Muscle strengthening in stroke rehabilitation: knowledge of and barriers to its use by UK neuro-physiotherapists

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Victor A Utti

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Muscle strengthening in stroke rehabilitation: knowledge of and barriers to its use by UK neuro-physiotherapists

DECLARATION

I hereby declare that the ideas, data analyses, results, and conclusions reported in this thesis are exclusively my own effort, except where otherwise stated and acknowledged. I also declare that this thesis is original and has not been previously submitted for any other award, except where otherwise stated and acknowledged.

Word count 48,500

DEDICATION

This thesis is dedicated to my daughters Princess Victoria Utti and Ekene Jovita Queeneth Utti to encourage them to aspire to achieve great academic heights.

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Abstract

Deficits in muscle strength are common after stroke and have a strong relationship to functional limitations experienced by stroke patients. Resistance muscle strengthening has been advocated in stroke rehabilitation, yet uptake in clinical practice appears limited. What constitutes muscle strengthening and the barriers and challenges preventing clinicians from implementing its use has not been investigated. This study provides an insight into the clinical decision making process by neuro-physiotherapists, factors that influence their decision to undertake strength training in stroke rehabilitation and the potential barriers to the implementation of muscle strength training.

A cross-sectional survey of 700 neuro-physiotherapists registered with the Association of Physiotherapists in Neurology (ACPIN) was conducted with a response rate of 57.2% (N = 401). The results showed 87.5% (N = 351) respondent neuro-physiotherapists undertake muscle strengthening $\chi^2 = 3.16$, $df = 3$, $p = 0.37$. Factors that influenced the use of muscle strengthening included reading of literature ($\chi 2 = 31.9$, $df = 1$, $p < 0.05$); attending continuous professional development programmes ($\chi 2 = 86.2$, $df = 1$, $p < 0.05$); and specialism of practice ($\chi^2 = 66.65$, $df = 5$, $p < 0.05$); while years of practice, and the number of patients managed weekly had a weak positive association. Comparative analysis showed that factors that constitute barriers to the use of muscle strengthening included: lack of time, excess work load, reduced staff, and poor cognitive abilities of the patients. It was also observed that neuro-physiotherapists were inclined to use an eclectic management approach in stroke rehabilitation, rather than a single based treatment approach.

Key Words: Muscle weakness, Muscle strength training, Knowledge, Clinical decision making, Barriers, Evidence-Based Practice.

Abbreviations

ACPIN	Association of Chartered Physiotherapists in Neurology
ACSM	American College of Sports Medicine
AHSA	American Heart and Stroke Association
BHF	British Heart Foundation
CCTs	Controlled Clinical Trials
CI	Confidence interval
CIMT	Constraint Induced Movement Therapy
CINAHL	Cumulative Index to Nursing & Allied Health Literature
CSP	Chartered Society of Physiotherapy
CVA	Cerebro-vascular accident
DOH	Department of Health
EBP	Evidence-Based Practice
ESD	Early Supported Discharge
FES	Functional Electrical Stimulation
H1	Hypothesis one
H2	Hypothesis two
H3	Hypothesis three
H4	Hypothesis four
H5	Hypothesis five
H6	Hypothesis six
H7	Hypothesis seven
HCPC	Health and Care Professions Council
IBITA	International Bobath Institute Teacher Association

ICF	International classification of functioning, disability and health
MST	Muscle strength training
NHS	National Health Service
NICE	National Institute of Health and Care Excellence
NOA	National Audit Office
ONS	Office of National statistics
Phi	Phi Coefficient
PNF	Proprioceptive Neuro-muscular Facilitation
PRT	Progressive Resistance Training
RCP	Royal College of Physicians
RCT	Randomised Control Clinical Trial
RM	Repetitive Maximum
SPSS	Statistical Products and Services Solutions
UK	United Kingdom
USA	United States of America
WHO	World Health Organisation

Glossary and Definitions

Working definitions of some key terms

This thesis has a clinical connotation with the use of words detailing medical and physiotherapy terms. In view of this perspective, recurring terms and concepts used in the context of this thesis are explained in this glossary:

Clinical reasoning – this is defined as the thinking and decision-making process applied by the clinical practitioners in making critical clinical decisions involving patient management. According to Higgs and Jones (2000: p3) "*clinical reasoning is the process whereby the therapist helps patients structure meaning, goals and health management strategies based on clinical data, patient choices, and professional judgment and knowledge*".

Cognitive functioning - Cognitive function refers to a person's ability to process thoughts. Cognition primarily refers to things like memory, the ability to learn new information, speech, reading, and comprehension. After a stroke, many people experience difficulties in attention, concentration, memory, perception, and other areas of cognition.

Concentric contraction – Concentric contractions are those which cause the muscle to shorten as it contracts during a movement action.

Conventional Physiotherapy – this is the use of a combination of active and passive exercises and other fundamental techniques in the rehabilitation of patients.

Dynamic strength (isotonic strength) - the muscle strength in the mid range of a dynamic movement.

Eccentric contraction – Eccentric contractions are the opposite of concentric and occur when the muscle lengthens as it contracts during the movement action.

Evidence based practice (EBP) - an extensively accepted definition of EBP is "*the conscientious, explicit and judicious use of current best evidence in making decisions about individual patients*" (Sackett et al., 1997: p71). The definition was expanded in the year 2000 to reflect the addition of patient values in the evidence-based process. Evidence-based practice is therefore combination of clinical expertise with best research evidence and patient values (Sackett et al., 2000).

Hemiplegia - hemiplegia means paralysis of one side of the body. The term *hemi* denotes one side, while *plegia* implies paralysis or weakness. About 80% of people who have a stroke end up having some degree of motor and movement impairment on one side of the body. This is usually the contra-lateral side to the affected brain, but in certain instances can be on the same side. Occasionally, after a stroke, hemiparesis may occur, which is described as a mild weakness on one side of the body.

Isokinetic strength – described as muscle contractions at a constant velocity with a variable resistance through the movement.

Isotonic Contractions - Isotonic contractions are contractions causing the muscle to change length as it contracts and cause movement of a body part.

Knowledge - in the context of this study, physiotherapy knowledge was derived from Titchen (2000) and is based on three types of knowledge in physical therapy: propositional (derived from research), craft knowledge or clinical knowledge (derived from practice), and personal (derived from self). According to Titchen (2000: p21) "*professional craft knowledge' or 'practical know-how'. This knowledge is expressed and embedded in practice and is often tacit and intuitive*".

Muscle strength – defined as the ability to generate force against a load and is assessed as the maximum load that can be moved or the maximum torque that can be generated during a movement. It can also be described as the maximal force or torque that can be generated by a muscle or muscle group at a specific velocity with the application of any form of resistance.

Muscle strengthening - in the context of this study, muscle strengthening is described as performing any exercise activity primarily to improve the strength and muscular endurance. It is carried out by performing: repeated muscle contractions with the application of resistance by body weight, elastic devices, free weights, specialised machine weights, isokinetic devices, as well as concentric, isometric or eccentric contractions of any muscle groups.

Muscle weakness - defined as an inability of muscles to contract normally even when force is exerted. In the case of a stroke patient, muscle weakness, is described as the inability of a patient to generate normal levels of muscle force under a specific set of testing conditions (Bohannon, 1995). Muscle weakness is a major cause of physical impairment after a stroke.

Peak torque - the maximum point on the strength curve obtained during a contraction in Newton metres.

Stroke - referred to as cerebrovascular accident (CVA) and defined as a clinical syndrome characterised by rapidly developing signs of focal disturbance of cerebral functions, lasting more than 24 hours, with no apparent cause other than of vascular origin (World Health Organisation, 1988).

Stroke Rehabilitation - is the process by which patients who have suffered a stroke undergo management to help them return to meaningful physical and functional activities to as near normal as possible. Stucki et al. (2007: p39) described rehabilitation as “the health strategy that aims at enabling people with health conditions experiencing or likely to experience disability to achieve and maintain optimal functioning in interaction with the environment". However, the main purpose of stroke rehabilitation is to attain functional independence that facilitates patients to return to their previous activities and become reintegrated into community life so as to meet their desires and expectations as much as possible.

Structure of the Thesis

This thesis is presented in six chapters:

Chapter 1 explains the background of the research study, statement of the problem, rehabilitation of stroke in the United Kingdom, perspective of muscle strengthening in stroke rehabilitation, the clinical decision making process in stroke rehabilitation, and the rationale of the study.

Chapter 2 begins with descriptive details of the search engines consulted in sourcing the literature review and other reading materials evaluated in this study. It also provides a theoretical orientation of the study based on application of muscle strength training in stroke patients, and exploring factors that potentially affect muscle strengthening in stroke rehabilitation. The outline include: (1) muscle weakness in stroke; (2) strength training in physiotherapy; (3) spasticity and strength training; (4) factors that affect the clinical decisions of physiotherapists engaged in stroke rehabilitation, and 5) barriers faced by neuro-physiotherapists in the uptake of physiotherapy interventions including the use of muscle strengthening in stroke rehabilitation.

Chapter 3 contains the research methodology applied in this study, encompassing the research setting, research design, research paradigm and philosophy of the study, sample strategy, and the description of the types of data analyses used.

Chapter 4 presents the results of the study, first detailing the quantitative results which include descriptive and demographic characteristics of the respondents, preliminary descriptive data analyses, and inferential data analyses. This is followed by thematic description of the open-ended questions, which were interpreted to justify some of the results of the study.

Chapter 5 discusses and interprets the results presented in chapter 4, and comparative evaluation of this study and previous studies. More emphasis is placed on the interpretation of the hypotheses and, using the responses from the open-ended questions (qualitative analysis), a relationship was created to better explain the results obtained from the quantitative questions.

Chapter 6 focuses on the reflexivity of the research, reflection and appraisal of the study methodologies, limitations of the study, recommendations for future studies, what could have been done differently and my personal perspective about the entire research process.

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CHAPTER 1: Introduction

1.0. Overview

This chapter discusses the background to the study, explores the prevalence of stroke in the United Kingdom (UK) and the cost implications of managing stroke in the UK. Brief insights to the management approaches used by neurological physiotherapists in the rehabilitation of stroke patients are highlighted, followed with an overview justifying the need to strengthen weak muscles post-stroke. Additionally, the clinical decision making process of neuro-physiotherapists is explored, to comprehend the rationale of neuro-physiotherapists in selecting certain treatment procedures in the rehabilitation of stroke patients.

1.1. Statement of the Problem

Presently in the United Kingdom (UK), there is limited evidence on how widely muscle strengthening is used in stroke rehabilitation. No study in the UK has investigated the clinical decision making process involved in the use of resistance muscle strengthening by neuro-physiotherapists, or the barriers associated with its use. Similarly, there is scant evidence of what type of muscle strengthening is used in clinical practice. Jones et al. (2003) conducted a survey on the use of resistive exercise training in stroke rehabilitation in the UK. The study observed that neuro-physiotherapists acknowledged they undertook resistance muscle strengthening in stroke rehabilitation. However, the survey did not determine its actual reported use, or how frequently muscle strengthening was used in practice.

Hence, Jones et al. (2003) recommended that further studies be undertaken to investigate the actual use of muscle strengthening in stroke rehabilitation in clinical practice, the clinical decision influencing its use, as well as the frequency, intensity and duration of their application. Technically, to achieve any meaningful gains in muscle strength in either normal individuals without any pathological conditions, or in stroke patients, there should be a quantifiable relationship between the volume, intensity, and frequency of muscle strength training (Flavo et al., 2010; Folland and William, 2007; Gordon et al., 2004).

Therefore, this thesis sought to fill the gap in knowledge, by investigating the knowledge, barriers, frequency of application, and the clinical decision-making of neuro-physiotherapists in the selection of resistance muscle strengthening as a treatment modality in the rehabilitation of stroke patients. To begin with, this thesis provides an overview of stroke in the UK, explores the possible motor and movement problems associated with stroke, as well as the frequent approaches used by neuro-physiotherapists in the rehabilitation of stroke patients.

1.2. Stroke in the United Kingdom

Stroke, referred to as cerebrovascular accident (CVA), is defined as, "*a clinical syndrome characterised by rapidly developing signs of focal disturbance of cerebral functions, lasting more than 24 hours, with no apparent cause other than of vascular origin*" (World Health Organisation, 1988: p105). A stroke can occur as a result of a haemorrhage in one of the arteries in the brain, or as a result of blockages within the blood vessels in the brain known as infarction (Royal College of Physicians, 2012). The effects of a stroke depend on the location and severity of either the vascular infarct or the haemorrhage in the brain (Bhatnagar et al., 2010). Stroke may result in the disruption of diverse motor and sensory functions, and in severe situations a stroke can lead to death or unprecedented physical and functional impairments (Lecouturier et al., 2010; Lee et al., 2011).

Stroke is one of the major causes of morbidity and mortality in the UK (Scarborough et al., 2009); according to Townsend et al. (2012), in 2010 stroke was the fourth largest cause of death in the UK after cancer, heart disease, and respiratory diseases, resulting in almost 50,000 deaths. While this figure appears high, it should be noted that the incidence and mortality rate of stroke in the UK is decreasing; this is arguably because of enhanced and efficient healthcare services provided within the National Health Service (Stroke Association, 2013).

This accomplishment is as a result of the intensive and effective health campaign by the National Health Service (NHS), advocating preventive health education, as well as aggressive rehabilitation and health promotion activities (Bhatnagar et al., 2010; Lee et al., 2011). In spite of the decreasing incidence of stroke in the UK, it was estimated that about 135,000 cases of stroke occurred in 2012 (Townsend et al., 2012). The breakdown of these cases is as follows: England 107,300; Northern Ireland 4,000; Scotland 13,000 and Wales 11,000 (Royal College of Physicians, 2013; Stroke Association, 2013).

Regardless of the improved rehabilitation services provided for stroke patients by the NHS, stroke causes disabilities (Stroke Association, 2013), and it is the fifth leading cause of disability internationally (Johnston et al., 2009). Often, these disabilities are associated with motor and movement problems (Adamson et al., 2004). Statistically, based on the stroke audit carried out by the national sentinel stroke clinical audit, it was observed that, "*about half the numbers of people who survive a stroke are left* *with one form of disability; approximately 42% might be independent; 22% may have mild disability; 14% moderate disability; 10% severe disability; and 12% might have very severe disability*" (Royal College of Physicians, 2011: p43). Muscle weakness is one of the widely recognised outcomes of disability caused by a stroke; with over 80% of stroke patients experiencing problems with movement (Townsend et al., 2012).

Additionally, the types of functional impairment resulting from a stroke include: general movement problems 80%; problems with arm movement 70%; inability to use one arm and leg in the long term 40%; and spasticity 19% - 38% (Royal College of Physicians, 2012). These residual problems inevitably compel stroke patients to become dependent on others for everyday activities. Considering that the incidence of stroke cuts across different age groups including the active working population, economically this has potentially huge financial implications for the UK economy (Luengo-Fernandez et al., 2006).

The estimated economic cost of stroke to the UK economy in the financial year 2007/08 was estimated at £7 billion pounds (British Heart Foundation, 2009; Scarborough et al., 2009). This estimated cost encompassed: direct costs to the NHS amounting to about £2.8 billion; expenditures as a consequence of informal care amounting to approximately £2.4 billion; and costs incurred as a result of lost productivity and disability totalling over £1.8 billion (Scarborough et al., 2009). Saka et al. (2009) observed that the previously estimated figure of £7 billion had subsequently risen to a new value of £8.9 billion a year, representing the cost of treatment and loss of productivity as a consequence of stroke. In 2011, the estimated cost of the management and rehabilitation of stroke patients was 5% of the total UK

National Health Services cost (National Audit Office, 2010), demonstrating the huge financial implications involved in the rehabilitation of stroke.

Some scientific literature have demonstrated that deficits in muscle strength of the lower and upper limb appear to be one of the primary impairments which limits function following stroke (Bohannon, 2007; Harris et al., 2001; Harris and Eng, 2007; Ng and Shepherd, 2000). The relationship between muscle strength and function is strong (Dorsch et al., 2012; Milot et al., 2008; Ng & Hui-Chan, 2012; Saunders et al., 2014a), to the extent that muscle strength can be used to predict functional activities such as gait and walking speed (Nadeau et al., 1999). These scientific studies highlight the pivotal role of muscle strength to improving functional activities following a stroke.

Despite the perceived importance of muscle strength as an aspect of improving function post stroke, the relationship between muscle strength and functional performance might not indicate a causal effect (Bourbonnais et al., 2002), but may suggest that muscle weakness is a factor to consider to enhance the motor performance of individuals who have had a stroke (Signal et al., 2014). It must be noted that apart from muscle strength, there are other factors that play a role in the improvement of function post stroke. These include: cognition, the extent of injury caused by the stroke, the task to be performed, the abilities and capabilities of the individual who has suffered a stroke, and ultimately the type of interventions undertaken during the acute and recovery phases of stroke rehabilitation (Saunders et al., 2014b). Based on the literature, timely, proper and dedicated physiotherapy interventions can result in positive functional improvements post stroke (Johnston et al., 2013; McCluskey et al., 2013; Stevenson et al., 2004).

1.3. Neuro-physiotherapy interventions in stroke rehabilitation

In the mid-1950s, physiotherapy rehabilitation of patients with neurological diseases (inclusive of stroke) was mostly based on orthopaedic and compensatory principles of management: e.g. massage, heat, range of movement exercises including the use of pulleys, suspension, and weights (Flansbjer et al., 2006). Patients who presented with central nervous system damage were rehabilitated using muscle stretches, and bracing of the affected limbs; and were encouraged to compensate or rely more on the unaffected side (van Peppen, 2008). Conversely, in the 1970s, with advances in neurological sciences, the initial orthopaedic inclination developed into neuro-physiological approaches, pioneered by physiotherapists such as Bobath (Bobath approach), Brunnstrom (Brunnstrom approach); Knott and Voss (proprioceptive neuromuscular facilitation).

The neuro-physiological approach involves using key points of control, reflex inhibiting patterns and directional physical manoeuvrings to improve motor control, postural symmetry, balance, and movement impairments in stroke patients and other neurological conditions (van Peppen, 2008). In 1985, movement science (motor relearning programme) was proposed by Carr and Sheppard (1985). Movement science encourages the incorporation of functional training of key motor tasks such as sitting, standing or walking. It also requires the physiotherapist to analyse each task to determine the missing components of the performed task and facilitate these missing components to improve function (Carr and Sheppard, 2010).

However, with the advent of evidence-based research, adjuncts such as constraint induced movement therapy (CIMT), repetitive task-specific training (RTT), functional electrical stimulation (FES), motor imagery, mental practice, virtual reality, and muscle strength training exercises (MST) have been revealed to be effective when used in collaboration with these fundamental neurological approaches in stroke rehabilitation (Flansbjer et al., 2006; 2008). The main focus of this research study centres on the use of resistance muscle strengthening in stroke rehabilitation. The loss of muscle strength after stroke is considered an important determinant of disability (Patten et al., 2004), and it would therefore appear logical that some emphasis in the rehabilitation process should be directed at regaining muscle strength to improve function (Ada et al., 2006; Bohannon, 2007; Cooke et al., 2010a).

1.4. Stroke rehabilitation in the United Kingdom

In the UK, the Bobath concept is the most frequently used physiotherapy approach in the management of stroke patients (Davidson and Walter, 2000; Jackson, 2011; Lennon et al., 2001; Lennon, 2003; Raine et al., 2009; Tyson et al., 2009a). The Bobath concept is postulated as "*a problem solving approach to the assessment and treatment of individuals with disturbances of function, movement and postural control due to a lesion of the central nervous system (CNS), and can be applied to all degree of physical and functional disabilities*" (Raine et al., 2009: p3). The theoretical concept underpinning this approach is motor control and inhibition of abnormal postural reflexes (Lennon et al., 2006a; Raine, 2007). However, neuro-physiotherapists in the UK occasionally make use of other approaches such as movement science and proprioceptive neuromuscular facilitation (PNF), including basic passive/active exercise activities (Jackson, 2011). These basic approaches are often complemented with adjuncts such as functional electrical stimulation (FES); constraint induced movement therapy (CIMT), muscle strengthening, massage, splinting, virtual reality, mirror and mental therapy, as well as biofeedback therapy, to mention but a few (Raine et al., 2009).

Studies carried out in the last decade have suggested that muscle weakness seen in stroke patients can be improved by muscle strengthening exercises (Cooke et al., 2010a; Cramp et al., 2006; Donaldson et al., 2009; Flansbjer et al., 2008; Winstein et al., 2004; Yang et al., 2006). This school of thought on the use of muscle strengthening has challenged previously held assumptions suggesting that muscle strengthening should be avoided in stroke patients due to perceived complications such as increased spasticity and increased reflex activities (Bobath, 1990; Lennon, 1996).

This prior assumption was based on the perception that any increase in muscular effort against resistance, tended to increase spasticity and therefore negatively affected movement. Bobath (1990) suggested that the muscles in stroke patients were not actually weak intrinsically, but were unable to generate strength due to the exaggerated co-contraction of opposing muscle groups which resulted in increased tone. However, systematic literature reviews carried out by Ada et al. (2006); Bohannon (2007); Eng (2004); Harris and Eng (2010); Saunders et al. (2013), have observed that muscle strengthening in stroke patients does not necessarily increase tone or reflex activities. Rather muscle strength training in stroke facilitates mild to moderate effects aimed at improving the strength of the weakened muscles as well as enhances the physical and functional performance of daily activities (e.g. sit to stand, upper limb function and improvement in gait parameters).

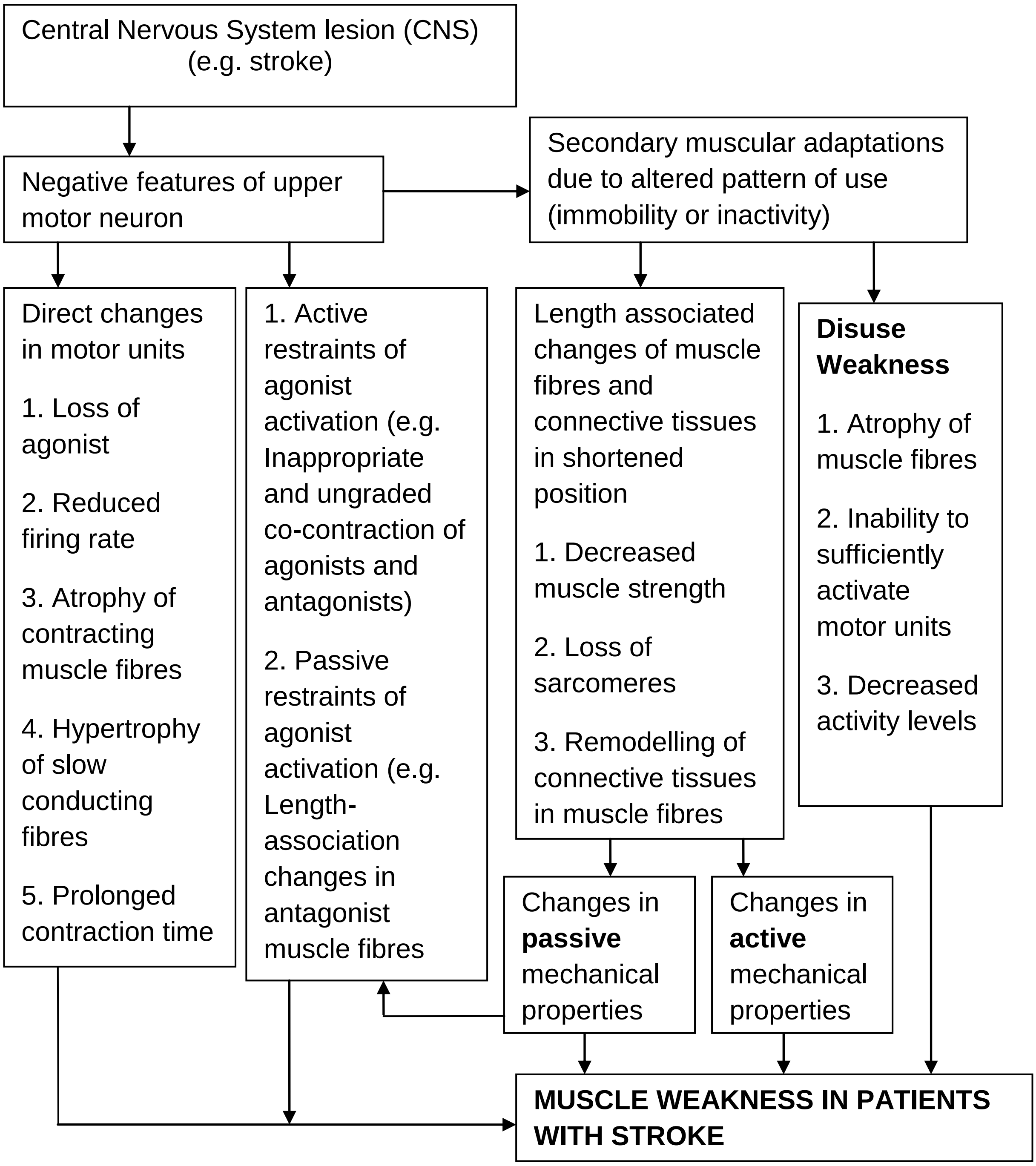
The rationale offered for undertaking muscle strength training post stroke, suggests that, when muscles are strengthened, they become more efficient at maximizing voluntary contractions (Harris and Eng, 2007); and this is followed by muscle hypertrophy and an increase in muscle fibre size (Shumway-Cook and Woollacott, 2007). Increased muscle fibre size has the potential to increase strength and therefore muscle force which ultimately improves function (Dobkin, 2008). With the debate and accumulating evidence towards the beneficial effects of resistance muscle strengthening as a component of motor rehabilitation, it is necessary to review the physiological perspective of muscle weakness post stroke, and to identify the training parameters that provide the potential stimulus for driving motor recovery.

1.5. Physiological perspectives of muscle weakness post stroke

After a stroke, disruptions of brain activities occur such as diminished neural transmission of impulses from the brain to the muscles, causing muscle weakness and reduced functional abilities (Patten et al., 2004; Ward, 2005). The damage caused by stroke combined with decreased mobility produces a decline in the muscle mass of the paretic muscles and to a lesser extent, in the non-paretic muscles (Gray et al., 2012).

Muscular weakness following stroke involves both direct (i.e. damage to neural structures) and indirect (i.e. muscular disuse subsequent to reduced physical activity) mechanisms that impact both the ability of the central nervous system to voluntarily activate skeletal muscles as well the force generating capacity of muscle (e.g. atrophy). It is important to recognise that the degree to which muscle weakness impacts functional ability varies greatly and is dependent on task demands. For any given activity, at least conceptually, increases in strength will not be beneficial until a certain threshold is reached. Once achieved, increases in strength will be accompanied by improved functional performance, at least to a certain point.

Fig. 1.1: Diagram showing causes of muscle weakness post stroke



Adapted from Ng and Sheppard, (2000): which shows how a stroke can lead to changes in the muscle (muscle weakness)

Figure 1.1 above shows how a stroke causes muscle weakness. The inability to generate normal amounts of force has been suggested to be the key limitation to improving functional activities (Ada et al., 2006; Mercier and Bourbonnais, 2004). The theoretical framework underlying the importance of muscle weakness and function physiologically is: moment of force about the velocity of movement (Torque = muscle force x moment arm). Therefore, acceleration of the mass of the body (or individual body segment) requires force generation by skeletal muscles (Bowden et al., 2011). A stroke impairs skeletal muscle force generation, limiting the acceleration of movement and therefore functional performance might be compromised.

Beyond the theoretical perspective, there is interplay of force-velocity relationships as well as the length-tension relationships of the muscles, causing muscle fibre tightness, shortening and contractures (Gray et al., 2012). In the affected arm and forearm muscles, there is a predominance of flexion shortening, while in the affected lower limb; lengthening of tibia and quadriceps muscles occurs; but there is a predominance of shortening in the gastrocnemius muscles (Carin-Levy et al., 2006).

Muscle weakness, and motor impairment, along with the resultant disability caused by reduced muscle strength, may constitute limiting factors in the rehabilitation of stroke patients. Therefore to maximize physical recovery, it has been recommended that active resistance strength training and intensive task-specific training are used to increase muscle strength and optimize motor performance (Ada et al., 2006; Bohannon, 2007).

Based on the research evidence supporting the use of muscle strengthening in stroke rehabilitation, the intercollegiate stroke working party in the United Kingdom advocated the inclusion of muscle strengthening post-stroke in the NICE guidelines on stroke management. The statement reads: "*training strength seems a logical treatment for patients with weakness of voluntary muscle contraction. Fears that this treatment would worsen increased tone limited its use in the past, but the evidence available now shows this fear to be unfounded, thus, advocates the use*" (Royal

College of Physicians, 2008: p78). This statement at that time purportedly lessened the debate over the use of muscle strengthening in stroke rehabilitation.

Although neuro-physiotherapists acknowledge they use muscle strength training (Jones et al., 2003), it is assumed that gaps may still exist between scientific evidence in stroke rehabilitation and its application in clinical practice (Walker, 2007). These gaps between what therapists say and what they practise is not peculiar to the UK alone, but has also been observed within neurological practice in North America.

Two studies conducted in Canada (Menon et al., 2009; Rochette et al., 2007) observed that, in spite of more than 1800 documented studies on stroke rehabilitation, and well over 900 published randomised controlled trials (RCTs) investigating stroke rehabilitation, best practices were not routinely applied. Similarly, Johnston et al. (2013) in a recent study observed that only 58% of New Zealand physiotherapists align with the recommendations of the New Zealand clinical guidelines for stroke management (2010) which advocates the use of strength training for the management of muscle weakness seen in stroke (Stroke Foundation of New Zealand, 2010). Based on these studies, there is a need to explore the clinical decision making process and knowledge of neuro-physiotherapists regarding the use of muscle strengthening; and whether there are barriers or challenges preventing them from using muscle strengthening in stroke rehabilitation in clinical practice. In the UK, uptake and the clinical decision involved in the use of muscle strengthening in the rehabilitation of stroke has not been studied.

1.6. Clinical decision making and factors affecting it in stroke rehabilitation

Clinical reasoning or decision-making process is described as, "*the process in which therapists, structure meaning, goals, and management strategies based on research evidence, clinical data, and professional judgment and knowledge*" (Higgs and Jones 2008: p11). It is regarded as an integral component to being a clinician (Norman, 2005); whereby cognitive decision-making processes are used to optimally evaluate a patient's problem, plan and implement interventions, manage dysfunctions, impairments and physical disabilities (Edwards et al., 2004; Jensen et al., 2000; Jones et al., 2008).

Across the disciplines involved in the rehabilitation of stroke patients (physiotherapy, occupational therapy, nursing and medicine), there are differences in the ways that clinical decision making has been studied. For example, research on clinical decision-making in medicine has focused on decision making models used by practitioners (Tonelli, 2006); while in physiotherapy, clinical reasoning has focused on the behavioural attributes demonstrated by physiotherapists (Herbert et al., 2005). Clinical rehabilitation incorporates evidence based practice to direct the best practice for patient rehabilitation and in the attainment of optimal outcomes (Wainwright and McGinnis, 2008). Clinical decision-making integrates clinical expertise, best available evidence and clinical judgement (Jensen et al., 2008), and develops through several other channels such as, knowledge gained from continuing professional development, personal elements and professional experiences that provide the framework on decision making (Wainwright et al., 2011). While some of these clinical reasoning processes, abilities and behavioural attributes have been described in the literature; this has not been explored within the context of muscle strengthening in stroke rehabilitation.

After a stroke, motor and movement problems reduce an individual's ability to participate in functional activities (Langhorne et al., 2009). These problems post stroke occur as a result of the following: muscle weakness, reduced cognitive functional abilities, reduced sensorimotor input, poor movement coordination, spasticity, and other factors such as the task, the individual, and the environment (Shumway-Cook and Woollacott, 2007). Muscle weakness happens to be one of the common physical features, and one of the widely recognised impairments caused by stroke (Langhorne et al., 2009; Patten et al., 2004), thereby creating significant challenges in the rehabilitation journey of stroke patients (Burke et al., 2009; Glinsky et al., 2007; Langhorne et al., 2011).

The clinical decision taken by the clinical physiotherapists to strengthen muscles post stroke is dependent upon the therapist's critical thinking disposition, and influenced by his/her philosophical perspectives and preconceptions of the effectiveness of the intervention. Studies on clinical decision making, have observed that there are several factors that influence the decision to use or not to use a treatment approach. These include, guidelines and protocol supporting the approach (Ashford, 2014), the efficacy of the treatment approach (Jette et al., 2005; McCarthy, 2003; Scheffer and Rubenfeld, 2000), expert opinion (Davidson and Waters, 2000), experience gained from managing patients (Turner and Whitfield, 1999; Turner, 2001), and research-based evidence (Herbert et al., 2001; Jette et al., 2003a).

Of all these factors, the concept of research-based evidence marks a shift amongst clinical physiotherapists from a traditional emphasis on treatment procedures based on the opinions of experts to guide clinical practice (Sackett et al., 2000), to an emphasis on data-based and clinically relevant research (Jette et al., 2003a). It can be argued that although clinicians believe that research is important (Herbert et al., 2001; Jensen et al., 2001), there are factors that may lead to the underuse of research-based evidence. These include personal beliefs (Metcalfe et al., 2001; Bernard and Wiles, 2001), levels of educational accomplishment (Bernard and Wiles, 2001), and organisation factors such as time constraint and excess workload (Jette et al., 2003a; 2005; Salbach et al., 2007). Some clinicians may deem certain evidence as not particularly relevant to practice (Herbert et al., 2001), while others might perceive it as a threat to client-centred care, and would prefer to practice routines they judge to be effective (Dubouloz et al., 1999; Salbach et al., 2010a).

As explained previously, in the past, the use of muscle strengthening in the rehabilitation of stroke patients, stimulated considerable debate (Ada et al., 2006; Bohannon, 2007; Cramp et al., 2006). This was because there were concerns that resistance muscle strengthening had negative effects on spastic muscles of patients with neurological conditions (Bobath, 1990). These concerns have now largely been alleviated, and muscle strengthening is currently considered to be beneficial in the rehabilitation of functional activities post-stroke (Ada et al., 2006; Bohannon, 2007; Cooke et al., 2010b).

Whilst some studies have established that there are positive functional effects with the use of muscle strength training exercise post-stroke (Donaldson et al., 2009; Flansbjer et al., 2008; Ouellette et al., 2004; Weinstein et al., 2004), other studies have suggested there are no convincing benefits derived from the use of muscle strengthening in improving functional outcomes (Kim et al., 2001; Kollen et al., 2006; Moreland et al., 2003; Morris et al., 2004). It can be argued that currently, the evidence in support of muscle strengthening includes some randomised controlled trials, which are small and not powered to identify differences within the interventions under investigation (Flansbjer et al., 2008; Kim et al., 2001; Lee et al., 2008). However, the few cohort studies that have investigated strength training in patients post stroke (Clark and Patten, 2013; Ryan et al., 2011; Sullivan et al., 2007) have provided moderate evidence to support the use of resistance muscle training in stroke rehabilitation.

Whilst the evidence base for strength training after stroke is growing, a recent meta-analysis investigating physical fitness training after stroke (Saunders et al., 2013), indicated that there is still insufficient evidence to draw robust conclusions about the efficacy of strength training alone, as opposed to strength training combined with other forms of training, for gains in physical fitness, mobility or physical function. Thus, there is a need to understand the clinical decision process of how and what determines neuro-physiotherapists selection to use muscle strengthening in stroke rehabilitation, and the barriers to its use, hence the stimulus for this study.

1.7. Scope of the Study

This study collated information from neuro-physiotherapists registered with the special interest group known as the Association of Chartered Physiotherapists in Neurology (ACPIN) in the UK. The study analysed the knowledge of, barriers encountered and clinical decision making of neuro-physiotherapists about the use of resistance muscle strengthening in stroke rehabilitation.

CHAPTER 2: Literature Review

2.0 Introduction

This chapter presents the search strategy used in sourcing articles that were reviewed, followed by an evaluation of articles on muscle strength training in stroke, including the frequency, duration and intensity of resistance strength training. Other issues addressed are the effects of muscle strength training on spasticity and neuroplasticity, barriers to the use of muscle strength training, the rationale for using muscle strength training in stroke management, and the clinical decision making process in neurological physiotherapy practice, especially in the use of muscle strength training in stroke management. A summary of the outcome from the different research studies is discussed along with the effects of muscle strength training on functional activities.

2.1. Literature search strategy

Electronic databases of the Albert Sloman library, University of Essex were searched (CINAHL, MEDLINE, OVID, PEDro, and PubMed). The keywords used include: **'stroke'; 'CVA'; 'CVD'; 'hemiplegia'; 'resistance'; 'strength training'; 'muscle strengthening'; 'physiotherapy'; 'physical therapy'; physiotherapist'; 'decision making'; 'clinical reasoning'; 'barriers' ; and 'knowledge'** (Appendix 2).

The following Boolean operators were used OR, AND, and NOT and truncation (*) to combine search terms and separate concepts in order to retrieve relevant articles. The 'AND' was used to restrict the search to obtain studies that covered the key words required; ‘OR’ was used to broaden the search to obtain studies with similar word meaning; and ‘NOT’ was used to restrict the search to avoid the retrieval of studies that did not have the search words or exclude all studies not containing the keywords (Aveyard, 2010; Bowling, 2002). Furthermore, the truncation (*) was used to expand the search term to include all forms of a root word (e.g. resistanc* retrieves resistance and resistant). Case studies, controlled clinical trials (CCTs), systematic reviews (SR), randomized clinical trials (RCTs), pre-test/post-test and non-controlled pre-experimental studies were included for review.

In addition to an e-database search, a grey literature search (scanning relevant websites such as conference proceedings of Association of Chartered Physiotherapists in Neurology [ACPIN], conferences on stroke management, rehabilitation of neurological conditions, International Association of sports medicine), citation searching, footnote chasing (technique used on locating useful information by searching the reference section of other papers), and a subject index search (searching library shelves, journal indexes, bibliographic descriptions of titles, and abstracts) were also undertaken.

2.2. Inclusion and exclusion criteria

Inclusions:

a) Studies on stroke management which involved the use of any procedure involving resistance muscle strength training that reported indices of muscle force production (muscle strength, maximal force or torque production and muscle power output).

b) Studies that reported indices of correlation between muscle force production in stroke management, with either an improvement in function or **no** improvement in function of stroke participants.
c) Resistance muscle strengthening in stroke patients such as functional resistance exercises, progressive resistance exercise training (PRT), use of isokinetic machines, treadmill or cycle ergometer with measurable resistance, pneumatic machines (arm and leg press) weights, springs and therabands, functional electrical stimulation etc.
d) Muscle power output measured using dynamometry such as the cybex dynamometer, measurable isokinetic or hand-grip dynamometers and other strength measures, except the singular use of the Oxford grading scale.
e) Studies investigating the clinical decision of physiotherapists involved in stroke rehabilitation.
f) Only studies written in the English language were considered, and which investigated the use of resistance muscle strength training in stroke patients
g) The years considered ranged from January 1990 – January 2014. This is because the debate on the use of muscle strength training in stroke was a subject of contention in the 1990s

Exclusions:

a) Relevant research incorporating interventions of resistance muscle strength training (RT) in stroke, but recording mixed outcomes such as the effect of resistance training on the cardiovascular and respiratory systems (e.g. maximum oxygen uptake or cardio-respiratory fitness) were excluded (e.g. Clark et al., 2000; Duncan et al., 2003; Hill et al., 2012; Lee et al., 2008).

b) Relevant researches involving the use of resistance strength training in stroke rehabilitation, but incorporating other interventions (e.g. constraint-induced therapy - CIMT) were excluded.

c) Studies that carried out resistance strength training to reduce depression and anxiety and which were not necessarily aimed at improving muscle function or functional activities (Sims et al., 2009).

d) Research in which resistance training was combined with other interventions (e.g. aerobic conditioning), unless the added benefits of resistance strength training were delineated. Multiple publications of data from the same participants were excluded.

e) Studies with too many interventions including strength training were selectively excluded because they provided too many variables that may have technically influenced the results of the study, and not necessarily by the singular effects of resistance muscle training.

f) Studies carried out on any stroke or hemiplegic patient below the age of 18 years.

g) Studies not written in English language were excluded

h) Studies were excluded if indices used to measure the level of changes in muscle activities were basically a simple measure such as the Oxford scale (Medical Research Council scale - MRC). Whilst MRC is simple and rapid for clinical purposes, it may be considered conceptually weak as a physiological measure of muscle strength and assumed to be susceptible to investigator bias.

i) Studies published beyond 1990.

A total of 349 studies were first retrieved from the entire databases search, 110 from CINAHL, 79 from MEDLINE, 27 from PEDro, 102 from PubMed, and 15 from Ovid. For each of the databases used as a search engine, the relevant articles obtained were first matched by database and any article title that appeared more than once was recorded as a duplicate. Overall relevant articles retrieved from each database were matched together to eliminate duplicated papers (those that appeared more than once).

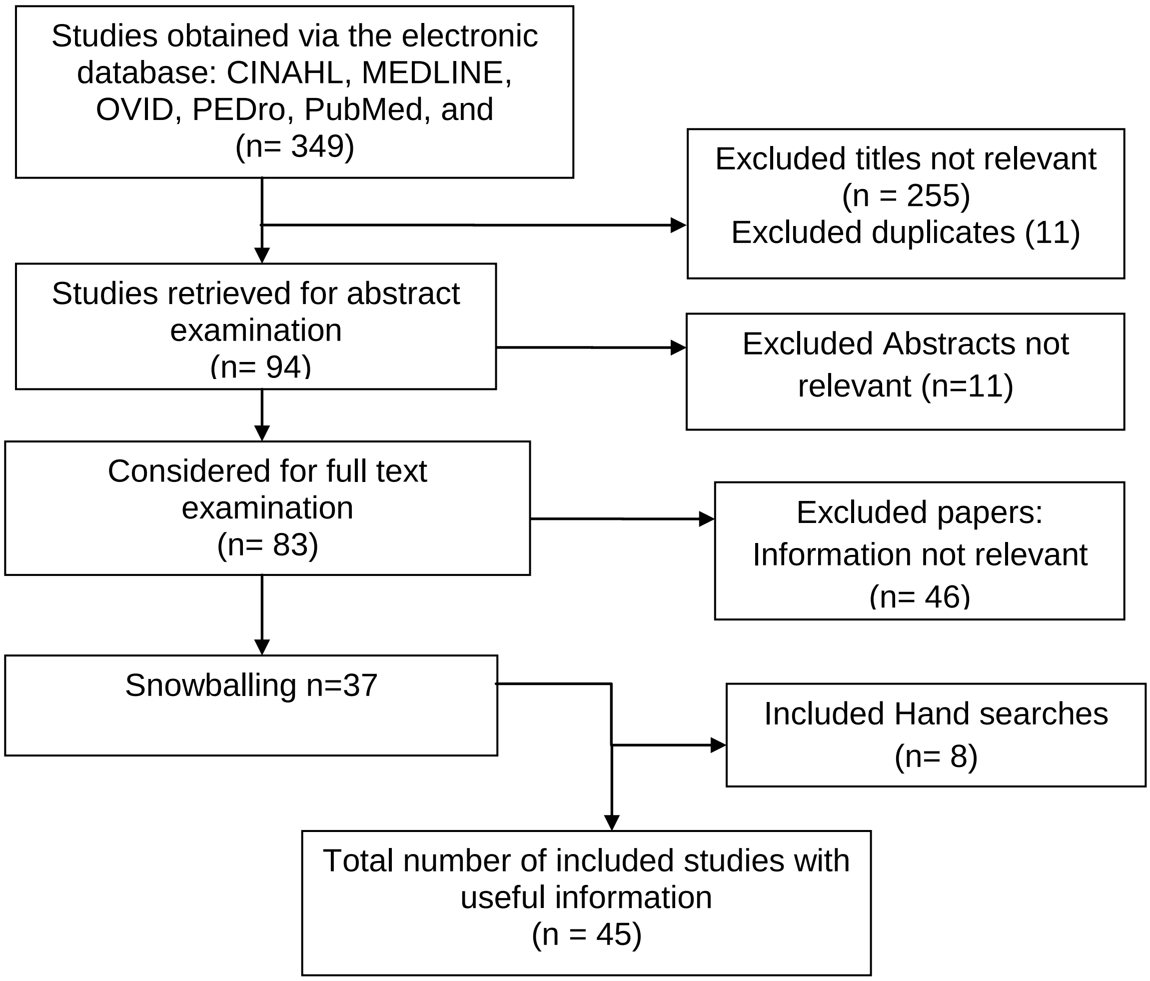
2.3. Sifting of the literature and data extraction

The relevant studies retrieved from each electronic database were filtered manually using three stages as described by Abubakari and Bhopal (2008). At the first stage after the input of the relevant keywords into each database, the titles of studies that met the inclusion and exclusion criteria were sifted to include only relevant study titles. Only studies with relevant titles were considered for abstract examination in the second stage. In the second stage, the abstract of each qualifying study was further examined for relevance, and only abstracts with relevant information that met inclusion criteria were considered for full text examination.

Full text examination of the methodology and findings of the retrieved studies were examined for relevancy and inclusion. Studies whose method and findings appeared relevant to the research aims were included. Full text examination of the selected articles was done using a critical appraisal skill programme tool (CASP). In each of the included studies, the data extracted comprised of the authors, year of publication, study design, aim of study, setting (country/district or hospital/community), follow-up period, participants (how and where recruited), outcomes, results/findings and conclusions.

Based on the flow chart (Fig 2.1) below, 45 articles that met the inclusion criteria on resistance muscle training in stroke were reviewed. However, these articles may not be a complete representation of all articles that meet the selection criteria of the study, and this is acknowledged as part of the limitations of this study. There is the possibility that some articles may have been inadvertently missed (failed to spot) during the search process (electronic and hand searches).

