were no health or other reasons that would preclude them from taking part (a copy of the general practitioner’s letter can be found in appendix two). Following confirmation from the general practitioner a copy of the information sheet and consent form were sent to each participant (a copy of these forms can be found in appendix 3 and 4). When participants returned the consent form they were then called and an appointment was arranged, to see them at home at a time convenient to them. All testing took place in the participant’s home.

Of the original eleven participants identified as suitable, six were unable to take part in the study. Two of the participants had experienced another stroke, one had developed cancer, one had died and the G.P of another participant reported that their health at present precluded them from taking part in the study. A further participant who was
suitable and agreed to take part was ill at the time of data collection therefore they were also not included in the study.

Five clients participated in the study (4 male and 1 female). The age range of the participants was 62-82 years of age (Mean = 75.5, SD = 8.29). The average length of time since their stroke was 13.4 months. All participants had suffered a first CVA. Two of the stroke patients had experienced right-sided paralysis and three had experienced left-sided paralysis.

The demographic details of individual stroke participants' (compiled from accounts given by the participants) are outlined in table 2.2.2.1.
Table 2.2.2.1  Demographic details of stroke participants

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>STROKE PARTICIPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One</td>
</tr>
<tr>
<td>Age</td>
<td>82</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
</tr>
<tr>
<td>Time since stroke</td>
<td>23 months</td>
</tr>
<tr>
<td>Side of weakness</td>
<td>Left</td>
</tr>
<tr>
<td>Handedness</td>
<td>Right</td>
</tr>
<tr>
<td>Marital Status</td>
<td>Married</td>
</tr>
<tr>
<td>Nationality</td>
<td>British</td>
</tr>
<tr>
<td>Education (highest level)</td>
<td>No formal qualification</td>
</tr>
</tbody>
</table>

Each participant provided details of their current social situation. Four of the stroke participants were currently living in their own home and received practical support from their spouse. One participant lived on his own and cared for himself. Details of the treatment history of each participant were also provided.

Stroke participant one was admitted to a medical ward in a general hospital and was then transferred to the stroke unit at one-month post stroke where he remained on the stroke unit for four months receiving physiotherapy and occupational therapy (daily initially) until discharge.
Stroke participant two was admitted to a medical ward of a general hospital. He was then transferred to stroke unit and received physiotherapy, staying there for six weeks until he was discharged home.

Stroke participant three was admitted to a medical ward of a general hospital. He was unsure when he was transferred to the stroke unit. During his stay on the stroke unit he received physiotherapy and occupational therapy.

Stroke participant four was admitted to a medical ward of a general hospital and was then transferred to the stroke unit. She was discharged 3.5 months post-stroke. On the stroke unit, participant four received physiotherapy and occupational therapy for twenty minutes a day.

Stroke participant five was admitted to a medical ward of a general hospital and was then transferred to the stroke unit. He was discharged after two months and received physiotherapy daily during his stay on the stroke unit.

2.2.3 United Kingdom Approach versus a Movement Science Approach (UKAMS)

The UKAMS study aimed to determine whether a typical UK approach or a movement science based approach is more effective in improving the movement abilities and functional independence of stroke patients. The UK approach, typically used at Queen’s
Medical Centre, aims to re-educate normal movement and therefore function, by the use of appropriate sensory and proprioceptive input, facilitation of selective activity and inhibition of abnormal tone and movement. These aims will be achieved by the handling skills of the therapist and using the influence of the environment to promote goal-oriented activities.

In the Movement Science based approach, the patient is regarded as an active learner in the rehabilitation process. Knowledge of biomechanics and motor control underpins the analysis of a client’s problems. The training that is given is specific to a particular task and environmental context. The patient practices specific tasks outside training sessions, monitoring themselves, or being assisted by relatives and staff. Clinical measurements are routinely used to assess progress.

As part of the UKAMS research project, clients had been screened for suitability to participate in the study. Each client was assessed on the following outcome measures at 1, 3 and 6 months post stroke:

2. Motor Assessment Scale (measure of motor function) (Ashburn, 1982).
4. Modified Ashworth Scale (spasticity measure) (Bohannon et al., 1987).


The following assessments were also administered at one month following the initial assessment:

1. Sheffield Screening Test for Acquired Language Disorders (screening for expressive and receptive language disorders) (Syder et al., 1993).

2. Rey Figure Copy (perception assessment) (Lezak, 1995).


The summary scores of the stroke participants performance on the Rivermead Motor Assessment (RMA) (Lincoln and Leadbitter; 1979), Barthel Index (Collen and Wade et al., 1988), Nottingham Sensory Assessment (NSA) (Lincoln et al., 1998) and the Ten Hole Peg Test (Annett, 1992; Annett and Kilshaw, 1983) at their six month assessment are provided in table 2.2.3.1.
A summary of these scores is provided as an indication of how the participants were progressing at home. A brief description of each of the measures is also provided.

<table>
<thead>
<tr>
<th>Participant</th>
<th>RMA (Arm section)</th>
<th>Barthel Index</th>
<th>Nottingham Sensory Assessment</th>
<th>Ten hole peg test (right hand in secs)</th>
<th>Ten hole peg test (left hand in secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke 1</td>
<td>11/15</td>
<td>20/20</td>
<td>1 (History of impairment)</td>
<td>13.75</td>
<td>26.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.44</td>
<td>22.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.46</td>
<td>21.16</td>
</tr>
<tr>
<td>Stroke 2</td>
<td>3/15</td>
<td>18/20</td>
<td>1 (History of impairment)</td>
<td>Not assessed</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Stroke 3</td>
<td>9/15</td>
<td>19/20</td>
<td>1 (History of impairment)</td>
<td>17.03</td>
<td>39.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.06</td>
<td>29.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.06</td>
<td>25.05</td>
</tr>
<tr>
<td>Stroke 4</td>
<td>10/15</td>
<td>17/20</td>
<td>2 (Normal)</td>
<td>34.38</td>
<td>18.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40.16</td>
<td>15.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.12</td>
<td>14.60</td>
</tr>
<tr>
<td>Stroke 5</td>
<td>15/15</td>
<td>20/20</td>
<td>2 (Normal)</td>
<td>16.05</td>
<td>15.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.05</td>
<td>12.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13.05</td>
<td>14.09</td>
</tr>
</tbody>
</table>

**Rivermead Motor Assessment**

The Rivermead Motor Assessment (Lincoln and Leadbitter, 1979) provides a series of items that were selected to assess the abilities of patients in all stages of recovery from
stroke. The assessment incorporates a wide range of items which include items which the most severely disabled patient in the early stages of recovery could perform and some items which only the minimally disabled patient could pass. The items are divided into three sections namely, gross function which deals with functional movement, leg and trunk function which deals with control of movement and the arm section which deals with both control and functional movement of the arm. For the purpose of this study, the scores for the arm section only were inspected. The arm section incorporated fifteen items which are scored at one point each.

**Barthel Index**

The Barthel Index (Collen and Wade et al., 1988) is used to assess functional independence. This scale is routinely administered by nursing staff in rehabilitation settings. It provides a score between 0 (total dependence) and 20 (functionally dependent, although not necessarily normal).

**Nottingham Sensory Assessment**

The Nottingham Sensory Assessment (Lincoln et al., 1998) assesses for sensory abnormalities in the hand, elbow, trunk, foot and knee. Each patient is assessed on the categories of light touch, pressure, two-point discrimination and kinaesthesia. The scoring is normal (2), impaired (1) or absent (0).
Ten hole peg test

The ten hole peg test (Annett, 1992; Annett and Kilshaw, 1983) provides some indication of a participants manual dexterity by timing how long it requires to pick up each of the ten pegs and place them in holes. The participants are allowed fifty seconds to complete the task.

2.2.4 Age-matched control group

Recruitment of age-matched controls was initially attempted from the stroke participants' partners in order to provide a suitable age, level of education and socio-economic matched group. Four of the stroke participants had partners who were approached to participate in the study however, two of the partners had a history of previous neurological illness and were excluded. One partner was in hospital for an operation at the time of data collection and another partner did not wish to participate.

In order to recruit a suitable age-matched control sample a local volunteer stroke organization was approached. Information sheets about the study were left with the coordinators of the project to hand to relatives, however without much success (a copy of the information sheet for the age-matched population can be found in appendix five). One volunteer was recruited from this process.
Attempts to recruit volunteers were also made from a mixture of people at a luncheon club (who had been approached through a psychologist in the older adult specialty where the investigator was currently on placement). Two participants were recruited from this process. My own grandparents were also approached. All the volunteers were healthy. None had a previous history of stroke or any other neurological disease and no significant problems with their hand movement due to arthritis. All age-matched controls were provided with an information sheet about the nature of the study and what to expect (see appendix five). Furthermore, the age-matched controls were required to give written informed consent.

Participants for the age-matched control group were excluded from the study if they had a history of stroke, a previous neurological illness or psychiatric history. Furthermore, participants were excluded if they had experienced any significant illness (e.g. cancer) or any problems with their hands e.g. arthritis or sprained wrists.

Six age-matched controls were recruited to participate in the study (3 male and 3 female). The age range of the clients was 52-78 years of age (Mean = 66.3, SD = 10.48). Demographics details of the age-matched control population are provided in the table 2.2.4.1 below.
### Table 2.2.4.1 Demographic details of the age-matched control group

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>AGE-MATCHED CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>55</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td>Male</td>
</tr>
<tr>
<td><strong>Handedness</strong></td>
<td>Right</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td>Married</td>
</tr>
<tr>
<td><strong>Nationality</strong></td>
<td>British</td>
</tr>
<tr>
<td><strong>Education (highest level)</strong></td>
<td>Ph.D. (SRN)</td>
</tr>
</tbody>
</table>

### 2.2.5 Young control group

The young control group was recruited from an undergraduate population. None of the group were paid to participate. All the volunteers were healthy. All young controls were provided with an information sheet about the nature of the study and what to expect (a copy of the information sheet can be found in appendix five). Furthermore, they were required to give written informed consent.
Participants for the young control group were excluded from the study if they had a history of stroke or any other neurological history or psychiatric history. Furthermore, they were excluded if they had experienced any significant illness (e.g. cancer) or any problems with their hands e.g. arthritis or sprained wrists.

Six young control participants were recruited to participate in the study (4 male and 2 female). The age range of the clients was 20-25 years of age (Mean = 21.5, SD = 2.34). Demographics of the young control population are provided in table 2.2.5.1 below.