Figure 2.1 Flowchart showing the sifting strategy



2.4. Strength training after stroke

In the last decade strength training has been advocated for clinically stable stroke patients (Billinger et al., 2014). Recently, the American Heart and Stroke Association (AHSA) advocated the use of resistance muscle strength training for stroke rehabilitation (Billinger et al., 2014). Similarly, the stroke intercollegiate working party made a similar recommendation in the National Institute for Health and Clinical Excellence (NICE) guidelines for the management of stroke (Royal College of Physicians, 2012; 2008). Strength training can be described as any exercise involving repeated muscle contractions against a load. The load can be provided by the use of free weights, manual resistance, elastic devices such as theraband or springs, progressive resistance exercises, functional resistance exercises, resistance provided from machine weights or isokinetic systems such as the cybex dynamometer, and the individual's body weight. The aim is to improve muscle strength, endurance and/or power (Saunders et al., 2014).

Unlike in orthopaedic rehabilitation where resistance muscle training is routine, in neurological rehabilitation, it is gradually gaining acceptance and being increasingly administered (Cooke et al., 2010a; Hedlund et al., 2012; Lee and Kang, 2013). Studies have shown that resistance muscle strength training post stroke produces considerable improvements in lower limb functional performance, trunk stability, sitting balance, sit-to-stand, standing balance, walking, stair climbing, and upper-extremity functions such as reaching and grasping (Andersen et al., 2011; Cooke et al., 2010a; Donaldson et al., 2009; Eng et al., 2004; Engardt et al., 1995; Flansbjer et al., 2008; 2006; Lee et al., 2013; Ouellette et al., 2004; Patten et al., 2006; Teixeira-Salmela et al., 1999; Wallace et al., 2006; Weiss et al., 2000; Yang et al., 2006). The rationale for the use of muscle strength training is that, different types of muscle strengthening programmes put specific demands on different muscles; for instance, the strength of the hip flexor muscles and the ankle dorsiflexors strongly correlate with walking speed and endurance in stroke patients (Dorsch et al., 2012). Similarly, the strength of the hip extensors, and knee extensors are important for the successful performance of stair climbing (Flansbjer et al., 2008; Yang et al., 2006).

Based on the accruing evidence of the beneficial effects of resistance muscle training in stroke management as a component of motor rehabilitation, this review of literature evaluates the different studies that have been conducted using resistance muscle strength training as a potential for driving motor and functional recovery following stroke; and the clinical decision or rationale in the use of resistance muscle training.

2.5. Muscle strengthening of the lower limb post stroke

Engardt et al. (1995) in Stockholm Sweden were amongst the pioneer researchers to explore the effects of resistance muscle strength training in stroke rehabilitation. They evaluated the effects of eccentric and concentric muscle strength training on the knee extensors and knee flexors in stroke patients. The participants were two groups of 10 ambulatory chronic stroke patients, exposed to either a concentric or eccentric resistance exercise regime twice weekly for six weeks, using an isokinetic dynamometer machine. Group one was exclusively exposed to eccentric resistance exercise, while group two was exclusively exposed to concentric resistance exercise at different velocities (60, 120 and 180 degrees per second).

The results showed that eccentric muscle training considerably increased the muscle strength of the knee extensors of the stroke participants by 25% - 35%, while concentric muscle training gained an increase of 23% - 28%. Furthermore, Engardt et al. (1995) recorded an improvement in muscle strength and subsequent gains in functional gait parameters, such as walking speed and stride length. It was observed that the improvement gained in knee torques was slightly greater using eccentric muscle strength training with a mean change of 33%, compared to a mean change of 24% using concentric muscle strengthening, although the difference observed between eccentric and concentric muscle strengthening was not statistically significant ($p > 0.05$).

Evaluation of this study showed some methodological flaws. Although the study involved two groups of participants, it was not randomised, and there was no control group. Thus, the positive outcomes recorded might not be exclusively attributable to either concentric or eccentric muscle strength training exercises. Besides, only a three minutes rest interval was allowed between the different muscle strength training exercises at the different velocities. Engardt et al. (1995) did not categorically explain how the rest period of three minutes for each exercise session impacted on the study. Although 3-5 minutes was recommended as rest period for healthy adults by the American College of Sports Medicine (2009), three minutes rest period may be inadequate for stroke patients. In addition, Engardt and colleagues also stated that each training session was followed by 20 minutes stretching of the knee joint given by the individual treating therapist. Stretching constitutes another form of physiotherapy treatment which may have impacted on the results of the study. Nonetheless, the positive results obtained by Engardt et al. (1995) initiated further debate on the use of resistance muscle strength training exercises in stroke management, challenging previously held assumptions that muscle strengthening exercises stimulated increased reflex activities (Bobath, 1990).

The research findings by Engardt et al. (1995) encouraged Teixeira-Salmela et al. (1999) to undertake a similar pattern of muscle strength training on the lower limbs of stroke patients in Ontario Canada. The affected lower limb of 13 chronic stroke patients presenting with either muscle weakness or increased reflex activity (hypertonicity), or presenting with both weakness and hypertonicity were strengthened. The strength training protocol used was an adaptation of standardised progressive resistance training, utilising isometric, concentric, and eccentric contractions of the hip (flexors, extensors, abductors), knee (flexors and extensors), and ankle (dorsiflexors and plantar flexors). After a 10 weeks strength training programme, the results obtained by Teixeira-Salmela et al. (1999) showed that the lower extremity strength increased by 42.3%, walking speed improved by 30.7%, and stair climbing improved by 37.4%. Ultimately, the positive results of this study built upon the initial research conducted by Engardt et al. (1995).

However, compared to Engardt et al.'s study (1995) which lasted only 6 weeks, the study by Teixeira-Salmela et al. (1999) lasted 10 weeks. Participants undertook concentric and eccentric progressive resisted muscle strengthening for 60 to 90 minutes three times per week for 10 weeks. The resistance training exercises were individually prescribed depending on the functional abilities of the participants (meaning there was no standard protocol used). This methodological approach may have created concerns and may have affected the credibility of the study with regards to standardisation of the types of resistance training used. Therefore, the results obtained from this study may be difficult to generalise across the management of most stroke patients. Although the participants were required to undertake resistance strengthening equating to between 50% and 80% of a single repetitive maximal (1RM), depending on their tolerance levels and capacity, this categorisation may have eliminated the standardisation of the exercise regime applied.

Other criticisms of the study by Teixeira-Salmela et al. (1999) include: firstly, all the participants were ambulatory chronic stroke patients, raising questions about the real benefits of muscle strengthening exercises, since it is assumed such participants were already functional. Secondly, the participants were functionally more active than the participants in Engardt et al. (1995). However, in contrast to Engardt et al. (1995), Teixeira-Salmela et al. (1999) had a control group to determine the effects of muscle strengthening on both groups of participants, while the former had only two treatment groups without a control group.

The main outcome measure used to assess the strength of the hip and knee flexors and extensors as well the ankle plantar-flexors and dorsiflexors by Teixeira-Salmela et al. (1999) was a Cybex II isokinetic dynamometer. The accuracy of the Cybex II in measuring the strength of the knee extensors and flexors may be debatable. This is because, for accuracy, the Cybex II requires the gravitational torque to be in a specific position within the axes of the range of movement (torques mutually exerted one on the other by the different forces and direction of movement). This may be slightly difficult to achieve with stroke patients. This is because technically the muscles of the affected lower limb in a stroke patient may either be weak and flaccid or they may be weak and spastic. Therefore, obtaining a valid result with this method meant the muscles had to remain fully relaxed during the passive fall (descending of the affected lower limb under the weight of the Cybex II machine) against the resistance offered by the dynamometer. This action may be difficult with this category of patients. In practice, several trials would need to have been performed in order to obtain the actual gravitational torque recordable by the Cybex II. Nevertheless, Teixeira-Salmela et al. (1999) recorded positive outcomes of the post-test analysis using the Cybex II machine.

Riolo and Fisher (2003), in an evaluation of the study by Teixeira-Salmela et al. (1999), observed that some of the outcome measures used to monitor the performance of the participants both pre-test and post-test appeared subjective (quality of life scale). Such subjective measures might not have objectively measured any associated functional improvement in the motor function of the participants in the intervention group.

In a follow-up study, Teixeira-Salmela et al. (2001) conducted strengthening exercises on 13 participants 9 months post-stroke, using exercises similar to the previous study of 1999. However, this study differed slightly because no special resistance equipment was employed; rather, body weight, sandbag weights and elastic therabands of eight different resistances were used for about 30 minutes to exercise the hip flexors, extensors and abductors, knee flexors and extensors, and ankle dorsiflexors and plantarflexors. The results obtained showed that during the first five weeks of the programme, walking intensity was increased from 50% to 70% of aerobic working capacity. Gait speed recorded post-training averaged 0.76 ± 0.37 m/second, which was significantly faster than the speed observed at baseline 0.60 ± 0.39 m/second, an improvement of 37.2%.

Unfortunately, there were no specifics on the intensity and types of muscle strengthening exercises carried out, which may therefore make it difficult to replicate by another researcher. Furthermore, Teixeira-Salmela et al. (2001) erroneously suggested that their study was a randomised controlled study, while in reality it adopted a pre-test/post-test research design (Riolo and Fisher, 2003). Since the study was not randomised, it raises the possibility of research bias in recording the progress achieved using muscle strength training.

Unlike the previous study that measured the affected lower limb muscle strength, sit-stand and stair climbing, Teixeira-Salmela et al. (2001) mainly evaluated improvements in gait parameters such as cadence, stride length, gait velocity and foot placement. Whilst the results of this study suggested there was significant improvement in functional motor activities in both control and test groups, the test group gained only a slight increase in functional activities compared to the control group; in spite of the fact that the test participants had additional training which was not standardised or recorded. Teixeira-Salmela et al. (2001) also observed changes in the joint profiles of the participants but gave a narrative description of these changes rather than analysing them statistically, thus, making the significance of the data difficult to determine.

Therefore, regardless of the 37.2% positive results obtained, the results of this study might not have provided convincing evidence to support the use of resistance strength training in clinical practice. This is because although participants improved, there was insufficient difference between the groups. Whilst this study suggests that aerobic exercise and strength training exercises enhance gait performance, the design of the study still calls into question the benefits of the use of muscle strength training (because the study was a pre-test/post-test design and involved only a single group of participants). Consequently, the strength of the evidence may be described as poor (Sackett, 2000). In addition, because there was no control group to make an effective comparison with, there are limits to the interpretation of the findings. This is based on the fact that, functionally, long-standing chronic stroke patients are expected to improve with everyday conventional physiotherapy practice and facilitation (Riolo and Fisher, 2003; Saunders et al., 2011).

Prior to the study by Teixeira-Salmela et al. (1999), Sharp and Brouwer (1997) undertook a six week pre-test/post-test study using muscle strength training of the lower limbs on 15 chronic stroke participants between 9 months and 18 years post-stroke. The study aimed to determine whether isokinetic muscle strength training could improve the strength of the hemiparetic knee musculature, improve functional mobility, and physical activity and to evaluate the effects of muscle strength training on spasticity in long-term stroke patients. Participants were required to perform isokinetic strength training of the quadriceps femoris and hamstring muscles of the affected lower limb. This study was similar to that of Teixeira-Salmela et al. (1999), for the participants recruited were chronic stroke patients. Thus, it suggests that these participants may have been previously exposed to a variety of conventional and unconventional rehabilitation procedures, signifying a possible methodological limitation to the results obtained.

Participants in the study by Sharp and Brouwer (1997) undertook exercises such as warm-up on a stationary bicycle, stretching of the quadriceps femoris and hamstring muscles of the involved lower limb, and strength training of knee extensors and flexors using an Orthotron isokinetic machine. The exercises were for 6 weeks (3 sessions per week), consisting of 3 sets of 6 to 8 repetitions using the affected leg at speeds of 30, 60, and 120 degrees per second.

The results of this study showed improved muscle peak torques of the hamstring muscles, the quadriceps femoris, peak knee flexors and extensor torques, with resultant improvement in gait velocity. The findings showed participants exhibited improvement in peak torque production of the affected hamstring and quadriceps muscles at all assessed speeds ($p < 0.05$), while tone remained consistent ($p = 0.87$). Gait velocity increased after training ($p < 0 .05$) and remained significant at follow-up ($p < 0 .05$). However, changes in stair climbing and timed up and go tests were not significant ($p = 0.37$; $p = 0.91$), although perceived gains in participants physical abilities at follow-up ($p < 0.01$) were observed. In summary, Sharp and Brouwer (1997) observed gains in strength and gait velocity, but no changes in reflex activity of the muscles. However, despite the observed gains recorded, there were no carry over effects or improvement four weeks after the study.

Other observations recorded were that gait velocity improved after training and this improvement was retained four weeks later, but there were no changes in Timed-Up and Go test (TUG) scores or in stair climbing ability. In contrast to the study by Teixeira-Salmela et al. (1999), Sharp and Brouwer (1997) observed some statistically significant changes in peak torque of the knee extensors and the knee flexors as well as walking speed - an improvement of 30.7% (1.03 ± 0.40 m/sec after training compared to 0.79 ± 0.31m per second, $p = 0.004$) pre-training. However, these results were not sustained four weeks after the intervention and this may question the efficacy of using muscle strength training exercises in the rehabilitation of stroke patients.

The outcome measures used in this study were the Cybex II isokinetic dynamometer and the pendulum test. The pendulum test was designed to measure the level of spasticity and observe whether spasticity increased as a result of the resistance muscle strengthening. Participants gained improved scores on the Human Activity Profile after training, and their scores continued to improve for a few weeks after the intervention. All participants subjectively reported perceived improvements in their functional abilities after resistance exercise training. The outcome measures used in this study appeared to provide more objective ways of recording the changes in muscle strength and functional activities compared to those used by Teixeira-Salmela et al. (1999). Nevertheless, it can be argued that the results may not be generalised, because the study was conducted on a long-standing (chronic) stroke population, and it provided weak evidence to support the use of strength training in all stroke patients.

Another flaw of the study by Sharp and Brouwer (1997) was that the participants were not randomised. It was essentially a pre-test/post-test study, which may have inadvertently sensitised the participants to what was being investigated (such as demand characteristics), thereby reducing the external validity of the study. A pre-test/post-test design has the disadvantage of often being time consuming and awkward to administer. Despite these limitations, the study provided useful evidence to suggest resistance strength training may have the capacity to improve muscle torque and functional ability without necessarily causing distortional reflex activities. This study provided support for the work by Engardt et al. (1995) on the use of muscle strength training.

While pioneer researchers in strength training in stroke rehabilitation focused on strengthening only the muscles of the affected lower limb, Weiss et al. (2000) differed methodologically from previous studies on resistance muscle strength training in stroke patients. In a study conducted in the United States, they strengthened both the affected and the unaffected lower limbs of stroke patients, using progressive resistance strength training. They argued that after a stroke, an individual becomes partially inactive and loses strength and functionality in not only the affected lower limb, but also in the unaffected upper and lower limbs. Carin-Levy et al. (2006); Scianni et al. (2010) supported this view that muscle weakness is present in both the affected and the unaffected limbs of stroke patients. Inactivity or immobilisation is thought to accelerate sarcopenia within two weeks of inactivity, decreasing mass muscle (Gray et al., 2012). Thus, damage caused by the stroke and decreased mobility would combine to produce a decline in muscle mass in the paretic muscles and, to a lesser extent, in the non-paretic muscles (Carin-Levy et al., 2006; Gray et al., 2012; Scianni et al., 2010).

In the affected upper and lower limbs, muscle weakness occurs primarily from the effects of the upper motor neuron lesion and secondarily from adaptations consequent to denervation, disuse muscle atrophy and inactivity. In contrast, muscle weakness in the unaffected upper and lower limb ipsilateral to the affected side of the brain occurs mainly as a consequence of disuse atrophy. Jorgensen (2001), however, suggested that the muscle weakness of the ipsilateral side of the stroke may occur as a result of bilateral projections of neural tissues to each cerebral hemisphere and not necessarily as a result of disuse atrophy. Thus, a lesion following a stroke affecting one hemisphere may cause bilateral motor effects on both the contralateral and the ipslateral limbs of the affected brain hemisphere. Hence, there may be a need to concentrate not only on the affected upper and lower limbs, but also on the non-affected upper and lower limbs. This is because there may be associated muscle weakness bilaterally.

Participants in the study by Weiss et al. (2000) were chronic stroke patients (one year and above post-stroke), very much like previous studies by Sharp and Brouwer (1997) and Teixeira-Salmela et al. (1999). The results of the study showed improved functional activities such as stair climbing and balance abilities, as well as improved knee extensor torque of the participants (lower limb strength improved by 68% on the affected side and 48% on the intact side). According to Weiss et al. (2000), the results of this study disproved the assumption that recovery after a stroke occurs predominantly within the first few months after a stroke and not later. However, it cannot be ruled out that these improvements resulted from the strengthening on the least affected side. Again, because the study lacked a control group, the results should be treated with caution.

Kim et al. (2001) conducted a separate study on the use of resistance muscle strengthening and the result were in contrast to the mild to moderate positive result obtained from the previous studies described above. In a double-blinded study conducted in Canada, 20 chronic stroke participants (with a history of a single stroke at least 6 months previously), were randomised into treatment and control groups. Strength training activities involved either 6-week interventions of maximal isokinetic strengthening (experimental group) or passive range of motion exercises (control group). The results obtained showed that both the experimental and control groups increased their strength and walking speed post-intervention. There were no differences in muscle strength, level-walking, stair-walking, and health-related quality of life (HRQoL–SF36). There were also no significant differences ($p > 0.05$) for any of the baseline parameters, such as lower limb torque, stair climbing speed, and level-walking speed between the two groups. Kim et al. (2001) recorded similarities in functional levels across the two groups (experimental and control). Nevertheless, they also observed that the experimental group tended towards greater strength improvement compared with the control group, but this was not significant ($p = 0.06$).

Moreland et al. (2003) conducted a randomised single blinded study on sub-acute stroke patients in Canada using progressive strength training. The study involved 133 stroke participants, randomised to either a distinct experimental group or to a control group (randomised group RT; control group CT). The experimental group participated in nine tailored lower-extremity progressive resistance exercises, while the control group performed the same exercises without resistance. In addition, all patients received conventional physiotherapy.

This study was similar to the progressive strength training research conducted by Weiss et al. (2000), but was distinctively different in terms of the research design (RCT with control group). The participants in Moreland et al. (2003) consisted of sub-acute stroke patients (less than 6 months post stroke), rather than chronic stroke patients as in previous studies (Badics et al., 2002, Kim et al., 2001, Sharp and Brouwer, 1997, Teixeira-Salmela et al., 1999).

Despite the methodological similarities between the studies conducted by Moreland et al. (2003) and Weiss et al. (2000), the latter reported a significant muscle strength increase of 68% on the affected side of the stroke patients and a 48% increase on the unaffected side. Moreland et al. (2003), on the other hand, reported evidence of a mild increase in functional muscle strength in the RT + CT group (9% - 40%) relative to baseline. However the changes observed did not significantly change the disability inventory or 2-minute walk distance ($p = 0.19$) in the experimental group compared to the control group. Moreland et al. (2003) noted that progressive resistance exercise, as applied in their study, versus the same exercises without added resistance did not affect common clinical measures of gross motor function and walking in stroke patients undergoing inpatient rehabilitation. However, as reported by other studies, Moreland et al. (2003) observed that there were no detrimental effects on muscle tone from the use of resistance muscle strength training.

The results obtained by Kim et al. (2001) and Moreland et al. (2003) contrasted with those of previous studies by Engardt et al. (1995), Sharp and Brouwer (1997), Teixeira-Salmela et al. (1999), Weiss et al. (2000). Nevertheless, because the study by Moreland et al. (2003) was a RCT, it may have produced a more objective clinical result. The significance is that, by using a RCT in which participants were placed in different controlled groups, the study would have tested the benefit of two different strength training programmes on gait. Unfortunately, in this study, strength training did not significantly improve gait when compared to other exercise programmes which did not involve strength training. Moreland et al. (2003) concluded that, although strength training has been shown to be helpful in a number of studies, the benefits are by no means consistent. Nevertheless, they also concluded that there is relative evidence to support the overall benefit of resistance muscle strengthening exercises for hemiparetic stroke patients; but, compared to other therapeutic exercises, strength training did not necessarily provide additional benefits.

Ouellette et al. (2004) conducted a RCT in the United States of America (USA) on chronic stroke patients (6 months to 6 years post stroke) similar to Weiss et al. (2000). They cited insufficient evidence from previous studies regarding the efficiency of muscle strength training on functional performance and disability as the main stimulus for undertaking the research. The study involved a 12-week high-intensity progressive resistance training programme (PRT) designed to examine the effects of lower extremity strength and power on both the paretic and non-paretic lower limbs. The fact that Ouellette et al. (2004) conducted a RCT made it different from Weiss et al.'s (2000) case-controlled study, or the pre-test/post-test studies of Sharp and Brouwer (1997), and Teixeira-Salmela et al. (1999).

The results obtained demonstrated a statistically significant increase in most of the muscle groups strengthened in the affected lower limb (peak power in the experimental group increased by 33.0% for paretic knee extension ($p < 0.01$) and by

28.5% for non-paretic knee extension ($p < 0.01$); while for the control group, there were marginal increases but these were not statistically significant.

The strength of this study is that the resistance training group significantly increased leg press, bilateral knee extension, and ankle plantar-flexion and dorsiflexion by between 11% - 67%, and this improvement was not observed in the conventional training (CT) group. These results therefore show consistency with those obtained by Engardt et al. (1995), Ouellette et al. (2004), Sharp and Brouwer (1997), Teixeira-Salmela et al. (1999), and Weiss et al. (2000). Ouellette et al. (2004) also demonstrated that muscle strength training significantly improved the functional motor performance of stroke patients such as: decreased stair climbing time; improved gait velocity; and improved sit-stand abilities. However, changes in these variables were not significantly different between both groups.

Despite the relatively positive results obtained from their study, Ouellette et al. (2004) concluded that more studies were required to corroborate their results, for this study was the first RCT at the time to investigate the effects of progressive resistance training on motor impairments, functional activities, and disability in chronic stroke patients. According to Ouellette et al. (2004: p1048), "*there is still conflicting evidence regarding the effect of lower extremity strength gains on functional performance measures, particularly in studies using resistance training as the sole intervention*" .

Yang et al. (2006) conducted a RCT in Taiwan, similar to that conducted by Ouellette et al. (2004), on the effects of repetitive task-oriented muscle strengthening of the lower limb muscles to evaluate its impact on stride length, cadence and gait. There were 24 participants in the experimental group and 24 in the control group. However Yang et al. (2006) recruited only stroke patients who were capable of ambulating at least 10 metres without any assistive device. Understandably, patients with such capabilities may be described as having appreciable lower limb muscle strength, which could be regarded as a shortcoming. Besides, Yang et al. (2006) did not expressively define the term muscle strengthening. Furthermore, the activities undertaken by the participants were basically every-day activities such as sit-stand, single leg stance, and step standing. These activities can be described as closed chain exercises or body weight resistance, but not genuine external weight resistance exercises.

Regardless of the experimental flaws, Yang et al. (2006) observed that stroke participants in the experimental group performed better than the control participants. The results showed that the muscle strength changes in the experimental group ranged from 23.9% to 36.5% in the unaffected strong-side muscle groups, and from 10.1% to 77.9% in the paretic-side muscle groups. However, in the control group muscle strength changes ranged from a 6.7% gain to an 11.2% decline (Yang et al., 2006). The outcome measures used were functional activity measures such as a six-minute walk test, Timed-Up and Go test, step test and dynamometer. There were significant improvements in the values of all outcome measures assessed.

Flansbjer et al. (2008) conducted a RCT in Lund Sweden, evaluating the effects of progressive resistance training (PRT) on muscle strength, muscle tone, gait performance and perceived participation after stroke. The study aimed to explore three factors in assessing the effects of PRT on the strength and tone of the muscles in chronic mild to moderate post-stroke hemiparesis: evaluating whether changes in muscle strength affected gait performance; its impacts on perceived participation; and to determine whether the improvements gained were maintained over a period of one to two years.

The measures were dynamic and isokinetic strength tests: 3-metre walk test; TUG; maximum walking speed; 6MWT; and muscle tone assessed with the motor assessment scale (MAS). The results obtained showed improvements in all outcome measures from the baseline measurements. Flansbjer et al. (2008) recorded improvements in dynamic knee muscle strength of 41% to 75% following PRT, compared to the values of between 24% and 38% obtained by Badics et al. (2002), Ouellette et al. (2004), Sharp and Brouwer (1997). Additionally, Flansbjer et al. (2008) recorded improvements of between 14% and 64% for isokinetic knee muscle strength at 60º per sec, similar to that obtained by Teixeira-Salmela et al. (1999) and Weiss et al. (2000), compared with figures of between 17% and 130% obtained by Engardt et al. (1995) and Ouellette et al. (2004).

As in the previous studies (Teixeira-Salmela et al., 1999; Weiss et al., 2000), the participants in Flansbjer et al.'s (2008) study were chronic patients who were six months or more post-stroke. This means that these results may not be generalised for acute and sub-acute patients. Furthermore, the research therapist that supervised the resistance training was the same person who assessed dynamic strength and muscle tone outcomes, creating doubts about the validity and reliability of the results of the study.

Bale and Strand (2008) conducted a RCT pilot study in Norway evaluating whether functional muscle strength training of the leg in sub-acute stroke patients improves physical performance compared to traditional physiotherapy training procedures. Their participants were sub-acute stroke patients, but the study was not specific on the number of days post-stroke. This may imply six-months post stroke, which may not necessarily be classified as sub-acute stroke. The findings of the study demonstrated that all patients in the functional strength training group and 70% of the patients in the conventional or traditional therapy group rated their overall status as very much improved. This result does not, however, categorically suggest that functional strength training of the lower extremities was responsible for the improved physical performance among the intervention group. This is because both groups improved simultaneously, irrespective of the treatment carried out (strength training or traditional physiotherapy training). However, Bale and Strand (2008) argued that a mild to moderate relationship was demonstrated between gait speed and muscle strength in different muscle groups of the affected lower limb of stroke patients in the intervention group.

In the UK, few studies have evaluated the effects of muscle strengthening in stroke management (e.g. Cooke et al., 2010a; Donaldson et al., 2009). Cooke et al. (2010a) and Donaldson et al. (2009) undertook RCT's comparing conventional therapy with functional strength training (CPT+FST) and conventional therapy and conventional therapy (CPT+CPT). These studies were conducted in two phases: the first phase aimed to compare the efficacy of FST in the restoration of lower limb function post-stroke; while the second phase investigated restoration of upper limb function post stroke.

Cooke et al. (2010a) recruited sub-acute stroke patients with an average stroke onset of 32.43 days. This was a RCT with three groups of stroke participants (CPT+CPT; CPT+FST; and control CPT only). Participants performed repetitive exercises of functional tasks such as sit-to-stand-to-sit, stair climbing or step ups, inside and outside walking, transfer training, bed mobility, and treadmill training with and without the use of a bodyweight support system. The intervention was done for an average of 60 minutes, 4 days a week for 6 weeks, by research physiotherapists who were independent of the clinical team. The study recorded increased function in the experimental groups (CPT+CPT and CPT+FST), compared to the CPT only group. Indices measured were walking speed, knee extension and flexion torques. After 6 weeks, walking speed was (CPT+CPT, p = 0.031; CPT+FST, p = 0.333), indicating that CPT+FST exercise training was not technically better than CPT+CPT as hypothesised.

Although there was functional improvement in both groups, statistically the CPT+CPT group appeared to perform better than the CPT+FST group. The variations in the study were attributed to the fact that CPT+CPT groups were exposed to the provision of additional sensory stimulation and preparation of joint and muscle alignment prior to activating the muscle or performing a functional task. It remains possible, however, that the functional activity included in routine CPT may have eroded the planned difference with experimental FST management. However, Cooke et al. (2010a) recognised this variation as a potential confounding factor, and therefore, the extra CPT encouraged sensorimotor interventions to enhance control and quality of movement because the group receiving additional physical therapy in the form of CPT showed greater improvement than the group that received it in the form of FST. In addition, routine lower-limb activity of the CPT+CPT group could have added to the benefit of routine CPT, and the extra FST was insufficient to provide further benefit.

An explanation for this experimental anomaly comes from the fact that the addition of CPT training to the protocol of CPT+CPT group created a simulation of the FST protocol. Hence the increased functional performance obtained in the CPT+CPT group compared to the CPT+FST group. It can be argued that comparative trials in the previous studies on muscle strength training tend to avoid including strength training in the control intervention, unlike in the study by Cooke et al. (2010a). In addition, the number of repetitions undertaken in the CPT + CPT protocol may have simulated exercises like progressive strength training which helped improve the functional strength of the CPT+CPT group.

Nonetheless, it was observed that the advantage of extra therapy was statistically significant for the FST+CPT group for knee flexion peak torque at outcome (p = 0.016). Generally, participants in the experimental groups (CPT+CPT and CPT+FST) achieved a walking speed of greater than 0.8 m/s at outcome and follow-up than the control CPT only group. The results support the experimental hypothesis that progressive strength training improves function in stroke patients. Furthermore, 6 weeks may not be adequate to record substantial difference in function. The American College of Sports Medicine (ACSM) recommended 12 weeks of regular training to achieve appreciable benefits with the use of resistance muscle strength training.

What is not clear about the study by Cooke et al. (2010a) is that, although intensity, duration and frequency were discussed, there was limited information on how functional activities undertaken by participants were measured. Although the experimental groups undertook functional activities such as sit-to-stand and stand-to-sit, the dose of eccentric or concentric activities was not objectively quantified. It is assumed that most of the exercise activities carried out by CPT+CPT and CPT+FST groups may have formed part of a typical clinical conventional physiotherapy exercise regime.

2.6. Muscle strengthening of the upper limb post stroke

Compared to the affected lower limb post stroke, there appear to be a limited number of research studies that have specifically concentrated on the upper limb. Winstein et al. (2004) assessed the effects of muscle strength training in the upper limbs by conducting a non-blinded RCT on acute stroke participants in the USA. They evaluated the immediate and long-term effects of upper-extremity rehabilitation approaches compared with standard care. The study stratified the participants according to the severity of the stroke and participants were randomly allocated to one of the three groups in the study (conventional physiotherapy; functional task practice; and muscle strength training). The duration and frequency of the intervention for all participants was carried out for 1 hour per day on 5 days per week for a period of between 4 and 6 weeks, with a minimum overall dose of 20 hours a week. The outcome measures used to monitor progress were: performance measures of impairment (Fugl-Meyer Assessment); strength (isometric torque); and function (Functional Test of the Hemiparetic Upper Extremity - FTHUE). The results of the study demonstrated an improvement from baseline values after the exercise period in all three groups.

Winstein et al. (2004) observed that participants in the strength training group gained a statistically significant improvement ($p < 0.05$) compared to the participants in the other two groups. They therefore concluded that the immediate benefits of a functional task approach appeared similar to those of resistance strength training, but muscle strengthening appeared more beneficial with a carryover effect in the long-term.

Donaldson et al. (2009) conducted a randomised experimental study of CPT+CPT, CPT+FST, and CPT only, but on upper limb function of stroke participants with similar characteristics to Cooke et al. (2010a). This was the phase II study, while Cooke et al did the phase 1. Contrary to the results obtained by Cooke et al. (2009), Donaldson et al. (2009) observed that the CPT+FST group performed better in most of the outcome measures used as indices to measure any change. For example, one of the outcome measure (nine hole peg test), recorded median values with greater improvement in the CPT+FST group of 0.11 (IQR 0.27) pegs/second, which is 0.3 pegs/second higher than the median change in the CPT+CPT and CPT only groups of 0.08 (IQR 0.17). The results were not statistically significant, although subjects in the CPT+FST group achieved better results than the other two groups. The results support the experimental hypothesis proposed by Donaldson et al. (2009), that progressive strength training improves function in stroke patients. The results appear encouraging compared to previous assumptions that muscle weakness of the upper limb following a stroke may be difficult to rehabilitate.

The positive result obtained by Donaldson et al. (2010) was echoed by Harris and Eng. (2010), who explained that over 40% of stroke patients may never recover or regain the ability to undertake functional use of the upper limb in performing activities of daily living. However, with repetitive functional tasks, this figure may reduce.

Similarly, Thielman et al. (2004) conducted a pre-test post-test study to investigate the rehabilitation of the upper limb post stroke, using task-related training versus progressive resistive exercise. Twelve participants (5 months to 18 months) post stroke were recruited. The study evaluated the effectiveness of two rehabilitative approaches at improving the reaching function of the paretic upper limb in chronic stroke participants. The progressive resistance training group executed whole-arm pulls against the resistance of an elastic band. Participants were required to hold one end of the elastic theraband, while the other end was secured at a height parallel to the subject's elbow. The theraband was pulled in 4 directions: backward (shoulder and elbow extension), forward (shoulder and elbow flexion), contralateral (shoulder adduction and internal rotation, elbow flexion), and ipsilateral (shoulder abduction and external rotation, elbow extension) to the impaired side.

Based on the results of the study, Thielman et al. (2004) noted significant effects of upper limb and trunk functional ($F_{1,8}$ = 14.0, p < 0.01, $\eta 2$ = 0.64) pre-test and post-test. It was observed that, significant improvement was found only for low-level functional participants compared to high level functional participants (i.e. participants with low functional muscle activity).

2.7. Muscle strengthening of both upper and lower limbs post stroke

Whilst most of the research studies evaluated the effects of muscle strength training in improving the strength and functional activities of only the affected lower and sometimes the affected upper limb of stroke patients, Badics et al. (2002); Bourbonnais et al. (2002); Page et al. (2008) differed by evaluating the effects of resistance training on both the upper and lower limbs. Bourbonnais et al. (2002) in Canada conducted a single-blinded, randomised, controlled trial on 25 chronic stroke participants. This study differed from previous studies, because either the upper or lower limb was evaluated (upper limb n = 13 or lower limb n = 12); the untreated paretic limb of each group served as a control for the other group. The intervention was a motor re-education programme using a force-feedback programme thrice weekly for 6 weeks. Baseline and post intervention assessments of the performance of both the upper and the lower limb showed moderate gains in strength of the upper limb, ranging from 21% to 42% (or about 35% on average). However, when measurements obtained 2 weeks after initiating the treatment were compared with those obtained after treatment completion, the range was from 15% to 43% about (27% on average). Bourbonnais et al. (2002) concluded that the results obtained corresponded with those of previous studies (Engardt et al., 1995, Sharp & Brouwer 1997, Teixeira-Salmela et al., 1999, Weiss et al., 2000), indicating that strengthening programmes are effective in increasing the strength of paretic muscles in chronic stroke subjects.

Badics et al. (2002) undertook resistance strength training exercises on both the upper and the lower limbs, using the closed chain isokinetic machine (Proxomed device). The training consisted of 20 repetitions 3 to 5 times weekly for four weeks. Participants performed extension of the knee and hip joints, while arm presses with extension of the elbow joint and retroversion of the shoulder joint were used to strengthen the triceps muscle. This was a four-week study designed to evaluate the effects of muscle strengthening on tone and reflex activities.

Interventions used included closed chain exercises, which were not specified but involved applying targeted resistance strengthening to the upper and lower limb muscles (hip and knee flexors and extensors; shoulder and elbow flexors and extensors). The study did not specify the frequency of the exercises, although the authors stated that exercises were carried out for two to three days a week. The results obtained showed that the extensor strength of the leg muscles increased by 31.0 % and the supporting strength of the upper limbs increased by 40.2%. It was observed that the difference versus the baseline was statistically significant for both variables. Similar to the studies by Engardt et al. (1995); Badics et al. (2002); Sharp and Brouwer (1997); Teixeira-Salmela et al. (1999), it was observed that closed chain strength training exercises significantly improved muscle strength without necessarily causing hyper-tonicity and increased reflex activities of the affected muscles, as suggested in previous literature (Bobath 1990).

Page et al. (2008), on the other hand, conducted a single-blinded crossover randomised controlled pilot study in which a recumbent cross trainer locomotor machine (NuStep TRS 4000) was used. Upper and lower limb reciprocal resistance training was assessed. Participants were divided into two groups, the test group (NuStep machine and home exercise programme – HEP). After eight weeks of using the locomotor resistance machine, the scores obtained using Fugl-Meyer and Berg Balance scales, showed changes in functional activities after NuStep participation. The participants in the NuStep +HEP exercise group displayed a +4.0 mean score change on the Fugl-Meyer, and +4.3 mean score change on the Berg Balance Scale. It was stated that these values transferred to participants' daily lives, where they reported being able to ambulate longer. However, based on the structure of the NuStep TRS 400, it may be difficult to quantify how a recumbent machine would strengthen both the upper and lower limbs. The NuStep provided an attached reciprocal leg/arm extension exercise movement against graded loads while the subject remains seated. However a flaw of this study is that the NuStep machine seems to be built for basically lower limb resistance as a leg press machine and not for upper limb resistance press. Hence the observed effects on the upper limb function may be contestable.

2.8. Intensity of muscle strengthening in stroke rehabilitation

Although strength training has been shown to be have mild to moderate beneficial effects post stroke, there are limited data to establish the dose-response required to establish the potential benefits of resistance training. The American College of Sports Medicine (ACSM) describe an effective exercise training dose as distinct exercise parameters of intensity, duration and frequency of application to effectively cause a beneficial change in muscle strength or functional abilities (ACSM, 2009). The AHSA recommended that strength training ought be conducted at 50-80% of the 1-repetition maximum (1-RM) for 10-15 repetitions for 2-3 days per week, and that resistance can be increased as tolerance permits for people with stroke (ACSM, 2009).

The interventions of some trials (e.g. Ouellette et al., 2004; Teixeira-Salmela et al., 1999; Wallace et al., 2006) meet some of the criteria and demonstrate appreciable benefits. However, similar benefits have been noted in trials whose interventions did not meet the ACSM criteria (Badics at al., 2002; Bale and Strand, 2008; Flansbjer et al., 2008). Other trials may have met the criteria of the ACSM, but the interventions were not fully reported especially with regards to exercise intensity (e.g. Cooke et al., 2010a; Yang et al., 2006). Arguably, the standardisation and dose-response or the intensity required for muscle strengthening exercise considered therapeutically appropriate is still considered a contentious issue (ACSM, 2009). This is because the recommendation applies to healthy normal individuals without an underlying pathology. The recommendation by the ACSM was first suggested in 2003, prompting researchers to further explore an appropriate dose-response for patients with muscle weakness following neurological pathologies such as a stroke.

Gordon et al. (2004) conducted a study in the USA, designed to establish the quantity of resisted exercise stroke patients may be able to carry out based on their capability and function. They recommended 10-15 repetitions for each set of resistance exercises at training intensities of 60% of 1RM to elicit maximal gains in stroke patients. They further suggested that resistance exercises in pathological conditions, especially neurological patients, should be applied methodically using reduced loads but with higher repetitions to achieve any meaningful output in muscle strength and functional activities.

In the UK, Wallace et al. (2010) conducted a study which aimed to standardise the intensity of muscle strength exercises in the treatment of the upper limb in rehabilitation medicine. The participants of the study included 11 chronic stroke patients with middle cerebral artery affectation who were a minimum of 1 year post-stroke. In the study, treatment consisted of a combination of strength and progressive resistance functional task training upper limb exercises and graded isotonic strength training. This involved 60%-80% of maximal isometric voluntary contraction measured in mid-range. All 11 participants attended therapy sessions for one hour daily over 10 consecutive working days which was in line with the ACSM guidelines (ACSM, 2009).

The results of the study indicated that nine goals were reached as planned and five goals were exceeded, suggesting that 88% of the goals set were successfully reached. There was a significant effect of the time of performance of upper limb function using the action research arm test (ARAT); the score was $\chi 2$, 3 = 15.618, $p < 0.001$ due to an improvement immediately after training, and was maintained at the three month follow-up stage ($z = -2.384$, $p = 0.016$).

Although the study by Wallace et al. (2010) was not a randomised controlled study; this fact was acknowledged and the researchers recommended that further studies be carried out. On evaluation of the study, it was observed that they did not specify the functional abilities of the participants, apart from stating that they were required to have some extension of the wrist. In addition, the minimum muscle strength of the participants was stated using the Medical Research Council (MRC) grading, but a more objective or calibrated muscle strength measurement (hand dynamometer), could have been used. Nevertheless, the study by Wallace et al. (2010) categorically explored the possibilities of achieving graded resistance exercise, dose-response and the intensity of exercises suitable for managing upper limb dysfunctions in stroke patients.

The issues of dose-response or intensity of resistance exercise required to be beneficial in the rehabilitation of neurological patients, such as stroke patients, is a key issue yet to be fully resolved (Kwakkel et al., 2004; Kwakkel, 2006). Knowledge about intensity or dose-response is still lacking in practice; often in the case of stroke management, what the clinician uses may be described as ungraded manual resistance exercises, which are not quantifiable or measurable. Realistically, only exercise regimes such as cycle ergometry, treadmill, or the use of calibrated isokinetic machines can be measured or monitored objectively, in order to regulate the frequency and intensity of exercise application. In principle, the effectiveness of resistance exercise training programmes depends on factors such as frequency, intensity of training, type of resistance, sets of exercises and the repetition being performed at regular intervals of 2 – 3 days per week for between 6 to 12 weeks to achieve any functional benefits. There are health benefits associated with the use of resistance muscle strength training as a counter measure in neurological conditions where muscle weakness compromises function (e.g. neuro-musculoskeletal disorders, immobilisation, injury, prolonged bed rest or conditions such as stroke), but these exercises may need to be objectively quantified.

The American College of Sports Medicine (ACSM) and American Heart Association (AHA) suggested physical activity and exercise recommendation (strength training) for people with stroke. This is incorporated in the guideline for elderly people (Gordon et al., 2004; Nelson et al., 2007). However the recommendation of the intensity suitable for stroke management is not based on a systematic review of the evidence, but supported by a small number of studies including some of which are uncontrolled (Whitall et al., 2000), and non-randomized (Rimmer et al., 2000). Other aspects of the recommended guidelines of the ACSM are based on recommendations for healthy people (ACSM, 2009) and non-stroke patient groups (Fletcher et al., 2001). Therefore the quality of the evidence is low and there is a lack of generalisability.

There are numerous plausible benefits for people with stroke associated with participation in, and adaptations from, resistance exercise training but the evidence appears incomplete and current recommendations are not based on randomized controlled trials and systematic reviews.

Clinical practice guidelines for fitness training after stroke do exist but these are weakly supported in terms of amount and quality of evidence. Peterson et al. (2005) and Rhea et al. (2003) conducted meta-analyses to determine the dose-response of exercises. They stated that when muscle strength training is carried out, the dose-response relationship is vital to the prescription of proper doses of training. The consequences of over-prescription of resistance training exercises might lead to over-stress injuries, while under-prescription might result in a failure to achieve the desired strength improvement. Although Rhea et al. (2003) specifically discussed the dose-response relationship as it affects athletes; it equally applies to patients with pathological conditions that may require their muscles to be strengthened. As previously stated, to achieve meaningful improvement in muscle strength, there should be a quantifiable relationship between the volume, intensity, and/or frequency of training.

Similarly, Andersen et al. (2011) in Denmark conducted 12 weeks of intensive rehabilitation comprising high-intensity strength training with near-maximal loads and body weight supported treadmill training (BWSTT). Strength training was performed unilaterally with the paretic leg only, while the contralateral non-paretic leg was used as a control leg that was tested but not resistance trained. The experimental design was a within-subject repeated measure with the paretic leg as the experimental leg and the non-paretic leg as the control leg.

All 11 participants were chronic stroke patients (greater than 6 months post stroke) who were attending outpatient service and had received at least 2 and 7 hours per week of rehabilitation, except one participant who had received none at all. The study comprised high intensity training lasting 90 minutes 5 times weekly for 12 weeks. The intervention consisted of 4 elements: high-intensity strength training; BWSTT; aerobic exercise; and functional training. The results showed that in the affected lower limb (experimental limb) knee extensor torque increased significantly in response to the intervention.

The values obtained showed significant improvements in knee extensor and flexor strength increased during all contraction modes and velocities. In the paretic leg, knee extensor torque during slow eccentric, static, and slow concentric contraction ($p = 0.01 – 0.001$) and gait performance increased 52–68%. Andersen et al. (2011) concluded that a regulated intensity of resistance exercises post stroke lead to clinically relevant neuromuscular improvements, stimulating increased lower limb voluntary strength and improved gait velocity during a wide range of contraction methods and velocities.

2.9. Spasticity and muscle strengthening in stroke rehabilitation

Spasticity typically denotes the effect of damage to the segments of the brain cells or spinal cord responsible for the control of voluntary movement (Richardson, 2002; Welmer et al., 2010). Spasticity causes tightness of the upper and lower limbs, leads to pain, and produces uncontrollable or involuntary limb movements in stroke patients (Smania et al., 2010). Despite the increased tone (hypertonia) that comes with spasticity, it usually co-exists with muscle weakness, and often interferes with general limb movements and gait (Smania et al., 2010).

In the past, neuro-physiotherapists thought spasticity needed to be reduced first before progressing to improve motor control in stroke rehabilitation. Lennon (2001: p925) stated that "*the reason why strength training was avoided was that*, *clinical therapists using Bobath's concept believed that overexertion will produce overflow and irradiation through the body, thereby reinforcing abnormal tone and stereotypical mass patterns of the affected side"*. Therefore, resisted exercises were usually avoided in patients with abnormal tone, mass movement patterns and mal-alignment. According to Lennon (1996: p37) "*too much effort by the patient and overuse of the unaffected side reinforced abnormal tone and movement of the affected side*".

Uncertainty around the effects of resistance muscle exercises on spastic muscles encouraged physiotherapists treating spastic stroke patients to rely on only functional approaches like the Bobath concept, the Brunnstrom approach, and other facilitating approaches (O'Dwyer et al., 1996). These management approaches were thought to empower patients to perform activities of daily living by improving normal motor patterns without necessarily stimulating muscle hypertonicity or spasticity (Lennon, 2001).

What is known about spasticity is that there may not necessarily be any cofounding relationship between spasticity and muscle weakness; rather, with a brain lesion, spasticity and muscle weakness coexist. The coexistence is based on partial or temporary damage to the motor cortex secondary to the brain injury (Ivanhoe et al., 2004; Sommerfeld et al., 2004; Wallace et al., 2010). Therefore, when there is associated spasticity in a stroke patient, appropriate management procedures are required to make the patient more functional.

The results obtained in the study conducted by Sharp and Brouwer (1997) showed that paretic muscle strength improved after training ($p < 0.05$) while tone remained consistent ($p = 0.87$). Gait velocity increased after training ($p < 0.05$). However, changes in stair climbing and Timed Up and Go scores were not significant ($p = 0.37$; $p = 0.91$). Sharp & Brouwer (1997) reported that there were no detrimental effects of isokinetic muscle strengthening on muscle spasticity; rather, there was slight improvement. The relaxation index of the muscles, although not statistically significant, showed some degree of flexor torque production ($r = 0.49$). However, they observed that for the participants with more severe spasticity, the relative gain in flexor torque and the relaxation index was 0.35, suggesting that the ability to improve flexor strength appeared to be weakly associated with the intensity of extensor spasticity.

The results appeared consistent with those obtained by Nakamura et al. (1995), who observed that there was no association between hyperactivity of the patellar tendon reflex with either isometric or isokinetic knee extensor strength. Despite the dynamism of the study by Sharp and Brouwer (1997), the results may technically be disputed. Methodologically, the study was not randomised, and may have contained errors based upon the fluctuations of spastic muscles depending on the time of day and other factors that may excite or relax spastic muscles. Nevertheless, the results of this study disproved the previously held assumption that muscle strengthening stimulated more reflex spasticity.

Studies by Badics et al. (2002); Cramp et al. (2006); Teixeira-Salmela et al. (1999); on resistance muscle strength training in spastic stroke patients, observed that spasticity was unrelated to locomotor impairments, but rather that isokinetic knee extension strength in the paretic limb appeared to be strongly enhanced with the use of progressive strength training programmes.

On the other hand, a systematic review (Morris et al., 2004) reported finding no evidence that muscle strength training increased spasticity or decreased the articular range of movement of the affected limb. Morris et al. (2004) reviewed eight articles including those by Bourbonnais et al. (2002); Sharp and Brouwer (1997); Weiss et al. (2000). Morris et al. (2004) observed that all the authors reported there may be a weak significant reduction in musculoskeletal impairments among patients treated with resistance muscle strengthening, without promoting further reflex spasticity.

Other systemic reviews by Ada et al. (2006); Bohannon (2007); Harris and Eng (2010) investigating whether muscle strengthening interventions increased strength, spasticity and functional activities in stroke patients, reaffirmed that muscle strengthening interventions were not harmful to stroke patients. Rather, muscle strengthening statistically augmented functional motor activities. The question however, is how clinical neuro- physiotherapists go about managing the treatment of stroke patients, with or without the presence of spasticity.

2.10. Muscle strengthening and brain plasticity post-stroke

Plasticity of the brain, usually referred to as neuroplasticity, is the ability of the brain to restructure, forming new neural connections after a neurological injury such as a stroke (Ward, 2005). Plasticity of the brain is facilitated by a number of factors that trigger neuronal stimulation. These may include physical activities, motor and cognitive learning, and environmental factors (Duffau, 2006; Elbert and Rockstroh, 2004). Studies on adult stroke patients have demonstrated functional changes in cortical excitability, metabolic rate, or blood flow after motor therapy, demonstrating evidence that increasing the intensity of post-stroke therapy and providing efficacious rehabilitation programmes, can enhance motor recovery (Gauthier et al., 2008).

In the adult brain, the degree of neuroplasticity that can occur is not fully known. However, it is acknowledged that with repetitive motor stimulation, facilitation of neural reorganisation occurs, allowing the brain cells to adjust and compensate in response to positive external stimuli such as resistance muscle strength training (Dimyan and Cohen, 2011). Brain mapping studies in patients have revealed that the brain reorganizes after stroke in relation to recovery of motor function. According to Cecatto and Chadi (2007: p137), "*stimulation-based therapy seems to play an adaptive role in the injured brain, modifying the functional organisation of the remaining cortical tissue, leading to clinical improvements*".

Muscle strengthening exercises can be regarded as repetitive and stimulatory, and hence may play an active role in the plasticity of the brain. The plasticity of the brain and adaptation of the human motor system in response to resistance exercise has been documented by different studies (Aagaard, 2003; Folland and Williams, 2007; Griffin and Cafarelli, 2005; van Cutsem et al., 1998). These researchers observed that there is a simultaneous enhancement in the firing rate and the recruitment of muscle motor units during exercise activities.

Patten et al. (2013), in a study conducted in the USA, investigated the effects of high-intensity and dynamic resistance training (power training) and whether it facilitated the recovery of motor functions in the upper-extremities of post-stroke participants. The study involved 19 chronic stroke participants (7-18 months post-stroke) in which the effects of two types of upper-extremity rehabilitation programmes were investigated: functional task practice (FTP) and functional task practice combined with upper-extremity dynamic high intensity resistance training, referred to as HYBRID. The outcome measures used for the upper-extremity assessment included the Wolf Motor Function Test (WMFT) and Fugl-Meyer Motor Assessment (FAS). Spasticity was measured using the Ashworth scale, while ADL function was measured using the functional independence measure (FIM). The results showed significant improvements in WMFT and FAS scores, although these were greater in the participants who received HYBRID training compared to FTP ($p = 0.049$). In addition, the functional improvements were significantly retained six months post-intervention ($p = 0.03$), and spasticity was barely affected as Ashworth scores were unchanged ($p > 0.05$). The results of the study by Patten et al. (2013) demonstrates that muscle strength training as a component of upper-extremity rehabilitation, promotes greater functional gains and drives neural plasticity following stroke. Thus, the study contributes to an evolving body of contemporary evidence regarding the efficacy of high-intensity muscle training in neuro-rehabilitation and the physiological mechanisms that mediate neural recovery.

Flavio et al. (2010), in another study, conducted resistance muscle training exercise on normal athletes in the USA. The study aimed to establish whether resistance muscle training induced supraspinal adaptations and movement-related cortical potentials (MRCP). Eleven participants performed progressive high intensity unilateral maximal and submaximal leg extension exercises on a modified leg press three times per week for three weeks but not on consecutive days. The results demonstrated that supraspinal adaptive changes do occur, stimulating plasticity when repetitive high intensity strength training exercises are carried out. The results were consistent with the study by Holtermann et al. (2007).

Research studies on neuroplasticity have shown that strength training activities such as resistance exercises, functional electrical muscle stimulation, modified mental practice, and intensive functional muscle training seem to have positive effects on motor system reorganization (Cecatto and Chadi, 2007; Pomeroy et al., 2010). Teixeira-Salmela et al. (1999) examined the effects of strengthening on the isokinetic torque of the lower extremity muscles. They argued that, rather than enhancing spasticity as previously claimed, there was evidence of improved functional motor activities such as increased gait speed, improved velocity of movement and stair climbing abilities. It can be argued that resistance strength training exercises play a positive role in improving the cognitive aspects of movement in stroke patients. This is probably because the corticospinal system is designed to have some overlap between motor neurons innervating muscles at one or multiple joints, which encourage the relearning of movement patterns. Strength training exercise is assumed to provide the corticospinal system with the flexibility to relearn movement, despite damage to parts of the primary motor cortex and its descending tracts activating the afferent and efferent pathways, along with synchronisation and cross-education of the motor units. When muscles are strengthened, they primarily become more efficient in maximizing voluntary contraction, leading to hypertrophy and an increase in the size of the muscle fibres (Harris-Love et al., 2011).

2.11. Systematic reviews on muscle strengthening post stroke

Systematic review of studies on muscle strength training by Eng (2004) concluded that there is insufficient or limited evidence supporting the use of muscle strength training on functional outcomes in persons with stroke. Eng (2004) was of the opinion that, although the majority of studies that evaluated muscle strength as an outcome demonstrated some improvements with levels of evidence ranging from II to V which is limited to very good outcome (Engardt et al., 1995; Badics et al., 2002; Bourbonnais et al., 2002; Kim et al., 2001; Moreland et al., 2003; Weiss et al., 2000). The designs of these studies are generally less rigorous pre-test/post-test studies with conflicting results in the controlled trials. Eng (2004) equally stated that two studies (Kim et al., 2001; Moreland et al., 2003) with slightly more rigorous RCT designs with PEDro scores of 7 out of 10 did not show statistically significant outcomes.

Kollen et al. (2006: p76), on the other hand refuted the efficacy of muscle strength training in the rehabilitation of stroke patients in a systematic review stating that; "*Impairment-focused programs such as biofeedback, neuromuscular electrical nerve stimulation, cardiovascular fitness training and muscle strengthening fail to generate functional improvements*". They also stated in their review of some clinical trials that the rationale for the different management approaches in stroke rehabilitation, including strength training, is still weak. However, this review conflicts and contrasts with some of the results from the other systematic reviews on muscle strengtrh training in stoke rehabilitation (Ada et al., 2006; Bohannon, 2007; Harris and Eng, 2010). The views of Kollen et al. (2006) had been previously echoed in two other systemic reviews (Eng, 2004; Morris et al., 2004). Firstly, Morris et al. (2004) reported an inconclusive verdict on the effectiveness of muscle strengthening in enhancing the performance of functional activities in stroke patients; and secondly, Eng (2004: p191) concluded that: *"Many research questions remain to be answered to optimize strength training in persons with stroke, particularly in identifying the types of muscle contraction, optimal training intensities, and the complementary role of other rehabilitation interventions (e.g. functional electrical stimulation, treadmill training)".* Some of the reviews questioning the effect of muscle strength training on function after stroke have generated further debates about the use of muscle strengthening in stroke management.

However, a systematic review conducted by Ada et al. (2006) on muscle strengthening interventions, including progressive resistance exercises undertaken in acute, sub-acute and chronic stroke patients from a pool of 15 clinical trials out of a total of 102 studies, produced different findings. Ada et al. (2006) concluded that muscle strengthening interventions had a weak to moderate positive effect on both strength (standardized mean difference of 0.33, 95% confidence interval 0.13 to 0.54) and activity (standardised mean difference of 32 at 95% confidence interval 0.11 to 0.53). In addition, Ada et al. (2006) reported that resistance muscle strength training had no effect on spasticity, refuting the preconception that spasticity increased with the use of resistance strength training. Despite these general results during the sub-acute phase, Ada et al. (2006), observed in their review that muscle strengthening interventions eventually increased strength by 0.45 at 95% (confidence interval: 0.12 to 0.78; $p = 0.01$).

Similarly, Bohannon (2007) conducted a systematic review on the use of resistance muscle strengthening in stroke patients. Bohannon (2007), similarly to Ada et al. (2006), concluded that resistance muscle training programmes positively facilitated increased strength and functional activities in stroke patients. Furthermore, he cautioned that, regardless of the mode of resistance training carried out by the clinician, resistance exercises should be directed at the functional motor activities the patient has difficulty performing (trunk stability, sit-stand activity, balance or gait).

The effects of strength training on upper limb function have been debated in several empirical studies and systematic reviews, including Eng (2004); Morris et al. (2004); Ng and Sheppard (2000); Pang and Eng (2005); van Peppen (2004). Interestingly, Morris et al. (2004) in a systemic review reported no significant effect using strength training in the rehabilitation of stroke patients. This result contrasts with studies conducted by Harris and Eng (2010), who recorded moderate improvement; and Eng (2004), who recorded inconclusive and marginal improvement in upper limb muscle strength and function with the use of muscle strengthening exercises after a stroke. Nevertheless, some of these studies have suggested that, with the use of muscle strength training exercises, there is a positive feedback mechanism of reactivation of both neural and muscular systems which can help stimulate an improvement in functional activities.

2.12. Summary of the research studies on muscle strengthening in stroke patients

In summary, after reviewing several articles considered suitable, the following conclusions were reached and they provided some of the themes used in developing the study questionnaire:

2.12.1. Stage of stroke that resistance training was carried out

The stages of stroke in which participants were recruited varied across the different studies. It was observed that five studies undertook muscle strength training in acute stroke participants (Cooke et al., 2010a; Donaldson et al., 2009; Moreland et al., 2003; Patten et al., 2006; Winstein et al., 2004). Only one study (Bale and Strand, 2008) recruited sub-acute stroke participants (32 days to 90 days post stroke). Cooke and et al. undertook muscle strengthening in participants (34 ± 20 days after stroke); participants in the study by Donaldson et al. were 7 days to 90 days post stroke; Moreland et al. recruited 30 to 54 days post stroke; while Patten et al. did not specify the onset of stroke, but indicated that the participant in a single case study was an acute inpatient. On the other hand, Weinstein et al. differed slightly because they recruited participants as soon as they were admitted to hospital (2 to 35 days post stroke). However, the other 22 studies recruited chronic/community dwelling stroke participants (ranging from 9 months post stroke to 10 years post stroke), during which time it is assumed muscle strength may be expected to be appreciably stable for those participants exposed to conventional physiotherapy or any other forms of stroke rehabilitation programmes or physiotherapy treatment. It can be argued that because most of the participants in the chronic/community dwelling research studies were already ambulant; these participants may therefore have had some preserved force-generating capacity in the previously trained muscle groups.

2.12.2. Types of muscle strength training carried out

It was observed that varied types of resistance muscle strength training programmes were used to strengthen the muscles across the studies. These included concentric training, eccentric training, isokinetic strength training (e.g. isokinetic dynamometer), functional task training (e.g. sit to stand, stair climbing), progressive resistance training, locomotor resistance training (e.g. circle ergometer), pneumatic machines (e.g. leg and arm press), body supported treadmill training (BWSTT), weights, springs and elastic theraband. Whilst few studies used either two or three types of muscle strength training exercises, several studies used multiple strength training exercises combined with other forms of exercise activities, making it difficult to conceptualise the actual effects of resistance muscle strengthening as an effective tool in improving muscle strength and function post stroke.

Kim et al. (2001) appeared to be the only study that simply used one type of resistance muscle strength training (Kin-Com isokinetic dynamometer where participants carried out isokinetic strengthening exercises). Similarly, two studies used only two types of muscle strength training exercises (Bourbonnais et al., 2002, Weiss et al., 2000). Six studies with a total of 246 participants (between 10 to 48 participants in each study) employed a combination of two or more mixed resisted muscle exercises to the experimental limb using weights, exercise machines, or elastic devices in assessing the effects of resistance training (Bale and Strand 2008; Cooke et al., 2010a; Flansbjer et al., 2008; Ouellette et al. 2004; Teixeira-Salmela et al., 1999; Winstein et al., 2004). The majority of the studies, though, combined three or more types of exercises with resistance muscle strength training.

Isokinetic muscle training was observed to be the most frequently used resistance training (8 of the 30 studies reviewed). The studies that used isokinetic exercise dynamometers in combination with other exercises include (Bourbonnais et al., 2002; Clark and Patten, 2013; Cooke et al., 2010a; Cramp et al., 2010; Kim et al., 2001; Lee et al., 2013; Page et al., 2008; Sharp and Brouwer, 1997; Teixeira-Salmela et al., 1999). Four studies used concentric and eccentric resistance exercises in combination with other exercises (Cooke et al., 2010a; Clark and Patten, 2013; Engardt et al., 1999; Teixeira-Salmela et al., 1999).

It was observed that the use of eccentric contractions in resistance training may provide unique benefits for increasing neuromuscular activation post-stroke. It has been acknowledged that eccentric strength is more preserved than concentric strength following stroke (Engardt et al., 1999; Eng, 2009; Patten et al., 2006), suggesting that training with eccentric contractions may provide a more intense training stimulus. In post-stroke adults, Engardt and colleagues noted that the muscle strength of the paretic lower limb trained eccentrically improved, relative to the paretic lower limb trained concentrically.

Five studies used progressive resistance exercises (Cramp et al., 2010; Flansbjer et al., 2008; Moreland et al., 2003; Ouellette et al., 2004; Yang et al., 2006). Four studies employed pneumatic press strength training exercises (Andersen et al., 2011; Badics et al., 2002; Ouellette et al., 2004; Weiss et al., 2000). Seven studies used functional/task specific resistance training (Bale and Strand, 2008; Cooke et al., 2010a; Patten et al., 2006; Scianni et al., 2007; Sullivan et al., 2007; Thiemann et al., 2004; Winstein et al., 2004). Other types of resistance training used were BWSTT

(Duncan et al., 2011; Sullivan et al., 2007), cycling (Teixeira-Salmela et al., 2001; 1999), and treadmill training (Duncan et al., 2011; Sullivan et al., 2006). In addition, weights, elastic therabands and fixed resistances (Teixeira-Salmela et al., 1999) were utilised; and other types of resistance training used included: manual resistance, and every day functional activities such as sit to stand, body weight and fixed resistances. However these were combined with either isokinetic strength exercise or functional exercises.

It is pertinent to note that, the studies by Cook et al. (2010a); and Donaldson et al. (2009) differed from previous studies, because the participants were mostly sub-acute stroke and not chronic stroke patients (32.2 days SD = 14.0 post stroke). Furthermore, both studies were observer-blinded RCTs. However, the authors did not standardise the amount of resistance administered, except that all the patients performed five repetitions of the prescribed exercise regime. In experimental research of this nature, percentage standardisation may have been more appropriate to enable easy replication of the study in the future. In addition, the authors stated the research was 'strength training', but interventions were actually mixed training. Nevertheless, based on the results and the final outcome of the study, it appears apparent that the use of additional functional strength training in combination with conventional therapy positively enhance upper limb muscle function in the experimental group, compared to the control group, in all experimental parameters tested (such as grip strength, pinch force, elbow flexion and extension) (Donaldson et al., 2009).

2.12.3. Areas of the body strengthened

It was observed that the limbs strengthened varied between the affected and unaffected limbs. Bilateral lower limbs were strengthened most often, as seen in seven studies (Cramp et al., 2010; Cramp et al., 2006; Flansbjer et al., 2008; Page et al., 2008; Ouellette et al., 2004; Weiss et al., 2000; Yang et al., 2006). This was closely followed by five trials that undertook strength training exercises on only the affected lower limb (Engardt et al., 1995; Bale and Strand, 2008; Cramp et al., 2006; Sullivan et al., 2007). Three studies strengthened two limbs or all limbs (upper and lower limbs), the paretic upper and lower limbs, or the non-paretic lower limb (Badics et al., 2002; Bourbonnais et al., 2002; Sullivan et al., 2007). Four studies focused on only the upper limbs (Donaldson et al., 2009; Patten et al., 2006; Thiemann et al., 2004; Winstein et al., 2004). Three studies trained both the upper and lower limbs (Badics et al., 2002; Bourbonnais et al., 2002; Page et al., 2008).

In the lower limbs, muscle strength exercises were performed frequently on the hip flexors, extensors and abductors, knee flexors and extensors, and ankle dorsiflexors and plantarflexors. In the upper limb, the flexor and extensor muscle groups of the shoulder, elbow, and wrist were strengthened. However, it was noted that none of these studies specifically looked at muscle strength training of the trunk muscles. Three studies (Donaldson et al., 2009; Winstein et al., 2004; Thielman et al., 2004), incorporated aspects of trunk muscle strength training to improve upper limb function, but these studies did not specifically strengthen the trunk muscles; rather, they incorporated strength training exercises to help facilitate reaching activities and sitting balance.

2.12.4. Functional improvement with the use of muscle strength training

Based on the review of the literature, it was apparent that not all studies recorded positive outcomes with the use of muscle strength training in the management of stroke patients (e.g. Kim et al., 2001; Moreland et al., 2003). The outcomes obtained from the different studies are summarised accordingly below:

Muscle strength: In terms of increase in muscle strength, the recorded improved changes observed in studies that strengthened the lower limb varied (17% to 170%). Cooke et al. (2010a); Flansbjer et al. (2008); Sullivan et al. (2006); Teixeira-Salmela et al. 1999; Winstein et al. (2004) recorded statistically significant increases in muscle strength (between 30% - 42.3%) in the experimental groups compared to participants in the control group. However, the observed effects of resistance muscle training were minimal to moderate, indicating a low confidence effect (this means a difference that has minimum statistically significance for a 95% confidence interval, at the 5% level). Muscle strength was assessed at the hip, knee, and ankle joints, but not all studies measured each joint (example Engardt et al., 1995 and Sharp and Brouwer, 1997 measured only knee strength). Obvious functional change in strength was reported by Moreland et al. (2003). This may be because the participants recruited were from acute inpatient rehabilitation and the weights used were small ranging from 1.0kg to 2.1kg, which served to abnormally increase the observable percentage increase in strength. Either one or both of these factors may have contributed to the increased percentage gains in muscle strength, which evidently did not transfer to improved performance as recorded (Moreland et al., 2003). The conclusion was that, progressive resistance exercise as applied in their study versus the same exercises without added resistance found no significant difference in composite measure of muscle strength between the participants who received resistance training and those who received usual care at the end of intervention (low confidence effect).

Similarly, Kim et al. (2001) recorded a slight increase in muscle strength in both the experimental and control groups. However, there were no significant differences in composite measures of muscle strength between participants in the intervention group who undertook resistance muscle strengthening and the control group exposed to conventional physiotherapy management within the same experimental study.

Regarding knee extension activities carried out on a total of 65 participants, Bale & Strand (2008) and Kim et al. (2001) recorded no significant difference in knee extension torque between participants in the experimental groups who were exposed to between 6 to 12 weeks duration of resistance muscle strengthening and those who received conventional interventions. Contrary to these results, Engardt et al. (1995); Flansbjer et al. (2008); Teixeira-Samela et al. (2001); Weiss et al. (2000) recorded that resistance muscle strengthening exercises were associated with a statistically significant improvement in knee extension when compared to routine care at the end of the different interventions (increase of 43% to 77%). However, the results obtained from these four studies showed minimal to moderate statistical significance (low to moderate confidence effect). Increases were not always significant, particularly in comparison to alternative treatment physiotherapy treatment programmes. Increases appeared greater in the trained activities. A case example is Eng (2004) who observed that in RCT studies, non-strength variables in participants receiving conventional therapy recorded limited improvement after strength training exercises.

Similarly, Bale and Strand (2008) as well as Kim et al. (2001) documented no significant difference in knee flexion between participants in the intervention group who received resistance muscle strengthening and the control group who had routine physiotherapy management, Bale and Strand (2008) reported a very minimal difference, but the result was not significant enough to make any measurable statistical difference. Bale and Strand (2008) also noted that, while improvement of isometric muscle strength of knee flexors and extensors of the affected leg did not differ significantly between the groups, the symmetry of strength in knee flexors improved more in the functional strength training group.

Kim et al. (2001) showed patients allocated strength training of the involved lower limb on an isokinetic dynamometer (Kin-Com) exhibited no significant (borderline) improvement in the strength of the trained leg compared with controls (the sum of the percentage change in six muscle groups, $p = 0.06$).

Flansbjer et al. (2008) obtained a similar result to Bale and Strand (2008), recording a slight difference in knee flexion ability, but which was not sufficiently significant, and thus, a very low confidence effect was reported.

2.12.5. Walking speed, gait pattern and gait velocity

Walking speed: Mild to moderate statistical improvements in walking speed were recorded in 11 studies (Bale and Strand, 2008; Cooke et al., 2010a; Cramp et al., 2006; 2010; Engardt et al., 1995; Flansbjer et al., 2008; Ouellette et al., 2004; Teixeira-Salmela et al., 1999; 2001; Weiss et al., 2000; Yang et al., 2006). The changes observed varied due to the variability of outcome measures used across the studies, these changes were assessed by evaluating reported changes in self-selected walking speed, fast walking speed, and/or the 6-minute timed walk test. Bale and Strand (2008) observed a statistically significant improvement in 7 of 9 outcome measures in the functional strength training group (e.g. weight bearing, gait velocity and cadence) on the affected lower limb with the use of resistance muscle strengthening activities. Teixeira-Salmela et al. (1999) observed that walking speed after training averaged 1.03, 0.40 (SD) metres per second, which was significantly faster than before training (0.79, 0.3l m/sec), an improvement of 30.7% (p = 0.004).

It was observed that lower-extremity muscle strength is appreciably associated with improved walking performance, which indicates a potential benefit for resistance training in rehabilitation of walking performance after stroke. While some studies reported significant, though modest, improvements in walking speed or function (Andersen et al., 2011; Clark and Patten, 2013; Flansbjer et al., 2008; Ouellette et al., 2004; Sullivan et al., 2006), others studies yielded inconclusive results (Moreland et al., 2003). Eleven studies reported a change in gait speed as part of their functional outcome. Five studies reported statistically significant changes in gait speed $p < 0.01$ to $p < 0.05$ (Clark and Patten, 2013; Engardt et al., 1995; Sharp and Brouwer, 1997; Weiss et al., 2000; Yang et al., 2006). Due to the variety of outcome measures used across the studies, these changes were assessed by evaluating reported changes in self-selected walking speed, fast walking speed, and/or the 6-minute timed walk test. Where available, changes in self-selected walking speed were used. If both self-selected and fast walking speeds were reported, the average of the two gait conditions was computed and this average was used to evaluate changes post treatment.

2.12.6. General functional improvement observed from different studies

In most studies reviewed, it was observed that there were indications of weak to moderate effects to support the use of muscle strengthening in improving functions of the lower and upper extremities post-stroke; and on rare occasions the evidence was moderate. Surprisingly, some of these studies appeared to suggest that incomplete evidence was found for an improvement in gait performance or walking endurance. The physiological explanation for these results suggested that functional activities do not just depend on muscle strength, but also on other parameters, such as: the task, environment cognition, perception, and the individual (Shumway-Cook and Woollacott, 2007).

Similarly, limited evidence was found for an improvement in hand-grip force, dexterity, symmetry of weight distribution, transfer activities, gait speed and stair-climbing. Despite some discouraging results, it was observed from the literature review conducted that the use of resistance muscle strength training exercises produced relatively positive outcomes in the performance of functional activities in stroke patients.

Resistance training for patients with stroke described in the literature (Table 2.1) was accompanied by mild to moderate increases in muscle strength, sometimes in excess of 50%. However, these increases were not always significant, particularly in comparison to alternative treatments. Increases were greatest in the trained activities: for example, Engardt et al. (1995) found that concentric isokinetic training of knee extension yielded greater increases in concentric knee extension torque than in eccentric knee extension torque. This follows from the principle of specificity of training. Improvements in non-strength variables after strength training were common in the studies reviewed. Unfortunately, non strength variables rarely improved more for patients in resistance training groups than for patients receiving conventional therapy or other interventions. Patients whose resistance training involved body weight and functional activities such as sit-to-stand, however, seemed to realise greater improvements in some aspects of function (Duncan et al., 2011; Outermans et al., 2010; Sullivan et al., 2006). This too follows from the principle of specificity of training.

Studies by Cooke et al. (2010a); Horstman et al. (2008); Ouellette et al. (2004) suggested that muscle weakness appear to be the reason why stroke patients are unable to undertake physical activities. Limited data (3 studies, n = 168; 1 study, n = 31) suggest that strength may predict indices of disability. Likewise, Donaldson et al. (2009); Harris and Eng (2010); Pang et al. (2007) observed that there is a correlation between strength and lack of physical activities in stroke patients. Lang and Beebe (2007), Nowark et al. (2007) explained that muscle weakness is associated with loss of hand dexterity and fine movement, while Chae et al. (2002) discussed upper limb dysfunction. Similarly, Pollock et al. (2007); Pomeroy et al. (2008); Colebatch (1989) reported weakness of the lower limb muscles; Karatas et al. (2004) described weakness of trunk flexion and extension, while Outermans et al. (2010), Cooke et al. (2010a), Tyson et al. (2009b), Kollen et al. (2005), Teixeira-Salmela et al. (2001), Nilsson et al. (2001) all reported gait impairments and reduced walking speed. Previously, conventional physiotherapy management (movement facilitation, passive and active exercises) of stroke patients was based on the principle opposed to quantifying strength in hemiplegic persons (Bobath, 1990; Lennon, 1996). Resistance muscle strengthening in stroke rehabilitation was avoided on the grounds that it stimulated negative reflex activities.

The conflicting results obtained from some of these studies may therefore discourage clinical physiotherapists from actually performing muscle strengthening exercises. Arguably, the evidence for changes in functional ability in response to strength training is less clear, some studies have demonstrated significant gains in function (Bale and Strand, 2008; Clark and Patten, 2013; Teixeira-Salmela et al., 1999; Yang et al., 2006) while others are less convincing (Kim et al., 2001; Lee et al., 2010; Ouellette et al., 2004). Gains have been demonstrated in walking speed (Bale and Strand, 2008; Engardt et al., 1995; Lee et al., 2008; Sharp and Brouwer 1997; Yang et al., 2006); endurance (Flansbjer et al., 2008a; Hill et al., 2012; Ouellette et al., 2004; Yang et al., 2006), sit to stand (Weiss et al., 2000), stair climbing ability (Lee et al., 2008, Teixeira-Salmela et al., 1999) and upper limb function (Clark and Patten, 2013; Winstein et al., 2004). Some of the disparity in the extent of gains seen in function may relate to the specificity of the strength training to the function being evaluated, the parameters of the training, and the population under investigation. A number of studies indicate that when training is conducted at a low intensity, short duration or with insufficient progression of load, gains in response to training are limited (Cooke et al., 2010a; Flansbjer et al., 2008b; Kim et al., 2001; Moreland et al., 2003).

Hence, it is important to investigate the clinical decisions of neuro-physiotherapists regarding the use of resistance muscle strengthening in stroke rehabilitation.

2.13. Clinical decision making in stroke rehabilitation

In making clinical decisions, neuro-physiotherapists have traditionally drawn on knowledge acquired from basic physiotherapy training, clinical experience, clinical observations, clinical judgment, intuition, opinions of experts, opinions of colleagues, and occasionally textbooks (Jensen et al., 2000; Rothstein, 2000; 1997; Sackley and Lincoln, 1996; Salbach et al., 2010; Turner and Whitfield, 1997). Experience gained from working with patients in clinical practice has been identified as a huge factor that influence clinical decision in general physiotherapy practice (Davidson and Waters, 2000; Illes and Davidson, 2006; Turner et al., 2001); and in stroke rehabilitation (McGlinchey and Davenport, 2014; Nilsson and Nordholm, 1992; Sackley and Lincoln, 1996).

Other studies have observed that clinical experience and research evidence are the two factors that mostly influence clinical decision in stroke rehabilitation (Jette et al., 2003a; Jette et al., 2005; Salbach et al., 2007; Stevenson et al., 2004). Whilst these two factors have been acknowledged as leading factors in making clinical decisions, physiotherapists also use a variety of clinical reasoning strategies, and they consider different factors to influence their clinical decision-making in the planning and the delivery of physiotherapy post-stroke (McGlinchey and Davenport, 2014). These factors include the patient's presentation and response to therapy, prioritisation, organisational constraints and compliance with organisational practice (McGlinchey and Davenport, 2014).

Clinical experience encompasses the knowledge gleaned from the direct care of patients (Jensen et al., 2008). However, direct experiential knowledge differs in meaningful ways from processed knowledge, such as published reports from research studies (Herbert et al., 2005). The practicing physiotherapist may rely on personal experience or attempt to learn from the personal experiences of others, but with experiential knowledge, it is assumed that more is generally considered better than less (Salbach et al., 2007). Hence, expert opinion, when based on extensive experience with large numbers of patients with neurological conditions, may be viewed as the highest form of experiential evidence (Salbach et al., 2011). It is believed that clinical experience provides a tool to assess whether differences in individual patients are compelling enough to alter treatment strategies by providing a variety of cases to which a new patient can be compared (Turner et al., 2001). Whilst experience is widely accepted as a requisite for expertise, it does not equate to expertise and is not the only factor that contributes to expertise in professional practice (Jensen et al., 1992; Jensen et al., 2000). An identified problem with experiential knowledge is that it may be prone to multiple kinds of cognitive bias (Elstein and Schwarz, 2002). In addition, clinical practice experience may tend to be static, meaning clinicians may be slow to adopt more promising strategies given that experience alone might not provide enough motivation to change one's pattern of practice (Tonelli, 2006).

Research evidence also constitutes part of the clinical decision making process, with a number of clinicians agreeing that research is important in reaching clinical decisions in stroke rehabilitation (Bernard et al., 2001; Jette et al., 2003a; Jette et al., 2003b; Metcalfe et al., 2001). However, clinical decision is not a linear process, but can be conceptualised as a decision spiral linked to the clinical presentations of the patient, and the best available evidence. It has been suggested that some clinicians perceive research evidence as a threat to certain practice routines they judge to be effective but lacking sufficient research backing (McGlynn and Cott, 2007), while in certain cases, some clinicians deem it not particularly relevant to practice (Jette et al., 2003a; Jette et al., 2003b; Rappolt and Tassone, 2002; Salbach et al., 2007; Stevenson et al., 2005).

However, it can be argued that presently in the professional and scientific context of stroke rehabilitation, research-based evidence forms a part of the clinical reasoning process. Presently, there exist a multitude of research studies on stroke rehabilitation, such as the use of functional electrical stimulation (FES), constraint induced movement therapy (CIMT), the use of virtual reality (VR) and the use of resistance muscles strengthening (MST) as adjuncts in stroke management (Salbach et al., 2007; 2009). Similarly, research studies on stroke rehabilitation are progressing at an ever-increasing pace (Salbach et al., 2010). However, researchers have reported that some physiotherapists have difficulty interpreting or translating the best current research evidence into clinical practice (Jette et al., 2003a; Stevenson et al., 2005; Stevenson et al., 2006). Other researchers are of the view that the information may be available, but that physiotherapists may be unaware of its existence or are unable to make use of the information (Salbach et al., 2007; Stevenson et al., 2005). Besides, there may be gaps between what is known and what is done in clinical practice (Cormack, 2002).

A criticism levelled against the implementation of the results obtained from research-based evidence is that occasionally the outcomes produced by different researchers might appear inconsistent. Also, time and again the results tend to suggest divergent views, often resulting in diametrically opposed management procedures (McGlynn and Cott, 2007). In certain instances, physiotherapists are slow or reluctant to implement some of these new research procedures alongside already established management procedures (Salbach et al., 2009). These outlined problems are similar in the case of resistance muscle strength training in stroke rehabilitation (Johnston et al., 2013).

Muscle weakness and diminished exercise capacity are prominent features during the protracted recovery period post stroke (Bohannon, 2007; Potempa et al., 2005; Rimmer and Wang, 2005). That the uptake of resistance muscle strength training is limited or has not been emphatically taken up into clinical practice, which prompts the following question: what are the clinical decisions that influence the uptake of muscle strength training in the rehabilitation of stroke patients (Bayley et al., 2012; McCluskey et al., 2013). Studies in the United States, New Zealand and some countries in Europe (e.g. Netherlands and Sweden) have sought to document and categorise the scope of physiotherapy intervention for people following stroke. Whilst there appear to be regional differences in the content of therapy, many studies do not overtly characterise strength training as part of their categorisation of therapeutic interventions (Signal et al., 2014). Often they consider strength training with other interventions such as passive movement and selective motor control (DeJong et al., 2004; De Wit et al., 2006; Gassaway et al., 2005; McNaughton et al., 2005). In a study on stroke management in New Zealand, Johnston et al. (2013) observed that only 58% of physiotherapists in New Zealand actually undertake resistance muscle strength training despite the recommendations outlined in the New Zealand clinical guidelines for stroke management.

Similarly in the UK, Jones et al. (2003) observed that 62% of neuro-physiotherapists acknowledge they undertake muscle strength training, while 38% (N = 267 of 704) of the participants reported not using resistive exercise to strengthen muscles. Of the, 62% who reported its use, it was noted that this was dependent on several reasons. Clinical experience topped the reasons for their decision to use or not to use resistive exercise (74% of those reporting yes and 48% of those reporting no). Experimental evidence was chosen as the second reason by 17% of those using resistive exercise and 10% of those not using resistive exercise. Basic educational training was the least popular reason with 2% of those who used and 20% of those who did not use resistive exercise.

Jones et al. (2003) concluded that the most frequently given reason for decisions not to use resistive muscle exercise was that physiotherapists focused on normal movement/Bobath concept rather than on increasing muscle strength. Some of the reasons not clearly stated in Jones et al. (2003) that influenced the use of resistance muscle training included the use of clinical guidelines and the attendance at continuous professional development activities. Other issues or questions not fully explored in the study by Jones et al. (2003), which may require to be explored further, include the types of muscle strength training exercises, the duration, the frequency and intensity of its use, and for which specific motor dysfunctions or impairment(s) resistance strengthening is being used. This result appeared different from a previous study undertaken by Turner and Whitfield (1997) who recorded that the top four reasons ranked as factors influencing clinical decisions were: basic educational training, prior experience, special courses, and suggestions by colleagues. Research literature ranked seventh. In the study by Turner and Whitfield (1997), they concluded that clinical practice was rather based on anecdotal evidence and basic training rather than evidence as factors which informed the clinical decision of respondents in the rehabilitation of patients. In an earlier study, Turner and Whitfield (1996) recorded that the most frequently cited reason for neurological management was attending special courses and clinical experience; while journal articles and literature were least considered.

Another reason that may influence the clinical decision-making of physiotherapists in stroke rehabilitation may include time factor. It is also important to note that the average physiotherapy intervention time during either inpatient or outpatient rehabilitation of stroke patients is between 35 minutes to 60 minutes, and about 45 minutes devoted to initial assessment (Bernhardt et al., 2007; Bernhardt et al., 2008; Gassaway et al., 2005). In the UK, the NICE guidelines on stroke management recommends a minimum of 45 minutes of treatment time daily per patient during the acute phase of rehabilitation. There are currently no studies in the UK to confirm if time influences the decision to use or not to use muscle strength training. However, some observational studies conducted in Australia have highlighted that a considerable amount of the patients' time in physiotherapy may be spent on working the muscle function at low intensities and frequencies (Kaur et al., 2012; MacKay-Lyons and Makrides, 2002; West and Bernhardt, 2012). Some of these studies suggested that strength training has not been well integrated into current clinical practice, and when it has, it is likely to be undertaken within a short period of time at low intensity or at a training dose which may not meet the recommended guidelines (Signal et al., 2014). Therefore, the effects of resistance muscle strength training post stroke on functional improvement with the application of inadequate intensity and frequency of training may produce insignificant increases in muscle strength or in functional activities.

Davidson and Waters, (2000) conducted a survey on physiotherapists working in the United Kingdom. The aims involved: a) gathering demographic information about physiotherapists working with different patients; b) identifying assumptions surrounding physiotherapy intervention; and c) investigating the types of treatments used in patient rehabilitation. Davidson and Waters (2000), as with the previous studies, observed that physiotherapists found it difficult to describe a theoretical basis for their choice of treatment. However the respondents stated that, the reason for choosing a particular approach was based on experience rather than through the use of published research results. Bernard et al. (2001); McGlynn and Cott (2006); argue that, although most clinicians believe that research is important, some prefer to practise routines they judge to be effective, and which are not particularly linked to the evidence.

Korner-Bitensky et al. (2008) in a Canadian study of 1,800 rehabilitation clinicians provided some evidence that rehabilitation therapists do not routinely apply best practices in stroke management. Consequently, useful treatments may not be provided, and less effective or less beneficial treatments may therefore continue to be practised. This raises an intriguing question: If not research evidence, then what sources of evidence do neuro-physiotherapists rely upon in their day-to-day practice? Carr et al. (1994) carried out a survey on choice of treatment in stroke rehabilitation of Australian physiotherapists. This was based on a previous study of Swedish physiotherapists (Nilsson and Nordholm, 1992). The aims, as with the Swedish study, were to establish: a) choice of treatment in the rehabilitation of individuals following stroke; b) factors influencing the choice of treatment; c) the theoretical bases for choice of treatment; and d) attitudes towards changing interventions. The results showed that, with regards to factors influencing choice of treatments, respondents ranked clinical experience through working with patients and information from colleagues as the most important factor that influenced their choice of treatment.

It can be argued that presently, there is no literature specifically looking at the clinical decision making of physiotherapists exploring the rationale for the use or lack of use of resistance muscle training in stroke rehabilitation in the UK. The debate generated about the decision to use muscle strength training in stroke management may be similar to those generated in other neurological interventions (e.g. BWSTT, CIMT and virtual reality). However, resistance muscle strength training has the potential to be easily delivered within the neuro-physiotherapy units across the UK when compared to other interventions. Therefore, uptake might be expected to be faster compared to other interventions (BWSTT, CIMT and FES and virtual reality), which require specialist equipment or changes to the rehabilitation facilities to facilitate delivery. The delivery of resistance muscle strengthening can encompass many factors such as duration, frequency, time, the knowledge; organisational factors, the patient factors and several other factors. One method of understanding the delivery of physiotherapy is to explore the decision-making processes and barriers that guide this aspect of physiotherapy.

2.14. Barriers to the uptake of interventions in stroke rehabilitation

Physiotherapists involved in the management of stroke patients are expected to incorporate clinical experience with meticulous, precise and judicious use of research-based evidence to enable them to make informed decisions in the clinical management of their patients (Menon et al., 2009). According to Grol et al. (2004), some of the barriers identified with regard to the implementation of some research based evidence studies include lack of quality time in patient management, departmental and practice logistics, lack of staff competency, limited or no access to high-quality information, different conceptual models of theory, inconsistencies and contradictions with the expertise of clinicians, and finally the issue of colleagues and patients, who may insist on certain treatment approaches which are not supported by evidence based research.

Some studies argue that in spite of the expected benefits of implementing research based evidence, few physiotherapists do not readily consult the research literature to inform clinical decision making effective evidence based management difficult to accomplish (Jette et al., 2003a; McGinnis et al., 2009, McGlynn and Cott, 2007; Stevenson et al., 2005).

It can be argued that another probable barrier to the use of recent evidence-based procedures in clinical practice is that despite the awareness of clinical guidelines by physiotherapists, many may not have actually read those (Stevenson et al., 2004). This could be a result of time and pressure from an increasing patient caseload. Salbach et al. (2009) stated that the issue of time is not primarily due to lack of interest on the part of the physiotherapist, but may occasionally be due to a lack of mandate from the health care organisation. According to Salbach et al. (2009), it is due to the organisation's failure to provide protected time for clinical therapists to pursue evidence-based activities. Furthermore, the availability of relevant and up-to-date courses and departmental in-service training could be a barrier to the use of strength training in stroke management. The iimplementation of evidence-based practice is a complex task and is adversely affected by certain barriers.

Other studies have attempted to quantify the extent of the problem. Jette et al. (2003a), in a survey of 488 American neuro-physiotherapists found that a quarter of respondents rarely use research findings in clinical decision making, less than once in a typical month, compared to approximately 49% that reported its use in a typical month in Canada. Illes and Davidson, (2006), in another survey of 124 Australian physiotherapists, observed that 43.9% indicated that they less often integrated research evidence with their expertise or clinical decisions. The finding of Illes & Davidson (2006); Jette et al. (2003a) appear consistent with the study by Metcalfe et al. (2001).

In a UK based study of barriers to implementing the evidence base in four NHS therapies (physiotherapists, occupational therapists, speech and language therapists and dieticians); Metcalfe et al. (2001) observed that in day-to-day practice, clinicians hinge their clinical decisions on expert advice and years of clinical experience rather than those advocated by research evidence. The result of this study re-echoes the observation made by Turner and Whitfield (1997), who observed that, best current research evidence was rarely applied to patient care by UK based physiotherapists in stroke management.

Limited continued education and ineffective follow-up by reading recent research findings in evidence based journals may prevent some clinicians from embracing dynamic evidence regarding patient management (Jette et al., 2003a; Salbach et al., 2007). On the other hand, negative perceptions about some hotly debated research studies like strength training in stroke rehabilitation tend to present unforeseen barriers in the acceptance and implementation of such management procedures (Johnston et al., 2013).

Despite the acknowledged benefits of muscle strength training in stroke management and the recommendations in the NICE guidelines (Royal College of Physicians, 2008: section 16.15.1), there may be barriers that may militate against its use. One of these has been that physiotherapists are overly cautious in their rehabilitation of people with stroke for fear of adverse negative reactions (Brazzelli et al., 2011; Rose et al., 2011). Despite these fears, no fatal or adverse events have been reported in the literature on the use of strength training in people with stroke, and it is considered a safe and relatively low risk intervention (Billinger et al., 2014). Some studies have reported adverse events, but not adverse effects in response to strength training in a detailed manner (Hill et al., 2012; Lee et al., 2008; Ouellette et al., 2004; Stuart et al., 2009; Sullivan et al., 2007).

However, one frequently mentioned barrier to implementing resistance muscle training is patient tolerance (Bayley et al., 2012). The recommendation for the implementation of strength training stipulates that people with stroke work at an intensity of 50-80% of 1-RM for 30 minutes, 2 - 3 times weekly. Considering the allocated time (30 minutes to 45 minutes) for general stroke rehabilitation, this may be difficult to achieve, because more time may be required to work the muscles at the required intensity and frequency. In Australia Kaur et al. (2012) conducted a systematic review and reported that low level of physical activity within physiotherapy sessions is of concern, considering that clinical guidelines suggest that rehabilitation after stroke should be structured to provide practice time as much as possible, and that at least one hour per day should be spent in active task practice. The review suggested that stroke patients are actively engaged for only about 33 minutes of active task practice in each therapy session which falls well short of the recommended target if it is the only session provided during the day.

It is currently accepted that some physiotherapists use strength training in the management of stroke patients in the United Kingdom (Jones et al., 2003). However, much of the evidence supporting the content of the use of strength training, as well as acceptance, awareness of, and the knowledge about its application has not been fully established. It is assumed that there may be certain barriers militating against the successful implementation of strengthening in stroke rehabilitation. These barriers may include: ability to seek research evidence; awareness of the available evidence; clinical management skills; excessive caseload; knowledge of alternative management approaches; attitude towards certain management procedures; sticking to known approaches; and lack of the willingness to accept change in practice (Greenhaghl, 2004; Grol and Wensing, 2004; Jette et al., 2003b; Rapport and Tassone, 2002).

Interpretation of new and often contentious evidence-based research studies on management procedures can militate against the acceptance of such procedures in clinical practice. Despite clinical physiotherapists accepting and indicating that evidence-based practice is necessary in helping to improve the quality of patient care

(Jette et al., 2003b; Salbach et al., 2007), a sizable number of clinical therapists often avoid procedures that may be contentious preferring instead to rely on anecdotal routine procedures which have limited scientific evidence (Schreiber and Stern, 2005). Furthermore, clinicians may not adopt an evidence-based procedure if they do not believe in the evidence; understand the evidence or if they do not know the fundamentals concepts surrounding the evidence (Stevenson et al. 2005; Rapport and Tassone 2002). Moreover, clinicians may be wary and sceptical of accepting new knowledge due to negative perceptions of research and may deter its use in clinical practice as described in similar studies (McGlynn, 2007; Rappolt and Tassone, 2002).