Table 2.2.5.1  Demographic details of the young control group

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>YOUNG CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One</td>
</tr>
<tr>
<td>Age</td>
<td>20</td>
</tr>
<tr>
<td>Sex</td>
<td>Female</td>
</tr>
<tr>
<td>Handedness</td>
<td>Right</td>
</tr>
<tr>
<td>Marital Status</td>
<td>Single</td>
</tr>
<tr>
<td>Nationality</td>
<td>British</td>
</tr>
<tr>
<td>Education (highest level)</td>
<td>Undergraduate</td>
</tr>
</tbody>
</table>
2.3 Equipment and tests

Quantitative and more qualitative assessments were used in this study.

2.3.1 Quantitative assessments

Ten Hole Peg test

The equipment included a test board (39cm by 24cm) with ten holes in a line along each side (each hole was 2.5 cm apart and 1cm in diameter), ten pegs (6.5 cm long 10mm diameter), a stopwatch, pen and scoring sheet (a copy of the scoring sheet can be found in appendix seven).

The ten hole peg test was selected as it provided an indication if participants had difficulty in understanding the instructions to a simple task.

Grip Strength

An electronic dynamometer (model number 0030J4) was used to measure grip strength.

Grip strength was selected, to provide a functional measure of a participant’s recovery of hand function.
Assessment of Perceived Stiffness

The equipment for this task involved a board (60cm by 21cm) with two parallel wooden bars (60cm long and 5cm apart) mounted on top. The bars were held apart with weak elastic bands so that light pressure allowed them to be squeezed together. The dynamometer was slotted between the bars and attached to a wooden block which was mounted on the back bar and could be slid along it (see figure 2.3.1.1). Moving this block varied the force that was required to press the bars together on each side. For example when the block slid to the far right N force (16 newtons) was required to press the bars together at the side compared to N force (101 newtons) at the far left. A picture of the equipment is provided.
This newly designed piece of equipment was intended to be less open to subjective bias in assessing effort than the contralateral limb-matching task that has previously been used in Rode et al.'s study (1996). Following extensive pilot work which incorporated looking at the method used in Rode's study as well as other possibilities, it was felt that a measure of stiffness was less bias than asking clients to make a judgement from weights that could be affected by contextual cues.
2.3.2 Qualitative assessment

Interview schedule

A copy of the interview schedule can be found in appendix six.

The interview schedule was designed in order to explore participants' subjective experiences of recovery and to investigate how stroke participants defined effort and if they were able to rate the amount of effort that they put into a particular task. A further reason for designing the interview schedule was that it felt important to incorporate a more subjective element into the study to couple the objective measure of perceived stiffness.

The interview schedule was developed during the pilot stage of the study and evolved following comments from stroke participants and physiotherapists on the stroke unit at Nottingham City Hospital (details of the development of the interview schedule are reported in the pilot work section).

2.4 Experimental procedure for stroke participants

The experiment was run over one session lasting approximately one hour and thirty minutes. The tasks were presented in the same order for each of the stroke clients (peg
board, grip strength, assessment of perceived stiffness, and the interview schedule). Data for each participant was collected on a standard form that was produced for the study (a copy of this can be found in the appendix seven).

Before the session began, the experimenter went through the consent form with each participant to ensure that they had read the information sheet, had been given the opportunity to ask any questions and also to make sure that they were not unclear about any aspect of the experiment. Furthermore, the experimenter also wished to make clear that the participant was free to withdraw from the experiment at any time. All participants were then asked to sign the consent form. It was explained that if they were unable to give their signature then a relative could sign on their behalf however all of the stroke participants were able to give written consent themselves.

1. Peg Board

The participants were seated in a chair/wheelchair at a standard height dining table. The peg board was placed on the table in front of the participant. Before each trial, the participant was asked to place their hands on their lap and to return them to this position after completing each trial.

The participants were required to transfer the pegs one at a time from the far holes to the row of holes nearest to them, first using the right hand and then on the next trial, using
the left hand. These two tasks were performed alternately three times. The time to complete this task was recorded with a cut-off at 50 seconds.

A demonstration and verbal instruction was given at the start of the test and was repeated when necessary before each trial. No practice trials were given. The verbal instructions were the same for each participant. *"With the right hand, start at the left end of the row of pegs and move them one at a time into the empty holes immediately opposite on the board so that the nearest holes are filled from left to right".*

The board was then turned round and the participant were instructed to use their left hand and, *"start at the right end of the row of pegs and move them one at a time into the empty holes immediately opposite on the board, so that the near holes are filled from left to right".*

2. Grip Strength

Grip strength was then measured in both the right and left hand. The dynamometer was held in front of participant so that a comfortable power grip was possible with the elbow slightly flexed. Grip strength was defined as the best of three attempts on the dynamometer. The reading was recorded in Newtons.
3. Assessment of Perceived Stiffness

The assessment of perceived stiffness equipment was placed on the table in front of the participant. The participant was asked to place their hand across the two bars where they were strapped with a strip of velcro in order to stop them slipping and to ensure that all participants' hands remained at the same position during the task. Participants were then instructed that they would be blindfolded and would be asked to grip each bar one side at a time and to decide which side felt stiffer. There was no restriction as to the number of times that a participant could press the bar.

The wooden block with the dynamometer attached (altering force) would start at the left side and would be moved along by two and a half centimeters at each step. Each time the participant would be asked which side was stiffer. The block would be moved until the participant commented that the opposite side was stiffer. At this point, the block would be moved back in the opposite direction, by half a centimeter until the participant reported that each side felt equally stiff. When the participant described each side of the equipment as equally stiff, the actual force required to squeeze the bars together at each side of the equipment was measured. The participant would be asked to remove their hands from the bars and the investigator would take the reading by pressing the bars and gaining the force required to reach resistance at each side, using the dynamometer (the measure of force was taken in Newtons). This process would then be repeated this time starting on the right hand side. This procedure would then be repeated once more with the
block starting at each side, giving a total of four reading on the right side and four on the left side for each participant.

4. Interview Schedule

Following the assessment of perceived stiffness task the interview schedule was given. The interview started with the participant being asked about their arm function immediately following their stroke. The interview would then progress through their experience of recovery asking if they noticed any difference in the amount of effort that they were required to put into movement of their recovering arm. Clients would also be asked about their present arm function. Finally, they would be asked if they believed that it was possible to rate the mental effort and physical effort that they put into a particular task. Participants' answers were written down verbatim by the investigator. The interviews were not recorded.

2.5 Experimental procedure for the age-matched and young control participants

The tasks were presented in the same order for the control participants (peg board, grip strength, assessment of perceived stiffness) and the same strict experimental procedures were adhered to. The main difference in the procedure for the control group was that the interview schedule was not given. In order to provide some equation with the stroke participants' experiences of recovery the age-matched control participants were asked
about their experiences of physical strength that they put into tasks using their arm, as
they got older. Questioning the age-matched controls in this way was felt to be a suitable
parallel to the stroke participants’ experience.

Before the session began, the experimenter went through the consent form with each
participant to ensure that they had read the information sheet, had been given the
opportunity to ask any questions and to make sure that they were not unclear about any
aspect of the experiment. Furthermore, the experimenter also wished to make clear that
the participant was free to withdraw from the experiment at any time. All participants
were then asked to sign the consent form.

2.6 Reliability and Validity of the measures

The ten-hole peg board test and grip strength measure are both standard measures used in
stroke rehabilitation by a number of rehabilitation professionals. Each measure has
demonstrated good reliability in previous studies (Heller et al., 1987). The reliability of
the assessment of perceived stiffness is discussed in the result section.

The interview has often been denied a scientific status, as it hardly fulfills such traditional
requirements of method, as reliability and validity. However, Kvale (1983) argued that
from a phenomenological and hermeneutical understanding of science it is possible to re-
interpret the ordinary criteria for evaluation of this data.
The validity of the interview schedule depends on its adequacy according to the researcher’s aims (in the case of this study to gain an understanding of the client’s experience of recovery of arm function and an insight into the factors which may influence recovery with particular relevance to participants’ reports of effort). For validity purposes, it is necessary to reflect upon the extent to which the presented information reflects the relevance and utility of the knowledge that was obtained. In this study, the interview schedule was necessary, as the purpose of this study was to look at participant’s experiences of recovery but also to see if the phenomenon of “effort” was reported by stroke patients following recovery and to assess if it could be reliably measured.

2.7 Ethical concerns

During the design of the study and throughout the pilot stage of the study, ethical issues were of considerable concern particularly because the study involved working with a client group who are predominately elderly and disabled. Furthermore, the study involved asking clients to carry out tasks using their recovering arm which could lead to concerns about increased spasticity.

The following ethical points were included in the design and implementation of the study:
1. The participants’ information sheet and consent form emphasised that participation in the study was in no way connected to their ongoing healthcare. In particular, participation was not a proviso of continuing with any form of treatment, presently or in the future. Participants were free to decline taking part or withdraw from the study at any time.

2. The information sheet gave brief details about why the research was being carried out and what was involved in taking part. Participants were also encouraged to contact myself to discuss any queries that they may have. Participants were only accepted for the study if they read the information sheet and signed the consent form. All participants were judged able to give informed consent.

3. Confidentiality was maintained throughout the study. Participants were identified by a number on the data score sheets. The consent form (with their name on it) was kept in a locked filing cabinet. The data was also coded before being entered into a computer. Permission to keep personal information on a computer was obtained from the local Data Protection Officer.

4. A concern that had been highlighted from the pilot work was that clients may “over-do” the physical effort resulting in spastic muscle tightening in their recovering arm. To safeguard against this training in brief exercise techniques was undertaken which could be used if a client developed problems of spasticity. The training was given by
a senior physiotherapy at Nottingham City Hospital (Specialist in Neuro-rehabilitation). The training involved learning some relaxation strategies to help loosen muscle tightness if any occurred for a client.

2.8 Data analysis

The analysis of the data was both descriptive and statistical. The data was analysed using scatter plots to look at correlations in the data. The scatter plot is a tool which gives a clear impression of the degree of relationship between two variables. In order to quantify this more precisely parametric tests were then conducted to provide values of the significance of the data. A Pearson’s product-moment correlation was carried out.

Parametric analysis was conducted as the data from the assessment of perceived stiffness task was on an interval scale and gave a reasonable approximation to normal distribution.

Mann Whitney U Tests was used to ascertain whether there was any difference in performance between each of the groups. All statistical analysis was completed using SPSS for Windows 8.0.