Several surveys have been conducted in the UK to determine the clinical practice pattern of stroke management in the UK (e.g. Davidson and Waters, 2000; and Lennon, 2003), but whilst these surveys have detailed some insights into factors that influence physiotherapists' choices regarding stroke rehabilitation, there is as yet no study that underpins the assumptions underlying practice. To date only the study conducted by Jones et al. (2003) has investigated the use of strength training by physiotherapists in the UK; there is still a dearth of knowledge about what influences their decision to undertake strength training, the type of challenges they face and the barriers affecting practice. Furthermore, knowledge on the pattern of use is yet to be established. Despite the fact that clinical neuro-physiotherapists acknowledge they undertake muscle strengthening, the questions are how often do they strengthen the muscles, and what is their rationale for using muscle strengthening?

In summary, the following factors have been observed that can potentially pose a barrier or that may influence the clinical decision to use or not to use a treatment approach in clinical practice. These are: continuing professional development, expert opinion, specialism of practice, experience from patient management, guidelines /protocol, research-based evidence, and knowledge from basic educational training.

2.15. Research Questions:

The following research questions were formulated based on the gaps in the review of literature and the background to the study:

1. Do physiotherapists in the UK undertake muscle strengthening?
2. Does clinical specialism influence the decision to undertake muscle strengthening?
3. Does attending continuing professional development workshops and seminars influence the decision to use muscle strengthening in stroke rehabilitation?
4. Does reading of research articles influence the decision to use muscle strengthening in stroke rehabilitation?
5. Does experience as a neuro-physiotherapist influence the decision to undertake muscle strengthening (years of practice)?
6. Does the number of patients managed influence the decision to undertake muscle strengthening?
7. Are there barriers that militate against the incorporation of muscle strength training into stroke rehabilitation amongst neuro-physiotherapists in the UK?

2.16. Research Hypotheses

1. There will be no difference in the use of muscle strengthening across the UK.
2. There will be a positive association between the use of muscle strengthening and the specialism of practice, such that some specialisms might undertake muscle strengthening more than other specialisms involved with the management of stroke patients.
3. There will be a positive association between the attendance at continuous professional development programmes and the use of muscle strengthening in stroke rehabilitation.
4. There will be a positive association between the reading of research articles and the use of muscle strengthening in stroke rehabilitation.
5. There will be a positive association between the use of muscle strengthening and the number of years practised as neuro-physiotherapists.
6. There will be a positive association between the number of patients managed and the use of muscle strengthening.
7. There will be barriers faced by neuro-physiotherapists in the use of muscle strengthening in stroke rehabilitation.

The views of respondents will give more meaning to a confirmation or refutation of these hypotheses.

2.17. Significance of the study:

The results of this study will help to understand the management sequence that neuro-physiotherapists undertake in the rehabilitation of post stroke patients with muscle weakness. It is expected that this study will add to the existing body of knowledge on muscle strengthening techniques in stroke rehabilitation, and help understand the factors that influence clinical decision making and barriers to the implementation and use of muscle strengthening.

Table 2.1: Evaluation of studies undertaken to elaborate the effects of resistance muscle training post-stroke

Research Article	**Type of patients & Research design**	**Research Activity conducted**	**Outcome of research study**	**Critical Evaluation and Comments**
Andersen et al. (2011) Effects of intensive physical rehabilitation on neuro-muscular adaptations in adults with post stroke hemiparesis Journal of Strength and Conditioning Research 1-10	N = 11 Duration: 6 months post-stroke chronic stroke outpatient Requirement: Some voluntary muscle contraction in the paretic lower limb & Independent ambulatory patients Design: Within-subject repeated-measures design with the paretic leg as experimental leg and the non-paretic leg as the control leg. Objective was to improve walking speed, ambulatory speed, ambulatory safety, and maximum walking distance and to enhance the maximal muscle strength	Body supported weight treadmill training (BWSTT) followed by isokinetic resistance weights training Duration: 12 weeks Activity: The intervention comprised 4 key elements: (a) high-intensity strength training; (b) BWSTT; (c) Aerobic exercise; (d) functional training. High-intensity strength training was performed 3 x weekly, and aerobic exercise and functional training were performed 2 times weekly Frequency: 4-12 times weekly	After the 12-week conditioning program, knee extensor and flexor strength increased during all contraction modes and velocities in the paretic leg. Significant increases were observed for agonist EMG amplitude at slow concentric and slow eccentric contraction. Twitch torque increased, whereas twitch time-to-peak tension remained unchanged. By contrast, no significant changes were observed in the non-paretic	Strength training was performed unilaterally with the paretic leg only (PAR). The contra-lateral non-paretic leg was used as a control leg that was tested but not resistance trained (CON). There were 4 different strength training activities undertaken. Thus may be difficult to ascertain the particular strength training activity that would have had a more beneficial or functional effect.

Badics et al. (2002) Systematic muscle building exercises in the rehabilitation of stroke patients Journal of Neurorehabilitation 17: 211 – 214	N = 56 (56 lower limb, 36 upper limb) Residential neuro-rehabilitation Some voluntary muscle contraction in the paretic lower limb & Independent ambulatory patients Duration: 3 weeks to 10 years post stroke Design: Non randomised pre-test–post-test trial	Resistance weights (leg and arm press) Activity: 3 - 5 sets of 20 repetitions at 20% - 50% max Frequency: 2-3 times weekly Duration: 4 weeks	The study observed mean strength gain for the lower extremity of 31% while the upper extremity recorded an increase of 36.8% - 40.2%. Results showed that at 4 weeks, leg press increased 31.0%, and arm press increased by 40.2%	Functional activities not tested. However, spasticity was measured using the Ashworth scale and no changes were recorded. Clinical and neurologic follow-up examinations during and after the exercise program did not show any increase in muscle tone in any one case. However, other undesirable complications like joint pain or other signs of muscle overwork were absent. All of the 56 patients reported subjective benefits
Bale & Strand (2008) Does FST of the leg in sub-acute stroke improve physical performance? A pilot RCT Clinical Rehabilitation 22: 911–921	N = 18 (Intervention: 8 participants; 3 males and 5 females Control:10 participants 4 males and 6 females) Duration: 3 weeks to 10 years post stroke Design: Randomised trial of resistance training plus usual care	Activity: Resistance training with eight tailored exercises for the affected lower limb (stepping, sit-to-stand, heel/toe raising, and bridging). Tailored progression included using weights. Frequency: 50 minutes 3 days per week Duration: 4 weeks	Maximum weight-bearing on the affected leg improved more in the functional strength training group than in the training-as-usual group. However, the difference in change was not statistically significant	Very small sample size Poor external validity. The finding of the study was poorly reported

Bourbonnais et al. (2002) Effect of force feed-back treatments in patients with chronic motor deficits after a stroke American Journal of Physical Med Rehabilitation 81:890–897	N= 25 Community dwelling patients Independent ambulatory patients Duration: > 34 months post stroke Design: Single blind Randomised controlled trial	Upper limb and lower limb force feedback training dynamic strength training exercise Activity: upper limb 6-8 repetitions at 20% - 35%, progressing to 40% - 60% maximum Lower limb – 6 – 8 repetitions at 40% - 60% progressing to 70% - 90% maximum Frequency: 3 times weekly Duration: 6 weeks	Upper limb strength training recorded increases of 21%-42%, while lower limb recorded increases of 39% - 81% Measures: Fugl-Mayer test, TUG, & Chedoke-McMaster stroke assessment arm component stages 3 - 6	With the exception of the handgrip force, strength measurements of the treated limb increased after completion of the treatment. The outcome measurements of the upper limb of the subjects included in the upper paretic limb were not significantly different after treatment from those measured in the lower paretic limb. At 6 weeks, upper limb tests (Fugl-Meyer, TEMPA, and Box & Blocks, alternating movement) did not improve significantly. TUG did not improve significantly.
Clark & Patten (2013) Eccentric vs. concentric resistance training to enhance neuromuscula	N = 34 Community dwelling neuro- rehabilitation Some voluntary muscle contraction in the paretic lower limb & Independent ambulatory patients	Either CON-only or ECC-only resistance training of the paretic leg (lower limb eccentric & concentric muscle contraction Activity: lower limb 5 weeks dynamic high-	19 individuals with chronic hemiparetic stroke were randomly allocated to functional task practice (FTP) or hybrid (FTP and power training) for upper limb and then crossed over the alternative treatment. Assessments including	Significant improvement in WMFT-FAS was seen in the hybrid group compared to FTP alone post treatment (p=0.049) and at 6 months follow up (p=0.03). No significant difference in Ashworth scores were seen between groups.

r activation and walking speed following stroke Neuro-rehabilitation and Neural Repair 27(4) 335 -344	Duration: Above 18 months post stroke Design: Randomised controlled trial (concentric or eccentric exercises)	intensity resistance training Followed by 3 weeks of clinic-based gait training. Frequency: 3 times weekly Duration: 5 weeks	Wolf Motor Function Test (WMFT-FAS), upper extremity Fugl-Meyer Motor Assessment (FMA), Ashworth Scale, and functional Independence Measure (FIM) were conducted at baseline, post intervention and 6 months follow-up.	Significantly greater number of individuals in the hybrid group had a MID of two points or greater on the FIM compared to the FTP only group at post treatment and 6 month follow up (p=0.05).
Cooke et al. (2010) Efficacy of functional strength training on restoration of lower-limb motor function after stroke: phase 1 RCT Neuro-rehab & Neural Repair **24**(1):88-96	N = 109 In-patient neuro-rehabilitation Some voluntary muscle contraction in the paretic lower limb & Independent ambulatory patients Duration: 1-13 weeks post stroke Design: Randomised controlled trial	Body weight resistance exercises of both lower limbs (STS& other functional activities) Frequency: 4 times weekly Duration: 6 weeks	It was observed that at 6 weeks, knee torques increased in group undergoing CPT+CPT, but no significant added benefit was observed in the FST group compared to the CPT	At 6 weeks, gait speed & symmetry improved in group undergoing CPT+CPT group, but no significant benefit noticed in the CPT+FST group. The researchers stated the study was strength training, but intervention was actually a mixed training

Cramp et al. (2006) Low intensity strength training for ambulatory stroke patients Journal Disability & Rehabilitation 28 (13 &14): 883 – 889	N = 10 Community dwelling patients Independent ambulatory patients Duration 6 – 12 months Design: Non-random self-controlled trial	Resistance weights and elastic bands and body weights Exercises included wall squats, step-ups & 3 other lower limb exercises Activity: 3 sets of 10 repetitions, beginning at 20% 1 RM & increasing to 50% 1RM Frequency: 2 times per week	At cessation of training, isometric and isokinetic knee extension strength increased a mean 0–34%. Increase was significant in paretic limb. At 6 months, knee extension torque increased 32% - 34% on paretic side and 6% - 17% on non-paretic side. Knee flexion torque increased 0% on paretic and 6% on non-paretic side	Only isometric strength increased significantly in paretic limb. Knee flexion strength did not increase significantly in either limb. Participants recruited to the study were required to be able to ambulate independently either with or without walking aids and it was anticipated that they would demonstrate mild to moderate muscle weakness Only paretic knee extension torque increased significantly at all testing velocities
Cramp et al. (2010) Effectiveness of community-based low intensity exercise programme for ambulatory stroke survivors Journal Disability & Rehabilitation	N = 18 Already discharged from rehabilitation and community dwelling Independent ambulatory patients Duration 3 – 12 months post stroke Design: Time series experimental design	The participants completed baseline exercise programme of 4 weeks 1) a group exercise programme of low-intensity progressive resistive exercise and functional tasks for lower limb muscles 2) Repeat assessment after cessation of exercise.	Lower limb muscle strength improved after training. Paretic knee extension strength increased from after 16 exercise sessions. Walking velocity increased significantly, from 0.54±0.07 to 0.75±0.08. Balance and everyday function were also significantly improved ($p<.003$). There were marked individual variation in the response to training, and	The exercise regime was delivered by fitness instructors and not the principal researcher or a physiotherapist. The quality of the exercise sessions delivered may be difficult to ascertain. Again, the sessions were undertaken at leisure centres twice weekly for 14 weeks with physiotherapy support and the minimum attendance requirement was 16 sessions. Those who completed additional training

28: 883 - 889				did not show benefit.
Donaldson et al. (2009) Effects of conventional physical therapy and functional strength training on upper limb motor recovery after stroke 23(4) : 389 – 397	N = 30 Type of patients not fully stated 7 days to 61 days Randomised controlled trial	Resistance exercise raising bags using the upper limb Activity: 1-5 sets of 10 repetitions Frequency: 4 times weekly Duration: 6 weeks	Following treatment active ROM, tapping rate & grasp-release improved in resistance training groups. However, improvements were not significantly different from the other groups	Attrition rate was 6.7% at the end of treatment and 40% at follow-up. (Inter- quartile range) increases in ARAT scores were 11.5 (21.0) for CPT; 8.0 (13.3) for CPT + CPT; and 19.5 (22.0) for CPT + FST. The results were not statistically significant, although subjects in the CPT + FST group achieved the clinically important improvement.
Engardt et al. (1995) Dynamic muscle strengthening in stroke: effects on knee ext torque, EMG activity, and Motor Function Arch Phys Med. Rehab 76: 419 – 425	N = 20 ambulatory stroke patients (two groups of 10 patients) Duration: Minimum of 6 months post stroke Mean > 26 months Ambulating independently Design: Non-randomized trial	Concentric vs. eccentric isokinetic exercises of the knee extensors at different velocities (both limbs) Activity: 15 sets of 10 reps at 100% max after 3 sets of 10 sub-max Frequency: 2 times weekly Duration: 6 weeks	Both groups recorded increased muscle strength significantly (concentric and eccentric strength), but each increased more in its own mode of training. However eccentric training group improved in weight-bearing symmetry during sit-to-stand, while concentric group improved in gait variable.	Study was not randomised, there was no control group. Improved function may be attributable to natural recovery process. Pioneers of muscle strengthening

Flansbjer et al. (2006) Knee muscle strength, gait performance, and perceived participation after stroke Archives of Physical Medicine and Rehabilitation 87(7) 974-80	N=50 (38 men & 12 women) Community dwelling patients Independent ambulatory patients Duration: 6 – 48 months Design: Non-random self-controlled trial	Resistance pneumatic with weights while carrying out flexion and extension of the lower limbs Exercises included wall squats, step-ups & 3 other lower limb exercises Activity: 1 sets of 5 repetitions, beginning at 25% 1 RM Followed by 2 sets of 6 to 8 RM at 80% max Frequency: 2 times per week for 10 weeks	There was a significant correlation between knee muscle strength and gait performance for the paretic but not for the non-paretic lower limb. Strength for the paretic limb explained 34% to 50% of the variance in gait performance; the addition of strength for the non-paretic limb explained at most a further 11% of the variance in gait performance. There was a significant correlation ($p<.01$) between gait performance and perceived participation; gait performance explained 28% to 40% of the variance in perceived participation	Age influenced the predictions in this study were age contributed to the relationship between TUG and knee extension strength, and right sided weakness that contributed to the relationship between TUG and knee flexion strength.
Flansbjer et al. (2008) Progressive resistance training after stroke: effects	N=24 Community dwelling patients Independent ambulatory patients	Resistance pneumatic with weights while carrying out flexion and extension of the lower limbs Exercises included wall squats, step-ups &	At 10 weeks resistance training group increased 21.3% - 70.1% in the torque on the paretic side and 13.9% - 43.8% in the torque of the non-paretic side. Increases in	Although the resistance training group showed improvement in TUG scores (19.2%), fast gait speed (14.4%) and in 6MWT Perceived participation was assumed to have increased

on muscle strength, muscle tone, gait performance and perceived participation Journal of Rehabilitation Medicine 40(1): 42-48	Duration: 6 – 48 months Design: Non-random self-controlled trial	3 other lower limb exercises Activity: 1 sets of 5 repetitions Beginning at 25% 1 RM Followed by 2 sets of 6 to 8 RM at 80% max Frequency: 2 times per week for 10 weeks	resistance training group were significantly greater than in the usual or conventional activity group	in the resistance training group, but the changes did not differed significantly from that of the conventional group.
Kim et al. (2001) Effects of isokinetic strength training on walking in persons with stroke: a double-blind controlled pilot study Journal Stroke Cerebro-vascular Disease 10 (6) 265 – 273	N = 20 patients dwelling in the community (2 groups of 10 each) Duration: Minimum of 6 months post stroke Ability to ambulate independently Design: Randomized controlled trial	Compared passive range of motion exercises with Isokinetic flexion & extension of resistance exercises of the hip, knee, and ankle of the hemiplegic limb using an isokinetic dynamometer Activity: 3 sets of 10 reps at 100% max Frequency: 3 times weekly Duration: 6 weeks	After 6 weeks, there was improved strength with a mean of 7% – 155% on the paretic side. However, there was limited improvement in the resistance group in gait speed, stair climbing speed and health related quality of life Measures: Chedoke-McMaster stroke assessment, HRQoL & SF-36 QoL.	Presented as a double blinded study, but not stated if the therapists were fully blinded & how many therapists carried out the study. Gait velocity & stair climbing improved in the 2 groups but not there was no statistically significant Difference

Hill et al. (2012) American Journal of Physical Medicine & Rehabilitation 91(4) 265 – 273	N = 12 community dwelling patients in the (2 groups of 10 each) Minimum of 6 months post stroke Ability to ambulate independently Randomized controlled trial	Compared passive range of motion exercises with Isokinetic flexion & extension of resistance exercises of the hip, knee, and ankle of the hemiplegic limb using an isokinetic dynamometer Activity: 3 sets of 10 reps at 100% max Frequency: 3 times weekly Duration: 6 weeks	After 6 weeks, there was improved strength with a mean of 7% – 155% on the paretic side. However, there was limited improvement in the resistance group in gait speed, stair climbing speed and health related quality of life Measures: Chedoke-McMaster stroke assessment, HRQoL & SF-36 QoL.	Presented as a double blinded study, but not stated if the therapists were fully blinded & how many therapists carried out the study. Gait velocity & stair climbing improved in the 2 groups but not there was no statistically significant Difference
Lee et al.(2013) The Effects of Isokinetic Eccentric Resistance Exercise for the Hip Joint on Functional Gait of Stroke Patients	N = 20 (2 groups) In-patient neuro-rehabilitation Some voluntary muscle contraction in Duration: >3 weeks post stroke Design: Randomised controlled trial (RT + cycling vs. RT + cycling vs control)	The aim of the study was to determine the effects of resistance exercise strengthening of the hip flexor and extensor muscles on functional gait of stroke patients Frequency: 3 times weekly Duration: 10 - 12 weeks	The experimental group improved compared to the control. After 3 and 6 weeks of treatment, baseline muscle strength in hip, stair up and down time, TUG time and 10m gait improved. The control group showed no significant increase in hip muscle strength, stair up and down time, TUG time or 10 m gait velocity.	The muscle strengthening exercise was executed on a Cybex 770 dynamometer which requires some level of functionality to undertake its use.

Moreland et al. (2003) Progressive resistance strengthening exercises after stroke: a single-blind randomized controlled trial. Arch Phys Med Rehabilitation 84:1433-40	N= 133 in-patients undergoing rehabilitation RT + CT vs. CT RCT Conventional physiotherapy vs. Conventional physiotherapy and resistance training Sub –acute – chronic < 6 months	Weights & body weight resistance exercise: STS & eight other mostly functional (both lower limb exercises) Activity: two sets of 10 repetitions at subjective moderate resistance Frequency: 3 times per week Duration: 62 days	Strength of study is that at discharge, RT + CT group increased significantly (79% - 300%) relative to baseline. Measures: Chedoke-McMaster stroke assessment stage 3, 4, or 5 for lower limb.	At discharge, the increase was significant. However, improvements in Disability Inventory and 2-minute walk test did not differ between groups. No significant difference in length of stay or in changes in disability inventory or 2-minute walk distance
Ouellette et al. (2004) High-intensity resistance training improves muscle strength, self-reported function, and disability in long-term stroke survivors *Stroke* 351404-1409	N = 42 Community-dwelling weak to moderate stroke volunteers with residual muscle weakness 6 months to 6 years since stroke Ability to ambulate independently Randomized single blinded controlled trial	High intensity exercise training exercises: upper limb strength vs. resistance exercise Upper limbs stretches (4 limbs) Leg press lower limbs Activity: 3 sets of 8–10 reps at 70% 1RM Frequency: 3 times weekly Duration: 12 weeks	After 12 weeks, it was observed resistance training group achieved increased mean strength of 11% – 67%. Resistance Group's strength gains were appreciable improvement in some self-reported function but not in performance based function. Measures: 6 minute walk test, stair-climbing time, gait velocity and repeated chair-rise time	Study involved performance based functional measure. This may not be sensitive to task specific functional measures. Other: at 12 weeks, 6MWT and maximum gait velocity increased significantly in both groups. Changes in these variables and stair climb time, STS time & habitual gait velocity were not significantly different between groups.

Page et al. (2008) Resistance-based, reciprocal upper and lower limb locomotor training in chronic stroke: a RCT Clinical Rehabilitation 22: 610–617	N = 8 Out-patients dwelling in the community Duration: Minimum of 12 months post stroke Ambulating independently Design: Randomized, controlled, single-blinded crossover study	To determine efficacy of a bilateral reciprocal training regimen on the affected leg (dynamic balance and impairment) Frequency: 30 minutes each session, three days a week Durations: 8 weeks	Subjects were randomized: a) a resistance-based, reciprocal, affected leg locomotor training protocol using the NuStep apparatus and (b) a home exercise programme (HEP) consisting of self-supervised practice with fractionated joint movements of the lower limb.	Patients in the two treatment groups demonstrated impairment reductions as shown in Fugl-Meyer test and Berg balance scales. These trends were exhibited despite the group participants were assigned. It was observed that impairment reductions and balance gains may be achieved using a resistance-based, reciprocal upper and lower limb locomotor training protocol.
Sharp & Brouwer (1997) Isokinetic strength training of the hemiparetic knee: effects on function and spasticity Arch Phys Med Rehabilitation 78: 1231 – 1236	N = 15 patients dwelling in the community Minimum of 6 months post stroke Ambulating independently Non-randomized, self-controlled trial	Isokinetic exercise involving flexion and extension of knee of the affected lower limb Activity: 3 sets of reciprocal knee extension 6 – 8 reps at 100% max Frequency: 3 times weekly/40mins daily Duration: 6 weeks	Electromyography after 4 weeks, moderate strength increase of the paretic muscle. After 6 weeks there was 16% - 154% significant increase in flexion & extension strength, gait velocity and stair climbing speed Measure: Timed Up & Go test & Human Activity Profile Score (HAP)and Dynamometry measures	Observed eccentric muscle strength training exercises better in stroke than concentric Purported to be a randomised control trial, but would have been better described as non-randomised, self-controlled trial

Sullivan et al. (2006) Combined task-specific training and strengthening effects on locomotor recovery post-stroke: a case study Journal of Neurologic Physical Therapy 30 (3) 130 - 140	N=80 Community dwelling patients Independent ambulatory patients Acute 7day – 61 days 6 – 48 months Randomised controlled trial (CT + RT vs. CT)	BWSTT & upper extremity ergometry vs. BWSTT & loaded lower extremity ergometry vs. BWSTT & extremity resistance training using elastic bands Activity: 3 sets of 10 repetitions at 80% 10 RM Frequency: 2 times weekly Duration: 6 weeks	After 6 weeks, BWSTT + resistance training group gained significantly in comfortable gait speed 17.5%, fast gait speed 12.5 %, and 6MWT distance 22.7%. However, increases were not significant different from the other groups	The strength of the study was not made available
Teixeira-Salmela et al. (1999) Archives Physical Med Rehabilitation 80: 1211 – 1218	N = 13 chronic community dwelling chronic, weak stroke patients (7 subjects served as controls) Minimum of 9 months post-stroke A randomized pretest and post-test control group, followed by a single-group pretest	Isometric, eccentric, and concentric exercises using sandbags and weight machines Activity: 3 sets of 10 reps to the hip, knee, and ankle at 50% of 1-RM Frequency: 30 min 3 times weekly for 10	Improved ability to do household chores as reported by 39.2% increase in Activity scores Patients improved max patello-femoral angle at push-off and knee flex angle during swing in both limbs. Increasing in movement, power and work in hip and ankle and stair climbing Measures: Dynamometry,	Although the study reported increases in lower limb torque, participants were independently ambulant for 15 minutes with or without assistive devices. They had an activity tolerance of 45 minutes with rest intervals. This may not be a true measure as the participants were already confident and capable of undertaking several activities.

	and post-test design.	weeks Duration: 10 weeks	Human Activity Profile (HAP), and the Nottingham Health Profile (NHP)	
Teixeira-Salmela et al. (2001) Archives Physical Med Rehabilitation 80: 1211 – 1218	N = 13 chronic community dwelling chronic, weak stroke patients Minimum of 9 months post-stroke Design: A pretest and post-test control group, followed by a single-group pretest and post-test design.	Exercises consisted of warm-up, aerobic exercises, lower extremity muscle strengthening and cool-down. Activity: Not explicit, 3 sets of 10 reps to the hip, knee, and ankle at 50% of 1-RM Frequency: 30 min 3 times Duration: 10 weeks	After 10 weeks training, subjects were able to generate higher levels of powers and demonstrated increases in positive work performed by the ankle plantar flexor and hip flexor/extensor muscles. Research found improvements between pre-test/post-test measurements in gait velocity, cadence, and stride length.	Researchers described the changes in joint profiles rather than statistically analysing them, making the significance of the data difficult to determine. Study suggests that aerobic exercise and strength training can enhance gait performance; because used a single group and a pre-test/post-test. The strength of the evidence is poor
Thielman et al. (2004) Rehabilitation of reaching after stroke: task-related training vs. progressive resistive exercise.	N = 12 Duration: 5-18 months post-CVA (group divided within groups into high and low-level group) Design: Pre-test /post-test trial. - pre group: pre in proximal and distal upper	Training (trunk unrestrained) using the paretic limb Task-related training (TRT) involved reaching to objects placed across the workspace. Progressive resistive exercise (PRE) involved whole arm pulling against resistive therapeutic	Task related training resulted in increased substitutive trunk use at the target ipslateral to the moving arm and for midline and contralateral targets after PRE. Only low-level, TRT subjects straightened hand paths, which suggested better coordination of elbow-shoulder motion,	No significant differences between training conditions were found for other kinematic variables

Arch Phys Med Rehabil 85:1613-8	task related training	tubing in planes and distances similar to that in TRT. Duration: 4 weeks Frequency: 1 – 2 weekly (12 sessions).	and improved on the RMA. High-level subjects decreased trunk use at Ipslateral target after PRE, which was not observed after TRT. .	
Wallace et al. (2010) Standardising the intensity of upper limb treatment in rehabilitation medicine Clinical Rehabilitation 24(5): 471–478	N = 11 Duration: 12 months post stroke Design: Intervention research pre/post treatment	Strength of the affected upper limb using isotonic strength training at 60-80% of maximal isometric voluntary contraction measured in mid range Four blocks of strength training and three blocks of functional task practice.	Significant improvement in strength and functional activities for patients that completed the study. The outcome measures used (ARAT, Borg, & MRC), showed indices of improvement following the interventions.	Despite improvement noticed with other outcome measures, for the nine-hole peg test there was no significant change in values from the unaffected hand over time ($F(3, 21)=0.165$, $p=0.919$), indicating that any change in ratio scores was due to changes in the affected hand.
Weiss et al. (2000) American Journal of Physical Med. Rehabilitation 79 (4) 369 - 376	N = 7 home dwelling patients (minimum of 12 months post stroke, inability to stand independently > 15 sec on paretic lower limb	Use of resistance weight training using a pneumatic machine on both the hemiplegic and affected limbs. and Activity: Up to 3 sets of	There was improved strength with a mean of 2 – 77%. Significant improvement was observed using five outcome measures.	Procedure well explained. Study similar to previous studies, but in this study patients unable to stand for greater than 15 seconds. All parameters measured improved, but not in walking

	Design: Pre-test /post-test trial. Time series clinical trial: pre-test values compared to weeks 4, 8 & 12	8 to10 repetitions at 70% of 1repetition maximum (1RM) Frequency: 2 times weekly Duration: 12 weeks	Measures: Motor Assessment Scale, Berg Balance Scale, Sit- Stand performance, walking stair climbing speed	or stair climbing speed or unilateral stance time.
Winstein et al. 2004 A randomized controlled comparison of upper-extremity rehabilitation strategies in acute stroke: a pilot study of immediate and long-term outcomes. Arch Phys Med Rehab 85 (4): 620–628	N = 64 in-patients with recent stroke Acute, sub-acute, and weak patients Design: Non-blinded, randomized controlled design (baseline to post intervention, 9 months).	There were 3 groups: Group 1 received standard inpatient physio care (SC) only Group 2 received strength training & functional task training TRT or PRE in addition to SC Group 3 received strength training & functional task training in addition to SC Duration: 4 - 6 weeks	There was a significant increase in isometric torque when comparing groups 1, 2 & 3 pre and post-treatment. Measures: muscle strength, Fugl-Meyer Assessment, isometric torque and functional test of the affected upper limb. Test was concentrated on the upper limb, unlike previous lower limb studies. Participants were acute patients between 2 and 35 days post-stroke.	Compared with SC participants, those in the FT and ST groups had significantly greater increases in FM scores (P=.04) and isometric torque (P=.02) post treatment. Treatment benefit was primarily in the less severe participants. Similar results were found for the FTHEU and isometric torque. During the long term, at 9 months, the less severe FT group continued to make gains in isometric muscle torque, significantly exceeding those of the ST group (P<.05).
Yang et al. (2006) Task-oriented	N = 48 Independent ambulatory patients	High intensity exercise training exercises: upper limb strength vs. resistance exercise	Strength of the study: At 4 weeks, increases in strength in resistance training group ranged from	All functional outcomes except the step test were statistically significant

progressive resistance strength training improves muscle strength and functional performance in individuals with stroke Clinical Rehabilitation 20: 860-870	Randomised Control trial	Upper limbs stretches (4 limbs) Leg press lower limbs Activity: 5 minutes at each station with intensity 'graded' to each subject's functional level' Frequency: 3 times weekly Duration: 4 weeks	12% to 47.4% on the paretic side and 17.5% to 28% on the non-paretic side. Increases were significantly greater for all six muscle action in the resistance group	
Systematic Reviews				
Ada et al. (2006) Strengthening interventions increase strength and improve activity after stroke: a systematic review. Australian Journal of Physiotherapy 52: 241–248	N = 15 trials out of 102, Design: Systematic review with meta-analysis of randomised trials	Strengthening interventions including progressive resistance exercise	Strengthening interventions increase strength, improve activity, and do not increase spasticity. These findings suggest that strengthening programs should be part of rehabilitation after stroke No effect on spasticity.	Strengthening interventions had a small pos. effect on both strength (standardized mean diff. SMD)

Bohannon (2007) Muscle strength and muscle training after stroke Journal of Rehabilitation Medicine 39: 14–20	N = 15 Search identified 3 SRs, 5 RCTs and 7 other studies	Muscle strength and muscle training of the lower limbs after stroke	No statistical pooling. The ability of strengthening to enhance the performance of functional activities or participation remains uncertain, except perhaps regimens involving repeated sit to stand or step up manoeuvres.	Only articles addressing training of the lower limbs were included. Impairments can involve the non-paretic limbs and the trunk, as well as the more obvious paretic limbs.
Eng (2004) Strength Training in Individuals with Stroke Physiotherapy Canada 56(4): 189–201	N = 12 trials (9 lower limbs & 3 upper limbs) Electronic databases were searched for trials conducted from 1966 to 2002.	Level of evidence was graded using the PEDRo scores (1 -10), and nine of the studies were RCTs with PEDRo scores ranging from 2 to 7	The review noted that there is to suggest that the strength protocols in the studies reviewed may not be sufficient to transfer the strength gains to functional tasks without complementary task-specific practice. Many of these studies did not match the strength training protocol to the requirements of the functional tasks (e.g., ranges of motion, speeds of contraction, magnitude and type of contraction) which would enhance the specificity of the training	This review concluded that evidence for the effect of strength training on function after stroke was poor or insufficient.

Morris et al. (2004) Outcomes of progressive resistance strength training following stroke: a systematic review Clinical Rehabilitation 18: 27–39	N = 8 trials out of 350, Electronic databases were searched for trials conducted from 1966 to 2002.	This review was done to determine whether progressive resistance strength training reduces impairments, activity limitations and participation restrictions post-stroke.	They found out that there was evidence to suggest that progressive resistance strength training programmes reduce musculoskeletal impairment after stroke. Whether strengthening enhances the performance of functional activities or participation in societal roles remains unknown	Based on the results of this systematic review, it was suggested that muscle power could be compromised in some individuals after stroke, in addition to their difficulties activating muscles with appropriate timing and force generation to match varying tasks constraints
Harris & Eng (2010) Strength training improves upper-limb function in individuals with stroke A Meta-Analysis *Stroke* 41:136-140	N = 13 out of 650 trials identified, 13 Electronic databases were searched from 1950 to 2009	Randomized controlled trials that examined the effect of graded strength training program compared with one-dimensional or multi-dimensional programs were included. One arm of the trial had to include a component of strength/resistance training as an element of the intervention and comparison with a control group.	Strengthening interventions had a small positive effect on both strength and function, but no effect on spasticity.	The review was basically for the use of muscle strength training for the upper limb. Concluded that there is evidence that strength training can improve function without increasing tone or pain in individuals with stroke. The review recommended future trials investigate the intensity, frequency, and specificity of strength training required for improved performance in daily activities

Pak & Pattern (2008) Strengthening to Promote Functional Recovery Poststroke: An Evidence-Based Review Topics Stroke Rehabilitation 15(3):177–199	N = 11 The research studies included in were randomized clinical trials (RCTs), systematic reviews, and meta-analyses	This review was done determine whether high-intensity resistance training counteracts weakness without increasing spasticity post-stroke. it also evaluated if resistance training effectively improve functional outcome compared to traditional rehabilitation programs.	The review concluded there is evidence to suggest that resistance training produces increased strength, gait speed, and functional outcomes and improved quality of life without exacerbation of spasticity.	Only 11 studies met the inclusion criteria for the review carried out. Author suggested that there is limited/moderate evidence Authors suggested that historically, strengthening has been excluded from neuro-rehabilitation programs because of the concern that high-exertion activity, including strengthening, would increase spasticity. Contemporary research studies challenge this premise.
Saunders et al. (2014) Cochrane review Physical fitness training for stroke survivors	N = 32 These were different trials (cardio respiratory = 14 trials; resistance = 7 trials; and mixed training =11 trials)	14 trials that looked at resistance muscle training. Mixed and cardio respiratory trials were not looked at. , Total n = 14	Statistically significant improvement was observed only in FAC scores and max. Walking speed after walking training. However it was observed that any training induced benefit appear to be associated with specific or task related training	Mixed results from the studies evaluated, however there was moderate significant effects with the use of resistance muscle strength training. Advice for further investigations and research to be undertaken

Clinical decision making				
Davidson & Waters (2000) Physiotherapists working with stroke patients: A national survey Physiotherapy 86 (2): 69-80.	N = 973 Participants: Physiotherapists in the UK Design : National Survey(cross-sectional)	This study was designed to develop an insight into the existing profile of physiotherapists working with stroke patients in the United Kingdom. The study focused on the approach to treatment, conflict with other professionals and assumptions or beliefs surrounding different neurological intervention.	The findings revealed that stroke patients were treated across different locations (the community, medical wards, elderly wards and stroke units. The results showed a great deal of variation in the beliefs held by physiotherapists about treatment of stroke patients, despite the strong similarities in stated approach. The analysis also revealed the extent to which physiotherapists are in conflict with other professionals (namely doctors and nurses) about delaying walking with patients and their early discharge.	This questionnaire primarily used closed responses with limited options. However, the questionnaire attempted to provide answers which catered for most respondents. Junior physiotherapists with less than one year's postgraduate experience were excluded from participating,

Illes & Davidson (2006) Evidence-based practice: a survey of physiotherapist current practice Physiotherapy Research International 11(2) 93–103	N = 124 Participants: Physiotherapists in the Australia Design : National survey(cross-sectional)	The study was aimed investigating Australian physiotherapists' self-reported practice, skills and knowledge of evidence-based practice, and to examine differences between recent and experienced graduates physiotherapists with low and high levels of training and physiotherapists working in private practice and hospital settings	The result observed that recent graduates rated their evidence-based practice skills more highly than more experienced graduates. However, they did not perform evidence-based practice tasks more often. Physiotherapists with higher levels of training rated their evidence-based practice skills more highly, were more likely to search databases and to understand a range of evidence-based practice terminology than those with lower levels of training. This was also similar with private practice physiotherapists.	Physiotherapists were found to have a very positive attitude towards evidence-based practice, but despite this positive attitude some clear deficits emerged, in particular searching for and critical appraisal of research literature. Physiotherapists are unlikely to use resources they are not confident they can utilize effectively
Jette et al. (2003) evidence-based practice: beliefs, attitudes, knowledge, & behaviours	N = 488 Participants: Registered therapists with the APTA Design: A cross-sectional survey using mailed questionnaires	The study attempted to describe the beliefs, attitudes, knowledge, and behaviours of physical therapist as they relate to evidence-based practice (EBP) and to generate hypotheses	Evidence to suggest that physical therapist use evidence based literature to inform practice. There are barriers which include organisational and logistics. Younger graduate tended to use evidence more than the	The response rate (48.8%), was low, there were issues of reliability for some items, and a lack of information about the validity of the questionnaire used.

of physical therapists Physical Therapy 83 (9) 2003	Location: USA	about the relationship between these attributes and personal and practice characteristics of the respondents.	older graduates.	
Jette et al. (2005) Physical therapy interventions for patients with stroke in inpatient rehab facilities Phys Therapy 85:238 –248	N = 972 Participants: Stroke patients undergoing physiotherapy treatment Design: Information collected from therapist data form showing management carried out Location: USA	The aim of this study was to describe physical therapy provided to patients with stroke in inpatient rehabilitation facilities	It was observed that therapists selected an eclectic approach to intervention rather than specific intervention techniques. The approach to patients' care included interventions to remediate impairments and to compensate for functional limitations.	Therapists also reported frequently using motor control and motor learning approaches to facilitate all activities
McGlinchey & Davenport, (2014) Exploring the decision-making process in the delivery of physiotherapy in stroke unit Disability and Rehabilitation 1-8	N = 7 Participants: Neuro-physios in 2 sites of same NHS hospital Design: Focused ethnography Location: UK	Observation of the participants and interview sessions on factors that influenced the planning and delivery of physiotherapy sessions	Interconnected relationships in all the themes. The themes identified include: Planning the ideal physio The reality of physio delivery Factors that influence the choice of delivery	Factors that influence choice of delivery include: clinical experience, CPD and research-based factors.

Rappolt & Tassone (2002) How rehab-therapists gather, evaluate and implement new knowledge	N = 24 Participants: 11 OTs & 13 PTs Design : semi-structured interviews	The study focused on gaining an understanding of therapists methods for conducting their continuing education and translation of research into their clinical practice 11 OTs and 13 PTs, who treat low back pain agreed to be interviewed	Most participants were unsystematic in their approaches to evaluating and implementing new knowledge into practice Formal continuing education was highly valued and viewed to be in inadequate. Participants relied on informal consultation with peers as a source of new knowledge. Those practicing in isolation felt disadvantaged compared to their counterparts who were in an institutional setting. Others resigned to the organisational barriers as implementation of new knowledge	-Participants listed lack of resources for necessary equipment or materials and cumbersome admin rules for applying new rules were cited as drawbacks to evolution of their practice -Interdisciplinary programs were viewed as deterrents to practice innovations when team members could not be persuaded to make necessary changes -Time constraints due to increasing caseloads, were significant barriers to implementing new knowledge
Salbach et al., (2007) Practitioner & organizational barriers to evidence-based practice of physical therapists for people with	N = 270 Participants: Only therapists who treated people with stroke were eligible to participate Design: A cross-sectional survey using mailed questionnaires	The study was aimed at identify practitioner barriers (education, attitudes and beliefs, interest and perceived role, and self-efficacy) and organizational barriers (perceived support and resources) to physical therapists' implementation of	It was observed that only 50% of the respondents had learned the basics of EBP in their academic preparation or received training in searching or appraising research literature. 78% of the participants stated that research findings are useful in	Limited knowledge and lack of basic educational training, negative perceptions about research and physical therapists' role in EBP, and low self-efficacy to perform EBP activities represent barriers to implementing EBP for people with stroke that can be addressed through continuing

stroke	Location: Neurological practice therapists in Ontario, Canada.	evidence-based practice (EBP) for people with stroke.	improving clinical practice, but 55% were of the view that a divide exists between research and practice.	education. It may be an understatement to assume that organizational provision of access to web-based resources may be inadequate to enhance research use by clinicians.
Salbach et al., (2009) Factors influencing information seeking by physical therapists providing stroke management *Physical Therapy* 89: 1039–1050	N = 270 Participants: Only therapists who treated people with stroke were eligible to participate Design: Survey questionnaire Location: Neurological practice therapists in Ontario, Canada.	Questionnaires were used to identify barriers to implementing EBP at the practitioner, organization, and research levels, and to measure the performance of EBP activities of the respondents.	The study observed that the factors that were independently associated with reading research literature two or more times in a typical month were membership in a professional physical therapy organization, research participation.	
Stevenson et al., (2004) Do physios' attitudes towards evidence-	N = 30 Participants: Primary care musculoskeletal physiotherapists	The aims of this study were to investigate physiotherapists' attitudes towards EBP and to examine change in	The result of the study observed physiotherapists reported that they relied more on courses and in-service training for informing their clinical	Some of the respondent physiotherapists reported difficulty in reading journals and could not identify opinion leaders in key areas. In terms of clinical practice,

based practice change as a result of an educational programme?	Design: Intervention study Location: MSK therapist (community North Staffordshire).	their attitudes following an education package, which utilized local opinion leaders	practice. Most agreed that clinical practice should be based on the best available evidence and that they would change their clinical practice if evidence suggested they should do so.	literature, journals and research were ascribed low priority throughout.
Turner & Whitfield (1996)	N = 180 Participants: NHS hospital PTs%, in facilities providing PT clinical education. Design: Cross national Postal questionnaire survey Location: England & Australia.	The was designed to elicit information concerning their reasons for choice of physiotherapy treatment techniques; and background characteristics of participating physiotherapists: 1 Number of years since original qualification as a physiotherapist. 2 Whether the original qualification as a physiotherapist was diploma, graduate diploma or degree. 3 Post-qualification education undertaken; practice-related	The results indicated that both Australian and English respondents rely heavily upon their initial training when selecting techniques for treatment. This dependence on initial training would inevitably also influence the physiotherapists' experience of the effect of a technique on prior patients - which was the second most frequently given reason for technique selection listed by all respondents.	Reading was confined mainly to CSP's *Physiotherapy* and newsletters; exclusively so by 29%. Readership of other PT or medical journals limited. Slightly more extensive readership amongst graduates.

		courses, diploma, degree or higher degree.		
Turner & Whitfield (1997a) Physiotherapists' use of evidence-based practice: Physiotherapy Research International **2** (1):17–29	N = 180 (England) N= 141 (Austrialia) Participants: NHS hospital PTs%, in facilities providing PT clinical education. Design: Cross national Postal questionnaire survey Location: Australia.	This was a replication of Turner & Whitfield 1996, amongst hospital PTs (99% graduates) RR 59%, in facilities providing PT clinical education	The study observed high readership of the journal amongst participants; 90% read other journals. There was infrequent but widespread readership of medical & other journals. Readership greatest among participants enrolled on higher degree courses.	The questionnaire was designed to elicit information concerning (a) background characteristics of participating physiotherapists, and (b) their reasons for choice of physiotherapy treatment techniques. Rationale for EBP was: basic training, prior experience and suggestions from colleagues.
Turner et al., (1999) Physiotherapists' reasons for selection of treatment techniques: A cross-national survey Physiotherapy Theory and Practice 15 235–246	N = 180 (England) N= 141 (Austrialia) Participants: Physios in England & Australia. Design: Cross national Postal questionnaire survey Location: England & Australia.	The questionnaire was designed to elicit information concerning participants' reasons for selecting physiotherapy treatment techniques.	It was observed that for most techniques, selection was based primarily upon what was taught at initial training. Attendance at a practice-related course was favoured for specific techniques e.g. McKenzie. Prior experience with patients was also a	The results showed no major differences between the two national groups in the reasons they provided for their choice of treatment techniques, despite two decades of degree level education in Australia. Use of journal literature, and in particular research literature, as a basis for selecting techniques was virtually absent.

CHAPTER 3: Methodology

3.0. Overview

The previous chapter looked at stroke rehabilitation and evaluated the literature on resistance muscle strengthening, the clinical decision making process, and the possible barriers and challenges militating against the uptake of new procedures in rehabilitation of stroke patients, including the use of resistance muscle strengthening. This culminated in the formulation of research questions and hypotheses that were investigated.

This chapter presents the profile of the survey setting, the limitations of the data base used, the research design and the theoretical paradigm, the determination of the sample size, the questionnaire formulation and distribution. Other topics discussed include the procedures followed in conducting the pilot and main research surveys, the statistical methods used to analyse the data obtained and thematic interpretation employed to investigate the research questions. Additionally, this chapter provides details of how ethical approval was obtained for this study.

3.1. Profile of the research setting

This study was undertaken in the United Kingdom comprising: England, Northern Ireland, Scotland, and Wales. The target population was neuro-physiotherapists registered as members of the Association of Chartered Physiotherapists in Neurology (ACPIN). Permission to access the ACPIN database was obtained from the ACPIN Research and Ethics Committee (ACPINREC). When this study was conducted in

May 2012, ACPIN had a total of 2600 registered members who manage various neurological conditions such as spinal cord injuries, traumatic brain injuries, multiple sclerosis and stroke. The ACPIN database at the time showed that 1600 of the registered members indicated that their area of clinical specialty involved managing stroke patients as well as the rehabilitation of other neurological conditions. Therefore, the study population of this survey was based on 1600 ACPIN members involved in stroke rehabilitation.

It is important to mention that ACPIN is categorised as a clinical interest network group (CIG), recognised by the umbrella professional association known as the Chartered Society of Physiotherapy (CSP). While the CSP is an umbrella professional association, there is a regulatory body legally responsible for regulating all practising physiotherapists in the UK, known as the Health and Care Professions Council (HCPC) which regulates physiotherapy practice and 14 other Allied Health Professions. When this study was conducted in May 2012, the registered number of physiotherapists with the HCPC in the UK was 45908 (HCPC, 2012); and CSP membership was 43550 (CSP, 2012).

3.1.2. Acknowledged limitations of using the ACPIN database

Recruitment of participants in this survey was by purposive sampling. This is a type of sampling design used when a limited number of individuals possess the peculiarity of the research interest (Bryman, 2012). In this survey, a deliberate effort was made to obtain a specific representative sample population of neuro-physiotherapists who manage stroke patients (ACPIN). One of the disadvantages of this type of sampling is that the population selected may not be totally representative of the entire population, due to the potential subjectivity of the research database. Secondly, the results from such a survey may not be categorically generalisable. Another disadvantage is that the data base may not be fully updated: in this study, it was observed that information on the contacts of some of the intended respondents was not correct at the time of this research study. Despite these disadvantages, using purposive sampling (ACPIN data-base) appeared to be the only viable sampling technique suitable to obtaining information from this select group of physiotherapists.

3.2. The research design

A cross-sectional survey was selected as the research design suitable for achieving the aims and objectives of this study. Generally, a cross-sectional survey investigates a snapshot of a particular population (Cohen et al., 2011), and arguably provides the opportunity for description, comparison, analysis and interpretation of the characteristics of a study population within a set period of time (Bryman, 2012; Cohen et al., 2011). There are other types of surveys that could have been used in this study, such as longitudinal or panel surveys. However unlike a cross-sectional survey, a panel or longitudinal survey involves following-up the participants over a period of time to observe associated changes in the study population (Bryman, 2012; Carlson and Morrison, 2009; Cresswell, 2013; Fowler, 2009). Hence, considering the short time-frame of this study and the need to gather information from a cross-section of neuro-physiotherapists within a stipulated period, a cross-sectional survey was selected as appropriate to accomplish the study's aims and objectives.

Despite the advantages of a cross-sectional survey, there are documented limitations and disadvantages to its use. A cross-sectional survey does not measure or establish causality between two or more variables unlike a randomized control trial (RCT), a cohort study, or a case-control study; rather, it measures association between variables (dependent [response] and independent [explanatory]) in a target population (Blaikie, 2009; Bryman, 2012, Cohen et al., 2011; Rossi, 2010; Carlson and Morrison, 2009). This limitation of the cross-sectional design serves to limit generalisation of the results obtained (Blaikie, 2009; Carlson and Morrison, 2009; Cohen et al., 2011; Rossi, 2010).

Another disadvantage of using a cross-sectional survey is the potential for a few respondents to misinterpret some of the survey questions, which may have hindered them from providing illuminating information as required by the study. In this study, it was observed that, in certain instances, respondents did not precisely respond to some of the issues that the researcher hoped to explore. However, the problem of misinterpretation of the research questions was minimised by conducting a pilot study to explore how participants interpreted the survey questions. Based on the feedback from the initial pilot study, the researcher decided to include some open-ended questions, which enabled the respondents to provide more vivid explanations in their responses to some of the questions.

Thus, the questionnaire used in this survey was a mix of closed and open-ended questions, allowing for the collection of information and pairing of information so that the relationship between the data obtained was easily analysed. It is important to mention that a cross-sectional design can adopt a positivist or naturalistic theoretical perspective based on the design of the study (either a quantitative or qualitative design). Often, cross-sectional surveys are erroneously described as belonging to the positivist ideology which can be used to map out research variables such as factors that influence the outcomes or the behaviour of a specific population. First and foremost, a positivist research approach is not limited to experimental or pseudo-experimental studies; rather, it can equally encompass descriptive, predictive or explanatory studies, especially when these take the form of a cross-sectional survey. However in this study, a positivistic research ideology was used to explore the knowledge about and barriers to the use of muscle strengthening by practising neuro-physiotherapists. The use of this paradigm was intended to gather data to deduce some facts and objective realities that exist in clinical practice regarding the use of resistance muscle strength exercises in stroke rehabilitation.

The purpose of this study was not only to investigate the knowledge about, attitudes towards, and barriers faced by UK neuro-physiotherapists regarding the use of muscle strengthening in stroke rehabilitation; it was also intended to explore factors that influence the clinical decision making by practising neuro-physiotherapists (research evidence; NHS guidelines/protocols; clinical experience; basic university education or training; information received from colleagues and peers; or experience from clinical practice). In healthcare research, quantitative researchers are often criticised for their inability to obtain realistic interpretative information or rich qualitative narratives from research participants (Cresswell, 2013). This is because quantitative research studies are often regarded as number crunching, unlike naturalistic qualitative research which examines the reasons why people do things in the way they do (Creswell, 2013; Bryman, 2012; De Vaus, 2002). However, open-ended questions were used in this study to epistemologically create an understanding of the responses obtained from the participants and facilitate a better interpretation. Hence, the choice to undertake a research survey with a mix of closed and open-ended questions.

3.3. Pilot Study

A pilot survey was conducted before the commencement of the main research survey. Pilot studies are often recommended by scholars to address a variety of issues, including preliminary scale development. A pilot can also address concerns such as the adequacy of a questionnaire, explores the potential problems that may be associated with the data collection, item difficulty, estimated response rates, internal consistency, and investigates the feasibility of the study (Johanson and Brooks, 2009; Prescott and Soeken, 1989).

The study questionnaire used in this survey was developed by selecting standardised questions from previous survey questionnaires on types of treatment approaches used in the management of stroke patients (Davidson and Waters, 2000; Jones et al., 2003; Turner and Whitfield, 1999); barriers in the management of stroke patients (Jette et al., 2003a; Salbach et al., 2007). The selected questions from these studies were compiled and designed to explore the knowledge about and barriers to, the use of muscle strengthening in stroke rehabilitation. The questions were all pertinent to the intended construct and variables of this study. Conducting a pilot survey helped to strengthen the properties of the questionnaire, and it also provided the researcher with an opportunity to modify certain phrases in the questionnaire, thereby producing a clearer picture for the main study.

3.4. Sample size determination for the pilot survey

Thirty-seven (37) participants were selected for the pilot survey. The figure was based on the works of Hertzog (2008) and Johanson and Brooks (2009), who made different recommendations about sample size depending on the purpose of the pilot study, and he recommended 30 to 40 participants for cross-sectional pilot studies. Johanson and Brooks (2009) suggested that 30 representative participants from the population of interest is a reasonable minimum recommendation for a pilot study where the purpose is a preliminary survey in either a discussion or exploratory pilot study. Isaac and Michael (1995) suggested that "*samples with participant numbers between 10 and 30 have many practical advantages*" (p. 101), including simplicity, easy calculation, and the ability to test hypotheses, yet "overlook weak treatment effects." Nonetheless, Johanson and Brooks (2009) concluded there is no right or wrong decision about the selection of the number of participants in a pilot survey, and participant numbers between 30 and 40 were recommended as appropriate. Therefore, the selected sample size for the pilot survey was 37 neuro-physiotherapists.

The contacts of the participants were provided by the ACPIN Research and Ethics Committee Officer. The pilot survey was conducted in November 2011 for a period of four weeks. Using the Kwik survey web host (KWIK SURVEY), 37 pilot questionnaires were e-mailed in the first week of November 2011. After two weeks, the initial response rate was 10 respondents. An e-mail reminder was sent to non-respondents two weeks later in the third week of November, yielding six more responses, making a total of 16 respondents at the end of the four weeks pilot survey period. Of the 16 participants, 10 completed the survey questionnaire, while six were incomplete. This statistically represented a 43.2% response rate but only about 28% completion rate for the pilot survey.

Descriptive analyses of the 10 respondents, who completed the pilot study, showed that six respondents practised in England, three respondents in Scotland and one in Wales. There were no responses from Northern Ireland. The grades or NHS ranks of the respondents that completed the survey were: two Band 8; four Band 7; three Band 6 physiotherapists and one in private practice/charity. Regarding the hospital or facility where the respondents who completed the survey worked, it was found that five worked within the NHS Foundation Trust, representing 50% of respondents who completed the survey; two respondents practised in a primary care/community representing 20% of respondents; 2 respondents worked in a General Hospital; and the last worked in a private facility. 60% of the respondents agreed that muscle strengthening is appropriate in stroke rehabilitation, while 40% did not support the use of muscle strengthening. Based on the responses and outcome of the pilot study, some of the questions were restructured and modified.

In the pilot survey, provisions were made for respondents to offer comments and suggestions on necessary adjustments to the wording of the questionnaire. Feedback and observations received were acted upon to improve the quality of the main survey questionnaire. One of the suggestions by a respondent was to include a categorical definition of muscle strengthening at the beginning of the questionnaire to enable respondents to understand what constitutes muscle strengthening. Another respondent recommended that the main survey questionnaire should provide for open-ended questions to allow respondents make further comments, especially those with negative views about the use of muscle strengthening in stroke patients: "*the questionnaire can better be streamlined to allow respondents with divergent views on muscle strengthening to express their views or they should have been directed to move on to other questions that represented their views*". All suggestions and comments were taken into consideration in the final design of the main survey questionnaire. Furthermore, based on the responses of the pilot survey, the items on the questionnaire were modified from the 32 questions in the pilot survey to 23 questions in the main survey questionnaire.

3.5. Main questionnaire design

The main questionnaire had 23 questions, covering: demographic data; knowledge of strength training; types of muscle strengthening undertaken; factors that influence the choice of muscle strengthening; and barriers/challenges to its use in the rehabilitation of stroke patients. Most of the questions were closed-ended questions, with a few open-ended questions to enable the respondents to provide detailed information where required. The introductory page of the survey contained information explaining the concept and purpose of the study. Participants were also given assurance that the information gathered would be treated with the utmost confidentiality and anonymity. Additionally, the instruction page stipulated that participation was optional (Appendix 3).

Demographic information gathered from the questionnaire included: the region of the UK where respondents practice (survey item 19); NHS rank/grade in the hospital (survey item 20); length of time qualified as a physiotherapist (survey item 21); hospital facility where respondents work (survey items 22); and years of clinical experience as a neuro-physiotherapist (survey item 23).

The next set of questions sought to obtain information about respondents' specific area of clinical practice i.e. specialism of practice (survey item 1), how often respondents managed stroke patients (survey item 2); the number of stroke patients managed (survey item 3); and their knowledge of muscle strength training (survey item 4); whether the respondents considered the use of muscle strengthening as appropriate using a 7-point Likert scale (ranging from ‘very appropriate’ to ‘very inappropriate’); and if respondents use muscle strengthening in stroke rehabilitation (survey item 5). Those that indicated they do not use muscle strengthening were requested to progress to question 13, while those that indicated yes continued with the questionnaire (Appendix 3).

The next set of questions were muscle strengthening specific such as: stages of stroke rehabilitation they use muscle strengthening (survey item 6); factors that influence their decision to undertake resistance muscle strengthening (survey items 7, 13 and 14); types of muscle strengthening undertaken by neuro-physiotherapists (survey item 8); frequency of muscle strengthening exercise (survey item 9); and aspects of the body frequently managed by the use of muscle strengthening in clinical practice (items 10, 11 and 12).

The last set of questions investigated barriers and challenges influencing the use of muscle strengthening (survey item 17) and whether there are approaches that conflict with the use of muscle strengthening in stroke patients (survey item 18). Open-ended questions were used to enable respondents to explain in detail what constitute barriers and challenges.

Likert scale was used for the questionnaire items exploring knowledge, barriers, and skills related to the use of muscle strengthening. The anchors for the 7-point Likert scale were: ‘very appropriate’; ‘appropriate’; ‘slightly appropriate’; ‘neutral’; ‘slightly inappropriate’; ‘inappropriate’; and ‘very inappropriate’). Other questionnaire items seeking information required “yes/no” responses. Open-ended questions were used for some aspects of the questionnaire to facilitate qualitative interpretation of the respondents’ knowledge of muscle strengthening. Unlike closed-ended questions that encourage short or single-word answers, open-ended questions are intended to allow more narrative responses than closed-ended questions (Cohen et al., 2011).

3.6. Sample size determination for the main survey

Selecting an appropriate sample size is crucial in a cross-sectional survey to ensure that a reliable statistical power and confidence level are obtained in the outcome of the study (Cohen et al., 2011). Whilst it can be argued that conducting a survey with a small sample size might result in the omission of significant research findings; it is equally true that a relatively large sample size might be tantamount to wasting valuable time and resources (Bryman, 2012; Cohen et al., 2011). Therefore, an appropriate sample size was required in this study to avoid these problems.

The results obtained from the pilot were used to compute the sample size for the main survey. The pilot survey yielded a response rate of 43.2% and completion rate of 28%. The completion rate was used to compute the expected sample size for the main research survey using the Raosoft sample size calculator (Raosoft, 2011). The values were imputed based on a population of 1600 registered ACPIN members who treat stroke patients, at a confidence level of 95% and a margin of error of 3%, with an assumption of a 28% completion rate. This resulted in an estimated sample population of 560 participants. To avoid the problems of non-response, the decision was made to use a larger sample size (greater than 560); therefore, an additional 25% was included to resolve the potential issues of missing data and also to minimise sampling error. It can be argued that as sample size increases, sampling error decreases. This number is based on the fact that previous surveys with physiotherapists as participants had only yielded return rates of 58.3% (Foster et al., 1999); 61% (Haboubi and Lincoln, 2003); and 76% (Stenmar and Nordholm, 1994). As response rates for electronic surveys were suggested to be lower than their paper equivalents (Faulx et al., 2005), the computed sample was 700 participants who were invited to participate in the online survey to allow for a minimum response rate. Fowler (2009) reiterated that it is paramount to select an appropriate sample rather than a small sample size which may lead to the exclusion of a sizable number of the intended population selected for the study and which may evidently result in the omission of important research findings. The goal was to create a sample size large enough to obtain data that may be generalised to the population of all neuro-physiotherapists registered with ACPIN who manage stroke patients.

3.7. Distribution of main survey questionnaire

An electronic survey of neuro-physiotherapists involved in stroke rehabilitation in the UK was conducted using electronic survey software known as the Kwik survey. Respondents initially pooled to participate in the pilot survey did not participate in the main survey to avoid duplication of information. The main research survey lasted for ten weeks. Kwik survey has facilities that allow respondents and non-respondents to be tracked. A modified Dillman three-step mailing/internet procedure (Dillman, 2009) was followed to optimise the response rate. The first electronic questionnaire was sent in early May 2012, three weeks later, a reminder was sent to non-respondents. A second reminder was mailed to non-respondents at the end of May 2012, and a third and final reminder/questionnaire was sent in June 2012. After ten weeks, 410 respondents had completed the online survey out of a total of 700 initially invited to participate. However, only 401 completed the survey with nine incomplete responses, representing a 57.2% completion rate.

Table 3.1: Response rates from the main research survey

	Rate of Return
a. Number of surveys electronically mailed	700
b. Number of responses returned	410
c. Number of responses that met criteria for analysis	401
Raw response rate c/a	57.2%
d. Number of survey questionnaires returned (Undeliverable via email)	12

3.8. Reliability of the questionnaire

Prior to conducting the pilot study construct/content validity of the questionnaire was carried out. Four experienced practising neuro-physiotherapists in different areas of stroke rehabilitation were requested to contribute to the development of the questionnaire. These included: clinical stroke specialist (n = 1); physiotherapists that worked in an acute stroke unit (n = 2), and a physiotherapist that worked in the community involved in stroke rehabilitation (n = 1). Slight modifications were made to some of the questions based on the feedback received from the practising clinicians before the survey questionnaire was finalised and tested in a pilot survey.

3.9. Approach to data analysis

The data obtained was analysed using descriptive and inferential statistics using the Statistical Products and Service Solutions version 19 (SPSS 19). All closed questions were quantitatively analysed using SPSS 19, while open-ended questions were qualitatively organised based on the emergent themes. Therefore the sequence of data analysis used in discussing the results obtained involved more of quantitative analyses and less qualitative descriptive analyses (QUANT + qual). In this study, the researcher employed a mixed strategy only in the discussion aspect of the study. The purpose of using a mixed strategy was to obtain different but complementary information, to gain a better understanding of the research problem. Furthermore, the purpose of triangulating was to use the open-ended responses to corroborate the findings of the quantitative data obtained (Hanson et al., 2005). According to Creswell and Clark (2007) and Creswell (2013), QUAN + qual discussion often produced stronger evidence through the convergence and corroboration of findings by adding insight and meaning that might have otherwise been missed.

3.9.1. Weighting and analysis of the data obtained

As previously mentioned, the questionnaire used in this study involved closed and open-ended questions; hence the analysis of the data obtained involved a mix of quantitative and qualitative interpretation. Johnson and Onwuebuzie (2004) explained that there are three priority decisions in the analysis of data that involves a mixture of quantitative and qualitative data. Priority may be given to the data in several ways, that is more quantitative and less qualitative (QUANT + qual); more qualitative and less quantitative (QUAL + quant); or equal consideration of quantitative and qualitative (QUANT + QUAL), where the capital letters indicate the principal method. In any mixed research study only one of these sequences of data analysis can be followed. However, Morgan (1998) argued that it may be impracticable and contradictory to give equal priority to two methods and that instead one may take precedence while the other will support or give meaning to the data obtained.

Furthermore, there have been discussions about when it is appropriate for a research study to mix methods. Creswell (2013) suggested that the mixing of methods in a research study can occur at different stages: either at the data collection; data analysis; or data discussion, interpretation and integration stages. Taking cognisance of the research questions of this study, the decision was made to use the mix methods approach only during the discussion and interpretation stages of the results. Figure 3.1 illustrates the synthesis of how the data obtained was interpreted. The diagram also indicates that quantitative data was given priority over the qualitative data. Creswell (2013) maintained that, in a mixed research study the interest of the researcher determines which paradigm to assign priority or give more weight when conducting and analysing a research study.

Accordingly based on the rationale provided by Morgan (1998), a decision was reached to give more weight to the quantitative data and less weight to the qualitative data in the discussion of the results. Therefore a (QUAN + qual) was used only in the discussion of the results. This decision stemmed from my understanding of the research, namely that that quantitative data obtained will explain the associations between the different variables and the qualitative data will play a complementary role, by elaborating, clarifying and providing a better understanding of the quantitative data.

Figure 3.1: Flow diagram showing how the data obtained was interpreted

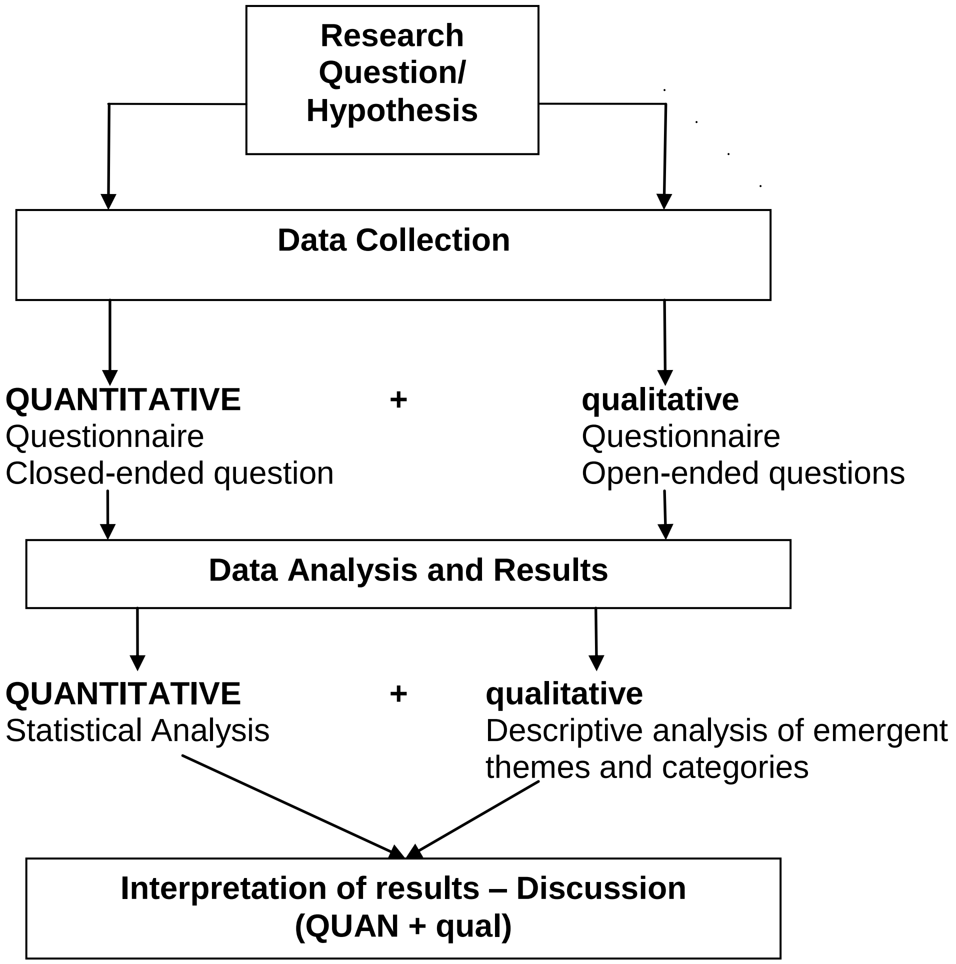


Figure 3.1: Flow diagram showing how data obtained was interpreted

Adapted from Glozah F. (2011) University of Essex Ph.D. Thesis

3.9.2. Quantitative data analysis

Before the commencement of data analysis, all quantitative data (*N* = 401) was scrutinised and screened statistically using SPSS 19 for accuracy of data entering, checking for outliners and upholding the assumptions of normality (Pallant, 2007).

The data obtained from the survey was analysed using descriptive statistics (frequencies and percentages); the prevalence of the use of muscle strengthening amongst respondents was estimated using percentages and frequencies. Chi-square and Spearman's rho correlation coefficient statistical tests were used to evaluate any associations between the variables. The statistically significant level was set at $\alpha = 0.05$.

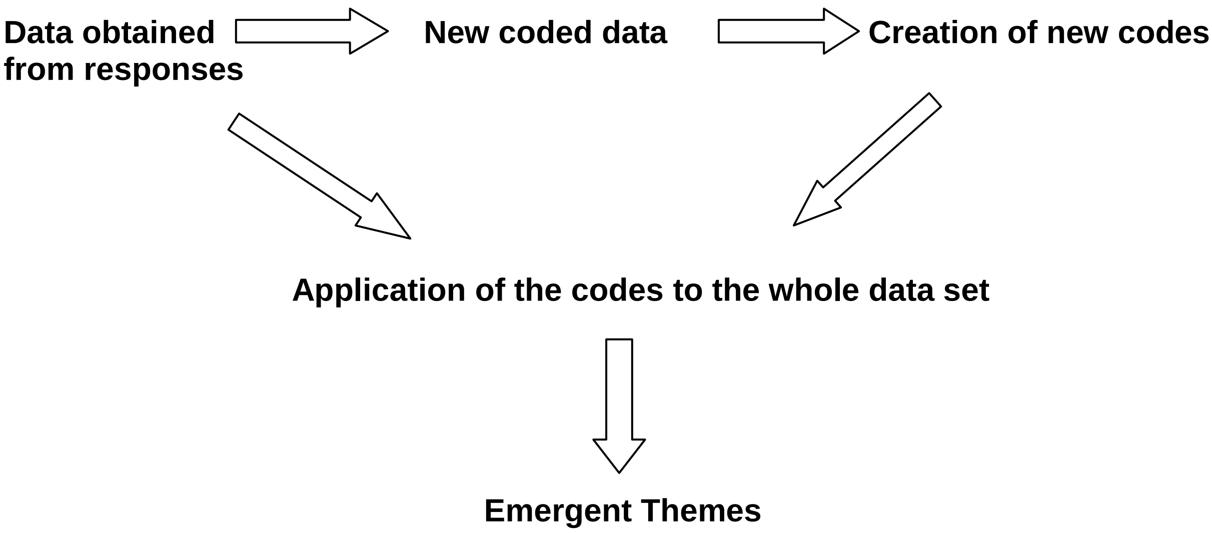
3.9.3. Qualitative analysis

Descriptive analysis was used to identify emergent codes and themes from the open-ended questions in this cross-sectional survey study. Initially the researcher planned using thematic analysis to analyse the open-ended questions, however, after the collation of data, it arose that the data obtained from the open-ended questions though extensive and informative, appeared insufficient to generate analytical themes to progress to thematic analysis. Therefore, the best option at presenting the qualitative data analyses was by discussing the emergent themes. Emergent themes involve a process of abstraction - creating categories from the complexity of the data (Burnard et al., 2008). The development of emergent themes reflects the efforts to bring interpretive insight, analytic scrutiny, and aesthetic order to the data collected. The development of emergent themes is an iterative and generative process; the themes emerge from the data and they give the data shape and form. Emergent theming formalizes analytic connections among pieces of data but does not constitute the end of analysis. Some qualitative researchers believe that emergent themes are part of the process that lead to generalizable theories; whereas, others use emergent themes to provide rich and detailed insight into the micro and meso-levels of intersubjective experience. In this study, after the themes were identified, they were assembled to establish substantive connections.

3.9.4. Formulation of codes

In this study, codes were used as tags or labels for assigning units of meaning to the descriptive information compiled from the open-ended transcript of the survey questionnaire. Codes were attached to ‘chunks’ of varying size – words, phrases, sentences or whole paragraphs as described by Miles and Huberman (1994: p.56). Eventually, the codes were collated as descriptive emergent themes which identified patterns in relation to the research question (Braun and Clarke, 2006). Recurring phases were collated to form initial codes. Codes with similar meanings were grouped together to form umbrella themes (Fig 3.2).

Fig. 3.2: Process of coding and building emergent themes from the data



Adapted from: Miles M & Huberman A (1994) *Qualitative data analysis: an expanded sourcebook*. Sage Publications

3.10. Ethical consideration and procedures

Ethical approval was strictly and rationally followed based on the guidelines laid down by the University of Essex Ethics Committee. Ethical approval was obtained from the University of Essex School of Health and Human Sciences Ethics Committee, before the commencement of the pilot study which lasted four weeks; further approval was sought for the main study which lasted ten weeks. Since the study was designed as a survey study of a particular group of physiotherapists (ACPIN), enquiries were made by the researcher to ascertain if additional ethical approval was required for the study. The researcher was advised that the only ethical approval required was that of the University of Essex Ethics and Research Committee (Appendix 1).

Rational measures were established by adhering to the principles of voluntary participation; informed consent, anonymity and beneficence were included in the introductory page of the online survey questionnaire. Based on the stipulated guidelines of the (Chartered Society of Physiotherapy, 2009 and University of Essex, 2009), the first page of the research questionnaire clearly explained the objectives, rationale, significance and purpose of the research study (Appendix 3). Informed consent was sought from the participants (See Appendix 3).

Apart from obtaining relevant demographic data such as the type of facility respondents practice, their rank (NHS banding) at their practice facility, no other demographic data such as name, age and date of birth were required for this study. In addition to ensure participants' confidentiality, the data collected was securely locked in a safe cabinet. The respondents were provided with a detailed explanation in the introduction section of the questionnaire about how the results of the study would be disseminated.

3.11. Acknowledged limitations of the survey questionnaire

There were some limitations to this study. One of the obvious limitations is the format of the survey questionnaire which may have necessitated comparatively superficial answers. Although the questionnaire included both open-ended and closed-ended questions, the closed-ended questions might have resulted in some respondents feeling that none of the options were appropriately meet their answers. Thus, they may have just answered either ‘yes or no’. Similarly, the open-ended sections might not have allowed for the expression of the full range of responses some of the respondents would have given to a questionnaire with a more open-ended format. Nevertheless, it is debatable whether or not the conciseness of the questionnaire contributed to the relatively moderate response rate. According to Jones et al. (2003: p7), “*in questionnaire-based research studies, there is a trade-off between the amount of information required by the questionnaire and the response rate*”.

CHAPTER 4: RESULTS

4.0. Overview

The previous chapter examined the research design, how the research questionnaire was developed, and the processes involved in conducting both the pilot, and the main research surveys, including an insight into the data analyses used to explore the research questions.

Chapter 4 discusses the results of the study under three different sections. The first section explains the descriptive analyses of all the demographic variables obtained from the study; the second section focuses on inferential statistical analyses, exploring the research objectives to evaluate associations between the variables. The third section focuses on the description of emergent themes and categories obtained from the open-ended questions of the survey questionnaire to give meaning / explanation to some of the observed associations between the variables studied.

4.1. Descriptive analyses of the demographic data

A total of 700 neuro-physiotherapists practising in the UK were invited to participate. 410 neuro-physiotherapists responded, but, of those only 401 respondents fully completed the survey, while 9 respondents attempted some of the questions without fully completing the survey. For this reason, those responses were regarded as incomplete and were not included in the final data analyses. Consequently 401 responses were analysed representing 57.2% response rate. Based on survey participation rating, a response rate of 80% is described as very good; 65% to 79%

as good; and 50% to 64% as average (Fowler, 2009). Therefore, the response rate obtained in this survey might be considered as an average response rate.

Descriptive analysis of the region of practice in the UK showed 60.8% of the respondents practise as neuro-physiotherapists in England; closely followed by Wales 16.2%; Scotland 15.5%; and Northern Ireland 7.5% (Table 4.1). this suggests that the bulk of practising physiotherapists in the UK practise in England.

With regards to the rank/grade of the respondents based on the NHS Banding system (Table 4.1), it was observed there were more Band 7 (Senior 1) respondents 32.7%, followed by Band 6 (29.7%); Band 8 (14.7%) and Band 5 (11.0%). On the other hand, independent practitioners and consultant physiotherapists / physiotherapy managers were the least group of respondents 2.7% and 1.7% respectively (Table 4.1).

The results in Table 4.1 also show the years of practice of the respondents as neuro-physiotherapists. Respondents with 1 - 5 years practice experience were more (31.6%); followed by respondents with 6 - 10 years practice (26.1%), 11 - 15 years (18.7%), 16 – 20 years (11.7%), and 26 years and above (6.7%). The least group of respondents were participants with 21 - 25 years of clinical practice experience (5.0%).

Table 4.1: Descriptive demographic characteristics of the respondents (N = 401)

Demographic Variables	**Description**	***N***	***(%)***
Region of the UK	England	244	60.8
	Northern Ireland	30	7.5
	Scotland	62	15.5
	Wales	65	16.2
Rank in the NHS	Band 5	44	11.0
	Band 6	119	29.7
	Band 7	131	32.7
	Band 8	59	14.7
	Extended scope/Clinical specialist	30	7.5
	Consultant/Manager	7	1.7
	Independent practitioner	11	2.7
Years practised as a Neuro-physiotherapist	1 – 5 years	127	31.7
	6 – 10 years	105	26.2
	11 – 15 years	75	18.7
	16 – 20 years	47	11.7
	21 – 25 years	20	5.0
	26 years and above	27	6.7

N = Number/frequency;

% = Percentage

Table 4.2 shows the number of stroke patients treated by respondents weekly, 147 respondents representing 37.1% managed 1 - 5 stroke patients weekly, followed by respondents that treated between 6 - 10 patients weekly (29.1%) and the least (3.9%) represent respondents that treated 26 patients and above weekly. Based on the results, it is assumed that when this study was conducted, most of the respondents were actively engaged in the rehabilitation of stroke patients and treated between one and five patients weekly.

The type of hospital facility respondents worked in showed: primary care / community recorded the highest number of participants (31%), closely followed by those who worked in NHS Foundation Trust/Teaching Hospital (29.7%), private physiotherapy practice (5.7%), while the least number of respondents worked in voluntary/charity organisations (1.9%), based on the distribution shown in Table 4.2.

Specialism of practice showed 95 respondents representing 23.7% indicated their specialism as acute stroke management (Table 4.2), closely followed by community based physiotherapists (20.7%), and stroke rehabilitation (18.0%). However, it was observed that a sizable number of respondents (20.2%) selected the option ‘others’ as their specialism of practice. The subgroup ‘others’ was further analysed to explore why such a large number of respondents 20.2% (81 out of 401) selected this choice (Table 4.3). The result showed that 39 respondents out of 81 (48%) indicated they worked in early supported discharge (ESD), which may be described as working in the community. This has been acknowledged as one of the limitations of this study. This shortcoming may be as a result of the design of the survey questionnaire (ESD and the other specialities selected by respondents shown in Table 4.3 were not specifically mentioned in the survey questionnaire). This suggests a poor question, but was not identified when the pilot survey was conducted.

Table 4.2: Descriptive demographic characteristics of the respondents (N = 401)

Demographic Variables	**Description**	***N***	***(%)***
Number of patients treated	1 – 5 patients	149	37.1
	6 – 10 patients	88	21.9
	11 – 15 patients	71	17.7
	16 – 20 patients	50	12.4
	21 – 25 patients	23	5.7
	26 patients and above	16	3.9
	Don’t treat stroke patients	4	0.9
Type of Hospital Facility	Acute Trust/General Hospital	108	27.0
	NHS Foundation Trust/Teaching Hospital	119	29.6
	Primary care/Community	125	31.1
	Private practice	23	5.7
	Voluntary/Charity	8	1.9
	Others	18	4.4
Specialism of practice	Acute Stroke unit	95	23.7
	Community stroke/other neurological conditions	83	20.7
	General neuro/occasional management of stroke	17	4.2
	Neuro-rehab managing different stages of stroke	53	13.2
	Stroke Rehab ward different stages of stroke	72	18.0
	Others	81	20.2

N = Number/frequency
% = Percentage

Table 4.3: Specialism of practice representing ‘Others’ (N = 81)

Other specialism of Practice	***N***	***%***
Intermediate care managing stroke & different types of patients Including MSK & Respiratory patients	30	37.0
Early supported discharge (ESD)	39	48.2
Education & Research	2	2.5
Head Injuries & stroke	5	6.1
More involved with admin & policy	5	6.1

N = Number/frequency; *%* = Percentage

4.1.2. Appropriateness of muscle strengthening in stroke

Respondents were also required to rate the appropriateness of muscle strengthening in stroke rehabilitation. This was measured on a 7 point Likert scale (‘very appropriate’, ‘appropriate’, ‘slightly appropriate’, ‘neutral’, ‘slightly inappropriate’, ‘inappropriate’ and ‘very inappropriate’). 49.6% selected muscle strength training to be ‘very appropriate’, 7.0% selected ‘neutral’ and 0.8% rated resistance muscle strength training in stroke rehabilitation as ‘inappropriate’ (Table 4.4).

The seven responses were collapsed into two categories (‘Appropriate’ and ‘Inappropriate’). The variables collapsed into ‘appropriate’ as a positive response included: very appropriate, appropriate, and slightly appropriate; while neutral, inappropriate, slightly inappropriate, and very inappropriate were collapsed to form an ‘inappropriate’ category (Table 4.4).

Table 4.4: Appropriateness of muscle strengthening in stroke (N = 401)

Appropriateness of Muscle strengthening Inappropriate)	Frequency	%	Collapsed (variables) (Appropriate &
Very Appropriate	199	49.6	
Slightly Appropriate	114	28.4	355 (88.5%)
Appropriate	42	10.5	
Neutral	28	7.0	
Slightly Inappropriate	15	3.7	46 (11.5%)
Inappropriate	3	0.8	
Very Inappropriate	0	0	

Looking at the collapsed variables (Table 4.4), the result showed that 88.5% of respondents regarded muscle strength training as appropriate in stroke rehabilitation, while 11.5% described it as inappropriate.

4.1.3 Descriptive analysis of respondents that undertake muscle strengthening

A sum total of *N* = 351 respondents representing (87.5%) acknowledged they undertake muscle strengthening, while *N* = 50 respondents representing (12.5%) did not undertake muscle strengthening in stroke rehabilitation (Figure 4.1). There were 244 respondents from England (216 out of 244 selected yes, while 24 out of 244 respondents selected no), 30 respondents from Northern Ireland (24 Yes; 6 No), Scotland 62 respondents (52 Yes; 10 No), and Wales 65 respondents (56 Yes; 9 No) (Figure 4.2 and Table 4.5).

Table 4.5: Distribution of respondents that undertake muscle strengthening (N = 401)

	Region of Practice in the UK				
Undertake Muscle Strengthening	England	Northern Ireland	Scotland	Wales	Total (%)
Yes	216	24	52	59	351 (87.5%)
No	28	6	10	6	50 (12.5%)
Sum	244	30	62	65	401 (100%)

Figure 4.1: Distribution showing responses of all the respondents

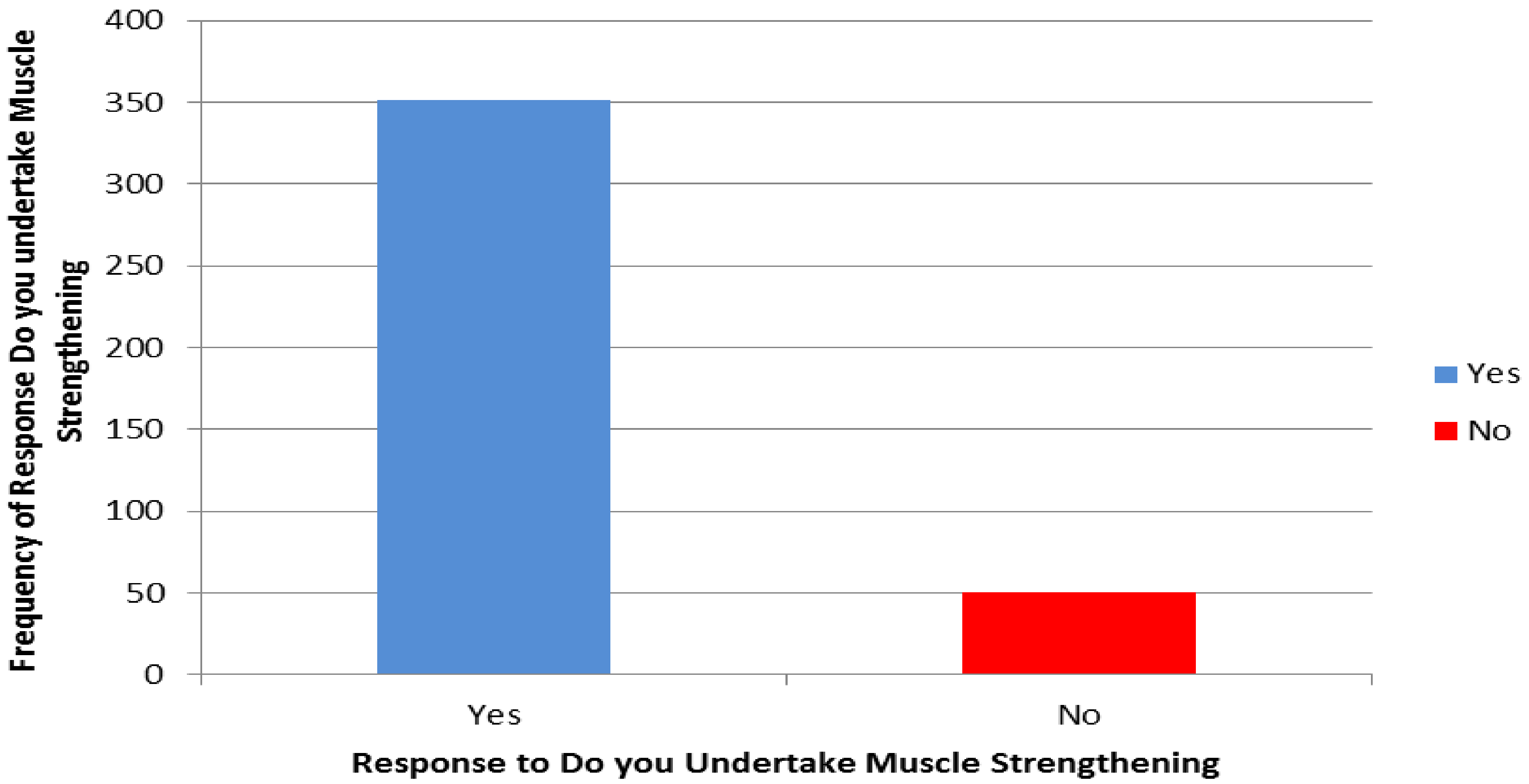
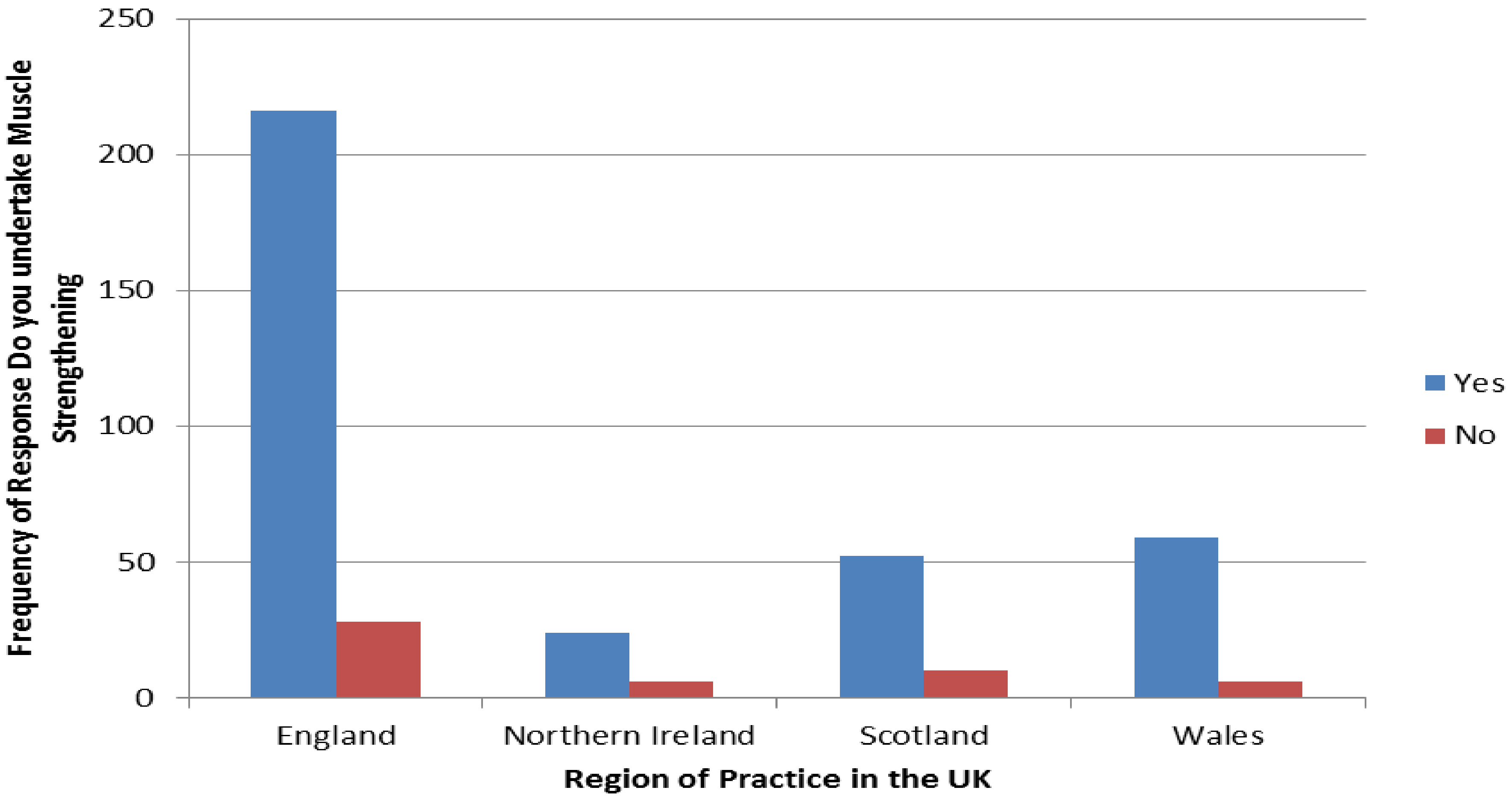


Figure 4.2: Distribution of responses based on location of practice in the UK



4.1.4. Stages of stroke rehabilitation respondents undertook muscle strengthening

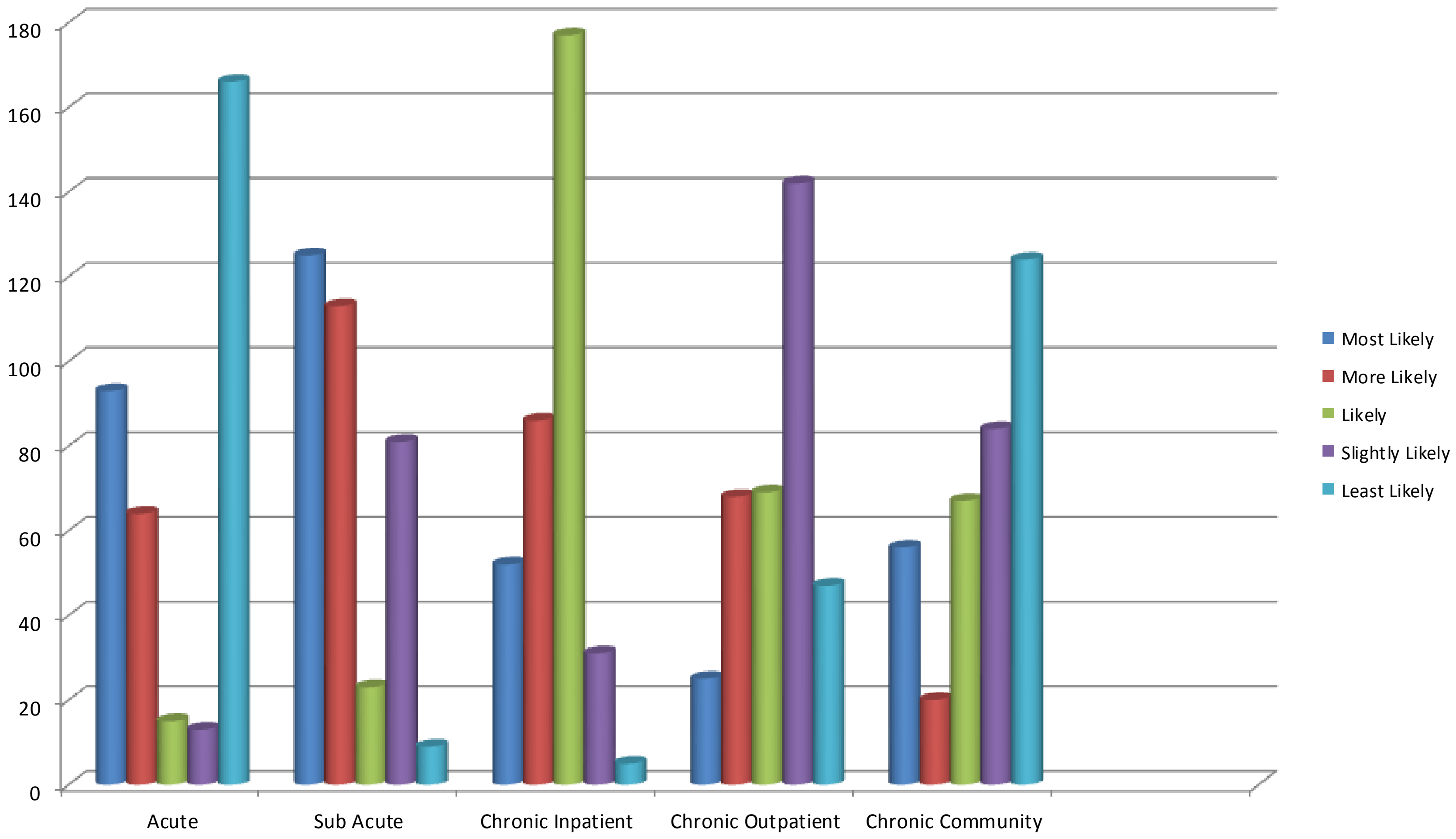
Only participants who responded ‘Yes’ to the question ‘do you undertake muscle strengthening’, were required to progress onto the next set of questions (Questions 6 to 12). These questions were specific on the use of muscle strengthening. However, those who responded ‘No’ progressed to Question 13 (please see questionnaire in Appendix 3). As a consequence, this group of questions had only 351 respondents instead of 401. Stroke rehabilitation was divided into five stages (acute, sub-acute, chronic inpatient, chronic outpatient, and chronic community). Based on 351 respondents that acknowledged they undertake muscle strengthening, 93 respondents (26.5%) were most likely to use muscle strength training during the acute stages of stroke rehabilitation; 125 respondents (35.6%) during the sub-acute stages; 52 (14.8%) in the chronic inpatient rehabilitation stages; 25 respondents (7.2%) during the chronic outpatient stages and 56 (15.9%) during the chronic community stages of stroke rehabilitation (Table 4.6).