The qualitative interview schedule data was reported on an individual case basis. No formal systematic analysis of the qualitative data was undertaken. There were two main reasons for this. Initially when the study was being designed a questionnaire was planned for the stroke participants. However, following piloting of the questionnaire it became
apparent that this asked too many leading questions and that it did not capture the intricacies of this topic area therefore it was decided to design an interview schedule. On analysing the interview schedule participant's verbatim descriptions were reported. A number of ways to formally analyze the qualitative data were considered. However, the decision to use a more formal method was discounted. Problems that resulted from this decision will be reported in the discussion section.
3 RESULTS
3.1 Preliminary Analysis

Following the collection of the data from the stroke participants and the control groups, the results were initially examined. Inspecting the data highlighted that there appeared to be some inconsistencies. Specifically, the data appeared to indicate that the equipment for the assessment of perceived stiffness did not provide a consistent reading of force on each side. This finding then raised issues about the accuracy of the equipment. It was therefore decided to assess the accuracy of the equipment.

3.1.1 Assessing the accuracy of the assessment of perceived stiffness equipment

In order to investigate the accuracy of the assessment of perceived stiffness measure, thirty-one points were measured out and marked at the back of the equipment. Each of the thirty-one points were plotted one centimeter apart. The wooden block with the attached dynamometer (altering force) was then moved to each of the thirty-one points and a reading was taken at the left-hand side and then the right-hand side. This procedure was conducted starting with the dynamometer moving from the left side through to the right side and then the reverse. The procedure was always carried out by the investigator and was conducted on three separate occasions in order to ensure that the readings from the dynamometer were consistent over a number of trials. Following this, each of the readings from the thirty-one points on the assessment of perceived stiffness were
recorded in SPSS and placed in a scatter plot (see figure 3.1.1.1). As a result of this process, it became apparent that the reading at each of the points was not always the same (reasons for this are provided in the discussion section).

Figure 3.1.1.1 Scatter plot of the readings taken three times at each of the thirty-one points at one centimeter intervals on the assessment of perceived stiffness equipment.

The scatter plot in figure 3.1.1.1 shows the readings taken at each of the thirty-one points on three separate occasions. The data in figure 3.1.1.1 clearly highlighted that at each
point in the equipment, the reading was not always the same. If the equipment had been 100% accurate then it would be expected that there would have been one line for the measures taken on each side and that all the points would have fallen on that line.

Several possible explanations of the factors that could have attributed to the variability of readings from the equipment are considered in the discussion section.

The present study has identified three hypotheses which concern the phenomenon of effort during the recovery of arm function following a stroke and whether it can be precisely measured. In order to evaluate these hypotheses, the following descriptive and statistical analyses were carried out.

### 3.2 Hypothesis one

**Perceived stiffness can be measured reliably**

In view of the problems with the equipment, the difference scores for each of the four trials between the right and left side were used in the calculation to inspect the reliability of the measure of perceived stiffness. The difference scores were calculated as the equipment had demonstrated a drift in the absolute readings therefore a way to minimize this effect was to look at the difference scores. Table 3.2.1.1 provides all the participants readings from the assessment of perceived stiffness along with calculations of their
difference scores. Table 3.2.1.1 also provides information on the gender of each
participant and the side of paralysis for the stroke participants.

Table 3.2.1.1  Participant’s readings on the assessment of perceived stiffness for
the left side, right side and the difference scores (readings taken in
Newtons).

<table>
<thead>
<tr>
<th>Stroke Participants</th>
<th>Age matched Controls</th>
<th>Young Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant</td>
<td>L</td>
<td>R</td>
</tr>
<tr>
<td>L→R</td>
<td>34</td>
<td>58</td>
</tr>
<tr>
<td>1</td>
<td>39</td>
<td>51</td>
</tr>
<tr>
<td>(M) L→R</td>
<td>36</td>
<td>65</td>
</tr>
<tr>
<td>R→L</td>
<td>25</td>
<td>64</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
<td>87</td>
</tr>
<tr>
<td>(M)</td>
<td>25</td>
<td>87</td>
</tr>
<tr>
<td>(L)</td>
<td>32</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>60</td>
</tr>
<tr>
<td>(M)</td>
<td>35</td>
<td>66</td>
</tr>
<tr>
<td>(L)</td>
<td>46</td>
<td>66</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>68</td>
</tr>
<tr>
<td>(F)</td>
<td>46</td>
<td>29</td>
</tr>
<tr>
<td>(R)</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>5</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>(F)</td>
<td>62</td>
<td>52</td>
</tr>
<tr>
<td>(R)</td>
<td>46</td>
<td>59</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>51</td>
</tr>
<tr>
<td>(M)</td>
<td>60</td>
<td>62</td>
</tr>
<tr>
<td>(R)</td>
<td>60</td>
<td>57</td>
</tr>
<tr>
<td>6</td>
<td>49</td>
<td>54</td>
</tr>
</tbody>
</table>

Pearson’s product moment correlations were completed for all the difference scores for
the assessment of perceived stiffness. These demonstrated a significant relationship
between the difference scores over each of the four trials (p < 0.01, 2-tailed, N=17).

Results of this analysis can be found in table 3.2.1.2.

Table 3.2.1.2 Bivariate correlation of the difference scores for all four trials on the assessment of perceived stiffness (N=17).

<table>
<thead>
<tr>
<th></th>
<th>Difference 1</th>
<th>Difference 2</th>
<th>Difference 3</th>
<th>Difference 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference 2</td>
<td>.80**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference 3</td>
<td>.90**</td>
<td>.75**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference 4</td>
<td>.71**</td>
<td>.70**</td>
<td>.75**</td>
<td></td>
</tr>
</tbody>
</table>

Note: ** p < .01 (2-tailed)

3.3 Summary on hypothesis one

The data demonstrated that the difference scores can be used to give a reliable measure of perceived stiffness across the four measurement trials. The difference scores will therefore be used in the calculations of the remaining hypotheses.

3.4 Hypothesis Two

Stroke participants perceive increased stiffness on the paretic side.
In order to investigate this hypothesis the mean of the difference scores on the assessment of perceived stiffness and the standard deviation of the difference scores were calculated for all participants (see table 3.4.1.1).

<table>
<thead>
<tr>
<th>Participants</th>
<th>Mean of the difference scores</th>
<th>Standard deviation of the difference scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke participant 1</td>
<td>-26</td>
<td>11.22</td>
</tr>
<tr>
<td>Stroke participant 2</td>
<td>-55.5</td>
<td>8.58</td>
</tr>
<tr>
<td>Stroke participant 3</td>
<td>-22.75</td>
<td>7.93</td>
</tr>
<tr>
<td>Stroke participant 4</td>
<td>3.75</td>
<td>12.94</td>
</tr>
<tr>
<td>Stroke participant 5</td>
<td>1.25</td>
<td>5.74</td>
</tr>
<tr>
<td>Age matched control 1</td>
<td>-12</td>
<td>4.89</td>
</tr>
<tr>
<td>Age matched control 2</td>
<td>0.75</td>
<td>4.99</td>
</tr>
<tr>
<td>Age matched control 3</td>
<td>-8.75</td>
<td>4.03</td>
</tr>
<tr>
<td>Age matched control 4</td>
<td>-17.25</td>
<td>11.35</td>
</tr>
<tr>
<td>Age matched control 5</td>
<td>-13</td>
<td>2.44</td>
</tr>
<tr>
<td>Age matched control 6</td>
<td>-16.25</td>
<td>6.13</td>
</tr>
<tr>
<td>Young control 1</td>
<td>7.25</td>
<td>6.70</td>
</tr>
<tr>
<td>Young control 2</td>
<td>2.25</td>
<td>10.37</td>
</tr>
<tr>
<td>Young control 3</td>
<td>1.25</td>
<td>6.18</td>
</tr>
<tr>
<td>Young control 4</td>
<td>3.5</td>
<td>7.76</td>
</tr>
<tr>
<td>Young control 5</td>
<td>7.5</td>
<td>4.93</td>
</tr>
<tr>
<td>Young control 6</td>
<td>-0.75</td>
<td>21.07</td>
</tr>
</tbody>
</table>

3.4.2 Investigating the normal range of scores on the assessment of perceived stiffness

Before any conclusions could be reached about the stroke participants’ data, it was crucial to establish what the normal range of difference scores was for the two control groups on the assessment of perceived stiffness.
The standard deviations were calculated for each of the control groups to look at the variability of the difference scores in each group. A difference in variability between the control groups was found with the mean of the standard deviation being 5.6 for the age-matched controls compared with 9.5 for the younger group. A Mann Whitney U test was also conducted on the variability scores for the age matched control group and the young control group which was statistically significant (U=7, p < 0.05, 1-tailed, n=12). This suggested that there was greater variability in the young control group.

The average of the mean difference scores for the age-matched controls and the young controls were also compared. This data further exemplified that there were differences between the control groups. The age-matched control group showed higher difference scores with a mean of 11.08 (range 0.75-17.25) compared with the young controls 3.5 (range 0.75-7.25). While it is important to acknowledge the small number of participants in each group and that neither of the control groups were not matched for the effect of sex differences. A Mann-Whitney U test was carried out on the data. The age-matched controls showed significantly higher mean differences on their absolute scores than the young control group (U=5.5, p < 0.05, 1-tailed, n=12).

The difference in the ability to match for stiffness between the young pilot controls and the age-matched controls was a post hoc result that was not actually tested for but perhaps indicate an age difference. Several explanations for the difference between the
young controls and the age-matched controls in their ability to match for stiffness will be considered in the discussion section.

3.5 Stroke participants' performance

A difference in variability was found between the stroke group (9.3) and the age-matched controls (5.6). A Mann Whitney U test was carried out to examine the variability across the difference scores for stroke participants and the age matched controls. These results were statistically significant (U=5, p < 0.05, 1-tailed, n=11).

The mean difference scores for the stroke patients and age-matched controls were compared with higher difference scores in the stroke group 19.85 (range 1.25-55.5) compared to 11.08 (range 0.75-17.25) in the age-matched control group.

A Mann-Whitney U test was conducted on the absolute mean difference scores for the stroke participants and the age-matched controls. There were no significant differences in their mean difference scores (U=10, 1-tailed, n=11).

3.6 Summary of stroke participants performance for the perceived stiffness data

The raw data highlighted that there were participants in the stroke group who showed much larger difference scores than any of the participants in the age-matched or young
control group. Table 3.2.1.1 highlights this with stroke participants one, two and three all showing high difference scores, in the direction of their hemiparesis.

The relationship of perceived stiffness to grip strength was then investigated for all participants.