Table 4.6: Stages of stroke respondents were most likely undertake muscle strengthening (N = 351)

Stage of Stroke	*N*	*%*
Acute	93	26.5
Sub-Acute	125	35.6
Chronic Inpatient	52	14.8
Chronic Outpatient	25	7.1
Chronic Community	56	15.9
Sum	351	100%

N = Number/frequency; *%* = Percentage

Figure 4.3: Stages of stroke respondents are most likely to undertake muscle strengthening in stroke rehabilitation



4.1.5. Muscle groups frequently strengthened by respondents

The results in Table 4.7 show the muscle groups frequently strengthened. Based on the responses from 351 respondents that acknowledged they undertake muscle strengthening, the findings were: the hip/pelvic muscles recorded the highest 92 respondents (26.2%); lower leg muscles *N* = 84 (23.9%); quadriceps/hamstrings *N* = 75 (21.4%); followed by the trunk muscles *N* = 64 (18.2%); the biceps/triceps recorded *N* = 20 (5.7%); hand *N* = 9 (2.6%) and the least was the fore-arm muscles *N* = 7 (2.0%). It was observed that the upper limb muscles especially the hand and fore-arm muscles were least strengthened, while the large muscles of the affected lower limb (e.g. quadriceps and hamstrings) appeared to be strengthened more often.

Table 4.7: Muscle groups most likely to be strengthen by respondents (N = 351)

Muscle Groups	*N*	*%*
Biceps/Triceps	20	5.7
Fore-arm	7	2.0
Hand	9	2.6
Lower leg	84	23.9
Pelvic/Hip	92	26.2
Quadriceps/Hamstrings	75	21.4
Trunk	64	18.2
Sum	351	100%

N = Number/frequency;
% = Percentage

4.1.6. Types of muscle strengthening respondents undertook

In relation to the types of muscle strengthening respondent neuro-physiotherapists undertook (Table 4.8), manual resistance was used the most *N* = 136 (38.7%); weight resistance *N* = 75 (21.4%); theraband/springs *N* = 59 (16.8); locomotor training *N* = 37 (10.5%); FES *N* = 28 (8.0%); BWSTT *N* = 9 (2.6%) and isokinetic strength training recorded the least number of respondents *N* = 7 (2.0%).

Apart from the closed-ended question on types of muscle strengthening, which had seven options available, an open-ended question specifically requested respondents to indicate other types of muscle strengthening exercises that they undertake. The most common muscle strengthening activities outlined included: PNF with manual resistance; repetitive functional training such as sit-stand; assisted-resisted exercises; concentric and eccentric muscle exercises; closed chain exercises (squatting); and various functional progressive resistance exercises (Appendix 7).

Table 4.8: Types of muscle strengthening respondents undertake (N = 351)

Muscle Groups	Frequency	%
BWST	9	2.6
FES	28	8.0
Isokinetic	7	2.0
Locomotor machines	37	10.5
Manual resistance	136	38.7
Theraband/springs	59	16.8
Weights	75	21.4
Sum	351	100%

N = Number/frequency; *%* = Percentage

4.1.7. Factors that influence respondents to undertake muscle strengthening

There were seven factors that were evaluated to observe the one that mostly influenced the clinical decision of respondents to undertake muscle strengthening (Table 4.9). Experience gained from managing patients was *N* = 76 respondents (21.7%); continuing professional development *N* = 63 (17.9%); guidelines/protocol *N* = 56 (15.9%); research evidence *N* = 54 (15.4%); basic education *N* = 26 (7.4%) and the least was routine clinical practice *N* = 23 (6.6%). In the current study, it was observed that experienced gained from patient management and CPD were selected as the factors that mostly influenced respondents, while basic education and routine clinical practice were the factors selected by respondents as least to influence their clinical decision to undertake muscle strengthening.

Table 4.9: Factors that influence the use of muscle strengthening (N = 351)

Muscle Groups	*N*	*%*
Basic Education	26	7.4
Continuing professional development	63	17.9
Experience from patient management	76	21.7
Guidelines/protocol	56	15.9
Information from colleagues	53	15.1
Research evidence	54	15.4
Routine clinical practice	23	6.6
Sum	351	100%

N = Number/frequency; *%* = Percentage

4.1.8. Frequency respondents undertake strength training

Respondents were asked how frequently they undertook muscle strength training when managing stroke patients (Table 4.10). It was observed that respondents predominantly undertook strength training once weekly *N* = 137 (39.1%); twice weekly *N* = 74 (21.1%); once in a while *N* = 38 (10.9%); once daily *N* = 36 (10.3%); once in two weeks *N* = 28 (7.9%) and the least was undertaking muscle strength training only when necessary *N* = 21 (5.9%); followed by undertaking muscle strength training once in six weeks N = 17 (4.8%). Although the results show how frequently respondents undertake muscle strength training, this survey did not ask respondents about the intensity and dose or number of repetitions resistance strength training was undertaken. Future studies, can be carried out, where the dose/intensity/duration of the application of muscle strength training can be verified.

Table 4.10: Frequency of undertaking muscle strength training (N = 351)

Frequency of Strength Training	*N*	*%*
Strength training once daily	36	10.3
Strength training once weekly	137	39.1
Strength training twice weekly	74	21.1
Strength training once in two weeks	28	7.9
Strength training once in six weeks	17	4.8
Strength training once in a while	38	10.9
Strength training only when necessary	21	5.9
Sum	351	100%

N = Number/frequency; *%* = Percentage

4.2. Inferential statistical analyses / test of research hypotheses

Inferential statistics were used to evaluate the research questions discussed in chapter 2, and were used to either refute or accept the set hypotheses.

4.2.1. Muscle strengthening and region of practice

Hypothesis 1 (H1): Preliminary analysis using cross-tabulation and a Chi-square test were applied to investigate the number of respondents who use muscle strengthening in stroke rehabilitation based on region of practice in the UK, to confirm or refute hypotheses H1. The results indicated that, there was no statistical difference in the use of resistance muscle strengthening exercises across the UK amongst the respondent physiotherapists who participated in this survey ($\chi^2 = 3.16$, $df = 3$, $p = 0.37$); as shown in Table. 4.11.

Prior to this study, it was hypothesised that there will be no difference in the use of resistance muscle strengthening by respondent neuro-physiotherapists across the UK. The expectation was that the views of respondents would give more meaning to either a confirmation or refutation of this hypothesis (H1). The results showed there was no significant difference between the four regions of the UK; therefore, the null hypothesis (H1) was accepted, because the *p* value obtained was $p = 0.37$ which was greater than 0.05 ($p > 0.05$).

Table 4.11: Chi-square analysis of those who undertake muscle strengthening by region of practice (N = 401)

	Region of Practice in the UK					
Undertake MST	England	Northern Ireland	Scotland	Wales	*df*	*p*
					3	> 0.05
Yes %	216 (61.5)	24 (6.8)	52 (14.8)	59 16.8)		
No %	28 (56.0)	6 (12.0)	10 (20.0)	6 (12.0)		
Sum	244	30	62	65		

(χ^2 = 3.16, *df* = 3, *p* = 0.37)

df = degree of freedom;

p = level of significance,

MST = muscle strengthening

4.2.2. Muscle strengthening and specialism of practice

Hypothesis 2 (H2): A Chi-square test was applied to investigate if the specialism of practice influenced the decision of respondent neuro-physiotherapists to undertake muscle strengthening in stroke rehabilitation, to confirm or refute hypotheses H2. Conducting a Chi-square test between the variable ‘specialism of practice’ and ‘undertake muscle strengthening (Table. 4.12), yielded a moderate positive association ($\chi^2 = 66.64$, $df = 5$, $p < 0.05$); demonstrating minimal statistical significance ($p < 0.05$).

With regards to the predictive relationship between specialism of practice and the use of muscle strengthening in stroke rehabilitation, it was hypothesised that there would be a significant association between these two variables. However, contrary to expectations, this result showed a moderate association, predicting the possibility that the specialism of practice might influence neuro-physiotherapists to use muscle strengthening. Despite the weak positive association, H2 was accepted (Table 4.12).

A cross-tabulation of the specialism of practice and the use of muscle strength training identified the actual distribution of respondents who indicated ‘yes/no’ amongst the different specialisms (Appendix 4). The results showed that 64% of the respondents who selected ‘acute stroke’ as their specialism of practice undertook muscle strengthening, while approximately 36% did not undertake muscle strengthening, implying that approximately one-third of the respondents in acute stroke rehabilitation did not use resistance muscle strengthening (Appendix 4). However, the results showed that only few respondents from other specialisms such as: community rehabilitation and general neurology units reported not using muscle strengthening in stroke rehabilitation (Appendix 4).

Table 4.12: Statistical analysis of those who undertake muscle strength training by specialism of practice (N = 401)

	Specialism of Practice							
Description	Acute Stroke	Community	General Neurology	Neuro Rehab	Stroke Rehab	Others	*df*	*p*
							5	< 0.05
Yes %	61 (64.2)	74 (89.2)	17 (100)	53 (100)	70 (97.2)	76 (93.8)		
No %	34 (35.8)	9 (10.8)	0 (0)	0 (0)	2 (2.8)	5 (5.6)		
Sum	95	83	17	53	72	81		

($\chi^2 = 66.65$, $df = 5$, $p < 0.05$)

df = degree of freedom;

p = level of significance;

MST = muscle strengthening

4.2.3. Muscle strengthening and attendance at CPD activities

Hypothesis 3 (H3) of this study evaluated whether attending continuous professional development programmes influenced the clinical decision of respondent neuro-physiotherapists to use muscle strength training in stroke rehabilitation. A Chi-square test indicated a significant association: ($\chi 2$ = 31.9, df = 1, $p < 0.05$) and *phi* coefficient = 0.29 (Table 4.12). Although the effect size obtained for the *phi* coefficient was small (0.29), the result suggested a moderate significant association between attending continuous professional development programmes and the decision to use of muscle strengthening in stroke rehabilitation (Table 4.13 and Appendix 6)

Prior to the study, it was hypothesised that there would be a positive association between respondent neuro-physiotherapists who attended workshops/seminars, and the use of muscle strengthening. Respondents' views were expected to confirm or refute this hypothesis (H3). As predicted, the result obtained signified a moderate positive association ($\chi 2$ = 31.9, df = 1, $p < 0.05$); therefore H3 was accepted.

4.2.4. Muscle strengthening and reading of research literature

Hypothesis 4 (H4), evaluated whether the reading of evidence based literature influenced the clinical decision of respondents to undertake muscle strength training in stroke rehabilitation. A Chi-square test conducted for reading literature and the use of muscle strengthening showed a positive association: ($\chi 2$ = 86.2, df = 1, $p < 0.05$). Unlike the values obtained for the Chi-square test regarding attendance of continuous professional development activities, the effect size (*phi*) for read literature was 0.42 indicating more effect size. This showed that reading of evidence-based literature significantly influenced the use of strengthening amongst the respondents in this study (Table 4.13 and Appendix 5).

Table 4.13: Chi-square test for read literature/attend workshop (N = 401)

Description	Read Literature	Attend Workshop Seminar/Conference	***df***	***p***
Yes (%)	268 (66.8)	177 (44.1)	1	< 0.05*
No (%)	133 (33.2)	224 (55.9)	1	< 0 .05*
Sum	**401 (100)**	**401 (100)**		

df = degree of freedom; *%* = percentage; *p* = level of significance * = significant

CPD = ($\chi 2$ = 31.9, *df* = 1, $p < 0.05$)

Read literature = ($\chi 2$ = 86.2, *df* = 1, $p < 0.05$)

4.2.5. Muscle strengthening and years of practice as neuro-physiotherapists

Hypothesis 5 (H5) of the study was aimed at evaluating the relationship between the number of years of practice as a neuro-physiotherapist and the use of muscle strengthening in stroke rehabilitation. Using Spearman's rho correlation coefficient the result obtained was $r = 0.226$, $p < 0.05$. Converting the rho (r) to a percentage of variance by squaring r gave a value of $r^2 = 0.051$ multiplied by 100. The value obtained was = 5.1%. Preliminary analyses were performed to ensure there was no violation of the assumptions of normality, linearity and homoscedasticity. The interpretation of this relationship between the number of years of practice as a neuro-physiotherapist and the use of muscle strengthening indicated that there was a minimal positive association between the two variables ($r = 0.226$, $N = 401$, $p < 0.05$), shown in Table 4.14. This result may infer that the number of years of clinical practice experience as a neuro-physiotherapist might slightly influence the use of muscle strengthening in stroke rehabilitation.

4.2.6. Muscle strengthening and number of stroke patients treated

Similarly, H6 was evaluated using Spearman's rho correlation coefficient. The result obtained between the number of patients treated weekly and the use of muscle strengthening was $r = 0.196$, $r^2 = 0.038$ with a percentage value of 3.8% (Table 4.14). This showed a weak positive association between the two variables ($r = 0.196$, $N = 401$, $p < 0.05$). Again this result demonstrated that the number of patients treated had a minimal influence on the use of muscle strengthening in stroke management. Likewise, a weak level of association was obtained for the use of muscle strengthening and the Band or grade of the neuro-physiotherapist (r = 0.130, N = 401, $p < 0.05$) as shown in Table 4.14.

Table 4.14: Spearman's rho correlation of use of muscle strengthening and years of practice, number of patient treated and grade/rank in the NHS (N = 401)

Description	Spearman Rho (r)	r^2	*p*	Association
Years of practice as a Neuro-physiotherapist	0.226	0.051	< 0 .05*	Minimal
Patients treated weekly	0.196	0.038	< 0 .05*	Weak
NHS Banding/Grade	0.130	0.02	< 0.05*	Very Weak

df = degree of freedom; *p* = level of significance; * = significant

4.2.7. Barriers to the use of muscle strengthening

Hypothesis 7 (H7) investigated whether there were barriers preventing respondent neuro-physiotherapists from using muscle strengthening in stroke rehabilitation. The results showed that 64.6% respondents acknowledged encountering barriers/ challenges, while 35.4% stated that they had not experienced any barriers to the use of resistance muscle strength training in stroke rehabilitation (Table 4.15). Using a Chi-square test, the result obtained was ($\chi 2$ = 6.72, df = 1, $p < 0.05$); H6 was therefore accepted.

The question on barriers to the use of muscle strength training was followed-up with an open-ended question requiring the respondents to specifically outline the types of barriers or challenges that prevented them from undertaking muscle strengthening (Table 4.16). The responses obtained from respondents in the open-ended question showed that, the barriers and challenges preventing the use of muscle strengthening were: pain experienced by patients (e.g. shoulder joint pain); spasticity of the muscles; inadequate staff-patient ratio; excess clinical caseload, cognition; inadequate equipment; limited number of staff and limited time. Other barriers included inconclusive and conflicting literature on the use muscle strengthening; and in some cases confusing interpretation of the outcome or results of some of the research studies on muscle strengthening (Table 4.16).

Table 4.15: Chi-square test for barriers (N = 401)

Description	Barriers to the Use of MST	Concerns about the use of MST	*df*	*p*
Yes (%)	259 (64.6%)	154 (38.4)	1	0 .009*
No (%)	142 (35.4%)	247 (61.5)	1	< 0 .05*

$\chi 2 = 6.72$, $df = 1$, $p < 0.05$
df = degree of freedom; *%* = percentage; *p* = level of significance; * = significant

Table 4.16: Barriers mentioned by respondents as influencing the use of muscle strengthening in stroke rehabilitation

Types of Barriers	***N***	**%**
Cognition	29	8.38
Fear of shoulder sub-luxation	36	10.40
Hypertonic/spastic muscles	18	5.20
Inappropriate at certain stages	23	6.65
Inexperienced staff	19	5.50
Lack of patient motivation	21	6.07
Lack of resources/equipment	29	8.38
Limited Time	35	10.11
Limited number of staff	30	8.67
Muscles too weak or flaccid	16	4.62
Other medical issues/co-morbidities	20	5.78
Pain	19	5.49
Patients performing strength training wrongly	17	4.91
Therapist not sure of muscle strengthening	12	3.46
Avoiding complications	22	6.35
SUM	**346**	**100**

N = frequency/Number of occurrence; % = percentage;

4.3. Qualitative analysis of the open-ended questions

Responses obtained from the open-ended question were aimed at exploring the barriers and challenges faced by respondents in the use of resistance muscle strengthening in stroke rehabilitation. Coding of the responses followed words that were repeated, analogies and key-words-in-context, with connections to the research questions on the use of muscle strengthening. The emergent codes were them developed into emergent themes. The final descriptive emergent themes were selected as advocated by Braun and Clarkes (2006: p82) that "*a theme needs to capture something important about the data in relation to the research question, and present some level of patterned response or meaning with the data set*".

4.3.1 Transcription and coding process

The open ended questions were transcribed verbatim, enabling line by line coding and onward collation of the descriptive emergent themes. Each transcription was reviewed by the author to check for accuracy, and to reduce any possible transcription errors. An initial compilation of recurrent codes was carried out, and then descriptive emergent themes were then developed from a list of constructs/phases in accordance with the purpose of the research questions (Tables 4.17). Although some of the responses where very brief, however, most respondents provided quite detailed responses. Presenting every code and theme in its entirety is beyond the scope of this thesis, therefore, some aspects of the coding process are demonstrated using some selected examples to allow the reader understand the process of how emergent codes and themes were selected from the open ended responses of the participants to highlight and express the responses obtained.

4.3.2. Description of barriers to the use of muscle strengthening

Respondents were identified using unique respondent identifier code (RIC), using the demographics of the respondents (specialism of practice and band in the NHS). The respondent identifier codes used are as follows: AS = Acute Stroke (5, 6, 7 or 8); CM = Community (5, 6, 7 or 8); GN = General Neurology (5, 6, 7 or 8); NRU = Neurology Rehabilitation Unit (5, 6, 7 or 8); SRU = Stroke Rehabilitation Unit (5, 6, 7 or 8). All extracts were transcribed verbatim, including spelling and punctuation errors. This was vital in retaining the context of the responses to gain in-depth understanding rather than description.

4.3.2.1. Patient based issues

Issues relating to the patients appeared to be one of the main barriers to the implementation of muscle strengthening in stroke management. In the response to this question, the recurrent sub-themes revolved around cognition, co-morbidities (patients with other medical problems including poor skin condition), pain of the shoulder, patient motivation and the fact that some patients undertake muscle strengthening inappropriately. The following comments from some respondents illustrate these points:

…Cognition and communication impairments, when patients have severe sensory/proprioceptive impairments. But creative thinking enables you to overcome these barriers and you can mostly overcome them and incorporate some strength training using functional activities. (SRU6)

...Often, patients with cognitive problems, find it difficult to understand or follow exercise instructions. (AS7)

…The biggest challenge to the use of muscle strength training exercise is those patients who are medically unstable, frail and with post-stroke or pre-existing dementia. (CM7)

*…Skincare requirements means the patient spends large amounts of time on an air mattress making it difficult for such a patient to do exercises whilst in bed and weakening of the anti-gravity muscles leading to less stabilit*y. (AS6)

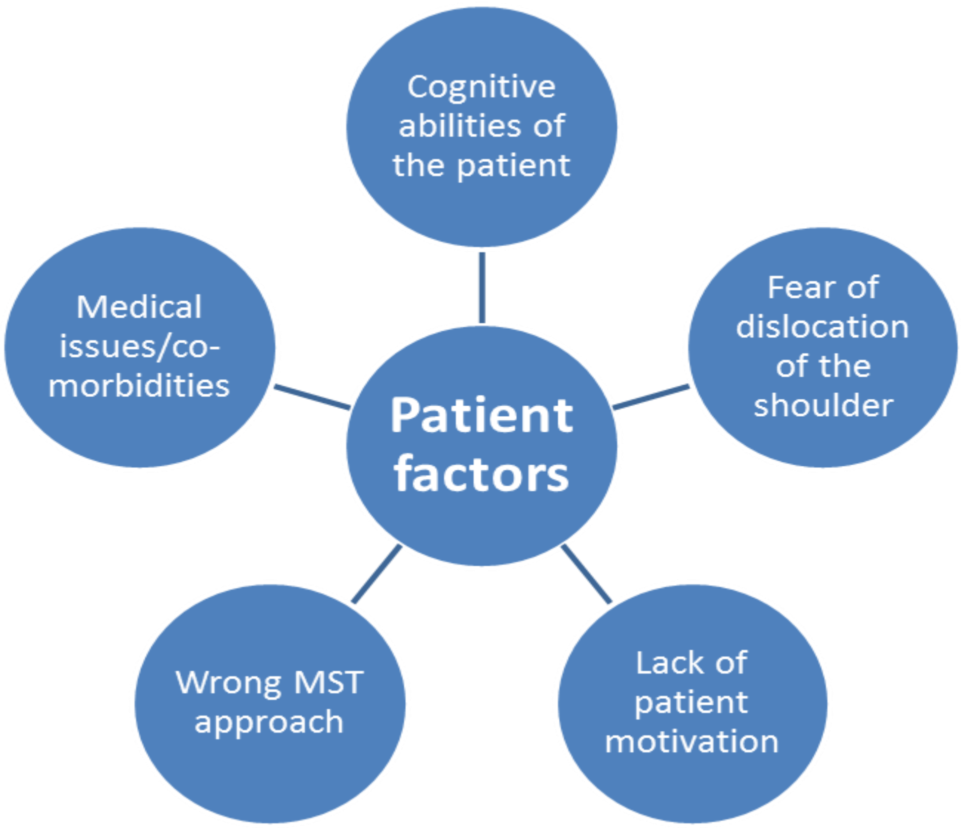
…… Motivation on the part of the patient, lack of muscle power in certain patients is a limitation because muscle movement cannot be initiated in a severely weak muscle; therefore in an acute setting exercise tolerance is a factor. (AS6)

…Clients (patients) previous experience of exercise (low, none, including poor compliance and family support), general frailty of client (patient), and other medical issues may prevent the use of muscle strength training. (AS7)

….*In my experience, acute patients do not feel comfortable with muscle strengthening. Strengthening (strength training) may be inappropriate in acute patients who have other co-morbidities. Most often the muscles are significantly flaccid*. (AS7)

Some of these quotes partially explain some of the barriers encountered by respondents. Respondents noted that these factors influenced their clinical decision to undertake or not to undertake muscle strengthening in stroke rehabilitation. Most of the responses appeared to be from respondents in acute stroke rehabilitation. Some respondents explained that during the acute stages, the patients might not be ready for resistance muscle strength training. Figure 4.4 below represent codes that were built based on the perspectives of the respondents. Respondents explained that patient's disposition to undertaking muscle strength training exercises after a stroke constituted a barrier.

Figure 4.4 – Linked codes representing how patient factors were grouped



4.3.2.2. Staff based Issues

Staff issues appeared to be a recurrent thing, the emergent codes included: time constraint, excess work load, insufficient staff, inexperienced staff, and some therapists not sure about muscle strength training. The following comments from respondents illustrate these points:

..Pressure of work; lack of quality treatment time; limited staff strength ultimately makes treatment longer than 45 minutes not achievable (strength training inclusive) (NRU6)

…*Lack of time often poses a challenge to the use of muscle strength training which requires time and preparation, can be difficult to meaningfully undertake muscle strengthening due to the number of patients seen within a short period of time* (CN5)

…t*ime constraint especially in a busy acute stroke unit, where you have to see several patients within a set time* (AS5).

…*There is very little time in the day to undertake elaborate or intensive exercise programmes such as functional strength training, and still have time to focus on other activities outside the work environment (GN8).*

The comments above on the conception of time as a barrier or constraint were identified by respondents. One respondent specifically mentioned that sometimes the rehabilitation process of stroke patients encroached into their personal time outside working hours. In other instances respondents stressed that time and pressure of work constituted a barrier particularly where they are mandated to see several patients within a set period of time.

Another recurrent sub-theme was the issue of inexperience among some of the rehabilitation staff. Some of the comments revealed concerns with the way in which some rehabilitation staff carried out muscle strength training inappropriately, which could often be detrimental to the patient's progress.

….I have seen patients who have been working muscles inappropriately, often, patients can compensate and some inexperienced therapists don't always appreciate this, so when they teach exercises they don't always work what they think they are working (SRU7).

…Where multiple staff are required due to high dependency level of patient, but there are staff shortages and where experienced therapists are required, due to complexity of handling, but often, there are only inexperienced members of staff available, coupled with inadequate/unavailable gym facilities (AS8)

…… Control, alignment and quality of movement are paramount in retraining normal movement. If an inappropriate amount of resistance is used technique deteriorates. Muscle strengthening exercises must be carried out under supervision where patient is correctly positioned for the particular exercise to ensure the correct muscles are worked at the required intensity. The effects on other parts of the body must be closely observed to gain maximum benefit from exercise. This can be difficult when

exercises are carried out by unqualified and less experienced staff. This is can be addressed through training (SRU7).

The avoidance of promoting compensatory strategies featured as another important theme that emerged from the responses of the participants in this study. Some of the comments made are presented below:

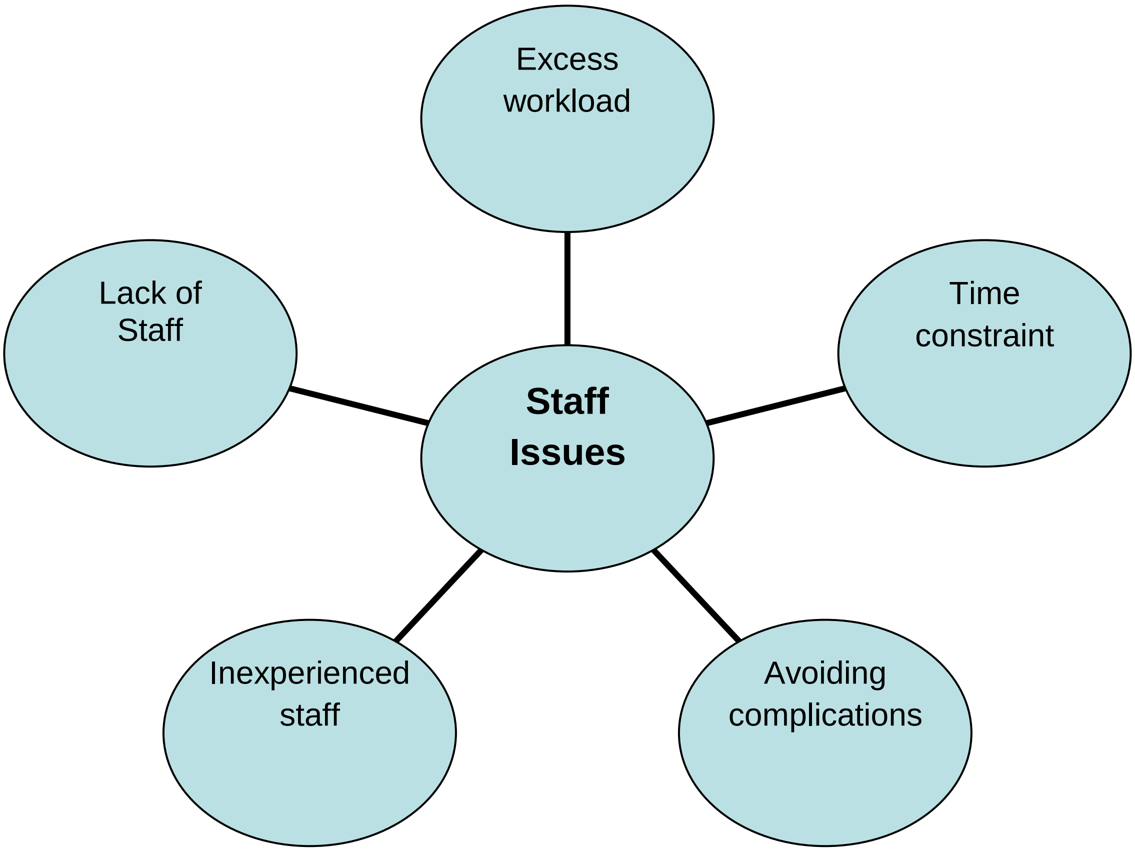
…It is important not to facilitate or promote abnormal compensatory movement. Rather than work on muscle strengthening which is more than likely to promote abnormal compensatory movement, I would aim to work for postural awareness and general non-compensatory mobilising exercises which would aim to lengthen shortened compensatory muscles and surrounding structures…… To facilitate normal muscle power activity it is most important to give a normal afferent input of good posture and alignment (CN6).

… *Strengthening very weak muscles is difficult; you will need to work to increase activation/drive first*. (SRU6)

….The challenge is to keep it at the right level to avoid compensatory strategies (SRU7)

These responses above may suggest that, although physiotherapists are willing to undertake muscle strengthening, there were y are simultaneously overwhelmed with other issues such as staffing and lack of facilities in which to carry out proper resistance muscle activities. In addition, therapists are wary of the fact that patients may try to compensate thus develop further abnormal synergies.

Figure 4.5: Linked codes representing how staff issues were grouped.



4.3.3.3 Organisational based Issues

Another recurrent theme was organisational issues, emergent codes included: lack of necessary equipment, limited number of staff and excessive work load. The following comments from respondents illustrate these points:

…Limited resources mean that my patients have limited access to treatments such as FES (CM6)

…..Appropriate/accessible/affordable strengthening equipment can be challenging, ensuring the patient has sufficient postural control, particularly around trunk/hips/shoulder girdles to allow strengthening of these muscle groups as well as more distal groups without detrimental compensations or fixations (GN6)

…Treating people at home you do not have access to equipment. Often, it is difficult to tie theraband to suitable places when on home visit in the community. There is a lack of resources to purchase motomed type machines for OP. No transport to get patients to access out patients if they have no family or friends to bring them (CM6).

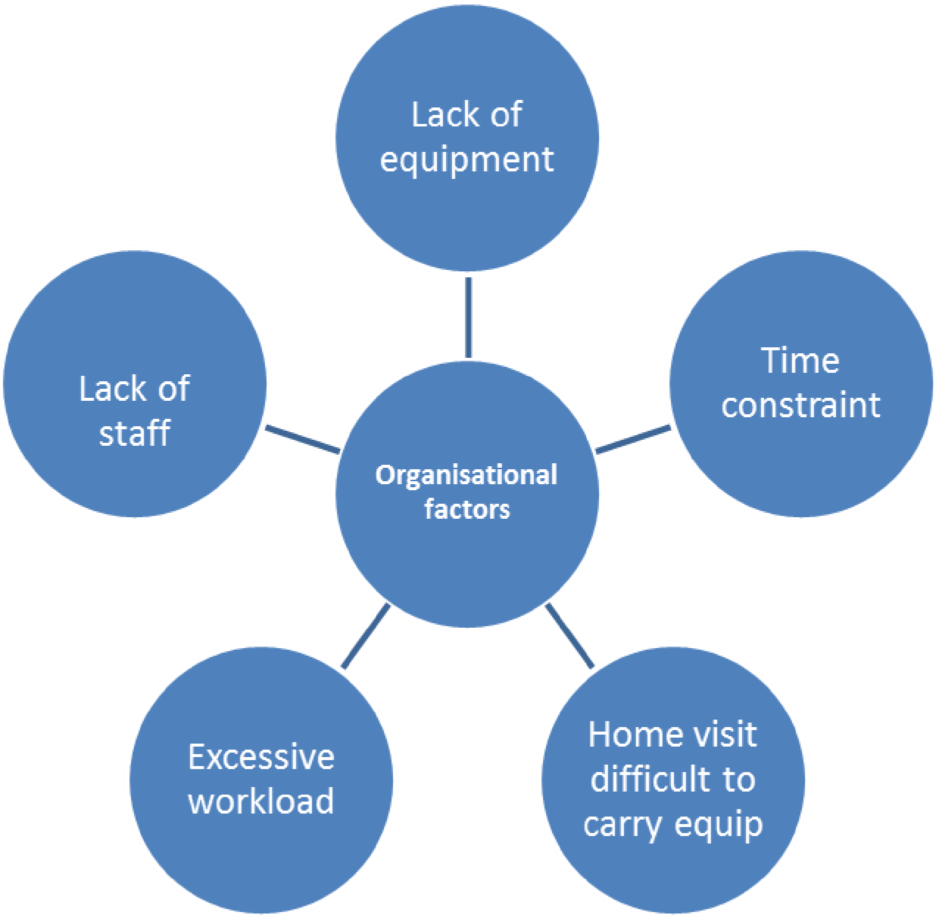
…the amount of time required to manage a patient using strength training and the physio therapy time schedule and patient work load, then the issue of the lack of appropriate strength training equipment (NRU6)

…reduced staff strength and limited resources making it difficult to undertake more comprehensive management for patients (CM7)

…. staff shortages and pressure of work does not allow for detailed strength training which takes time. When patients are asked to carry out these exercises, they make lots of mistakes and come back with complications (GN7).

These responses above suggested that, respondents to this survey were of the opinion that organisational factors also contribute to barriers in undertaking muscle strengthening. The sub-themes shown in figure 4.6 explain some these barriers.

Figure 4.6: Linked codes representing how organisational issues were grouped



4.3.3.4. Suitability of muscle strengthening at different stages of stroke

The appropriateness of subjecting certain categories of stroke patients to muscle strengthening featured as one of the barriers to the use of muscle strengthening in stroke management. In the response to this question, the recurrent sub-themes revolved around muscle flaccidity, hypertonicity of the muscles, painful movements. The following comments from respondents illustrate these points:

…*Strength training may be unsuitable during the acute stage of severe muscle weakness, rather facilitation exercises appear better, and other challenges include too many patients to see within a short period of time, limited numbers of staff and excess work load heaped on the therapists*. (AS7)

….I do not undertake strength training on acute stroke patients, sometimes impossible to perform muscle resisted exercises in very acute stroke patients (AS7)

… Often in severe CVA the muscles are obviously weak and flaccid. There is no way these muscles can be strengthened (AS6)

…Often patient participation and ability to carry out exercises on their own in the acute stages may be challenging, the muscles are obviously weak, making any management outside facilitation unnecessary. Patients may not require resisted exercises until during the chronic stages when they are way past the acute stages. (AS6)

… Fear of sub-luxation of the shoulder, reluctance of patients to follow instructions due to pain (SRU6)

In brief, the open-ended responses above illustrate how some of the respondents were of the opinion that they preferred to facilitate shoulder mobilisation, rather than strengthening the shoulder muscles. The reasons given included the fear of subluxation of the shoulder joint, as well as the fear of eliciting pain in the shoulder. The appropriateness of subjecting certain categories of stroke patients to muscle strengthening featured as one of the main barriers to the implementation of muscle strengthening in stroke management. In the response to this question, the recurrent sub-themes revolved around cognition, co-morbidities (patients with other medical problems including poor skin condition), pain of the shoulder, patient motivation, undertaking muscle strengthening inappropriately.

4.3.3.5. Coding framework of the responses obtained

The tables below (4.17a; 4.17b; 4.17c and 4.18) detail a clear and succinct description / explanation of how the raw responses from the open-ended questions were developed into descriptive emergent codes and themes. Similarly, Figures 4.7; 4.8 and 4.9 illustrate how the final themes emerged.

Table 4.17a: Example of how some of the initial coding of the open ended questions on barriers to using muscle strength training was carried out

<table>
<tr><th>Open ended transcript</th><th>Initial coding framework</th></tr>
<tr><td>Treating people at home you do not have access to equipment. Can't tie theraband to suitable places. Lack of resources to purchase motomed type machines for OP patients.</td><td rowspan="4">○ Difficult to undertake strength training
○ Lack of required equipment
○ Lack of resources
○ Conflicting information on muscle strength training
○ Some staff not comfortable with strength training in stroke patients</td></tr>
<tr><td>The Bobath approach from literature strength training may increase spasticity, so avoid strengthening as much as possible</td></tr>
<tr><td>Other colleagues often do not encourage muscle strengthening, it is my observation it is not done much when patients are in the acute and subacute stages</td></tr>
<tr><td>Some of the more senior colleagues often do not encourage strengthening</td></tr>
</table>

Table 4.17a: Example of how some of the initial coding of the open ended questions on barriers to using muscle strength training was carried out

<table>
<tr><th>Open ended transcript</th><th>Initial coding framework</th></tr>
<tr><td>..Often lack of time, there are too many patients to see in the acute unit within a limited period of time…</td><td rowspan="4">Time constraint
Too many patients to be seen within a short period
Busy acute stroke units
Time a huge factor
Limited/insufficient time</td></tr>
<tr><td>…lack of time due to the number of patients seen in a short period of time</td></tr>
<tr><td>…..there is the recurrent issue of limited/insufficient time to see several scheduled patients within a short period of time with limited staff numbers....</td></tr>
<tr><td>…. time constraint is a huge factor in a busy acute stroke unit</td></tr>
<tr><td>..acute patient too frail to commence resistance muscle activities often poor skin care needs meaning patients spend large amounts of time on air mattresses meaning difficult for patients to do exercises whilst in bed and weakening of muscles leading to less stability.</td><td rowspan="7">Muscle strength training may not be appropriate at certain stages
Time constraint
Not appropriate at certain times
Muscle are too hypertonic
Muscles are too weak or flaccid
May not be suitable to apply in home situations
Acute patient too frail for muscle strength training</td></tr>
<tr><td>..ST may be unsuitable at this stage of severe muscle weakness to commence strength training rather facilitation exs appear better</td></tr>
<tr><td>…..I have found it very difficult attempting muscle strengthening in flaccid and non-responding muscles</td></tr>
<tr><td>…..unsuitable at this stage of severe muscle weakness to commence</td></tr>
<tr><td>….Difficulty giving home exercise programme for those with very weak muscles - tend to use auto assisted, carer and FES</td></tr>
<tr><td>..acute patient too frail to commence resistance muscle activities often poor skin care needs meaning patients spend large amounts of time on air mattresses meaning difficult for patients to do exercises whilst in bed and weakening of muscles leading to less stability.</td></tr>
<tr><td>…often weakness can be identified but then it is difficult to find a way for the person to exercise that muscle because it is so weak</td></tr>
</table>

Table 4.17b: Example of how some of the initial coding of the open ended questions on barriers to using muscle strength training was carried out

Open ended transcript	Initial coding framework
…on some occasions patients who have been working muscles inappropriately. Patients can compensate and some inexperienced therapists don't always appreciate this so when they teach exercises they don't always work what they think they are working.	○ Staff not well trained ○ Inexperienced staff ○ Staff not sure what to do ○ Patient performing strength training inappropriately ○ Some staff not willing to undertake muscle strength training
..inexperienced or untrained staff may use muscle strengthening inappropriately, where effort is not isolated or results in unbalanced strengthening at the cost of range or function	
Other colleagues often do not encourage muscle strengthening, it is my observation it is not done much before patients subacute	
…pain of the hand due to spasms and oedema	○ Pain ○ Compensatory strategies ○ Cognitive issues with the some patients ○ Poor cognition and poor communication ○ Some patients unable to comprehend instructions ○ Co-morbidities and other medical issues
..the challenge is to keep it at the right level to avoid compensatory strategies	
Fear of subluxation of the shoulder, reluctance of patients to follow instructions due to pain	
..cognitive problems may make insufficient repetitions difficult to achieve_x000D_ Severe weakness makes home exercise provision difficult_x000D_ Fatigue	
..cognition and communication impairment some patient not fully able to comprehend instructions	
…poor Compliance_x000D_ and inadequate intensity to achieve any meaningful effects	
Often … because of poor skin integrity means the patients spend large amounts of time on air mattresses creating difficulty for patients to attempt any strength training	
When patients have reduced activity levels or minimal activity levels due to co-morbidities and other medical challenges	
…limited resources mean that my patients have limited access to treatments such as FES.	○ Limited resources ○ Insufficient strength training equipment ○ Limited access to suitable strength training facilities
…lack of equipment - we use theraband a lot working in the community we have to be imaginative using tins of beans etc, we also use static pedals.	
If the department has limited resources mean that my patients have limited access to treatments such as FES	
…..access to suitable facilities/equipment in some subacute setting sometimes pose challenges	

Table 4.18: An example of the final coding framework after reduction of the categories in the initial coding framework

Initial coding framework	Final coding frame work
○ Time constraints ○ Too many patients to be seen within a short period ○ Busy acute stroke units ○ Time a huge factor ○ Limited/insufficient time	Issues around limited time/ time constraint
○ Painful shoulder ○ Pain due to swelling	Pain as a limiting factor
○ Muscle strength training may not be appropriate at certain stages ○ Time constraint ○ Not appropriate at certain times ○ Muscle are too hypertonic ○ Muscles are too flaccid	Appropriateness of muscle strength training
○ Limited resources ○ Insufficient strength training equipment ○ Limited access to suitable strength training facilities ○ Access to suitable strength training facilities ○	Limited resources or lack appropriate equipment
○ Staff not well trained ○ Some inexperienced rehabilitation staff ○ Staff not sure what to do ○ Patient to staff ratio/lack of adequate staff ○ Time constraint ○ Some therapy not sure of muscle strength training in stroke management	Staff awareness and training Limited staff strength
○ Pain ○ Compensatory strategies ○ Cognitive issues with the some patients ○ Poor cognition and poor communication ○ Some patients unable to comprehend instructions	Poor patient compliance Pain experienced by patients Issues around cognition and understanding of what is required

Figure 4.7: An Example of how the final emergent themes were derived for organisational factors

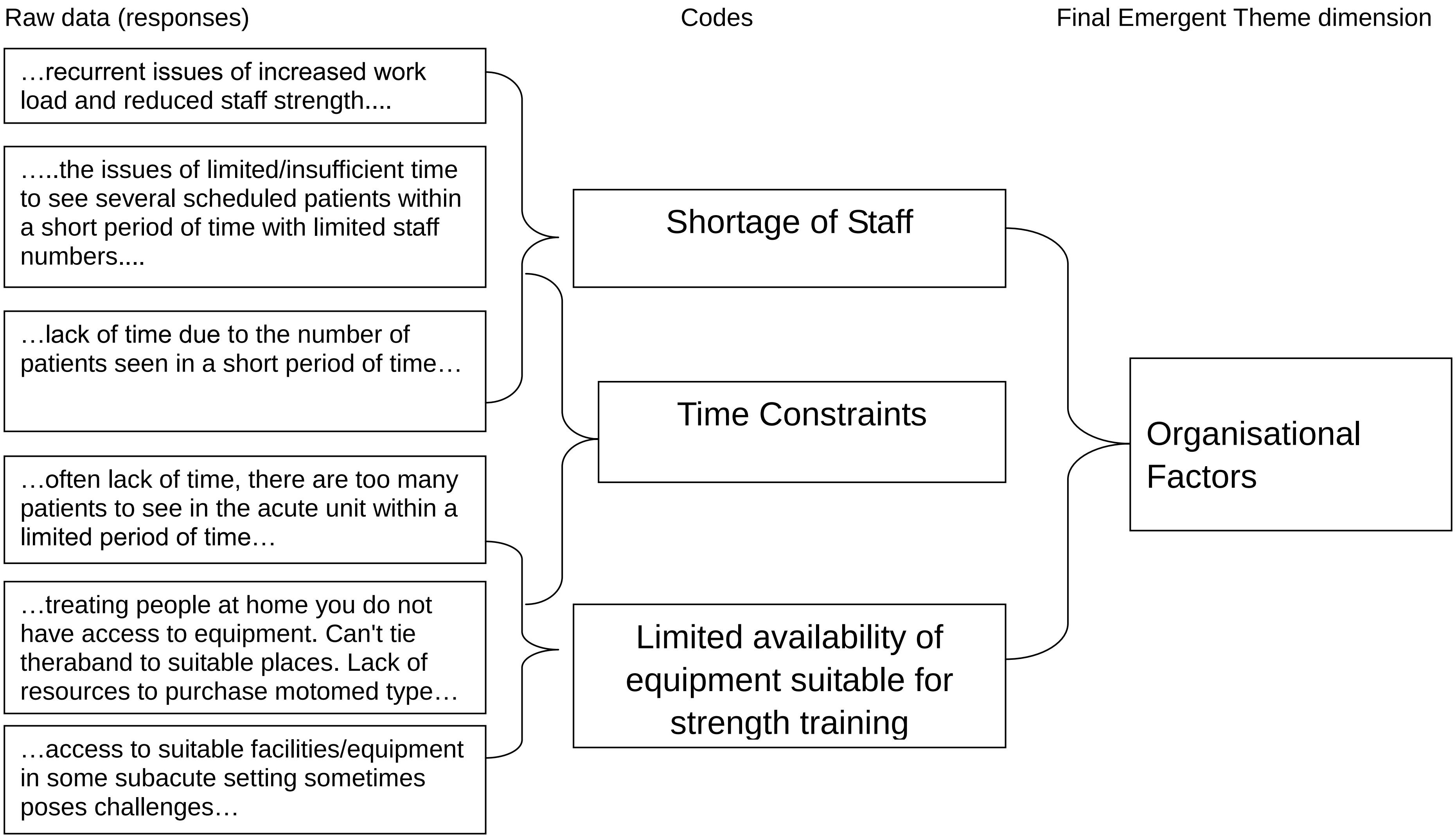


Figure 4.8: An Example of how the final emergent themes were derived for patient factors