3.6.1 The relationship between perceived stiffness and grip strength

The grip strength measures for all participants along with the mean strength in each hand and the difference in strength between hands are provided in table 3.6.1.1. Table 3.6.1.1 also provides information on the gender of each participant, participants' dominant hand and the side of paresis for the stroke participants.
Table 3.6.1.1  Grip strength and difference in strength between hands (Newtons)

<table>
<thead>
<tr>
<th>PARTICIPANTS</th>
<th>Right hand</th>
<th>Left hand</th>
<th>Mean of Right</th>
<th>Mean of Left</th>
<th>Difference in strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke 1*</td>
<td>218</td>
<td>83</td>
<td>193</td>
<td>108</td>
<td>85</td>
</tr>
<tr>
<td>(Male)</td>
<td>211</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Right Handed)</td>
<td>149</td>
<td>112</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke 2*</td>
<td>221</td>
<td>43</td>
<td>245</td>
<td>46</td>
<td>199</td>
</tr>
<tr>
<td>(Male)</td>
<td>253</td>
<td>53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Right Handed)</td>
<td>261</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke 3*</td>
<td>150</td>
<td>106</td>
<td>147</td>
<td>110</td>
<td>37</td>
</tr>
<tr>
<td>(Male)</td>
<td>149</td>
<td>114</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Right Handed)</td>
<td>143</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke 4**</td>
<td>73</td>
<td>155</td>
<td>98</td>
<td>170</td>
<td>-72</td>
</tr>
<tr>
<td>(Female)</td>
<td>92</td>
<td>165</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Right Handed)</td>
<td>129</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke 5**</td>
<td>221</td>
<td>217</td>
<td>235</td>
<td>251</td>
<td>-16</td>
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<tr>
<td>(Male)</td>
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<td></td>
</tr>
<tr>
<td>(Left Handed)</td>
<td>243</td>
<td>264</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age matched 1</td>
<td>369</td>
<td>294</td>
<td>341</td>
<td>292</td>
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</tr>
<tr>
<td>(Male)</td>
<td>324</td>
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<td></td>
</tr>
<tr>
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<td>329</td>
<td>295</td>
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<tr>
<td>Age matched 2</td>
<td>207</td>
<td>179</td>
<td>195</td>
<td>180</td>
<td>15</td>
</tr>
<tr>
<td>(Female)</td>
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<td>177</td>
<td></td>
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</tr>
<tr>
<td>(Right Handed)</td>
<td>198</td>
<td>184</td>
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<td></td>
<td></td>
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<tr>
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<td>239</td>
<td>288</td>
<td>243</td>
<td>271</td>
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<tr>
<td>(Male)</td>
<td>232</td>
<td>260</td>
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<td>(Left Handed)</td>
<td>257</td>
<td>265</td>
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<td>151</td>
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<td>51</td>
</tr>
<tr>
<td>(Female)</td>
<td>144</td>
<td>73</td>
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</tr>
<tr>
<td>(Right Handed)</td>
<td>180</td>
<td>112</td>
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<td>114</td>
<td>179</td>
<td>116</td>
<td>158</td>
<td>-22</td>
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<tr>
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<td>311</td>
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<td>303</td>
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<td>268</td>
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<td></td>
</tr>
<tr>
<td>Young controls 1</td>
<td>150</td>
<td>99</td>
<td>161</td>
<td>148</td>
<td>13</td>
</tr>
<tr>
<td>(Female)</td>
<td>160</td>
<td>187</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(Right Handed)</td>
<td>172</td>
<td>157</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young controls 2</td>
<td>392</td>
<td>409</td>
<td>385</td>
<td>413</td>
<td>-28</td>
</tr>
<tr>
<td>(Male)</td>
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<tr>
<td>Young controls 3</td>
<td>433</td>
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<td>416</td>
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<tr>
<td>(Male)</td>
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<tr>
<td>(Right Handed)</td>
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<tr>
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<td>(Female)</td>
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</tr>
<tr>
<td>(Male)</td>
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<td>343</td>
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</tr>
<tr>
<td>(Right Handed)</td>
<td>363</td>
<td>359</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Left-sided stroke  **Right-sided stroke
The grip strength data highlights that three of the five stroke participants provide evidence of paresis (participants one, two and four) while the performance of the other two stroke participants (participant three and five) provided grip strength that was within the range provided by the age-matched control group. Table 3.6.1.1 also highlights that in the control data all but four of the participants are stronger in their dominant hand.

3.6.2 Relationship between strength and perceived stiffness

In order to see if there was a relationship between strength and perceived stiffness the participants mean difference in grip strength and the sum of the mean difference scores on the assessment of perceived stiffness measure, were placed in a scatter plot (see figure 3.6.2.1).
Figure 3.6.2.1 Scatter plot of perceived stiffness (difference in force for left and right hand) against difference in grip strength.

A Pearson's moment correlation was conducted on the mean difference in grip strength readings and the mean differences on the perceived stiffness measure for the left and right side. There was a correlation ($r = -0.732$. $p < 0.01$, 2-tailed, $n=17$).
Across all participants in each of the three groups, there was a correlation between difference in grip strength and difference in perceived stiffness. The larger the difference in grip strength the larger the difference in perceived stiffness. This was further exemplified in the stroke group who had some of the largest differences in grip strength. Stroke participant two showed the largest difference in grip strength (see table 3.6.1.1) and displayed the largest difference in perceived stiffness (see table 3.2.1.1).

3.7 Summary on hypothesis two

All participants demonstrated a correlation between difference in grip strength and difference in perceived stiffness. The stroke participants can be seen to be putting in greater force on their non-paretic side when judging that the stiffness is the same (see table 3.2.1.1). This suggests that stroke participants were perceiving a greater stiffness on their paretic side when exhibiting the same amount of force on both sides.

3.8 Hypothesis Three

a) Stroke participants who perceive increased stiffness on their paretic side report greater effort in everyday life.

b) Stroke participants' who report a "sensation of effort" make a distinction between physical effort and mental effort.
In order to investigate the first part of hypothesis three the interview data (about participant’s experience of recovery and the role that they believe effort played in the recovery of arm function) was examined.

By looking at stroke participants’ performance in figure 3.6.2.1 (a display of the association between strength and perceived stiffness) and comparing it with stroke participants’ observations and comments from the interview schedule it was hoped to see if consistencies emerged between their reports of effort and their performance on the assessment of perceived stiffness.

**Stroke participant one (left-side paralysis)**

From figure 3.6.2.1, stroke participant one put in greater force with his non-paretic side when judging the stiffness to be equal. It was expected that this participant would report increased effort of his paretic side when carrying out tasks that involved movement.

During the interview, participant one frequently reported having to put in effort and really concentrate when tasks involved using his left hand. This participant provided a number of vivid descriptions and clear examples of particularly difficult everyday tasks.

This participant reported that,
“You have to put your mind to something and really concentrate to make your arm do it. When you use your left hand then you feel as if when you lose concentration then you will drop the thing”.

Participant one provided a number of everyday examples that he had difficulty with including putting on a glove. He commented that he was,

“Not able to do it automatically you really need to concentrate, the brain does not tell the body what to do”.

This participant also commented specifically on the difficulty of turning on a light switch saying,

“It’s hard work trying to turn on a light switch. I put in maximum effort but always find it difficult and usually have to do it with the right hand”.

Overall, this participant reported that he needed to concentrate much more when carrying out tasks with his left hand. This added concentration often left him feeling tired. However, he reported that putting in effort could be helpful commenting,

“If you set your mind to something then it helps”.
Stroke participant two (left-sided paralysis)

From figure 3.6.2.1, it can be seen that stroke participant two put in greater force with his non-paretic side when judging the stiffness to be equal. It was expected that this participant would report increased effort of his paretic side when carrying out tasks that involved movement.

Participant two provided a number of clear reports of putting increased effort when carrying out everyday tasks, since the stroke.

This participant commented that,

"I rarely do things with my left hand as it's weak and it involves too much concentration".

This participant also commented,

"I try to make my arm work but I'm not sure if it does any good".

Participant two again provided a number of everyday examples of difficulties that he experiences in performing everyday tasks,
"I'm unable to hold a pot when trying to cook. I have too think about it or the pot will start shaking and drop".

Participant two did comment that although it was a year after his stroke he believed that he was "still noticing small improvements" as he was "actively forcing his arm to work".

Stroke participant three (left-sided paralysis)

From figure 3.6.2.1, it can be seen that stroke participant three put in greater force with his non-paretic side when judging the stiffness to be equal. It was expected that this participant would report increased effort of his paretic side when carrying out tasks that involved movement.

Participant three reported that eating was a problem, and gave the example of trying to cut up food and finding it extremely difficult especially when distracted,

"When in the company of other I can't concentrate on what I'm doing and I get distracted".
Stroke participant four (right-sided paralysis)

From figure 3.6.2.1, it can be seen that stroke participant four put in greater force with his non-paretic side when judging the stiffness to be equal. It was expected that this participant would report increased effort of his paretic side when carrying out tasks that involved movement.

Participant four had experienced a right sided stroke. She commented that a year and four months after the stroke she had "approximately 60% recovery" on the paretic side. However, there were a number of particular tasks that she described as still being difficult.

This participant commented that,

"Some tasks require more mental effort, you especially have to concentrate when holding dishes or they will drop".

Similarly, "very automatic tasks like hanging out the washing take a long time and lots of energy".
Stroke participant five (right-sided paralysis)

From figure 3.6.2.1 it can be seen that participant five’s performance on the assessment of perceived stiffness is among the young pilot population, near the zero point and is very accurate at squeezing the bars and judging them to be equal. From this participant’s performance in figure two it would be expected that he does not report having to put increased mental effort into tasks when using his recovering arm.

Participant five, reported that he is not aware of presently having to put any effort into movement tasks involving his recovering hand. He commented that,

"Previously, I needed to keep practicing and help myself and this made my arm better".

3.8.1 Distinction between physical effort and mental effort

The second component of hypothesis three and a further complicating issue that was highlighted from the interview data was what participants are actually referring to when they discuss effort. Do stroke participants make a distinction between mental effort and physical effort? This was explored in the interview schedule when stroke participants were asked two questions in the interview schedule about making a distinction between physical and mental effort.
The specific questions that were asked in the interview schedule were,

- "Are you able to make a distinction between physical effort and mental effort when you are performing a task with your paretic arm?"

AND

- "How would you describe physical effort and mental effort?"