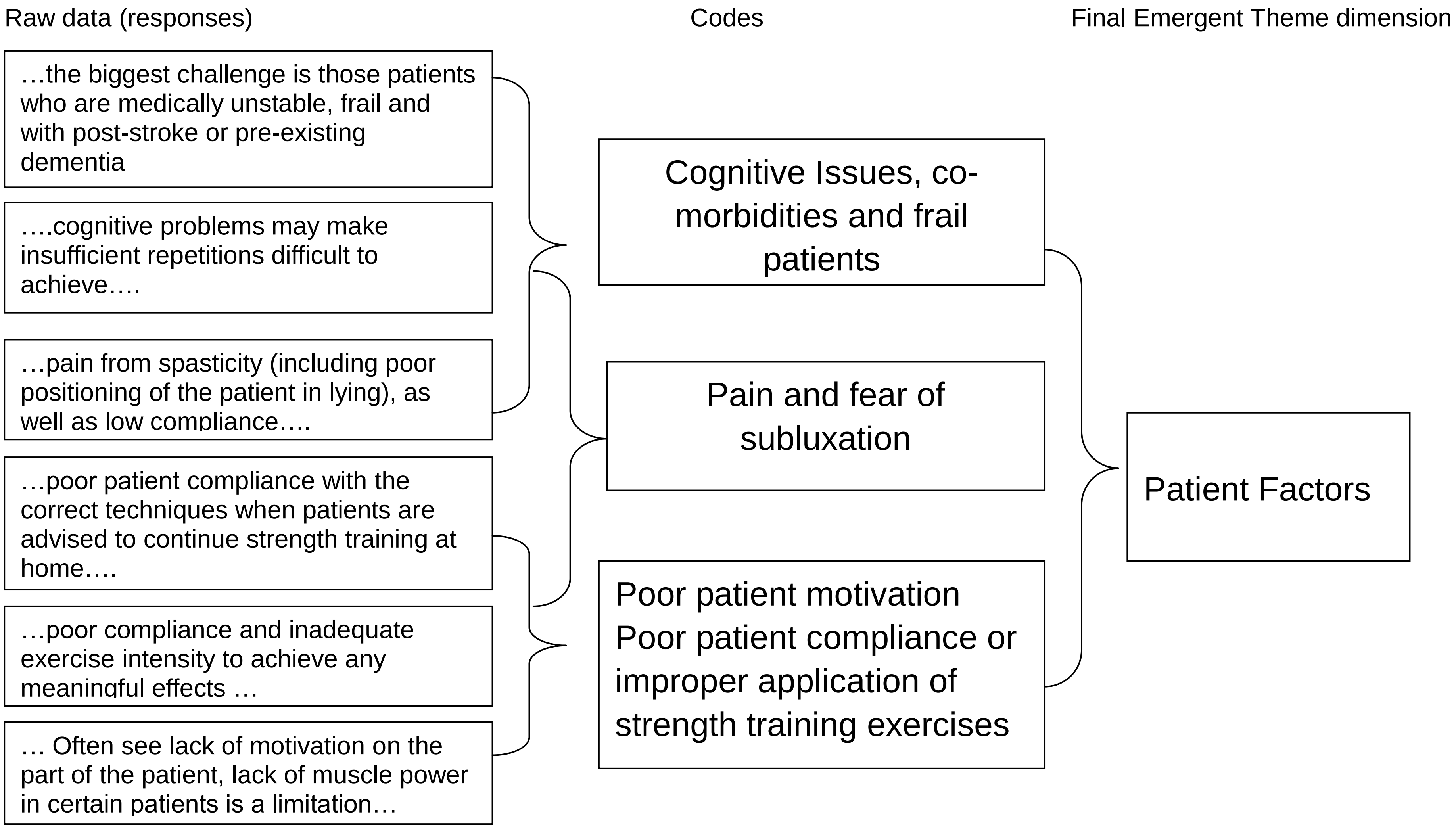


Figure 4.9: An Example of how the final emergent themes were derived for staff issues

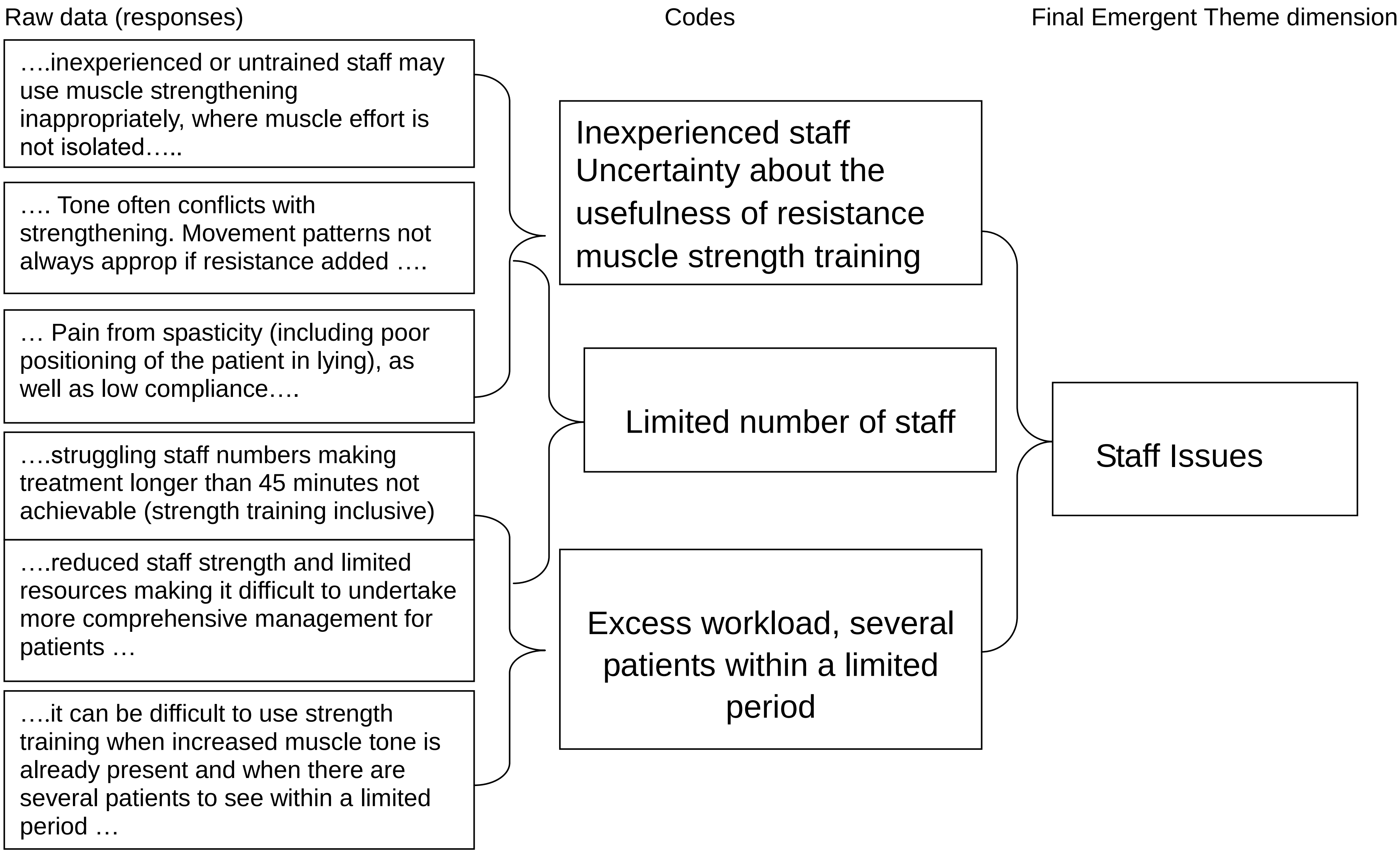


Table 4.19 below gives a descriptive overview of how recurrent emergent codes were developed into emergent themes on the barriers to the use of muscle strengthening in stroke rehabilitation. The responses were divided into four main themes: 1) Patient issues, 2) Staff issues, 3) Organisational issues and 4) Suitability of muscle strength training exercises in stroke rehabilitation.

Table 4.19: Shows how emergent themes/sub-themes on barriers were formed

1. Patient Issues a) Cognitive abilities of the patient to comprehend instructions b) Co-morbidities / Medical issues c) Compliance on the part of the patient d) Lack of patient motivation e) Patient performing muscle strength training wrongly f) Shoulder pain and the fear of shoulder subluxation g) Avoiding complications
2. Staff Issues a) Avoiding complications b) Inexperience of some of the rehabilitation staff c) Patient to staff ratio/lack of adequate staff d) Time constraint e) Therapist not sure of muscle strength training in stroke management
3. Organisational issues a) Excessive work load on staff b) Lack of necessary equipment c) Limited number of staff
4. Suitability of muscle strengthening at certain stages of stroke a) Hypertonic /Spastic muscles b) Muscles too weak or flaccid in the acute stages

Limitations to the qualitative analysis of this thesis

There were limitations to the way the open ended questions were analysed. Initially, the researcher proposed using thematic analysis to analyse the open ended responses. However after meticulously processing the obtained data, the researcher decided to analyse the data as emergent themes. This was because although the responses obtained were comprehensive, informative and wide-ranging, they were not exhaustive to progress into in-depth thematic or content analysis. This was because the open-ended questions were restricted compared to to the most common forms of qualitative research studies such as data generated through in-depth interviews, focus groups, textual field notes or field observations (this is reflected upon in chapter six of this thesis).

CHAPTER 5

DISCUSSION AND CONCLUSION

5.0. Overview

This chapter interprets the findings presented in Chapter 4, and explains associations between the variables obtained from the results. For purposes of clarity, this discussion will be presented separately for each hypothesis. This will be followed by the analyses of previous surveys conducted to investigate the factors that influence the clinical decision of physiotherapists in the selection of treatment approaches in stroke rehabilitation. Similarities and differences in the outcome of these studies will be discussed. The final section will discuss the conclusion and implications for clinical practice.

5.1. Hypotheses and relationships investigated

This study evaluated the knowledge about, the barriers to, and the clinical decision making of the use of resistance muscle strengthening in stroke rehabilitation by respondent neuro-physiotherapists in the UK. The results obtained, revealed that: (1) 87.5% of the respondents acknowledged they use resistance muscle strengthening in stroke rehabilitation; (2) there was a moderately positive association between the specialism of practice and the use of muscle strengthening; (3) there was a positive association between attendance at continuing professional development (CPD) programmes such as attendance at seminars / workshops and the use of muscle strengthening; (4) there was a positive association between respondents that read evidence-based literature and the use of muscle strengthening in stroke rehabilitation; (5) there was a weak/moderate positive association between the number of years in clinical practice as a neuro-physiotherapist and the use of muscle strengthening; (6) there was a weak association between the number of patients treated and the use of muscle strengthening; and (7) there was a positive association showing that barriers and challenges influenced the clinical decision of respondent neuro-physiotherapists in the use of muscle strengthening.

The results showed that four variables were moderately significant at the alpha set level ($\alpha = 0.05$). The strongest associations obtained for the use of muscle strengthening were for both the reading of literature ($\chi 2 = 86.2$, $df = 1$, $p < 0.05$) and the attendance at CPD ($\chi 2 = 31.9$, $df = 1$, $p < 0.05$). One variable was found to have moderate association - specialism of practice ($\chi^2 = 66.65$, $df = 5$, $p < 0.05$), while two variables had minimal association: the number of years practised ($r = 0.196$, $N = 401$, $p < 0.05$) and the number of patients treated ($r = 0.170$, $r^2 = 0.03$, $N = 401$, $p < 0.05$).

Descriptive analysis of the emergent themes, elaborated some of the reasons presented as barriers to the use of resistance muscle strengthening in stroke rehabilitation (e.g. poor cognition, co-morbidities, hypertonic muscles, shoulder pain, lack of time, limited staff numbers). The themes deduced from the interpretation of the open-ended questions were used to substantiate some of the findings of the quantitative results focusing on the initial research hypothesis. Interpretation and meaning of the open-ended questions were considered with the assumption that the responses provided by the respondents were true and realistic.

5.2. Use of muscle strengthening

It was hypothesised that there would be no difference in the use of resistance muscle strengthening between respondent neuro-physiotherapists across the UK. The result obtained (χ^2 = 3.16, *df* = 3, *p* = 0.37), showed that respondent neuro-physiotherapists in the UK use resistance muscle strengthening in stroke rehabilitation, and therefore (H1) was accepted. Further analysis of the result showed that *N* = 351 out of *N* = 401 (87.5%) of respondents acknowledged they undertake at least one form of muscle strengthening exercise in the rehabilitation of stroke patients (Figures 4.1 and 4.2). Also, the results showed that 88.5% of respondent acknowledged that the use of resistance muscle strengthening was appropriate in the rehabilitation of stroke patients, while 11.5% felt resistance muscle strength training may be inappropriate in stroke rehabilitation (Table 4.4).

The results obtained in this study appeared consistent with the results obtained by Jones et al. (2003), who recorded 62% (*N* = 437 out of *N* = 701) of respondent clinical physiotherapists acknowledged using resistive muscle strength training within the first three months post-stroke. In the current study, it was observed that approximately 64% (*N* = 61 out of *N* = 95) of respondents who work in acute stroke indicated they undertake resistance muscle strengthening in stroke management, while 36% (*N* = 34 out of *N* = 95), within the same specialism (acute stroke rehabilitation) indicated they did not make use of resistance muscle strengthening. This result showed similarities to the study by Jones et al. (2003) on resistive strengthening in acute stroke patients. However, compared to other specialisms such as general neurology, it was observed that a higher percentage of respondents in specialisms other than acute stroke rehabilitation, acknowledged using muscle strengthening (Appendix 4).

5.3. Specialism of practice and the use of muscle strengthening

With regards to the predictive relationship between specialism of practice and the use of muscle strengthening in stroke rehabilitation, it was hypothesised that there would be a positive association between these two variables. Using a chi-squared test, the results demonstrated a positive association (χ^2 = 66.65, df = 5, p < 0.05), suggesting that the specialism of practice might influence the clinical decision in the use or lack of use of muscle strengthening in stroke rehabilitation. Therefore, H2 was accepted, although the association was moderate based on the Cramer's V score which was 0.408 (Appendix 4). Prior to this study, the researcher hypothesised that specialism of practice would be highly significant. However, contrary to expectations, this result indicated only a moderate association.

A cross-tabulation of the specialism of practice and the use of muscle strength training identified the actual distribution of respondents who indicated 'yes/no' amongst the different specialisms (Appendix 4). The results showed that 64% of the respondents who selected 'acute stroke' as their specialism of practice undertook muscle strengthening, while approximately 36% did not undertake muscle strengthening. This implied that, in the current study, about one-third of the respondents who worked in acute stroke rehabilitation did not use resistance muscle strengthening, compared to respondents from other specialisms such as general neurology, neuro-rehabilitation units and community rehabilitation who reported a higher percentage of the use of muscle strengthening in stroke rehabilitation (Appendix 4).

Descriptive analysis of the emergent themes from the open-ended questions showed that some of the reasons provided by respondents for not using muscle strengthening during the acute stages of stroke rehabilitation included: the presence of medical co-morbidities; poor cognitive abilities of some patients at this stage of rehabilitation; and some patients appeared too weak to commence muscle strengthening. Although there is research based literature supporting the commencement of muscle strengthening activities within the first three months post-stroke (Cooke et al., 2009a; Donaldson et al., 2009; Jones et al., 2003; Outermans et al., 2010), it can be argued that some of the reasons provided by the respondents in the open-ended responses for lack of its use, such as medical co-morbidities, can be considered as legitimate. This is because increased physical activities might strain or aggravate some medical conditions in a stroke patient (MacKay-Lyons and Makrides, 2002a; MacKay-Lyons and Makrides, 2004). Similarly, clinicians have a clinical obligation to make guided clinical decisions based on the presenting clinical signs and symptoms of the patients they treat, to avoid causing or aggravating any risks to the acute stroke patient (MacKay-Lyons and Makrides, 2002b).

On the other hand, based on the emergent themes of the open-ended responses, it was observed that some clinicians were not convinced about the use of resistance muscle strengthening based on their opinion that muscle strengthening in stroke rehabilitation was inappropriate. The statement below provides an illustrative example:

"*I don't undertake resistance muscle strengthening; increased muscle tone conflicts with muscle strengthening, because it may have a negative effect on some of the patients treated*". (AS7)

However, comparing the responses from respondents who worked in other areas of stroke rehabilitation, it was observed that more respondents acknowledged using one form of muscle strengthening procedure in the rehabilitation of stroke patients, which is consistent with the study by Jones et al. (2003).

5.4. Factors that influence the decision to use muscle strengthening in stroke rehabilitation

It was hypothesised that there would be a positive association between respondent neuro-physiotherapists who read research-based literature and attended workshops /seminars, and the use of muscle strengthening. As predicted, the results obtained signified positive associations for reading of literature ($\chi 2 = 86.2$, $df = 1$, $p < 0.05$); and attending workshops/seminars ($\chi 2 = 31.9$, $df = 1$, $p < 0.05$); therefore, H3 and H4 were accepted and are discussed below.

5.4.1. Research-based evidence

In response to the question ‘have you read any literature on muscle strengthening in stroke rehabilitation’, 66.8% ($N = 268$ out of 401) claimed that they had read literature or articles on the use of muscle strengthening, while 33.2% ($N = 133$ out of 401) had not read any literature on muscle strength training. A chi-square test recorded a positive significant association ($\chi 2 = 86.2$, $df = 1$, $p < 0.05$). The results obtained in the current study seems to suggest that respondents consult relevant research-based literature to inform their clinical decision in the use of muscle strengthening in stroke rehabilitation (Table 4.13 and Appendix 5)

The finding obtained in the current study is not an isolated case; rather, it appeared consistent with studies that had previously explored how physiotherapists involved in stroke rehabilitation inform their decision making in stroke rehabilitation (Jette et al., 2003a; Salbach et al., 2007; Salbach et al., 2009a; Salbach et al., 2010). In a cross-sectional study conducted in Canada by Salbach et al. (2010) on the determinants of research-evidence used in the clinical decisions of physiotherapists providing services to post-stroke patients, they found that between 57.7% and 70.3% of Canadian physiotherapists use research to inform their clinical practice. In another Canadian study, Salbach et al. (2009a) reported that 73.3% of Canadian physiotherapists relied more on evidence-based research in stroke management than on other variables such as basic education. Salbach et al. (2009a) also found from a similar questionnaire survey conducted in 2009, comparing Canadian and American physiotherapists, that whereas 73.3% of Canadian physiotherapists read research literature two or more times in a typical month, 82% of American physical therapists reported reading research literature two or more times per month and basing their clinical decisions on the evidence in stroke rehabilitation (Salbach et al., 2009b; 2010).

In summary, in the current study, it was observed that research evidence featured as a prominent factor that influenced the clinical decision of respondents. This result is encouraging, as the observed use of research-based evidence in clinical practice might positively establish a therapeutic alliance that optimises functional clinical outcomes in the rehabilitation of stroke patients, but which needs to be subjected to a more rigorous research process.

5.4.2. Continuing professional development (CPD)

Continuing professional development (CPD) featured as another factor that influenced the clinical decision of respondents to use muscle strengthening in stroke rehabilitation. In response to the question ‘have you attended any seminar/workshop on muscle strengthening in stroke rehabilitation’, 44.13% (*N* = 177 out of 401) acknowledged that they have. But unlike reading of research-based literature that recorded 66.8%, fewer respondents appeared to have attended continuing professional development programmes (example seminars/workshops) on muscle strengthening in stroke rehabilitation. The result showed that 59.9% (N = 224 out of 401) respondents have not attended any CPD programmes, compared to 44.1% (N= 177 out of 401) respondents who had attended. Nevertheless a chi-squared test recorded a moderate significant association ($\chi 2 = 31.9$, $df = 1$, $p < 0.05$); indicating that CPD influenced the clinical decision of respondents.

Some of the reasons given for lack of CPD attendance were: increasingly financial constraints, and organisational problems in sponsoring therapists to external workshops and conferences. This may imply that clinicians may have to personally source sponsorship to attend CPD programmes to update their clinical knowledge on stroke rehabilitation. The objective of CPD is not solely to increase knowledge and skills on physiotherapy techniques; rather, it serves as a resource designed to improve patient outcomes by encouraging physiotherapists to streamline their practice based on the best current research evidence available (Bayley et al., 2012; Jette et al., 2003a; Rappolt and Tassone, 2002; Salbach et al., 2009; Salbach et al., 2007). It may not be sustainable for professionals to practise the same procedures in the same way for most of their working careers. French and Dowds (2008), in a CPD narrative review, explained that professional competence is a perishable commodity which can last for between three and five years. Therefore, it is imperative for professionals in clinical practice to continually update their practice knowledge for the benefit of the patients they treat, the individual therapists, and the healthcare team as a whole.

5.4.3. Other factors that influenced clinical decision to use strengthening

Apart from research-based evidence and attendance at continuing professional development programmes (CPD), there were other factors that influenced the clinical decision of respondents to use muscle strengthening in stroke rehabilitation. These factors were: experience from patient management, clinical guidelines/protocol, information from colleagues, routine clinical practice, and basic university education. These factors were ranked alongside research-based evidence and continuing professional development (Appendix 3). However, the responses from the respondents to this question with several other factors was fascinating, it was observed that, experience gained from working with patients was rated over and above the other factors in the decision to use muscle strengthening (Table 4.9). The results obtained were: experience gained from working with patients (21.7%), closely followed by attendance at continuing professional development (CPD) activities (17.9%), reading of guidelines/protocol (15.9%), and reading of evidence based literature (15.4%). However, it was observed that basic university education ranked as one of the least factors likely to influence the respondents in the decision to undertake muscle strengthening (7.4%).

This results showed some similarities to that obtained by Jones et al. (2003), in which they observed that, respondents selected clinical experience working with patients and constituted 74% (*N* = 291 out of 393) of the rationale that informed their decision to use resistive muscle strengthening in acute stroke management; while evidence-based literature constituted 17% (*N* = 67 out of 393). In the current study, when compared side by side with other factors, clinical experience came tops, while, research-based evidence appeared to be the fourth choice selected by respondents as the factor that mostly influenced their choice to use resistance strengthening constituting 15.4% (N = 54 out of 351). Comparably the results of this study appeared similar to Jones et al. (2003), but with a slight difference. The percentage decrease may be due to the fact that, there were several variables in the questionnaire of the current study (e.g. basic education, continuing professional development, experience from patient management, guidelines/protocol, information from colleagues, and routine clinical practice); compared to only three variables in Jones et al.'s study (basic educational training, clinical experience, and experimental evidence). Similarly, it was observed that CPD was selected as the second factor that informed the decision to use resistance strengthening in stroke rehabilitation constituting (17.9%) when ranked amongst the other factors that influenced respondent's clinical decision. These factors will be discussed individually under different sub-headings.

5.4.3.1. Clinical experience working with patients

Clinical experience gained from working with patients scored a relative high of 21.7% (Table 4.9) as a factor that influenced the choice of respondents to use resistance muscle strengthening. Clinical experience was selected over research-based evidence, attendance at continuing professional development programmes and basic educational training (i.e. knowledge derived with direct reference to academic training, academic research or published literature). A similar finding was observed by McGlinchey and Davenport (2013), when they explored the decision-making process in the delivery of physiotherapy in a stroke unit.

These findings in the current study seem to be in agreement with the results of a previous study, which examined physiotherapist reasons for treatment choice (Turner & Whitfield, 1997). This result also appeared consistent with the results obtained by

Stevenson et al. (2004), where respondents stated that the most important factors that influenced their treatment choice in stroke rehabilitation were: clinical experience from patient management and attendance at courses, while the least important factors were research/literature and reading articles/journals. Furthermore, the result of the current study appeared consistent with the results from previous studies (Jones et al., 2003; Lennon, 2003; Salbach et al., 2009), all of which noted that experience gained from working with patients influenced clinical decision more than other factors like basic educational training.

Equally Jette et al. (2003b) found that physiotherapists often based their decisions on clinical experience, rather than academic knowledge, when deciding discharging destination from acute hospital care. One possible explanation why respondents may base their decisions on clinical knowledge is that knowledge gained from clinical experience may be more contextually real and relevant to the physiotherapist than academic knowledge, which may not always be applicable to the particular clinical situation (McGlinchey and Davenport, 2013).

The findings of the current study cannot be described as conclusive; however, it may be beneficial to gain a deeper insight on why respondents selected clinical experience over other variables as the choice that influenced their decision to use resistance strengthening in stroke rehabilitation. This may have been achieved if respondents are asked to explain their reasons in an open-ended question rather than ranking their choice from a list of seven factors. Therefore, future studies may be required to further investigate therapists' choices as no definite conclusion was attributed to their choice in this study.

5.4.3.2. Basic university education/training

The results of the study unexpectedly showed that basic educational training appeared to be the least important factors out of seven selected by respondents as influencing their choice to use muscle strengthening 7.4% (*N* = 26 out of 351). Inadvertently, this finding may suggest that respondents did not consider their knowledge on the use of muscle strengthening in stroke rehabilitation as gained from basic university degree education. This was fascinating, yet contradictory to the anticipated results. I expected basic education to be among the first three reasons. This is because, in the last decade, the curricula of universities training physiotherapists in the UK have placed great emphasis on evidence-based management of several clinical conditions, including the rehabilitation of neurological patients (stroke inclusive). Hypothetically, and with hindsight of my position as a neurology physiotherapy lecturer involved in the training of physiotherapy undergraduate student are taught about the current evidence-based management of neurological conditions and other medical conditions.

However, the result of this study may not be an isolated finding: three different surveys on evidence-based practice, conducted in the USA, Australia and Canada (Jette et al., 2003a; Long et al., 2011; Salbach et al., 2007) observed that, despite the value placed on research-based evidence, approximately half the practising physiotherapists claimed they did not learn the foundations of research-based evidence as part of their academic preparation. Similarly, the result was consistent with Jones et al. (2003) who recorded 2%, compared to 7.4% in this study.

The questionnaire in the current study did not ask for the highest educational qualification of the respondents, and no definite conclusion can therefore be reached on why basic education has limited influence as a factor that influenced the clinical decision of the respondents. It can only be assumed that respondents seem to gain more knowledge about the use of muscle strengthening in stroke rehabilitation based on post qualification experiences or other factors such as reading of research-based literature or attending CPD activities. Nevertheless, it may be crucial that physiotherapists working in academia and practice placement facilitators find ways of encouraging and emphasising the concepts of research-based evidence to student physiotherapists during the course of training. Long et al. (2011) explained that, although the inclusion of research-based evidence in the health professional entry-level curriculum is relatively new, there is an urgent need to further expose entry level physiotherapy students to more research-based evidence in order to produce more proficient evidence-based practitioners. This point had been reiterated in a previous study by Turner et al. (1996: p27): "*academic and clinical staff who are responsible for delivering theoretical and clinical education to both undergraduate and qualified physiotherapists must ensure that recourse is made to the research literature to justify not only physiotherapy treatments, but also measurement and patient assessment*".

5.4.3.3. National Guidelines and the use of muscle strengthening

The results showed respondents selected clinical guidelines / protocols as the third factor out of seven that influenced their decision to use muscle strengthening in stroke rehabilitation 15.9% (*N* = 56 out of 351), and this result can be described as encouraging. Interestingly, guidelines/protocol was selected over research-based evidence. Logically, clinical guidelines are recommendations suggesting appropriate treatment and care for the management of people with specific conditions within the National Health Care Service (NHS) in the UK. It is assumed that the recommendations in guidelines/protocols provide an assimilation of the current evidence (Ashford, 2014). They are important in providing up-to-date appraisal and interpretation of the evidence and to enable clinicians to apply these evidence-based updates in clinical practice (Ashford, 2014; Wolf et al., 1999). Thus, it may be assumed that if respondents actually consult the clinical guidelines, they might inevitably be following the current research-based evidence.

However, sometimes these recommendations are not always followed (Francke et al., 2011). In a systematic review, Francke et al. (2011) observed that the implementation of the guidelines recommended for clinical staff continue to be a recurrent issue in healthcare practice. However, it can be argued that although clinical guidelines facilitate and assist healthcare professionals towards the best evidence, they do not necessarily replace the knowledge and skills of professionals. Therefore strategies may need to be developed to encourage practitioners to follow the recommendations of up-to-date clinical guidelines. Guidelines do not implement themselves spontaneously, but rely on clinicians to be proactive in implementing them (Ashford, 2014).

5.5. Barriers/challenges to undertaking muscle strengthening

The results of the study recorded that 64.6% of respondents acknowledged encountering barriers to the use of muscle strengthening, while the remaining 35.4% did not. The key issues outlined by respondents in the current study as constituting barriers to the use of muscle strengthening in the management of stroke patients were categorised into sub-groups: a) patient-based barriers; b) therapist-based barriers and c) clinical and professional reasons and organisational reasons.

5.5.1. Patient-based factors:

The factors classified as patient-based barriers were: reduced cognitive abilities; patients expressing fear of possible subluxation of the shoulder; poor compliance on the part of the patient and in certain instances, patient incorrectly applying muscle strengthening activities when given as home exercise activities; and patients experiencing pain of the muscle when undertaking resistance muscle strengthening.

One of the patient-based barriers reported by respondents in their responses to the open-ended question was the issue of reduced cognitive abilities. Cognition is how people learn, understand, reason and remember everyday activities. It is assumed that, because a stroke affects cognition, the resultant loss or diminished cognitive skills may affect their abilities of the patient to fully participate in rehabilitation activities post-stroke (Rasquin et al., 2005). However, two different studies (Parker et al., 2010; Zinn et al., 2004) observed that, in cases of mild to moderate stroke, the presence of cognitive impairment in stroke patients may not necessarily affect the overall management regime of either acute or post-acute rehabilitative care. These authors were of the opinion that stroke patients who had clinically moderate cognitive impairments were able to undertake rehabilitative activities at rates similar to those patients who had unimpaired cognitive abilities. Similarly, in another study Tang et al. (2013) observed that effectively implemented physical, and mentally tasking exercise programmes may play a dual role in enhancing physical and cardiovascular functions in stroke patients, as well as improving their cognitive abilities. It can therefore be argued that, undertaking progressive resistance exercises might possibly enhance the cognition and functional performance abilities of stroke patients rather than act as a barrier. This will need to be investigated further on a large scale research study for a definitive outcome.

Pain was cited as another patient-based barrier, extrapolated from the responses to the open-ended aspect of the survey. Some of these were explained in Chapter 4 (section 4.3.2), and illustrative examples are provided below:

"Some patients often complain of painful shoulder when asked to use an elastic theraband" (CN6).

"..When patients push themselves with upper limb strength training, pain can sometimes be reported" (GN7).

"…patients with associated pain from other musculoskeletal problems like OA of the hip and knee often avoid muscle strengthening activities" (GN6).

Other patients-based barriers such as medical problems including co-morbidities, poor skin condition pain of the shoulder, and lack of patient motivation have been highlighted in (section 4.3.2). However it should be emphasised that unique clinical circumstances, such as reduced cognitive abilities, the presence of co-morbidities, and the resolution of medical issues constitute genuine reasons to avoid muscle strengthening in stroke patients. Despite these patient-based factors, studies by Cooke et al. (2010a); and Donaldson et al. (2009) have suggested that the muscles of stroke patients should be put to work as soon as they are stable in order to enhance functional recovery.

5.5.2. Organisational barriers:

Some of the organisational barriers identified by respondents as preventing the use of muscle strengthening included: excessive patient caseload, limited number of therapists compared to the number of patients requiring rehabilitation, and limited time allocated to see each patient. It is pertinent to note that, time constraints emerged as one of the prominent themes constituting the greatest barriers within clinical practice to the implementation of muscle strengthening. These barriers will be discussed in terms of the following themes.

5.5.2.1. Insufficient time:

The issue of insufficient time was a significant barrier according to the results. Respondents specifically noted that they would prefer to have more time to be able to effectively undertake more dynamic rehabilitation of these groups of patients, including the use of muscle strengthening. Respondents also indicated that insufficient time had a negative impact on staffing strength due to staff absence as a result of pressures of work.

Respondents indicated that when they have to manage several patients within a limited time frame, it may be difficult to undertake comprehensive resistance muscle strengthening of the weakened muscles of the hemiplegic patient during a scheduled or allocated treatment time of 45 minutes or 60 minutes maximum, as evidenced in the following narrative statement:

“..*Lack of time due to the few staff numbers is a recurrent happening in the clinic”* (SRU6).

Another respondent indicated that limited time and pressure of work appeared to be a factor preventing its use in practice during scheduled working hours, as evidenced in the following narrative statement:

"..O*ften shortages and pressure of work does not allow for detailed strength training which takes time. However when patients are asked to carry out these exercises, they make lots of mistakes and come back with complications"*. (GN7)

Most of the responses reflected respondents concerns about time. Time to actually carry out the detailed and efficient muscle strength training was a concern in all settings, but participants agreed that they could do better with reduced workload (number of patients seen). This did not always mean that all the stroke patients would be placed on resistance muscle strength training because there are other rehabilitation approaches. Furthermore, apart from muscle weakness, there are frequently other rehabilitation tasks demanding physiotherapeutic attention.

This issue of time constraints in clinical practice constituting a barrier is consistent with the results of similar studies conducted on the use of evidence-based research findings in clinical practice Cimoli et al. (2012); and Fink et al. (2005) recorded insufficient time on the job as a significant barrier to the utilisation of research in practice to implement change.

5.5.2.2. Excessive patient caseload

This was a significant barrier mentioned recurrently by respondents. Some clearly stated that, on a typical day, 10 to 15 patients were treated, and clinicians were limited to barely 45 minutes to manage each patient. In this study excess patient caseload was cited as one of the barriers preventing clinicians from undertaking muscle strengthening which some respondents regarded as time-consuming. In previous studies by Jones et al. (2003) and Kamwendo (2002), increased workload and lack of time were reported as the most commonly mentioned barriers, as well as the inability to read and understand reports by the clinicians. The following quote is representative:

“Often, *reduced staff strength, excess workload and limited resources make it difficult to undertake more comprehensive management such as strengthening for patients*”. (AS7)

5.5.2.3. Professional and clinical constraints:

Similarly, respondents mentioned some professional and clinical constraints such as inappropriateness of undertaking strengthening of the muscles at the very early stages of stroke rehabilitation, especially in the first few days or weeks post-stroke (acute stroke); issues of excessive hypertonic/spastic muscles (spasticity); flaccid muscles that are unable to initiate any contraction; and the fear of shoulder subluxation when strengthening the shoulder muscles. Other therapist-based barriers included difficulties encountered in interpreting the results of research studies, as well as conflicting information on the research findings in the area of muscle strengthening in stroke patients.

5.6. Muscles frequently strengthened post stroke

It was observed that the muscles frequently strengthened by respondent neuro-physiotherapists were the pelvis/hip, lower leg muscles quadriceps/hamstrings, and the muscles of the trunk (26.2%, 23.9%, 21.4%, and 18.2% respectively). In contrast, the muscles selected as the least strengthened by the respondents were: the biceps /triceps, plus hand and fore-arm muscles (5.7%, 2.6% and 2.0%). The result of the current study showed that the trunk and the lower limb muscles were strengthened more frequently, when compared to the upper limb muscles in stroke rehabilitation. This may be explained by the premise that the trunk and core muscles of the pelvis and lower limbs facilitate the important role of supporting the body in antigravity positions, such as sitting and standing as well as the stabilisation of the proximal body parts during voluntary limb movements (Michaelson et al., 2001). Anecdotally, clinicians are more inclined to concentrate on balance functions and lower limb functional activities compared to upper limb functions. Furthermore, research has focused on lower limb motor impairment more than upper limb partly because lower limb interventions are more easily described, outcomes are more easily quantified, and mobility is considered a key functional outcome post stroke (Bosch et al., 2014). It is understood that, from three months post-stroke, approximately 37% of the individuals continue to have reduced upper extremities (UE) function (Baker and Brauer, 2005). The recovery of upper extremity function often lags behind the recovery of the lower extremities due to more complex motor skills required of the upper extremity in the activities of daily living. It can be argued that the lower limb is frequently the focus of initial rehabilitation, despite the fact that post stroke paresis of the upper-extremity is amongst the most significant and persistent physical disability following a stroke and represents a critical barrier to independence (Shelton and Reding, 2001). Therefore, the upper limb recovery needs to also be considered important because it is integral to the independence of the post stroke patient performing varied activities of daily living (Baker and Brauer, 2005).

5.7. Specific types of muscle strengthening undertaken

It was observed that the types of muscle strengthening frequently used by neuro-physiotherapists were: manual resistance, weight resistance, and the use of springs and elastic bands (38.7%, 21.4%, and 16.8%) respectively (Table 4.8). The types of muscle strengthening used less often were: body weight supported treadmill (BWSTT); and isokinetic muscle strengthening (2.6% and 2.0% respectively). In the open-ended question that followed, some respondents explained that manual resistance was easier, readily available and cheaper to carry out. This was also the case regarding the availability of springs and therabands. Some respondents were of the opinion that the unavailability of dynamic strength training equipment was a limiting factor in undertaking progressive strength training activities to help patients progress from one stage of rehabilitation to the next. This was expressed by two of the respondents as follows:

"..Treating people at home you do not have access to equipment, often impossible to tie an elastic theraband to a suitable place; no transport to get patients to access out-patients if they have no family or friends to bring them. (CN6)

*"Lack of resources to purchase appropriate equipment such as the motomed type machine for outpatient management "(*GN6)

Additionally, responses gained from the open-ended questions about the specific types of muscle strengthening exercises undertaken showed that respondent neuro-physiotherapists combined different types of resistance muscle strengthening, such as the use of graded resistance weights, use of therabands, springs and pulleys, isotonic contraction, calibrated machine resistance (treadmill, isokinetic dynamometers, and cycle ergometers), manual resistance and body weight resistance exercises such as squatting, single-leg stance and sit-stand activities were also identified as types of resistance weight exercises used by respondents (Appendix 7). Furthermore, respondents explained that they undertook a mix of treatment approaches including: the use of three main neurological approaches (Bobath concept, PNF and Movement Science); as well as adjuncts such as constraint induced movement therapy (CIMT), repetitive task training (RTT), treadmill training, and muscle strengthening to attain functional goals. The interpretation of these results suggests that neuro-physiotherapists across the four regions of the UK, practise a mixture of different types of treatments irrespective of the approach used (an eclectic approach).

It was observed that some of the responses from the open-ended questions appeared consistent with those obtained from a previous survey conducted by Lennon (2003), who investigated the approach most frequently used in stroke management in the UK. Lennon (2003) observed that despite the fact that 88% of UK-based neuro-physiotherapists acknowledged treating stroke primarily based on the Bobath concept, 31% indicated that they preferred a mixed approach (eclectic treatment approach). The results also appeared consistent with Tyson et al. (2009) who observed that 47% of respondents in the UK acknowledged combining different types of treatments and approaches that they considered suitable for improving motor and movement functions in stroke patients.

5.8. Frequency of undertaking resistance muscle strengthening

It was observed that most respondents undertook muscle strengthening only once per week (39%) or twice per week (21%) respectively (Table 4.10). Practically speaking, in order to build muscle strength, resistance muscle strengthening requires a regulated set of muscle exercises (2-3 sets), at a frequency of 2–3 days weekly, an intensity and duration of between 30 minutes and 60 minutes, over a period of between 6 to 12 weeks (ACSM, 2009; Cramp et al., 2006; Gordon et al., 2004). Therefore, undertaking resistance muscle strengthening only when necessary, as reported by one-fifth of the respondents, may not actually be considered as effective use of muscle strengthening. In consequence, for resistance muscle strengthening to be effective, it should be frequent, consistent and progressive as the muscle strength of the patient increases. Therefore there are still questions to be answered regarding the actual intensity and weight of the muscle strengthening exercises carried out, especially when activities like squatting, or single leg stance are used or applied as resistance muscle strengthening activities. This is because it may be difficult to quantify such exercises or progress them appropriately.

The research evidence indicates that strength training increases strength and has potential to improve function in stroke rehabilitation (Cooke et al., 2010a; Donaldson et al., 2009). Despite being strongly advocated in best practice guidelines (Royal College of Physicians, 2012); strength training at the recommended training parameters does not appear to have been well integrated into clinical practice. Rhea et al. (2003: p456), summarised this concept as follows: "*for a quantifiable relationship between dose (exercise) and response (specific health or fitness adaptations), and strength training, dose-response relationship is vital to the prescription of proper doses of training. Over-prescription of resistance training exercise may result in over-stress injuries, whereas under-prescription will result in a failure to achieve the necessary or desired strength improvement*". Moreover, despite the controversy surrounding the exercise dose-relationship appropriate for strength development in neurological patients (Gordon et al. 2004), effective strength development requires volume, intensity, and/or frequency of training exercises.

Furthermore, in this study, it was observed that a considerable proportion of respondents acknowledged the use of manual resistance as the muscle strengthening activity undertaken. Technically, manual resistance may be difficult to quantify and difficult to progress especially when different physiotherapists of varying individual strength manage the same patient.

However, it needs to be stated that the questionnaire used in current study was not specific on dose, duration and intensity of muscle strengthening application (Appendix 3); hence inferences cannot be made about dose response.

5.9. Summary

In summary, there is evidence to suggest that respondent neuro-physiotherapists in the UK make use of muscle strengthening in the rehabilitation of stroke patients. Factors respondents described as influencing their clinical decision to use muscle strength training included research-based evidence, continuing professional development, experience from working with patients, guidelines/protocols and to a lesser extent basic university training. Barriers were also mentioned as constituting reasons for the limited and infrequent use of muscle strength training in stroke rehabilitation and these barriers were summed up as patient based barriers, staff barriers and organisational barriers.

The issue of dose response was not studied in detailed in this study, therefore the researcher has recommended that a more robust and comprehensive study be carried out to verify the dose/intensity/frequency of the application of muscle strength training undertaken in clinical practice, as well as progressive strength training routines carried out by physiotherapists.

Although this study was based on the research ideas of Jones et al. (2003), this study went a step further by investigating the use of resistance muscle strengthening exercises at different stages of stroke management, and categorising the respondents according to their specialism of practice, the number of patients treated, number of years practised, and the type of hospital facility in which respondents practised. The questionnaire included slightly more demographic information, such as the categorising the specialism of practice (acute, sub-acute and chronic), and requested the region of practice of respondents.

Furthermore, respondents were required to rate some of their responses on a graded Likert scale rather than a ‘yes/no’ response. Open-ended questions were provided for respondents to elaborate certain answers. It is assumed this may have allowed the respondents the opportunity to provide elaborate answers to express their opinions concerning the use of muscle strengthening in stroke rehabilitation. It is assumed that the open-ended questions encouraged respondents to clarify some of the reasons why they avoided the use of muscle strengthening during stroke rehabilitation. The predominant reasons stated revolved around the following: fears that the patient may have medical co-morbidities, pain and cognitive issues. The captivating aspect of the open-ended questions was that details provided by the respondents gave an insight into the types of treatment procedures they carried out to achieve gains in muscle strength as well as improved muscle functional goals in stroke rehabilitation.

Furthermore, there is evidence to suggest that clinicians are willing to undertake more resistance muscle training activities to improve the muscle strength and functional activities of stroke patients, but they are faced with barriers, such as insufficient time, limited number of staff, and lack of appropriate equipment.

5.10. Implications of the Study

The results of this survey have implications for both clinical practice placement educators and academic training institutions involved in the preparation of students in the practice and academic environments:

5.10.1. Implications for Practice

This study has shown that UK-based neuro-physiotherapists undertake resistance muscle strength training as an adjunct in the management of motor and movement problems seen post-stroke. There were five factors that were identified as having mild to moderate significant influence on the use of muscle strengthening: experience gained from working with patients; reading of evidence-based literature; attendance at seminars/workshops; specialism of practice; and years of practice as a neuro-physiotherapist. However, the use of guidelines and protocols on the management of stroke was reported as being moderately used. Again, clinicians reported low attendance at external CPD activities. Physiotherapy is a lifelong learning profession; hence, lifelong learning should be continually encouraged, especially through attending of CPD activities. Apart from updating clinical skills, attendance of CPD activities is a requirement to maintain and update registration records with the HCPC and the CSP.

In consequence, the management of hospitals or other health care organisations where physiotherapists work should be encouraged to provide the logistic and financial support necessary to encourage staff to continually update their knowledge on best practises in the rehabilitation of stroke patients. Clinical staff can achieve this by attending workshops, conferences and seminars. Clinical neuro-physiotherapists should also be encouraged to familiarise themselves with the guidelines and protocols relating to the rehabilitation and management of patients. Furthermore there were barriers identified that reduce that uptake of undertaking muscle strength training, such as time constraints, inexperienced staff, limited staff numbers and excess caseload. These barriers can be improved upon by increasing the number of staff involved in the management of stroke patients, more time could be devoted in stroke assessment and management. Although the stroke audit policy states that each stroke patient such be managed for a period of 45 minutes, however, with limited numbers of staff and increased workload, the issue of limited/lack of time may continue to be a recurrent issue.