Each of the stroke participants' answers to these questions is provided below. The answers suggest clear individual differences in phenomenology, with three participants not experiencing a distinction between physical and mental effort and two participants experiencing it very clearly.

Stroke participant one commented,

- "I've not really thought about it".
- "I suppose I don't know".

Stroke participant two commented,

- "Not really."
- "I either can or can't do something with my arm it doesn't matter how hard I try to think about it".
Stroke participant three commented,

- "I don’t know”.
- “Not sure”.

Stroke participant four commented,

- “Yes”.
- “Some tasks require more mental effort, as you really have to concentrate on what you are doing eg. when holding a pot handle I have to concentrate or I will drop it.

Physical effort is more about the strength I put into a task.”

Stroke participant five commented,

- “I’m not sure”.
- “For some tasks, I needed to really concentrate eg. holding a cup of tea but the concentration got less as the task got easier and my arm recovered”.

3.9 Summary on the results of hypothesis three

The interview data provided subjective evidence to support the phenomenon of effort during the initial recovery but also after the initial recovery period had ended and in some cases up to over a year after their stroke. The results from hypothesis three also highlight that when stroke participants are asked specific questions about the distinction between mental effort and physical effort their answers highlight individual differences.
3.10 Additional themes that emerged from the interview schedule

During the interview a number of additional themes emerged that were not directly related to this study however they provide useful insights into clients’ experiences of recovery of arm function following a stroke.

3.10.1 Early experience of the stroke

The first question in the interview schedule asked, “I would like you to tell me what your arm felt like when you first had the stroke”. The descriptions of the arm following the stroke differed for each participant due to the severity of the stroke and the nature of the other difficulties that the stroke had left them with. However, one element that emerged from the interviews when people had first experienced the stroke was that they talked about the sensations that they experienced. The sensations that participants discussed most frequently included pain in their arm or shoulder and a tingling in their arm. Within the discussion of sensations, participants also expressed concern that, “all the sensations had gone from my arm” or that they could only feel “a very slight sensation when someone touched them”.

Participants were also asked, “What could you do and not do (following the stroke)”? Stroke participants described their recovery in two ways namely, in terms of the movement that they had and usefulness of their arm. There appeared to be a distinction
between movement and usefulness of the arm. The conversations centered on the everyday tasks that they were no longer able to conduct such as being able to self-care. One participant commented, “I’m able to pick up big and small things from the table, but my fingers won’t perform. My arm is useless”. While another participant said, “I can move it well, but I can’t do much of anything else with it”.

3.10.2 Practice and determination

Participants’ reports of the practice and determination that they put into movement were not directly related to this study however the comments that were made during the interview highlighted an important issue. When stroke participants talk about the amount of mental effort they have to put into a task using their paretic arm and when they describe the determination they put into their recovery are they describing the same phenomenon?

When asked, “Do you think that putting in more effort into movement has helped your arm recover or have you been trying to exert less force when carrying out a task?” Participants reported that they believed that practice and determination had played an important part in their recovery. This can be illustrated by one participant’s comment,

“You’ve got to keep working the arm. You need to keep at it. I kept practicing, picking things up and a few days later I noticed a difference.”
Another participant similarly reported,

"Exercising my arm made it stronger. I kept trying to lift up lots of different sized objects from my table".

Determination was seen as a personal characteristic and was compared to that of other people and their progress,

"I use to see other people on the ward and they had just given up. They would sit in bed all day".

3.10.3 Future hope for the arm

At the end of the interview schedule all of the participants reported that they did not believe that the recovery process had ended and that they were still noticing small changes or at least were expecting that changes were still possible. One participants reported that their, "arm still had a long way to go" while another commented that, "If I keep going it will get better eventually".
4 DISCUSSION
Within the neurology literature, there have been a number of reports from patients concerning an increased sense of effort during the recovery of their hemiparetic arm (Brodal, 1973; Gandevia, 1982; Head, 1918; Mach, 1906), yet, this area has still to be studied in depth.

The present study devised three hypotheses that attempted to examine stroke participants’ experiences of the phenomenon of effort following the recovery of arm function. The exploratory nature of this study compared stroke participants’ performance on the assessment of perceived stiffness with that of two comparison groups (an age-matched control group and a young control group). The stroke participants’ perception of perceived stiffness was then compared with each stroke participants’ reports of increased effort in everyday life when they performed a movement task with their recovering arm. Furthermore, the research investigated whether stroke participants make a distinction between physical effort and mental effort.

The findings of this study will be discussed in detail, in relation to each hypothesis. Furthermore, the clinical implications of these findings will then be explicated. This will be followed by a discussion of the limitations of this study, some unexpected difficulties that occurred and the study’s strengths. Lastly, the implications for future research into the phenomenon of “effort” will also be considered.
4.1 Explanations of the results

4.1.1 Hypothesis One

From the data in figure 3.1.1.1 it was highlighted that there were questions surrounding the accuracy of the assessment of perceived stiffness. Several explanations to account for the lack of accuracy of the equipment are considered.

One problem that was noticed during the data collection was that the fastener that attached the dynamometer to the wooden block (altering force) would sometimes become loose while a participant was carrying out the experiment. The loosening of the fastener lead to the dynamometer not being tightly pressed against the front bar leading to an inaccurate reading from the dynamometer being taken. It appeared from investigating this fault further that depending on the number of attempts that a participant might take to judge when the bars are equal this could have lead to the fastener being loosened further. The solution that was found for this problem was that following each trial the investigator checked that the fastener had not been loosened.

A subsequent problem that may have resulted in the equipment providing an inconsistent reading was that of human error. When each participant reported that the bars were equally as stiff on each side then the investigator would take the reading by pressing the bars until resistance was fully reached. However, the investigator may not have pressed
the bars completely on each occasion therefore not providing an accurate reading. Furthermore, it was noticed that the reading would change if the bars were pressed at even a very slight angle. For example, if the experimenter pressed the bars perhaps while leaning across a participant then the bars were not pressed until full resistance was reached again giving an imprecise measure.

It would have been desirable if these problems could have been identified during the pilot stage of the study and amended. The feasibility of this was limited both by the time available to the researcher, lack of resources and the already ambitious nature of designing a new measure. Therefore, the compromise that was sought was to pilot the equipment for major problems and then start data collection. As part of the exploratory nature of the study, the accuracy of the equipment would be assessed along with the results.

Despite the equipment problems, the results demonstrated that the difference scores provided a reliable measure of perceived stiffness across the four trials. The difference scores were used in order to minimize the drift that had occurred in the equipment when looking at the absolute readings.
4.1.2 Hypothesis Two

Hypothesis two proposed that stroke participants would perceive increased stiffness on the paretic side. The results examining the relationship between grip strength and perceived stiffness demonstrated that across all participants, there was a strong correlation between difference in grip strength and difference in perceived stiffness between hands. The larger the difference in grip strength the larger the difference in perceived stiffness. This was exemplified for the stroke participants who demonstrated the greatest difference in grip strength. Stroke participant two showed the largest difference in grip strength (see table 3.6.1.1) and displayed the largest difference in perceived stiffness (see table 3.2.1.1).

The results also highlighted that the stroke participants demonstrated greater perceived stiffness in their non-paretic hand (see table 3.2.1.1). From the data, the stroke participants can be seen to be putting in greater force on their non-paretic side when judging that the stiffness is the same. This suggests that stroke participants were perceiving a greater stiffness on their paretic side when exhibiting the same amount of force on both sides.

The results from this study appear to suggest that perceived stiffness could be predicted entirely from grip strength.
The results from this study indicate that a large difference in strength between each hand is likely to be accompanied by an increased sense of effort when carrying out a movement task with the paretic arm. If this is the case then it may be that a measure of weakness provides much useful information.

The results found in the present study parallel those discovered by Gandevia and McCloskey (1977). Gandevia and McCloskey studied the appreciation of heaviness, in a weight matching task, in eight participants with a "unilateral upper motor neuron" weakness and in ten healthy volunteers who received partial curarization of the forearm and hand. Curare was used as it selectively blocks transmission between the nerves and the muscle. Their results found that weights were judged as heavier when lifted by the weakened side in both the hemiparetic patients and the normal subjects weakened by curare. This compares to stroke participants in this study who were asked to judge when the stiffness that they put in is the same, they overestimated the amount of force that they put in on the paretic side.

Gandevia and McCloskey's (1977) study also included two patients who had experienced the mildest paresis of their group and who were accurate in estimating the weight. This corresponds to the stroke participant fives performance in the present study who was also very accurate when judging that the stiffness was the same.
Previous authors (Enoka et al., 1992; Jones, 1986) have provided strong evidence that in the normal motor control process we sense the force applied to lifting a weight in terms of the intensity of the motor outflow. In estimating the weights Gandevia and McCloskey (1978) reported that their participants placed greater reliance on upon sensing the effort or command that was put into lifting an object than upon alternative signals which they could have used. Proprioception feedback is used to signal force onset and movement but is believed to have little influence on the perception of force (Gandevia and McCloskey; 1978).

Gandevia and McCloskey (1977) suggest that objects are perceived as heavier when an increased command to the muscles is required. The increased command was required as the available motor outflow was reduced or because the neuro-muscular transmission was impaired. Experiencing damage to the efferent pathways means that the participants produce less than the expected motor outflow. Gandevia and McCloskey (1977) reported that the stroke participants in their study achieved the desired force by excessive generation of motor outflow which is hypothesised to correspond to the increased sensation of effort.

Sensory problems could provide a possible explanation for the results in this study. To investigate if sensory disturbances accounted for the results, participants’ scores on the Nottingham Sensory Assessment (Lincoln et al., 1998) for their hands and elbow were inspected (see table 2.2.3.1). The Nottingham Sensory Assessment was developed to
assess for sensory disturbance in both the upper and lower limbs. The measure provides
an estimate of sensory disturbance. Namely, if any participant scores less than 100% then
they have a sensory abnormality. Of the five stroke participants in this study, three
showed an impairment on the Nottingham Sensory Assessment (stroke participant one,
two and three). When the performance of these participants is compared with the of
results of the other stroke participants then the pattern of results is the same. The
important factor in the results is that weakness appears to predict perceived stiffness. This
is highlighted by participant four who showed no sensory abnormalities and who
performed no differently from the three participants who demonstrated sensory loss. This
finding corresponds with Gandevia and McCloskey’s (1978) results. In this study,
Gandevia and McCloskey proposed that proprioception feedback has little influence on
people’s perception of weight.

The conclusion in Gandevia and McCloskey’s study (1977) and the present study are also
consistent with Head and Holmes’ (1911) reports that judgements about weights may be
impaired in cortical disease.

The results suggest that there is a high correlation between how weak someone is and the
degree of effort that they experience therefore it appears that weakness predicts perceived
stiffness.
Control participant's data

From the results, the control participants (both the age-matched controls and the young controls) appeared to be relatively good at matching for perceived stiffness. In particular, the young controls appear to be very accurate in judging when they squeeze the bars that they are equal. This can be seen as they are gathered around the zero point on the graph (see figure 3.6.2.1). The graphical data seemed to highlighted that differences in accuracy between the young pilot subjects and elderly control occurred with the young controls being much more accurate. This finding is consistent also with the literature of Gandevia and McCloskey (1977) who found controls were accurate in their estimation of weight until their muscles became weak through the curare when they would increase the apparent heaviness of the reference weight. This post hoc finding was not expected in the results but it was a striking difference. Explanations to account for the difference in accuracy between the two control groups are considered.

One explanation to account for this difference in accuracy between the two control groups was that it was an age-related effect. There is much evidence from the gerontology literature that strength declines with age (Brill et al., 1998; Buchner, 1997; Tsutsumi et al., 1998) therefore considering a decrease in strength with age, then the age-matched control group are overestimating the amount of force that they put in on their dominant hand. At the end of the experimental procedure, the elderly controls were asked
if they were aware of any decrease in strength in their arm, all said no. One participant reported that they felt their accuracy in using their hands had declined with age.

It is acknowledged that the sensory motor system deteriorates with age. Therefore, these results can be understood by considering that people experience greater uncertainty about perceptions, as they become older.

While this is a potentially interesting result, generalising this result must be done cautiously. The experiment was not a perfect age experiment controlling for all variables between the young control subjects and the elderly controls. Several variables were not controlled for between the young control group and the elderly controls including socio-economic factors and educational attainment. Furthermore, there was a large difference in ages within the elderly sample, the youngest participant in the elderly control group being fifty-two and the oldest seventy-eight. There is also the difficulty that the groups are not equally matched for gender. The age-matched control group includes three males and two females while the young control group has four males and two females. Sex differences are likely to account for a greater difference in grip strength between the groups as opposed to the age effects. Resulting from these methodological problems, it would not be possible to call this a true age effect.
4.1.3 Hypothesis three

The third hypothesis proposed that stroke participants who perceive increased stiffness on their paretic side report greater effort in everyday life. Additionally, this hypothesis proposed that stroke participants make a distinction between physical effort and mental effort.

The first element of this hypothesis was investigated by examining the interview data from each of the stroke participants and comparing it with their performance on the assessment of perceived stiffness. The four participants who can be seen from figure 3.6.2.1 to be putting in the greatest amount of force on their paretic side all reported experiencing a sense of effort when using their paretic arm to perform everyday tasks.

If a large difference in grip strength predicted increased effort then it would be expected that the greater their weakness then the more effort that they would put in but this was not the case from the individual reports of the stroke participants. The greatest difference in grip strength was demonstrated by stroke participant two who did report having to put effort into movement tasks however, predominately participant two discussed the amount of movement that was possible and the usefulness of his arm. Stroke participant five whose performance was as accurate as that of the young controls did not report experiencing an increased sense of effort when he carried out a task that involved
movement on his paretic side. However, he reported that effort had been an important factor in the early stages of his recovery.

The second element of the hypothesis was investigated by examining participants’ answers to the specific questions that were asked about making a distinction between physical and mental effort. Individual differences occurred.

Individual differences may have resulted because these ideas are conceptually difficult to describe and to disentangle from each other. Furthermore, it is possible that simply by asking the questions that were asked was too broad to have any meaning. In answering each of the questions, participants were encouraged to reflect on the examples that they had given during the course of the interview in an attempt to focus their answers.

A further explanation is that when people talk about mental effort and physical effort then it is not clear what they actually mean and they may be addressing the same thing or something quite different. Therefore further exploration of the meaning of these terms to stroke participants may be more helpful.

The participants in this study reported on several occasions that there was a distinction between physical and mental effort.

Participant one highlighted this commenting that,
"You have to put your mind to something and really concentrate to make your arm do it. When you use your left hand then you feel as if when you lose concentration then you will drop the thing".

Participant three talked of his, "arm feeling heavy". He also reported that,

"I really have to concentrate or I'm not able to do a task. I can't be distracted or I will not be able to do the task".

It must also be considered that the different explanations may simply result from a difference in language and concept use.

The observations of the stroke participants provide subjective evidence to support the phenomenon of effort during recovery of arm function. In addition, the data provides evidence that increased effort occurs in the recovering arm after the initial recovery period has declined. These results contrast with those of Rode and his colleagues who reported that the sensation of effort ceases following recovery of arm function.

The data from the interview schedule also provided information on the role of effort for participants in everyday tasks. It was apparent from the interview data that putting increased effort into movement tasks in their recovering arm was an issue for stroke participants.
4.2 Clinical implications of the study

4.2.1 With reference to the value of focussing effort in therapy

The findings of this study would appear to suggest that the same results would have been achieved if the strength of each participant had been assessed. Therefore, a necessary starting point in future research would be to conduct a study to establish if this is the case and if the phenomenon of effort is as easily explained as this.

Depending on the results of assessing strength it may be that effort is not as simply explained as assessing strength therefore further investigations could again begin to address how this phenomenon of effort could be accurately measured. Randomised control trials to determine the strength and utility of different therapeutic approaches of focussing effort could then be developed in the future if previous studies supported that effort was an important factor. Ideas for future studies will be discussed in more detail in future research section.

4.2.2 With reference to increasing the understanding of the recovery process for rehabilitation professionals

A greater understanding of the mechanisms involved in recovery leading to the development of effective treatments would have huge benefits for both the patients and the rehabilitation professionals. This study demonstrated that patients' subjective
experiences can provide useful information that can further aid rehabilitation professionals understanding and is a valuable research area that needs further investigation.

4.3 Limitations of the study

The specific limitations of this study will now be addressed.

4.3.1 In relation to selection of participants and the small sample size

Selection was narrowed by the requirement that the participants be able to participate in an interview. It was also necessary that the participants had experienced a good recovery of arm function to enable them to be able to carry out the perceived stiffness task. In addition, the participants were selected from a previous study on arm function, as previous data on their recovery of arm function was available. Participants were also chosen at six months post stroke as this was felt to represent a population who had a more stable recovery. Each of these criteria led to the narrowing of the possible subject pool further.

The number of stroke participants involved in this study was small and their experiences may have occurred for the minority of stroke patients. Furthermore, there was a lack of strictness regarding the selection of the stroke participants on strict diagnostic criteria.
Data from CT scans was not inspected and could have provided further information on
the nature of the stroke that each participant had suffered and it would also have provided
information of any other brain anomalies for each participant allowing the study to be
more precise about the nature of their stroke. Data from the Nottingham Sensory
Assessment (Lincoln et al., 1998) gave some indication as to whether the participant had
experienced a pure motor stroke or not.

Selecting participants who had experienced poor physical recovery of their arm was
considered but would have raised a number of different issues and changed the emphasis
of this study. The same would be true if patients had been interviewed at a differing stage
in their recovery. Longitudinal studies have reported that stroke patients’ concerns with
physical treatment lessons as time after stroke elapses (Anderson, 1988; Jongbloed,
1994).

All the participants were selected from a large-scale study that was ongoing at the stroke
unit. It could be speculated that stroke patients who agree to participate in research are
different in a number of characteristics from the average stroke patient. They may have
higher motivation, had good relationships with therapy staff and felt that their treatment
had been successful. While this is not inherently a problem, examining the stories of such
participants can provide useful information and insights, but it is important to be aware of
these biases and that these issues may have had an effect on the results. It may have been
useful in this study to have tried to gain access to another stroke population as well.

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The age-matched sample did not necessarily provide an "ideal" comparison for the stroke participants. Two of the participants were significantly younger than the participants in the stroke group. If time restraints had not been so great then a more "ideal" comparison group could have been recruited. This could have been achieved by approaching a number of stroke organisations and accessing their carers.

The study was also limited by the time available to the researcher to recruit participants (especially as there was access to only one stroke service). The small number of participants in each group also limited the scope of the study. This is related, in particular to examining within-group differences, notably within the stroke sample. It may be that a great deal is to be gained by looking at individuals within this population in more detail, particularly in relation to the interview schedule where participants could have been asked to describe in detail their experience of using their paretic arm. Additionally, a larger number of participants would have provided the opportunity to look at how generalisable the results were.

The experimenter anticipating the problems of recruiting stroke participants could have approached other stroke units at the design stage of the study which could have addressed the small sample size.
4.3.2 In relation to the measures

Assessment of perceived stiffness equipment

While much time was spent on the development of the equipment during the pilot stage of the study, little time was spent checking out the accuracy of the equipment. If time had been allocated not only for the design stage of the study but also to test the equipment then, some of these faults may have been identified at an earlier stage and the equipment could perhaps have been corrected. Due to few resources, it is unlikely that the equipment could have been altered.

Interview schedule

There were a number of difficulties in designing an interview schedule that would accurately encapsulate clients' beliefs around the role that effort played in the recovery of arm function. One problem that was highlighted from the study was the difficulty of disentangling the attribution element of clients' explanations of their recovery with the descriptions of the phenomenon of effort and its role in the recovery process. When clients have made a good recovery then they were likely to report that putting in effort had helped them. Conversely, if a client had not made a good recovery then they were more likely to report that effort played no part. It is unclear if this is the same notion as the "phenomenon of mental effort". This was further complicated as during the interview
clients also reported that determination aided the recovery process. What seemed to be being discussed here was more about personal determination and inner strength than “mental effort”.

Determination has being seen as an important personal characteristic of recovery in previous literature (Parry, 1997). The determination that clients spoke of in Parry’s study included elements such as maintained concentration, hard work and belief in the possibility of recovery and action according to that belief. Behaviours associated with this belief included wholehearted participation in rehabilitation and constant exercise. Other authors have also pointed out that there is a strong moral aspect to the idea of exercising both in “health” and after the onset of an illness (Gold, 1983; Kaufman, 1988; Turner, 1984a, 1984b). To perform physical exercise is to conform to Western values of action, perseverance, diligence and mastery over disease (Jongbloed, 1994 and Kaufman and Becker, 1986). In addition, exercises may offer the prospect of complete physical recovery. Studying patients after discharge from a stroke unit, Lewinter and Mikkelsen (1995a) suggest that;

"Training is a form of treatment that made sense to the patients.....it provided them with a meaningful set of rituals offering promise of normalization" (p9).