5.10.2. Implications for Physiotherapy Educators

Research based evidence was a prominent factor that influenced the decision of respondents to undertake muscle strengthening in stroke rehabilitation. This may suggest that academic institutions involved in the in the training of physiotherapy students have an important role to play in the process of sourcing the evidence Currently, research evidence is integrated into all course curricula of physiotherapy training institutions in the UK. However it is vital to make students more proficient in the critical appraisal of the research evidence. Students undergoing training should be encouraged to be aware that the concept of evidence-based practice is on-going and dynamic. As a consequence, EBP information cannot be solely obtained through the basic academic training provided during a standard physiotherapy degree course, but needs to be supplemented through attending continuing professional development (CPD) and other training activities including a concerted effort at reading of research-based literature.

In neurological physiotherapy, it can be debated that some of the management procedures of stroke patients are still based on anecdotal evidence and expert opinions (McGlinchey and Davenport, 2014). However, there is a developing and accelerating body of research-based evidence suggesting more effective ways of improving residual problems seen in stroke rehabilitation, such as muscle weakness and lack of functional activities following a stroke and other neurological impairments. Rather than academic staff delivering didactic lectures on treatment interventions, guided designs could be used, whereby students are encouraged to work in small groups of four or five. Students could be presented with a simulated clinical case scenario and be required to generate possible solutions based on research evidence. This may encourage physiotherapy students to integrate the available research-evidence in clinical practice to improve patient management.

I contend that professionally, I am an experienced lecturer, who has gained a deeper understanding of the possible impact of this thesis on my academic duties. I will endeavour to further enlighten the students of physiotherapy about the use of evidence-based procedures as well as the need to make students understand that in the management of stroke patients, the clinical presentations of the patient dictates the management approach to be used. Moreover, the finding of this study has prompted a self-re-evaluation of my role as a neurology lecturer and informed my decision to practise more critically, by finding ways of making the students understand and interpret the evidence about stroke rehabilitation (that muscle strength training has to be functional to be effective and meaningful).

5.11. Conclusion and Recommendations

It was acknowledged in Section 1.6 of this thesis that a variety of factors might influence the clinical decision of respondents on whether they use or not use muscle strengthening in stroke rehabilitation. The finding of this study observed that factors like the reading of evidence-based literature, attendance at seminars/workshops and specialism of practice influenced the decision of respondents to the use or non-use of resistance muscle strengthening. Similarly some of the factors that were reported that prevented neuro-physiotherapists from engaging in its use, included: cognition; pain; compliance; and hypertonicty of the muscles which were summed up as patient based factors. Other factors included limited number of staff, inexperienced staff and lack of resources which were categorised as organisational factors.

Muscle strengthening in physiotherapy management plays an important role in stroke rehabilitation. Therefore, its use should be encouraged as a part of the treatment, evaluation and goal-setting in stroke rehabilitation. The use of resistance muscle strengthening in stroke rehabilitation spans from the acute stages, through the chronic stages, to the community rehabilitation stages.

The recommendation based on the findings of this study is that further studies would be required to determine the actual dose/intensity of resistance muscle strengthening carried out in clinical practice. It is recommended that a longitudinal study followed by a semi-structured interview may be appropriate to explore the how respondents actually engage in the use of resistance muscle strengthening for stroke rehabilitation in clinical practice, rather than what is reported by respondents.

Chapter 6

Reflexivity and Critical Analysis

6.1. Reflexivity of the research

This chapter reflects on the methodological approach to this research study, and also discusses the reflexivity of my involvement in the entire research. Reflexivity has been described in a variety of ways, depending on the philosophical approach adopted by the writer (Shaw, 2010). Finlay and Gough (2003: p9) describe reflexivity as "*critical self-reflection of the ways in which the background, assumptions, and behaviour of the researcher impacts on the research*". On the other hand, Shaw (2010) describes reflexivity as examining one's conceptual assumptions and preconceptions, and how these may have affected the research decisions; particularly, the phrasing of the research questions, and the interpretation of the responses provided by the respondents to the research questions. Furthermore in reflexivity, the values and position of the researcher are examined; and the researcher's biases and prejudices are made explicit (Bolton, 2010; Colbourne and Sque, 2004; Cousin, 2009; Cunliffe, 2009).

Similarly, Clancy (2013); Holloway and Biley (2011) explained that, in reflexivity, apart from the researcher examining their personal motivations for undertaking the research; the methodological strengths and weaknesses, and the learning which takes place as a result of this process is utilized to improve research practice. Although these are simplistic descriptions for a complex concept, an objective reflexivity will be discussed using these points: a) how my prior attitude and preconceptions affected the study, b) how these preconceptions influenced the interpretation of the data obtained, and c) what I have learnt from undertaking this research study.

Preliminarily, this study was tilted towards the positivist quantitative paradigm (bias towards quantitative study, in which the researcher focuses on testing the research hypotheses quantitatively). There was limited or no consideration planned towards undertaking any qualitative analyses / discussion. However after conducting a pilot study, the responses obtained showed that respondents wanted to give more explanations on their clinical decisions or rationale for undertaking or not undertaking muscle strength training based on the requirements of the patients. Additionally, the respondents wanted to provide more information on the possible barriers/challenges to the use of resistance muscle strength training in stroke rehabilitation.

This informed my decision to remodel the study questionnaire to include some open ended questions to allow respondents express their thoughts; thereby, changing the dynamics of the research methodology from a fixed design to a mixed research approach (more quantitative and less qualitative analyses). This modification subsequently influenced how the results of the research were evaluated, analysed and discussed (Chapter 4). According to Ahern, (1999) an ideological shift is a dynamic concept in research, where methodical problems can be transformed into opportunities. In this study, a more robust and transparent argument that acknowledges the late decision to shift from a fixed research design to a more flexible approach is that it provided appropriate explanations on the barriers to the use or non-use of some evidence-based rehabilitation procedures, thereby collaborating results of previous studies (Jette et al., 2003; Jette et al., 2005; Salbach et al., 2007). By the same token, using a mixed methodological approach presented an opportunity to expatiate on the observations made by Bayley et al. (2012); Signal et al. (2014), in research studies examining the possible barriers to implementing resistance muscle training. Although from the literature, one frequently mentioned barrier to implementing resistance muscle training is patient tolerance (Bayley et al., 2012). In this study apart from patient tolerance which was grouped as patient factors, there were other factors that were observed. These included, time constraint, inexperienced staff, limited staff numbers and organisational factors (Table 4.19).

Secondly, my quantitative positivist approach to this study may have also impacted on some aspects of the data analysis. It was observed that the data obtained from the responses to the open-ended questions appeared slightly insufficient for onward thematic analysis. Consequently the data obtained was analysed by descriptively presenting the emergent themes and categories and not by content or thematic analysis that the researcher intended. Nevertheless, the use of descriptive emergent themes in this study has its benefits as it provided insights into the micro and meso levels of intersubjective experience of the respondents about the use or non-use of muscle strength training in stroke rehabilitation (Section 4.3.2). This goes to support the discussion on emergent themes by William, (2008), who observed that emergent data collection and analysis can evolve over the course of a research project in response to what is learned in the earlier parts of a study. Often this flexible approach to data collection and analysis allows for ongoing changes in a research design as a function of what has been learnt, especially if the research questions and goals change in response to new information and insights.

Thirdly, there is the possibility that, the data gathered qualitatively may have some drawbacks, since they were obtained through a cross-sectional survey rather than through face-to-face interactive narrative, focus group discussions or semi-structured interviews (where possibly more collaborative information on the concerns and barriers of the respondents could have been explored in more detail). Nevertheless, I found that the emergent themes and categories from the open ended questions provided not just expressive information about how physiotherapists viewed the use of muscle strength training in stroke rehabilitation; but provided insights into the clinical decisions, rationale, possible barriers, challenges and experiences of the respondents across specialisms in stroke rehabilitation (as discussed Section 4.3.2). This is contrary to the positivist quantitative paradigm, which was originally intended (on which large amount of traditional research is based, where the position of the researcher is that of a detached observer). This has meant that "*researchers often tended to write themselves out of the text in the belief that to do otherwise would somehow contaminate the research*" (Scott, 1997: p133). However, Burns et al., (2012) argue that such objectivity may be a myth as it is not possible to separate the researcher from the research. In this case of this study, during the process of line by line coding of the descriptive summaries, it was difficult to completely detach myself from the process. Compiling and analysing the descriptive emergent themes meant that, I was absorbed in reflecting and interpreting the responses provided by the respondents, trying to make meaning and putting my thought process in the position of the respondents to effectively code and interpret their responses. According to Creswell, (2013), this process creates a relationship; whereby the researcher influences, and is influenced by the process of engaging in the analyses of the emerging codes and themes.

Fourthly, my initial preconceptions and opinions prior to conducting this research study, was of that the majority of UK physiotherapists report using the Bobath concept in the rehabilitation of stroke patients, thereby raising the clinical expectation that resistance muscle strength training may be sparingly used in the rehabilitation of stroke patients. However, the results of this study established that the majority of the respondent physiotherapists (87.5%) reported using resistive muscle strength training exercises at all stages of stroke rehabilitation (acute, sub-acute, and chronic), although less commonly used in the management of acute stroke patients. It was equally observed that, clinical research evidence, and participating in continuing professional development (CPD), clinical experience, and the patient's individual requirements constituted some of the main basis for the respondents' decision to do so. This was a realisation that that in research surveys; your data is squarely dependent on the responses obtained even when respondents may not have stated the obvious.

Finally, as previously mentioned, one of the aims of reflexivity is to gain insight from an experience to change future practice. Although this thesis turned out to be expansive; I have learnt the importance of an ongoing documented reflexivity in any research studies I am involved with. This includes the creation of a reflexive journal to provide a trail of decisions made, and an awareness of my personal influences at every stage of the research. On reflection, engaging in reflexivity during the initial stages of writing this thesis may have facilitated a different set of decisions, or influenced my engagement with this study. It would have also influenced my research methodology such as undertaking semi-structured interviews from a selection of the study respondents or otherwise, which I have reflected on in the appraisal of the study methodologies below (Section 6.2). It could be debated that in using a reflexive journal researchers are engaging in a critical dialogue with themselves (Dowling, 2006).

6.2. Reflection and appraisal of the study's methodologies

Firstly, the use of the ACPIN data base had its methodological limitations because the respondents, who participated in the study, may not be a finite representation of all the neuro-physiotherapists in the United Kingdom. It is assumed that there may be more physiotherapists actually involved in stroke rehabilitation, but not registered with ACPIN, therefore this study may not be a finite representation of all physiotherapists in the UK involved in stroke rehabilitation.

Secondly, the collection of data was by purposive sampling (convenient sampling) with known disadvantages such that the sample might not be easily defensible as a representation of the entire population due to its potential subjectivity. However, when this study was carried purposive sampling was best considered because of the study sort information from a particular group of physiotherapy professionals.

Thirdly, the study design chosen in the current research was an electronic cross-sectional survey (using closed and open ended questions in the questionnaire). This meant the collection of data in this research survey was subjected to a limited time frame. However on reflection, a longitudinal or panel study may have been considered, where data would have been collected over a longer period of time on the same respondents. It is assumed that, this might have provided a broader understanding of how respondents change their clinical decisions over time. However, with hindsight to the limited period of time required to complete this study, a cross-sectional survey was considered the best available option at the time.

Fourthly, the research study may have included the use of semi structured interviews or focus group discussions to obtain enriched qualitative data from the respondents, on the factors that influence their clinical decision to use muscle strength training in stroke rehabilitation. Proper face-to-face qualitative interviews exploring what factors inform the clinical decision of respondents to use or not to use muscle strengthening could have been beneficial. It is assumed respondents may have provided more distinct information compared to the use of open ended questions in the cross-sectional survey which had its limitations. Similarly, organising focus group discussions may have assisted in obtaining first-hand experience from the respondents about the use of muscle strengthening. It is assumed that focus group discussions might have explicitly given an in-depth understanding of the clinical decisions of the respondents, although focus group discussion also has its limitations.

Furthermore, in designing the survey questionnaire, I might have limited the Likert scale used to either three or five point likert scale rather than using a seven point Likert scale. This might have fashioned an easier way of recording the choices of the respondents. It may have equally reduced some of the problems faced with the analyses of data obtained. Finally, rather than enquiring about the use of muscle strength training generally through all the stages of stroke rehabilitation, I may have concentrated my research question on just one stage of stroke rehabilitation and one or two regions of the body (e.g. either only upper limb rehabilitation or lower limb rehabilitation). During the literature search, I discovered the literature review was voluminous because of the fact that the study investigated the generality of stroke rehabilitation.

6.3. Limitations of the Study

There were some limitations to this study. Firstly, the format of some of the questions necessitated relatively superficial answers especially in the case of some of the closed-questions (requiring Yes or No answers). This might have resulted in some respondents feeling that none of the options were appropriate for them (e.g. under 'specialism of practice' approximately 20.2% *N* = 81 out of 401 of respondents selected 'others' as their specialism). However, the open-ended question that followed allowed these respondents to indicate their precise specialism. The result showed that 39 respondents out of 81 (48%) indicated they worked in early supported discharge (ESD), which may be described as working in the community. This shortcoming may have affected the result on the specialism of practice. This shortcoming would have occurred as a result of the design of the survey questionnaire (ESD and the other specialities selected by respondents shown in Table 4.3 were not specifically mentioned in the survey questionnaire). This obviously suggests a poor question; however, this observation was not evident when the pilot survey was conducted. Nevertheless, it is arguable that the conciseness of the questionnaire contributed to the reasonable response rate achieved (58.2%). It should be noted that with questionnaire-based research, there is a compromise between the amount of information required by the questionnaire and the response rate.

A second limitation was the use of non-parametric statistics, most of the data generated were categorical variables (Ordinal variables), thus limiting the use of more diverse statistical analysis which may have fully inferred causation. However, the responses from the open-ended questions corroborated some of the findings. Thirdly the questionnaire did not ask about the highest educational achievements of the respondents. A few studies have reported that clinical reasoning process may be more advanced with physiotherapists that have gone ahead to undertake higher qualifications in physiotherapy practice (Jette et al., 2005; Salbach et al., 2010).

Lastly, only those registered with ACPIN participated. In the UK there are physiotherapists who are not registered with ACPIN and who manage stroke patients, thereby diminishing the ability to generalise the result of the study, or categorically state the findings extend to all physiotherapists who manage stroke patients.

6.4. Recommendations for further research studies

The thesis explored knowledge of and barriers to the use of resistance muscle strength training in stroke rehabilitation, and explored the clinical decision making associated with its use. There were noteworthy findings observed in this study (as discussed in chapters four and five); the findings include: the recognition that muscle strength training is accepted by respondents as an inclusive management procedure in the rehabilitation of stroke patients, and that certain factors constituted the clinical decision for its use or non-use. However what was intriguing were the findings associated with the barriers to its use (patient based factors, staff issues and organisational factors).

Lack of time was a significant barrier, constituting 10.1% of total comments (Table 4.16), and the nature of the comments was similar across all specialisms involved in stroke rehabilitation. Specifically, respondents wanted more time within their work hours to devote toward intensive stroke rehabilitation procedures. Respondent cited excessively workload and excessive demands of the current work environment as a limiting factor as evident in multiple comments made by respondents (see section 4.3.2.2). Respondents felt "*there was not enough time, there were also issues around staffing, and that neuro-physiotherapists are overworked, too many patients to cater* *for within a limited time duration*" (AS7); and respondent stated they are too busy to implement some evidence based research findings into practice. Lack of resources such as provision of necessary equipment or materials were cited as drawbacks to the evolution of their practice. These barriers were categorised as: organisational barriers; patient based factors; staff based factors, and the suitability of the use of muscle strength training at certain stages of stroke rehabilitation. These factors were derived from the descriptive emergent themes from the open-ended responses analysed qualitatively. Further studies are therefore required to explicitly explore how these factors constitute barriers to the use of resistance muscle strength training in clinical practice in the UK. This may be achieved by conducting further in-depth exploratory studies or semi structured interviews or focus group discussions to determine how these factors constitute barriers to the use of resistance muscle strength training; and to what extent these factors constitute barriers.

Secondly, there were some notable differences between respondents who worked in the acute stroke units compared to those who worked in other aspects of stroke rehabilitation. Further studies may be required to explore the rationale for this difference, apart from the patient based issues mentioned such as co-morbidities, pain, fragility and suitability of some of the patients. It was acknowledged that physiotherapists who treat acute stroke patients encountered more barriers to the use of muscle strength training than their outpatient and community colleagues. Further studies are advocated to better explore and explain the rationale for this difference.

Thirdly, the literature indicates that muscle strength training (either progressive resistance or functional resistance training) are considered efficient at improving muscle strength and function post-stroke (Cooke et al., 2010a; Cramp et al., 2006;

Donaldson et al., 2009; Flansbjer et al., 2008; Winstein et al., 2004; Yang et al., 2006). These gains following resistance strength training include central and peripheral activation with associated changes in muscle morphology such as increased muscle cross sectional area, and changes in muscular architecture and metabolites (Cecatto and Chadi, 2007; Gray et al., 2012). In this study, an area briefly touched was the frequency at which resistance muscle strength training in carried out stroke rehabilitation. The finding was not explicit because the question on frequency of application of muscle strength training only asked how often respondents undertook muscle strength training (see section 4.1.7)

Therefore, there is need for further research to be conducted to determine frequency, duration, dose, and intensity of the use of muscle strength training in practice. The American Heart and Stroke Association (AHSA) recommend that strength training be conducted at 50-80% of the 1-repetition maximum (1-RM) for 10-15 repetitions for 2-3 days per week, and that resistance be increased as tolerance permits for people with stroke (Billinger et al., 2014). Most strength training guidelines do not describe how to establish 1-RM or RM sets, nor do they provide examples of specific exercises or exercise progressions and modifications for people with stroke (Billinger et al., 2014; Mead and Van Wijck, 2013), thus, making implementation challenging. Physiotherapists are often more familiar with utilising body weight and alterations such as change in step or seat height to alter training intensity.

The issue of dose response was not studied in this thesis, therefore, the researcher has recommended further research studies that will be robust and comprehensively explore the dose/duration/intensity/frequency of the application of muscle strength training in stroke rehabilitation. Further studies can also be carried out to verify the use of progressive strength training routines physiotherapists undertake in clinical practice. Additionally, further studies are required to observe the effects of intensity, frequency, dose of training and duration of resistance muscle strengthening on functional improvement in stroke rehabilitation. These studies may best be conducted as experimental studies with possible longitudinal follow-up of participants over a prolonged period of time.

6.5. What could have been done differently?

There are some amendments that could have been addressed if this process were to be completed again. Firstly, the whole research project could have been completed as a mixed research study (this means after the completion of the electronic survey questionnaire, a few participants would have been approached to conduct either a semi-structured interviews or focus group discussions). Focus discussions or semi-structured interviews of respondents would have been carried out directly after patient management which may have been deemed appropriate in gaining as close an account as possible. Potentially this interviewing approach or discussion might have allowed a greater amount of reflective time between the stroke rehabilitation undertaken by the respondent physiotherapists and the interview. This procedure could have seen the respondents give a deeper account of the rationale for their clinical decision.

There were several variables studied in this research study: knowledge, barriers; clinical decision making, types of muscle strength training, and frequency of muscles strength training. It may have been more rational if the study was limited to just two or three variables (e.g. use of theraband or springs in the rehabilitation of upper limb muscle strength).

6.6. Personal perspective

The journey through the doctoral process has been one with many challenges. The mostly quantitative nature of enquiry presented its challenge, and presented many unfamiliar terms and scientific approaches. This meant a basic depth of understanding had to be achieved before the study could begin to develop. Time management and dealing with commitments continually led to issues with prioritisation as this doctorate was completed part-time while working full-time and with the responsibility of a family. Nevertheless, I feel the process has improved my academic and research experience in a number of ways. It has improved my knowledge of clinical decision process of clinicians involved in the rehabilitation of stroke patients across the UK. I am hopeful that the enhanced knowledge gained will enable me to be more reflective in my role as a lecturer in neurological physiotherapy in emphasising the importance of research based evidence, whilst giving greater support to my students. The doctorate degree process has exposed me a range of research methods and new methodologies that will take my studies further in the future. It has also enabled me explore several literature on stroke rehabilitation in more detail and challenged my preconceived ideas regarding clinical decision making. Lastly, this process has given me confidence in my writing skills, critical analysis of research studies, and the discovery of new areas in the academic field.

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Appendix 1
Ethical Approval Page

School of Health and
& Human Sciences
University of Essex Wivenhoe Park
T 01206872854
F 01206873765

Colchester Campus
Wivenhoe Park
Colchester, CO4 3SQ
United Kingdom
T 01206873333
F 01206873598

www.essex.ac.uk

02 November, 2011

MR. V.A. UTTI
8 LIHFIELD CLOSE
COLCHESTER
ESSEX
CO1 2RG

Dear Victor,

Re: Ethical Approval Application (Ref 10049)

Further to your application for ethical approval, please find enclosed as copy of your application which has now been approved by Dr Wayne Wilson on behalf of the Faculty Ethics Committee.

Kind Regards

Mel Hassack
Graduate Administrator
Health and Human Sciences

cc: Jo Jackson, Supervisor
Sarah Manning-Press, REO

Appendix 2

Literature Review Search Strategy

Research Area

Muscle strengthening in stroke rehabilitation: knowledge of and barriers to its use by UK neuro-physiotherapists

Search methods

I searched five databases, CINAHL, MEDLINE, PEDro PubMed, and OVID (from January 1990 to January 2014). I searched trials and relevant conference proceedings. I checked reference lists and completed hand searches of references in order to identify any further published work that was not identified in the databases searched.

Selection criteria

The inclusion and exclusion criteria are detailed in chapter 2 of this study. The studies included in the search included case studies, pre-test/post-test studies, randomised and randomised cross-over trials, pilot studies, meta-analysis of studies and systematic reviews. Only articles in the English language were included in the final review. I included both full texts and abstracts in my search criteria to ensure that relevant papers were not missed. I considered all types of stroke of any severity and in all settings. I evaluated conventional physiotherapy rehabilitation and muscle strength training on stroke patients.

Types of research literature sourced

The researcher independently selected the trials, meta-analysis and systematic reviews for inclusion and I assessed the quality of the methodology used. The primary outcome was muscle strengthening in stroke rehabilitation: knowledge of and barriers to its use by UK neuro-physiotherapists and clinical decision making

Search Criteria for each Database

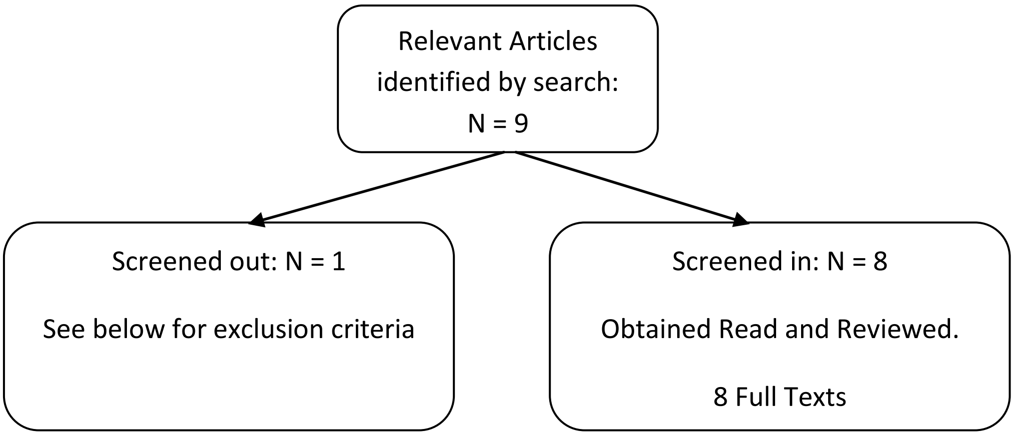
- ❖ stroke **OR** strok* **OR** CVA **OR** CVD **OR** hemiplegia
- ❖ resistance **OR** resistanc* **OR** strength training **OR** muscle strengthening
- ❖ clinical reasoning **OR** clinical decision making **OR** decision making
- ❖ knowledge **OR** knowledg*
- ❖ barriers **OR** barrier OR barrie*
- ❖ physiotherapy **OR** physio **OR** therapy **OR** rehabilitation

<u>Database Searched: CINAHL COMPLETE</u>

Search run: 31/01/2014
Dates Searched: January 1990 - January 2014

Search Number	Search Term	Results	Relevant articles that met the inclusion and exclusion criteria
1	stroke **OR** strok* **OR** CVA **OR** CVD **OR** hemiplegia	5,193	
2	resistance **OR** resistanc* **OR** strength training **OR** muscle strengthening	4,276	
3	clinical reasoning **OR** clinical decision making **OR** decision making	9,989	
4	physiotherapy **OR** physical therapy **OR** physiotherap* **OR** rehabilitation	16,034	
5	barriers **OR** barrier OR barrie*	8,192	
6	knowledge **OR** knowledg*	22,849	
7	#1 *AND* #2	144	9
8	#1 *AND* #2 *AND* #3	9	1
9	#1 *AND* #2 *AND* #4	354	7
10	#2 *AND* #3 *AND* #4	10	1
10	#1 *AND* #2 *AND* #5	5	1
11	#1 *AND* #2 *AND* #3AND #4*AND* #5	0	0

Database: CINAHL COMPLETE



CINAHL: Inclusion and Exclusion criteria

9 relevant articles were identified in this one article was excluded as it was in French. Of the other 8 texts that were all deemed to be relevant as they included information on muscle strength training in stroke rehabilitation. During the search several articles were excluded, ten were not in English, two were excluded as they did not include stroke but rather patients with obesity and chronic heart failure. 2 articles were excluded as they did not deliver muscle strength training, but were interested in body vibration training and Pilates and the last article was excluded as the research was on incontinence in stroke patients and not related to muscle strength training. Of the other six articles, three were chronic heart failure. All selected articles from CINAHL complete were deemed relevant and were read and reviewed.

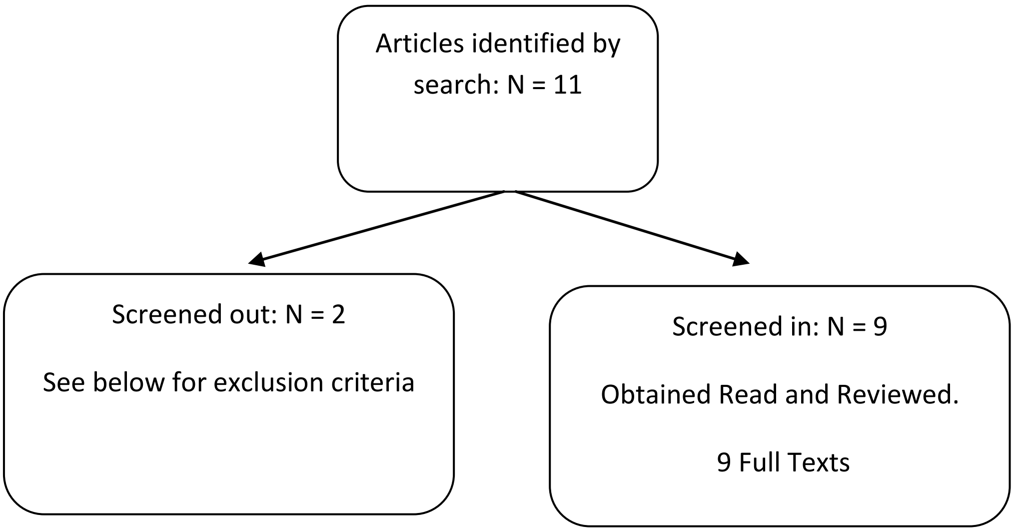
Database Searched: MEDLINE

Search run: 31/01/2014

Dates Searched: January 1990 - January 2014

Search Number	Search Term	Results	
1	stroke **OR** strok* **OR** CVA **OR** CVD **OR** hemiplegia	39,505	
2	resistance **OR** resistanc* **OR** strength training **OR** muscle strengthening	124,258	
3	clinical reasoning **OR** clinical decision making **OR** decision making	34,039	
4	physiotherapy **OR** physical therapy **OR** physiotherap* **OR** rehabilitation	55,757	
5	barriers **OR** barrier OR barrie*	150,849	
6	knowledge **OR** knowledg*	380,392	
7	#1 *AND* #2	1504	11
8	#1 *AND* #2*AND* #3	3	0
8	#1 *AND* #2*AND* #3 *AND* #4	0	0
9	#2*AND* #3 *AND* #4	10	1
10	#1 *AND* #2*AND* #5	0	0

Database: MEDLINE Search



MEDLINE: Inclusion and Exclusion criteria

11 articles were identified in MEDLINE search two article were excluded immediately as they measured other indices apart from muscle strength and functional improvement following strength training activities. All nine studies included were deemed to be relevant as they included information on resistance muscle training in stroke rehabilitation and its effect on functional activities.

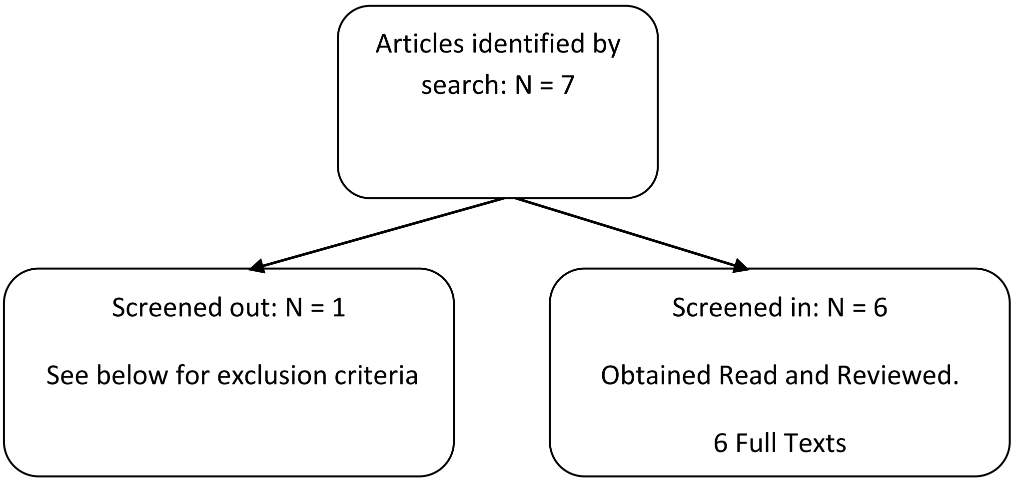
<u>Database Searched: PUBMED</u>

Search run: 15/01/2014

Dates Searched: January 1990 - January 2014

Search Number	Search Term	Results	Relevant articles that met the inclusion and exclusion criteria
1	stroke **OR** strok* **OR** CVA **OR** CVD **OR** hemiplegia	255,651	
2	resistance **OR** resistanc* **OR** strength training **OR** muscle strengthening	636,258	
3	clinical reasoning **OR** clinical decision making **OR** decision making	107,439	
4	physiotherapy **OR** physical therapy **OR** physiotherap* **OR** rehabilitation	380,392	
5	barriers **OR** barrier OR barrie*	150,849	
6	knowledge **OR** knowledg*	462,811	
7	#1 *AND* #2	12610	7
8	#1 *AND* #2*AND* #3	17	3
9	#1 *AND* #2*AND* #3*AND* #4	7	2
10	#2AND#3AND#4	82	2
11	#1*AND* #2*AND* #3*AND* #4AND#5	1	1

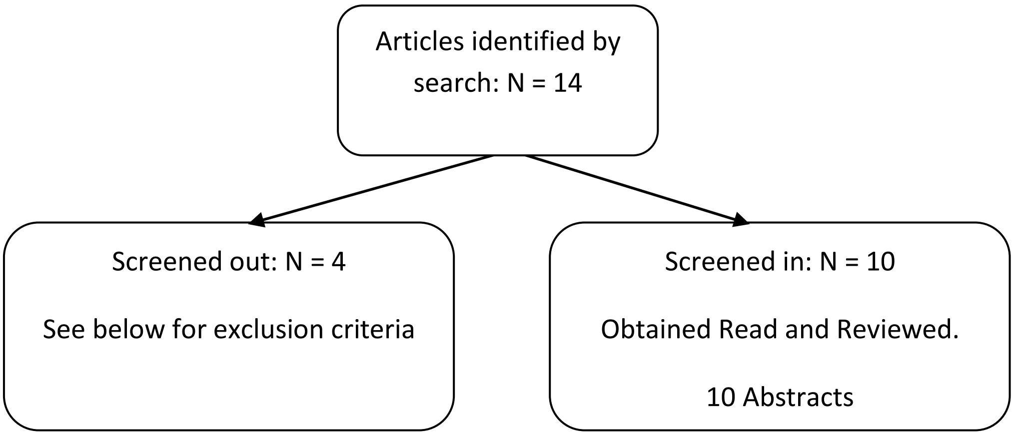
<u>Database: PUBMED Search</u>



<u>Database Searched: PEDro</u>

Search run: 15/01/2014

Dates Searched: Dates Searched: January 1990 - January 2014



<u>PEDro: Inclusion and Exclusion criteria</u>

24 articles were initially obtained with the search terms "stroke **OR** strok* **OR** CVA **OR** CVD **OR** hemiplegia AND resistance **OR** resistanc* **OR** strength training **OR** muscle strengthening" but adding clinical reasoning **OR** clinical decision making **OR** decision making produced 14 relevant articles. Applying the inclusion and exclusion criteria reduced the numbers to 14 of which 10 were relevant and 4 irrelevant to the study objectives.

Appendix 3

Introduction to the study

Research Title: Muscle strengthening in stroke rehabilitation, knowledge of and barriers to its use by UK neuro- physiotherapists

Investigator: Victor Utti: – Postgraduate Student

University Supervisors: Professor Joanna Jackson and Dr. Peter Martin School of Health and Human Sciences University of Essex

Background of the study:
Recent evidence based studies have prompted the National Institute for Clinical Excellence (NICE) to encourage the use of muscle strengthening in stroke management. This is contrary to previous assumptions that strength training in stroke patients had detrimental effects on spasticity and caused pain. Presently, it is acknowledged that muscle strengthening is used in stroke rehabilitation in the United Kingdom. However, there is no clear evidence, as to what constitutes strengthening in practice, the type of muscle strengthening that is prevalent and its efficacy. This study is aimed at investigating if physiotherapists actually use muscle strengthening because there is a lack of knowledge regarding how many therapists are using it, for what reason, the perceived barriers to its use and its future use.

Ethical Approval: Ethical approval was granted by University of Essex Research and Ethics Committee

Confidentiality: There is nothing that identifies you in this study. Your response will automatically be allocated a participant number by the survey program used. Direct quotes from the open-ended questions may be used but will not be identifiable to individuals. All data will be saved on an encrypted and password protected external hard drive which only the investigator has access to. In accordance with University policy, all data will be securely stored as above for 10 years

Why have I been selected as a participant?
You have been chosen due to your specialist interest in management of neurological conditions, stroke rehabilitation inclusive as indicated by your membership to association of physiotherapists in neurology (ACPIN). You are under no obligation to take part; however your participation will be highly appreciated

Contact information:
Researcher: Victor Utti:
E-mail Address: vutti@essex.ac.uk

Please read the survey information before you decide to complete this form. Tick the 'No' box if you do not wish to participate in the study.
By ticking the 'Yes' box below; you are consenting to taking part in this study.

Appendix 3

Survey Questionnaire

I confirm that I have read and understood the information page of this study. I understand that my participation is voluntary.

Yes ☐ No ☐

1. What clinical speciality/facility do you predominantly work in?

☐ Currently work in an acute stroke unit
☐ Work in a stroke rehabilitation unit which manages different stages of stroke patients
☐ Work in a neuro-rehabilitation in-patient unit which manages other neurological patients as well as stroke
☐ Work in general neurology out-patient unit with occasional management of stroke patients
☐ Work in the community with occasional rehabilitation of stoke patients
☐ I have not worked clinically with the stroke population in the past one year
☐ I am a Researcher/Educator and have not worked clinically with stroke patients in the past three years
☐ Others

If others, please specify

2. How often do you treat stroke patients?

☐ Daily
☐ Weekly
☐ Fortnightly
☐ Monthly
☐ Once in 3 to 6 months
☐ Once in 6 months or more
☐ Don't manage stroke patients

3. How many stroke patients do you treat on weekly basis?

☐ 1 – 5 patients weekly
☐ 6 – 10 patients weekly
☐ 11 – 15 patients weekly
☐ 16 – 20 patients weekly
☐ 20 – 25 patients weekly
☐ 25 patients and above
☐ Don't treat stroke patients

4. Based on your clinical experience, do you consider muscle strengthening appropriate as a treatment tool in stroke rehabilitation?

   ☐ Very Appropriate
   ☐ Appropriate
   ☐ Slightly Appropriate
   ☐ Neutral
   ☐ Slightly Inappropriate
   ☐ Inappropriate
   ☐ Very Appropriate

5. Do you undertake muscle strengthening in the management of stroke patients?

   ☐ Yes ☐ No.

If 'Yes' please outline the type(s) of muscle strengthening you undertake. If 'No' please go to Question 13

6. In your clinical experience at what stage of stroke rehabilitation are you most likely to commence muscle strengthening? Kindly tick as considered appropriate and rank between 1 and 5 (1= most likely and 5 least likely).

   ☐ Acute stage (Early Rehabilitation)
   ☐ Sub-acute stage
   ☐ Chronic stage (In-patient Rehabilitation)
   ☐ Chronic stage (Out-patient Rehabilitation)
   ☐ Chronic stage (Community based Rehabilitation)

7. What informs/influences your choice or decision to undertake strengthening in stroke rehabilitation? You can rank your choices on a scale of 1 to 7 (1= Most likely and 7 = least likely influence)

   ☐ Basic physiotherapy training and information while at university
   ☐ Experience through working with patients
   ☐ National guidelines/departmental procedure or protocol
   ☐ Information from CPD/seminar/workshop
   ☐ Basic Physiotherapy training and information while at university
   ☐ Influence and information from other physiotherapy colleagues
   ☐ Routine clinical practice at my place of work

8. Do you undertake any of these strength training interventions?

You can rank your choices on a scale of 1 to 7 (1= Most likely and 7 least likely)

- ☐ Isokinetic strength training
- ☐ Weight resistance strength training
- ☐ Use of elastic therabands and springs
- ☐ Body weight supported treadmill strength training (BWSTT)
- ☐ Locomotor based strength training (e.g. cycling/treadmill machines)
- ☐ Functional electrical stimulation (FES)
- ☐ Manual resistance

9. How often do undertake muscle strengthening on stroke patients?

- ☐ Once daily
- ☐ Once in a week
- ☐ Twice in a week
- ☐ Once in two weeks
- ☐ Once in 6 weeks
- ☐ Once in a while
- ☐ Only when necessary

If different from the choices given, please specify

10. What dysfunction(s) informs your decision to undertake strengthening in stroke rehabilitation? You can rank your choices on a scale of 1 to 7 (1= Most likely and 7 least likely).

- ☐ Upper limb dysfunction
- ☐ Hand and Dexterity dysfunction
- ☐ Lower limb dysfunction
- ☐ Gait dysfunction
- ☐ Balance dysfunction
- ☐ Shoulder dysfunction
- ☐ Foot dysfunction

11. What group of muscles do you strengthen the most during stroke rehabilitation? You can rank your choices on a scale of 1 to 7 (1= Most and 7 = least strengthened).

- ☐ Trunk muscles
- ☐ Biceps and Triceps
- ☐ Quadriceps/Hamstring
- ☐ Hand muscles
- ☐ Pelvic/Hip muscles
- ☐ Fore-arm muscles
- ☐ Lower Leg muscles

12. In your experience how will you describe the effects/improvements observed using strengthening exercises on the functions below? Please tick as appropriate

	Large impact	Moderate impact	Mild impact	No impact	Large negative impact	Moderate negative impact	Mild negative impact
Trunk stability	☐	☐	☐	☐	☐	☐	☐
Sitting	☐	☐	☐	☐	☐	☐	☐
Standing	☐	☐	☐	☐	☐	☐	☐
Balance	☐	☐	☐	☐	☐	☐	☐
Upper limb function	☐	☐	☐	☐	☐	☐	☐
Hand Dexterity	☐	☐	☐	☐	☐	☐	☐
Lower limb function	☐	☐	☐	☐	☐	☐	☐
Gait	☐	☐	☐	☐	☐	☐	☐

13. In the past year, have you attended any seminars/workshops on muscle strengthening in stroke rehabilitation?

☐ Yes ☐ No

14. In the past year, have you read any literature or research article on muscle strengthening in stroke rehabilitation?

☐ Yes ☐ No

15. In your clinical experience, can muscle strengthening be described as conflicting with any of the treatment approach(s) you use in stroke rehabilitation?

☐ Strongly Agree
☐ Agree
☐ Slightly Agree
☐ Neutral
☐ Slightly Disagree
☐ Disagree
☐ Strongly Disagree

16. Based on your clinical experience does muscle strengthening have a significant role or future as a treatment tool in stroke rehabilitation?
    - ☐ Very Significant
    - ☐ Significant
    - ☐ Slightly Significant
    - ☐ Neutral
    - ☐ Slightly Insignificant
    - ☐ Significant
    - ☐ Very Insignificant

17. In your clinical practice have you experienced barriers/challenges using strengthening in the management of stroke patients?

    ☐ Yes ☐ No

    If Yes please give as much detail as possible.

18. In your clinical practice has any of your stroke patients raised concerns of any adverse effects due to the use of strengthening in stroke rehabilitation?

    ☐ Yes ☐ No

    If Yes, please give as much detail as possible.

19. What region of the United Kingdom do you practice?

    ☐England ☐Scotland ☐Northern Ireland ☐Wales

20. What grade (NHS band or equivalent) are you?
    - ☐ Consultant Physiotherapist / Physiotherapy manager
    - ☐ Extended scope practitioner / Clinical specialist
    - ☐ Band 8
    - ☐ Band 7
    - ☐ Band 6
    - ☐ Band 5
    - ☐ Independent practitioner

21. How many years have you been qualified?
    - ☐ 0 – 5 years
    - ☐ 6 – 10 years
    - ☐ 11- 15 years
    - ☐ 16 - 20 years
    - ☐ 21 – 25 years
    - ☐ 26 years and above

22. Where do work/practise as a physiotherapist?
    - ☐ NHS University foundation Hospital Trust /Teaching Hospital
    - ☐ Acute Trust / General Hospital
    - ☐ Primary Care Trust / Community Hospital
    - ☐ Private practice
    - ☐ Voluntary sector / Charity

23. How long have you practiced as a neuro-physiotherapist?
    - ☐ 0 – 5 years
    - ☐ 6 – 10 years
    - ☐ 11- 15 years
    - ☐ 16 - 20 years
    - ☐ 21 – 25 years
    - ☐ 26 years and above

Kind Regards
Victor Utti
vutti@essex.ac.uk

Appendix 4

Undertake Strength Training * Specialism of Practice Cross-tabulation

			Specialism of Practice						Total
			Acute Stroke	Community	Stroke rehab all stages of stroke	General Neurology occasional stroke patients	Neuro rehab and stroke	others	
Undertake Strength Training	Yes	Count	61	74	70	17	53	76	351
		Expected Count	83.2	72.7	63.0	14.9	46.4	70.9	351.0
		% within Specialism of Practice	64.2%	89.2%	97.2%	100.0%	100.0%	93.8%	87.5%
	No	Count	34	9	2	0	0	5	50
		Expected Count	11.8	10.3	9.0	2.1	6.6	10.1	50.0
		% within Specialism of Practice	35.8%	10.8%	2.8%	.0%	.0%	6.2%	12.5%
Total		Count	95	83	72	17	53	81	401
		Expected Count	95.0	83.0	72.0	17.0	53.0	81.0	401.0
		% within Specialism of Practice	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Appendix 4

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	66.649[a]	5	.000
Likelihood Ratio	64.977	5	.000
Linear-by-Linear Association	35.374	1	.000
N of Valid Cases	401		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 2.12.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.408	.000
	Cramer's V	.408	.000
N of Valid Cases		401	

Appendix 5

Undertake Strength Training * Read any Literature on ST Cross-tabulation

			Read any Literature on ST		
			Yes	No	Total
Undertake Strength Training	Yes	Count	264	87	351
		Expected Count	234.6	116.4	351.0
	No	Count	4	46	50
		Expected Count	33.4	16.6	50.0
Total		Count	268	133	401
		Expected Count	268.0	133.0	401.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	89.197[a]	1	.000		
Continuity Correction[b]	86.191	1	.000		
Likelihood Ratio	88.575	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	88.975	1	.000		
N of Valid Cases	401				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 16.58.

b. Computed only for a 2x2 table

Appendix 6

Undertake Strength Training * Attended Seminar or Workshop Cross-tabulation

Count

		Attended Seminar or Workshop		Total
		Yes	No	
Undertake Strength Training	Yes	174	177	351
	No	3	47	50
Total		177	224	401

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	33.700[a]	1	.000		
Continuity Correction[b]	31.956	1	.000		
Likelihood Ratio	41.122	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	33.616	1	.000		
N of Valid Cases	401				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 22.07.

b. Computed only for a 2x2 table

Appendix 6

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.290	.000
	Cramer's V	.290	.000
N of Valid Cases		401	

Appendix 7

Other Types of muscle strengthening mentioned by respondents

Description
Assisted-resisted exercises
Circuit training
Concentric exercise
Core stability work
Closed chain exercises (holding the wall grid)
Cycling with resistance
Eccentric exercises
Dumb-bell work
FES
Graded muscle work
Isokinetic exercise
Locomotor activities (motormed)
Manual resistance
PNF with resistance
Repetition of functional resistance
Repetitive functional training
Single leg standing activities
Sit-stand activities
Springs
Squatting (using the body weight)
Therabands
Treadmill with resistance
Weight Resistance