An emphasis on determination and inner strength has been found elsewhere in the literature (Gold 1983; Kaufman, 1988) and reflects the value that Western culture and
medicine places on perseverance and "the idea that effort expended over a period of time (that is work) will yield some recovery" (Gold, 1983, p248).

A further problem with the interview schedule was that it was perhaps too broad to ask about the phenomenon of effort. It may be that a qualitative piece of research is needed to enable deeper examination of several aspects which this study uncovered including the factors underlying the way that some patients described progress of movement and further discussion about the difference between mental effort and physical effort. Furthermore, it would also have been beneficial to have each interview recorded and transcribed, as this would have provided greater accuracy.

Due to the complexity of this area it is possible that my training as a clinical psychologist (interested in neuropsychology) lead me to focus extensively on a specific area at the expense of other comments that participants made.

4.3.3 In relation to the analysis

Quantitative analysis

The number of stroke participants and controls in the study was small. This placed restraints on the statistical analysis that was possible. A further restraint on the statistical analysis was that the assessment of perceived stiffness had four trials. In order to conduct
within subject comparisons up to ten trials in the assessment of perceived stiffness would have been necessary. Increasing the number of trials was considered however, the physiotherapists who were consulted did not advise this, as there was the possibility that it could have lead to clients experiencing increased spasticity.

Qualitative analysis

A further limitation of the study was the decision not to provide formal systematic analysis of the qualitative data or to provide any form of independent check on the interpretation of the interview data. The justification and decision-making that lead to this will now be discussed.

Initially, the study was not intended to incorporate subjective reports from participants however as the pilot work progressed the importance of stroke participant’s accounts of their recovery and the frequency of their discussions around effort became apparent. Therefore, an interview format was designed to replace the questionnaire. This then lead to decisions about analysing the qualitative data. A number of methods of formal analysis were considered to analyze the interview data including grounded theory and discourse analysis but they were not appropriate for analysis of this data as no tape recording of the interviews had taken place, no supervision for the qualitative element was available and the investigator had limited knowledge.
A search of anthropological and sociological literature was undertaken for guidance in how subjective data was analysed before the development of more qualitative methods. Unfortunately, time constraints and the post-hoc decision to incorporate a qualitative analysis into the study meant that other approaches that were considered such as personal shaping could not be fully explored.

With hindsight, the design of the study could have incorporated a number of reliability checks. Namely, it would have been more valuable to collect stroke participant’s subjective descriptions of effort by asking them to describe their experience of moving the paretic arm. In doing this, no previous mention of effort would be introduced by the investigator thus allowing spontaneous comments to be noted. Furthermore, a questionnaire could also have been administered to each participant. This could have been devised from the pilot work and previous work (Parry, 1997). This questionnaire would contrast perception of physical effort (e.g. “Does this arm feel heavier when you lift it?”) and perception of mental effort (e.g. “Do you need to concentrate to avoid dropping things?”). Finally, a postal version of the questionnaire could have been sent out to participants at one month after the assessment to discover whether there was stability in their subjective ratings.
4.3.4 In relation to time and resource restraints

The research was conducted under extreme time restraints and with few resources. However, it would have been advantageous to assess a greater number of stroke participants and age-matched controls. Provision for this could have been incorporated into the early design stage of the study. A number of different stroke units could have been contacted as oppose to only using one stroke centre. Furthermore, the design may have compared stroke participants at varying stages of arm recovery.

4.3.5 In relation to the lack of normative data in this area

There is a lack of normative data about clients' subjective experiences of recovery within stroke rehabilitation, particularly concerning the role of effort during and after recovery of arm function.

4.3.6 In relation to the results

This study cannot claim generalisability due in part to the small sample size, and the fact that they did not represent the breadth of stroke experience. Generalising results from an exploratory piece of work is contentious, however, it does seem reasonable to consider that a good study can have an impact and contribute to knowledge in this area and
encourage further research in a potentially important area. This study has highlighted the need to extend both the breadth and complexity of research in this area as it could potentially be of great value to rehabilitation professionals and stroke patients.

4.4 Added difficulties in researching in the area of stroke rehabilitation

4.4.1 Problems inherent in using interviews with a stroke population

Any interview study of stroke patients necessarily excludes people with severe communication problems, and one has also to be aware that some interviewees are likely to have language deficits which will affect their accounts. This was of concern due to the already complex and confusing language used to describe effort.

4.4.2 Interviews as social interactions

Interviews are also seen as social interactions (Benny and Hughes, 1990) consequently, the power issues cannot be avoided. All of the stroke participants were aware from the information sheet that I was a trainee clinical psychologist who was working as a researcher in the contact with them. However, patients and carers would often ask my professional advice on issues ranging from their treatment to relationship difficulties. I chose to avoid extended responses to questions not related to the research.
4.5 **Strengths of the study**

4.5.1 *Exploration of an area with a lack of an accepted framework and language*

The results from this study added to the knowledge base of this relatively uninvestigated area. Furthermore, the study generated several strands of inquiry for future research (details can be found in the future research section).

4.5.2 *Innovation of designing new measures*

The exploratory nature of this study meant that there were no standardised measures therefore new measures had to be designed. Designing a new piece of equipment and an interview schedule can be time-consuming and risky however, this process turned out to be advantageous in two respects. Firstly, a better measure than that used in Rode's (1996) study has been designed. The contralateral limb-matching task used in Rode's study (1996) has been criticized in relation to the bias that may occur due to the participants being able to use contextual cues to make a judgement of weight. The assessment of perceived stiffness is a more objective measure as it provides exact readings, albeit with some degree of unreliability. Furthermore, the procedure meant that the participants were blindfolded, lessening the probability of judgements being biased by visual cues. Secondly, designing a new measure is a good way to learn the research process and an
extended pilot period to do this allows time to consider many of the research questions in more detail.

4.6 Future development of the research idea

4.6.1 Preliminary research questions

This study has highlighted that there are huge gaps in the knowledge of the phenomenon of effort and its role in the recovery of arm function. A key starting point for future studies would be to investigate the incidence and origin of effort in stroke patients during recovery of arm function. Examining this question may be best done by investigating a sub-group of stroke patients who have experienced a lacunar stroke. This has been the clinical population that have been studied in previous related studies (Doolittle, 1992; Gandevia and McCloskey, 1977; Weiller, 1995). Furthermore, this would provide a less complicated picture than cortical and sub-cortical lesions which could obscure the picture with the likelihood of cognitive or language impairments.

Another starting point would be to examine in more detail if stroke patients make a distinction between physical effort (matching for force) and mental effort (divided attention). A qualitative approach may be the most useful method to gain this information, as the aims would be exploratory rather than hypothesis testing. For a topic
that needs further exploration in the words of Ely (1991, p87), “entering a context with questions makes more sense than going in with answers”.

Following investigation of the preliminary research questions that have been identified, further work could explore if the phenomenon of effort can be accurately measured.

4.6.2 Replicating Rode’s study

Rode and his colleagues (1996) proposed that following a stroke the sense of effort is absent while there is no movement in the paretic arm; then, following the initiation of movement the sense of effort is great. Rode then reports that the sensations of effort decline as the recovery ends. However, in this study there was evidence that up to a year after their stroke the participant reported sensations of effort. This pattern contradicts that of Rode and has been supported by other literature (Doolittle, 1992; Parry, 1997). Additional research is needed to see if Rode’s results can be replicated.

A further logical extension would be to develop the assessment of perceived stiffness measure further. The equipment would seem to be a better way of assessing effort than the method used by Rode et al., (1996). The stiffness equipment offers a number of advantages over that used in Rode’s study namely, an exact measure can be given from the dynamometer. Secondly, it is not subject to the same contextual biasing that Rode’s study was as the participants were blindfolded.
4.6.3 Therapeutic evaluation

Following this preliminary research, future investigations may increase the complexity and breadth of the research to address questions of effort being therapeutically useful, for example, is it possible to train patients to focus effort and see if this results in significant functional gains.

Future implications of the work may include selecting patients who have reported high sensations of effort and teaching them mental rehearsal and visual imagery exercises (Jeannerod, 1994) with the aim of developing automatic activation of the motor system.

Trials could also evaluate the benefit of providing resistance training for patients who have reported increased physical effort. This would hope to increase the output of motor units that can be activated. Furthermore, it would be useful to evaluate if clients who reported increased effort in the initial stages of recovery would benefit from a particular type of therapy.
5 CONCLUSION
The present study has supported the hypotheses that stroke participants perceive increased stiffness on the paretic side. Furthermore, the results demonstrated that stroke participants who perceive increased stiffness also report increased effort in everyday life. What stroke participants mean when they report effort showed individual differences.

In addition to the theoretical implications for understanding the processes of recovery of arm function, these findings also highlight important implications for rehabilitation and therapy after stroke. Specifically, this study suggests that the role of effort may play an important part in recovery and needs to be investigated further. It may be that effort is a necessary precursor for effective motor rehabilitation.

Future research needs to give greater prominence to this topic. This study has provided some initial findings however, it has also highlighted the numerous questions that still need answering and the potentially usefulness of this topic.
6 REFERENCES


between impersistence, intellectual function and outcome of rehabilitation in patients with left hemiplegia. *Neurology*, 18, 852-861.


during imagined movement is proportional to mental effort. *Behavioural Brain Research*, 42, 1-5.


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Parry, R. (1997). *Disembodiment, reembodiment and attachment: Experiences during*
recovery and therapy following a stroke. Unpublished Masters dissertation, University of Nottingham, UK.


Dear [name of the Consultant],

I am planning to undertake a project as part of my Doctoral degree in Clinical Psychology, based at Leicester University. I have an ongoing interest in the area of neuropsychology and in particular, clients’ experiences of recovery following a stroke.

The name of the project that I am proposing to conduct is “The Role of Effort in the Recovery of Arm Movement following Stroke”. This study aims to conduct exploratory work investigating the role that “effort” may have in the recovery of arm movement following a stroke.

In my research, I hope to investigate if all clients report the phenomenon of effort following a stroke. I am also interested in the possibility of developing a measure of effort. The value of this type of research would be in telling rehabilitation professionals whether and or how we should measure effort in future studies of recovery.

Aims and Objectives

The aims of the research include:

- To investigate if all participants experience effort when using their recovering arm to perform a movement task following a stroke.
- To provide some preliminary ideas about the role of effort in the recovery of arm function.

The objectives are:

- To assess a number of participants (not greater than 12) who have had a stroke and who have recently been discharged from inpatient rehabilitation.

The assessment will involve asking the participant to carry out a series of simple arm function tasks. There will be three tasks the first a simple peg-board task, followed by a hand grip measure. The last task has been designed for the study and is called an
assessment of perceived stiffness task. Finally, participants will be asked about their experience of recovery using an interview schedule.

At this stage I am purposefully keeping the subject area broad, and may refine it depending on what the initial findings show.

Consent, Confidentiality and Reporting of Results

I will only assess and interview participants who have given written informed consent. The name or any identifying factors of participants will not be used in any reports or in the written dissertation. In the event that I assess participants from your district, I will not identify the site in any report given outside your district or my course. Only myself and my supervisor (Dr Alan Sunderland) will have access to the data. Before I write up my final analysis, I will give an interim report of my findings to your team so that they can have an opportunity to comment. At the end of the project I will provide the team with a report and would be willing to come and talk about the research.

I would be happy to discuss any questions or aspects of the study with you. I plan to start the project in November 1998.

Yours sincerely

Stella Sluman
(Trainee Clinical Psychologist).

Supervised by Dr Alan Sunderland
(Senior Lecturer in Rehabilitation Science).
Dear Dr [name of General Practitioner],

RE: PATIENT NAME, ADDRESS AND DATE OF BIRTH

This patient took part in a physiotherapy trial at Queens Medical Centre, X months ago. We are now planning a final follow-up visit to look at the role of effort in their recovery.

I would be grateful if you could let me know if their health or other concerns would preclude them from taking part. If I do not hear from you within three weeks then I will assume that this is acceptable.

If you have any queries then I would be happy to discuss them with you or send you further information.

Yours sincerely,

Stella Sluman
(Trainee Clinical Psychologist).

Supervised by Dr Alan Sunderland
(Senior Lecturer in Rehabilitation Science).
RESEARCH INTO THE ROLE OF EFFORT IN THE RECOVERY OF ARM FUNCTION FOLLOWING A STROKE

Thank you for thinking about taking part in this study. This information leaflet explains why I am conducting this study, what is involved if you agree to participate and what will happen to the information that is collected. If you decide that you are willing to take part, you will be asked to sign a consent form and will be given a copy to keep.

My name is Stella Sluman. I am a Trainee Clinical Psychologist interested in people's experience of the recovery of stroke. The project that I am working on is called "The Role of Effort in the Recovery of Arm Function following a Stroke". The project will be overseen by the Department of Clinical Psychology, University of Leicester and the Stroke Research Unit, Nottingham City Hospital.

WHY IS THIS STUDY BEING DONE?

For this research, I am trying to find out more about the role that effort plays in the recovery of arm function after a stroke. I therefore want to investigate the experiences of several people like yourself who have had a stroke affecting their arm. In particular, I am interested in the changes that people may have noticed in their arm when they were doing a movement task, since they first had a stroke. The aim of the research is to help rehabilitation staff understand more about the recovery process following stroke.

WHAT AM I ASKING YOU TO DO?

This is what will happen if you agree to take part. I will visit you at home, at a time that is convenient to yourself. I will initially ask you a few brief questions about your name, age, occupation and current health etc. I will then ask you to carry out three simple arm movement tasks. Following this, you will be asked about your experience of recovery of
your arm since the stroke and any changes that you have experienced. The tasks do not take very long and do not worry people when they are completing them. The whole procedure should last approximately 40 to 50 minutes. It will only be necessary to see you on one occasion.

DO I NEED TO TAKE PART?

NO. Taking part in this project is entirely voluntary. You can stop at any time and you do not need to give any reasons. Taking part will not interfere with your other treatment or any treatment in the future.

WHO WILL SEE ALL THE INFORMATION ABOUT ME?

All the information resulting from taking part in the study will be stored and analysed in a computer. It will be treated confidentially and you will be identified in the computer by a number. No one will know your name other than me and so there is no way that you can be identified.

At the end of the research, I will be producing a thesis that may contain some of the verbatim quotes that you provided. However, these will also be treated in the strictest confidence and you will again only be identified by a number.

THANK YOU FOR TAKING THE TIME TO READ THIS INFORMATION.

If you would like any other details in order to decide whether to take part in the project or you are unclear about any information, please contact me at the above address or telephone number.

If you are willing to take part in this study please complete the slip below and return it in the envelope provided (no stamp needed). You may also phone the Department.

I will then contact you to arrange an appointment time to come and see you.

Many thanks,

Stella Sluman
(Trainee Clinical Psychologist).

Supervised by Dr Alan Sunderland
(Senior Lecturer in Rehabilitation Science).
REPLY SLIP

I would like to take part in the Effort and the Recovery of Arm Function Project and agree to be sent an appointment.

Name.................................................. Address..................................................

..................................................

..................................................
10 APPENDIX 4 - CONSENT FORM

Research into the role of effort in recovery of arm function following a stroke
Stella Sluman (Trainee Clinical Psychologist)

Please read all of this page.

Have you read and understood the information sheet? YES / NO

Have you had an opportunity to ask questions and discuss the study? YES / NO

Have all your questions been answered satisfactorily? YES / NO

Have you received enough information about the study? YES / NO

Do you understand that you are free to withdraw from the study? YES / NO

• at any time YES / NO
• without giving your reason YES / NO
• without affecting your future medical care YES / NO

Do you agree to take part in the study? YES / NO

Signature (Patient/ Carer or Relative on patient’s behalf – delete as appropriate)

................................................................................................................

Patient’s Name (block capitals please) ..............................................................

Relative / Carer’s Name (where appropriate) .................................................

The study has been explained to the participant and he/she has indicated their willingness to take part. In cases of language disorders, the above relative/carer has agreed that the participant appears happy to take part and they have signed on the participant’s behalf.

Signature (Investigator) ................................................................. Date ....................

Name (block capitals) ..........................................................
APPENDIX 5 - VOLUNTEER’S INFORMATION SHEET

Division of Stroke Medicine / Stroke Research Unit, Clinical Sciences Building, Nottingham City Hospital (NHS) Trust, Hucknall Road, Nottingham, NG5 1PB, 0115 840 4789.

RESEARCH INTO THE ROLE OF EFFORT IN THE RECOVERY OF ARM FUNCTION FOLLOWING A STROKE

Thank you for thinking about taking part in this study. This information leaflet explains why I am conducting this study, what is involved if you agree to participate and what will happen to the information that is collected. If you decide that you are willing to take part, you will be asked to sign a consent form and will be given a copy to keep.

WHY IS THIS STUDY BEING DONE?

I am trying to find out more about the recovery of arm function after stroke and in particular what stroke participants have noticed about the effort that they experience. As part of the research, I am also interested in the normal processes of effort when carrying out a task with your hand and therefore need a healthy population to act as the controls group.

WHAT AM I ASKING YOU TO DO?

This is what will happen if you agree to take part. I will visit you at home, at a time that is convenient to yourself. I will initially ask you a few brief questions about your name, age, occupation and current health etc. I will then ask you to carry out three simple arm movement tasks. Following this, you will be asked about your experience of arm movements as you have got older and any changes that you have experienced.

The tasks do not take very long and do not worry people when they are completing them. The whole procedure should last approximately 40 to 50 minutes. It will only be necessary to see you on one occasion.
DO I NEED TO TAKE PART?

NO. Taking part in this project is entirely voluntary. You can stop at any time and you do not need to give any reasons.

WHO WILL SEE ALL THE INFORMATION ABOUT ME?

All the information resulting from taking part in the study will be stored and analysed in a computer. It will be treated confidentially and you will be identified in the computer by a number. No one will know your name other than me and so there is no way that you can be identified.

THANK YOU FOR TAKING THE TIME TO READ THIS INFORMATION.

If you would like any other details in order to decide whether to take part in the project or if you are unclear about any information, please contact me at the above address or telephone number.

Many thanks,

Stella Sluman
(Trainee Clinical Psychologist).

Supervised by Dr Alan Sunderland
(Senior Lecturer in Rehabilitation Science).
PREPARATORY ISSUES

Who I am
Reminder of the purpose of the study and design
Confidentiality issues

DEMOGRAPHICS

Name
Address
DOB.
Educational attainment
Occupation
Date of stroke
Treatment history (what sort of treatment, how long did it last, how often ie. weekly etc)
Past medical history (of relevance)
Dominant hand

EXPERIENCE AND SIGNS OF RECOVERY

I would like you to tell me what your arm felt like when you first had the stroke?
Could you feel anything at all?
What could you do and not do?
How did you know that your arm was getting better?

Prompts:-
Exploration of movement returning ie. were you able to carry out certain tasks therefore
did it come back gradually or was the movement sudden.
Did you experience any sensations during the return of movement? Can you describe these sensations?

Did you notice if there was a difference in the amount of effort that you put into movement in your paretic arm when carrying out a task during recovery? Ask for an example. Follow the example.

**EXPERIENCE OF EFFORT AND RECOVERING ARM FUNCTION**

At present as your arm is now what does it feel like?

What can't you do now?

When carrying out a task have you considered the effort that you put in?

Pick up on one of their examples and ask if they put in more effort than they had expected or less effort.

Prompt: perhaps explore the example more.

Do you think that putting more effort into movement has helped your arm recover or have you been trying to exert less force when carrying out a task?

Do you think that you would be able to rate the amount of effort that you were putting into a task with your recovering arm?

Draw on an example that has involved putting effort into movement. On a scale of 1-10 (1 = no effort, 10 = max effort) can you tell me how much mental effort you have to put in?
Could you also rate the physical effort that you put into that same task?

Are you able to make a distinction between physical effort and mental effort when you are performing a task with your paretic arm?

"How would you describe physical effort and mental effort?

Other people have described mental effort as “having to think about it” or “having to concentrate”. Do you agree with these statements?

How would you describe mental effort?
Appendix 7 - Data Collection Sheet

Participant Name:
Participant Age:
Date of Experiment:

1. Peg Board Test (Three trials)

<table>
<thead>
<tr>
<th>Right Hand (score in seconds)</th>
<th>Left Hand (score in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Hand Grip Measure (Three trials measure taken in Newtons)

<table>
<thead>
<tr>
<th>Trial</th>
<th>Right Hand</th>
<th>Left Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Table of measures when participants report stiffness in each hand feels the same (measure taken in Newtons)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Left Side</th>
<th>Right Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure One (L →R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measure Two (R →L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measure Three (L →R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measure Four (R →L)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: