EXPLORING THE MULTI-FACTORIAL MANIFESTATIONS OF JOINT HYPERMOBILITY SYNDROME AND THE IMPACT ON QUALITY OF LIFE

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ABSTRACT

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Exploring the multi-factorial manifestations of Joint Hypermobility Syndrome and the impact on quality of life

Introduction: Performing artistes have entertained audiences for thousands of years. Their repertoires require the integration of a well 'tuned' central nervous system and hypermobility. Hypermobility is a common phenomenon that is beneficial for some but not for others. This thesis discusses hypermobility associated with multisystemic symptoms referred to as Joint Hypermobility Syndrome (JHS). It is suggested that the multifactorial manifestations of the condition contribute to deconditioning thus impacting on the physical and mental well being of individuals with JHS.

Purpose: To explore the multi-factorial manifestations of JHS including functional difficulties and their impact on quality of life.

Methods: A two part study; part one, development of a questionnaire to assess for functional difficulties; part two, a mixed methods approach to explore aspects of JHS.

Results: Principal Axis Factoring was employed to explore the structure of the 9-item Functional Difficulties Questionnaire (FDQ-9) to assess functional difficulties reported in childhood and adulthood. Internal consistency was high (0.81), correlations between items were > 0.5 and preliminary findings suggested satisfactory construct validity. Test-retest reliability was good (ICC 0.96 [95% CI 0.92 to 0.98].

Patients with JHS were 3 [95%CI 1.95 – 4.56] times more likely to report functional difficulties both as a child and as an adult than healthy volunteers. Patients with JHS were significantly more likely to report dislocations, autonomic nervous system, gastrointestinal and cardio-respiratory symptoms than healthy volunteers. Chronic widespread pain reported by 86% of patients with JHS was a significant predictor of quality of life using the SF-12. Patients with JHS had significantly lower physical component scores than healthy volunteers (29.2 [SD 10.6] and 54.5 [SD 5.7]) respectively.

Conclusions The development of the FDQ-9 contributes to the understanding of the multi-factorial manifestations of JHS and their long term nature. These have important clinical implications as symptoms of JHS appear early in life. Management of this condition requires early recognition and an understanding of the multisystemic nature.

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Abbreviations

ADC	Adult Developmental Coordination Disorder/Dyspraxia Checklist
ADHD	Attention Deficit Hyperactivity Disorder
ANS	Autonomic Nervous System
APA	American Psychiatric Association
AUC	Area under a curve
B	Regression coefficient used to compute the regression equation
BJHS	Benign Joint Hypermobility Syndrome
BOT-MP	Bruininks-Osteretsky Test of Motor Proficiency
BP	Blood Pressure
BS	Beighton Score
ChAS-PT	Children Activity Scales
CFS	Chronic Fatigue Syndrome
CI	Confidence Interval
COMPS	Clinical Observations of Motor and Postural Skills
CNS	Central Nervous System
CR	Cardio-respiratory
CRB	Criminal Records Bureau
DCD	Developmental Coordination Disorder
DCDQ	Developmental Coordination Disorder Questionnaire
Df	Degrees of Freedom
DIY	Do-It-Yourself
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders 4th version
EDS	Ehlers-Danlos Syndrome
FDS	Functional Difficulties Score
FDQ-9	Functional Difficulties Questionnaire
FGID	Functional Gastrointestinal Disorders
GI	Gastrointestinal
GP	General Practitioner
GPAQ	Global Physical Activities Questionnaire
GTO	Golgi Tendon Organ
JHS	Joint Hypermobility Syndrome
HDCTs	Heritable disorders of connective tissues
HMSA	Hypermobility Syndrome Association
HSE	Health Survey for England
HV	Healthy Volunteers

IBS	Irritable Bowel Syndrome
ICC	Intraclass Correlation Coefficient
ICD-10	International Statistical Classification of Diseases and Related Health Problems 10th Version
ICF	International Classification of Functioning, Disability and Health
KMO	Kaiser-Meyer-Olkin
LCS	Leeds Consensus Statement
M	Mean
MABC	Movement Assessment Battery for Children
MAND	McCarron Assessment of Neuromuscular Development
MCS	Mental component Summary
ME	Myalgic Encephalopathy
MFS	Marfan Syndrome
MMD	Mixed Methods Design
MSDs	Musculoskeletal Disorders
NHS	National Health Service
OI	Osteogenesis Imperfecta
PCS	Physical Component Summary
PIP	Patient Information Pack
POTS	Postural Orthostatic Tachycardia Syndrome
ROC	Receiver Operating Characteristic
S	Sample
SD	Standard Deviation
SE	Standard Error
SDDMF	Specific Developmental Disorder of Motor Function
SF-12	Medical Outcomes Questionnaire Short Form – 12 questions
SF-36	Medical Outcomes Questionnaire Short Form – 36 questions
SPSS-16	Statistical Package for Social Scientists version 16
TMP	Test of Motor Proficiency
UK	United Kingdom
VIF	Variance Inflation Factor
WHO	World Health Organisation

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Chapter 1

1 INTRODUCTION

1.1 Overview

The overall purpose of this study was to explore the multi-factorial manifestations of Joint Hypermobility Syndrome (JHS) and the impact of this condition in relation to quality of life. This chapter introduces the reader to the essence of the thesis by exploring movement and hypermobility within the context of the performing artiste. Hypermobility and symptoms are discussed and their association with JHS established. The evolution of the study and the research journey are described. Functional difficulty impairments are one of the factors explored in this thesis by employing the term dyspraxia/Developmental Coordination Disorder (DCD). The hypothetical and theoretical rationale for an association between functional difficulties with a similar construct to dyspraxia/DCD and JHS are portrayed. Finally an overview of all the chapters of the thesis and a brief summary of their contents are presented.

1.2 Movement and hypermobility

Acrobats, dancers, performing artistes and gymnasts have entertained audiences all over the world for thousands of years. Their repertoires require precision, coordination and ultimate control of movement which contribute to the aesthetics and art of the entertainment. Movement occurs as a result of the interaction of the individual within their environment in relation to a particular task. In each individual the ability to perform complex sequential movements requires the integration of a well 'tuned' central nervous system (CNS). This integration is often referred to as motor control. Motor control is defined as 'the ability to regulate or direct the mechanisms essential to movement' (Shumway-Cook and Woollacott 2001 p1). The mechanisms essential to movement are; action, perception and cognition. Action is the movement demonstrated by the artiste and observed by the audience. Perception is more subtle for the audience to observe or describe but perception and action are mutually important and cannot be separated. Without perception the artiste would be unable to sense where they were positioned within their environment or the task they were performing. In the context of the performing artiste the choreographed movements are performed with intent and therefore cognition is essential. In addition to the aesthetic flow of coordinated movements these artistes demonstrate global hypermobility. Without this hypermobility they would be unable to achieve the required movement routines.

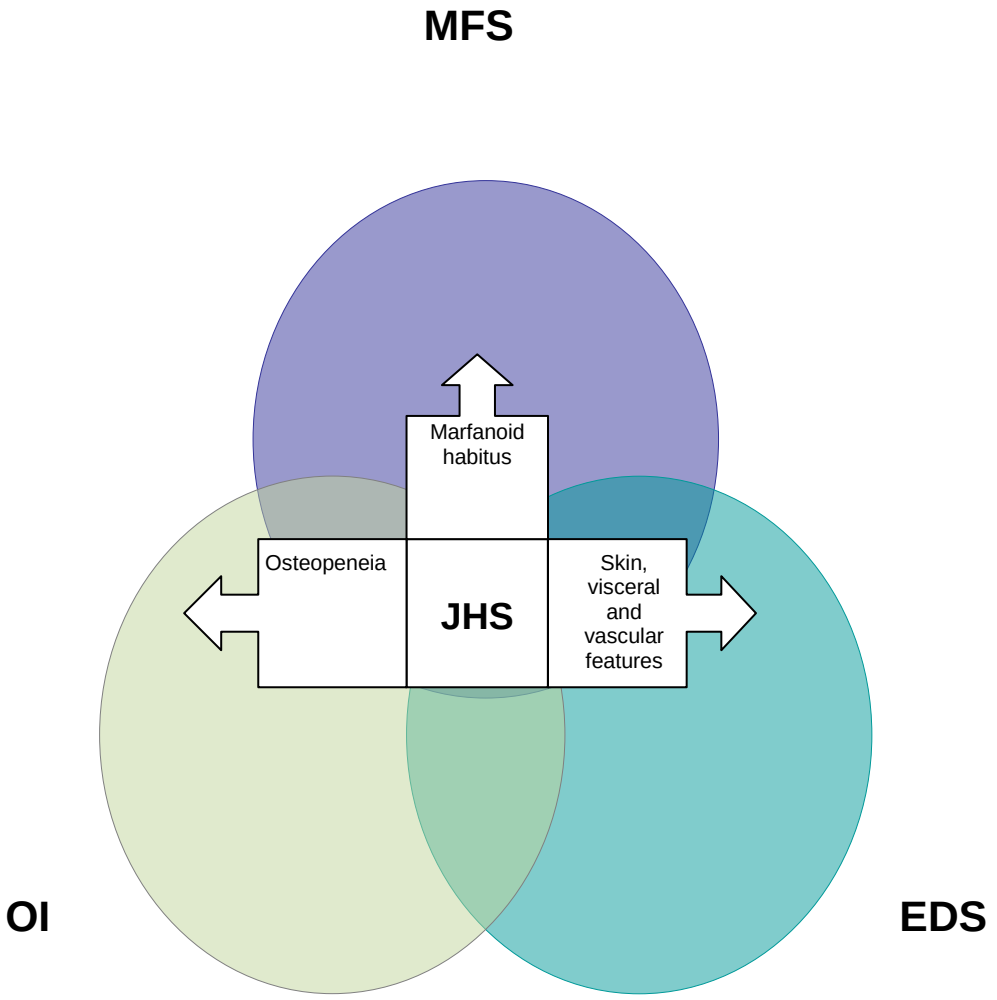
'Hypermobility is the result of ligamentous laxity' (Grahame 2003a p 2). It is suggested this ligamentous laxity may be acquired or inherited. Acquisition of hypermobility may be as a result of either physiological or pathological changes. Physiological acquisition may occur as a result of stretching and is often used by ballet dancers to stretch tissues around certain joints to enable optimal aesthetic movement. There are pathological conditions which contribute to hypermobility as a result of systemic diseases for example systemic lupus erythematosus, hyperparathyroidism and acromegaly (Beighton et al 1999). Where there are neurological deficits hypermobility is reportedly associated with hypotonia, this includes peripheral nerve injuries, Down's syndrome, poliomyelitis and the non-poliomyelitis enteroviruses (Martin et al 2005; Dhole et al 2009).

Hypermobility as a feature may be observed globally, unilaterally or in only one or a few joints (Al Rawi et al 1985; Larson et al 1987; Grahame 2003a). A hypermobile joint in this context is one in which excessive range of movement is demonstrated in the absence of a pathological condition and when age, sex and ethnicity have been considered. Hypermobility recorded in population studies has been found to be more prevalent amongst females than males (Al Rawi et al 1985; Pountain 1992) where it is possible that hormonal influences may contribute to increased joint laxity in women (Bird 2004). There is a higher prevalence of hypermobility amongst Asians and Africans than Caucasians and hypermobility is reported to decline with age (Beighton et al 1999; Verhoven et al 1999; Hakim et al 2010). Hypermobility is a common feature frequently reported amongst performing artistes and athletes (Gannon and Bird 1999; McCormick et al 2004; Stewart and Burden 2004; Collinge and Simmonds 2009). It would appear there may be two populations one set who benefit from their hypermobility. The other set who have little benefit and instead report musculoskeletal and systemic symptoms (Grahame 2010). This thesis will continue to discuss hypermobility associated with musculoskeletal and systemic symptoms.

1.3 Hypermobility syndrome

Hypermobility syndrome was a term first used by Kirk et al (1967) to describe the occurrence of musculoskeletal symptoms in those who were hypermobile, in the absence of any defined rheumatic disease. This term metamorphosed to joint hypermobility syndrome (JHS) and in the 1990s became known as benign joint hypermobility syndrome (BJHS). The term benign was added following the results of a clinical study by Mishra et al (1996) in which significant life threatening cardiac, bone, skin or eye irregularities were found not to be associated with JHS. This helped to differentiate BJHS from the other more serious hereditary disorders of connective tissue (HDCTs). The HDCTs are genetic disorders in which genes that encode the connective tissues are affected. This leads to aberrant connective tissues resulting in tissue fragility, laxity and sometimes failure (Grahame 2003b). The HDCTs showing symptom overlap are; Marfan syndrome (MFS), Ehlers-Danlos syndrome (EDS) and Osteogenesis Imperfecta (OI).

Figure 1-1 The heritable disorders of connective tissues (HDCTs)



Joint hypermobility syndrome (JHS), Marfan syndrome (MFS), Ehlers-Danlos syndrome (EDS), Osteogenisis imperfecta (OI). (Adapted from Grahame 2003a)

Symptom overlap

MFS:- arachnodactyly, greater arm span to height ratio, greater hand and foot to height ratios, mild scoliosis

EDS:- stretchy skin, papyraceous scars, striae atrophicae, easy bruising, delayed wound healing, dislocation/subluxations, uterine and rectal prolapse, hiatus hernia, hypotonia at birth, mild kyphoscoliosis

OI:- osteopenia, blue sclera

More recently clinicians have become aware of the myriad of symptoms associated with this multisystemic condition and therefore the term ‘benign’ was dropped (Grahame 2003a). For this thesis the term that will be used is joint hypermobility syndrome (JHS). It is now widely

acknowledged that the hypermobility form of EDS – previously known as EDS type III or EDS – hypermobility type (HT) is the same as JHS (Grahame 1999). JHS is acknowledged as a clinical entity in musculoskeletal medicine with a prevalence of between 30%-60% in those presenting with musculoskeletal pain to rheumatology and physiotherapy clinics (Grahame and Hakim 2004; Bravo and Wolff 2006; Clark and Simmonds 2011).

Tissue laxity, hypermobile joints and tissue fragility are commonly noted and it is thought these occur as a result of alterations in collagen synthesis. It is proposed that in those with hypermobility there is an abnormal ratio of type III to type I collagen (Child 1986). In addition in a small subset of those with JHS reduced levels of Tenascin-X in the extracellular matrix have been identified (Zweers et al 2005). Tenascin-X is an extracellular matrix protein and it is suggested that it is responsible for regulating the deposition of collagen (Bristow et al 2005).

The extracellular matrix consists of two classes of structural proteins, collagen and elastin. Collagen is an important contributor to the functional integrity of the connective tissues, is the most profuse protein in the human body with a tensile strength approaching that of steel (Levangie and Norkin 2001). There are many types of collagen the commonest of which are types I, II, III, V and XI. The commonest types of collagen and their distribution within the musculoskeletal system is shown (See table 1-1). Elastin has properties of elasticity so that when the fibers are deformed under stress they return to their original state following the removal of that stress. Elastin fibers are less abundant than collagen and in addition to being found in the musculoskeletal system are also found in the skin, arteries and trachea.

Table 1-1 Collagen types and distribution in the musculoskeletal system

Collagen type	Description	Distribution in the musculoskeletal system
I	Commonest fibril-forming collagen widely distributed in the body	Annulus fibrosus of intervertebral disc, bone, labrum, ligament, meniscus, tendon, skeletal muscle, synovium
II	Fibril-forming collagen	Annulus fibrosus and nucleus pulposus of the intervertebral disc, hyaline articular cartilage, meniscus
III	Fibril-forming collagen	Joint capsule, ligament, meniscus, tendon, skeletal muscle
V	Fibril-forming collagen	Hyaline articular cartilage, tendon, skeletal muscle
XI	Fibril-forming collagen regulates fibril size	Hyaline articular cartilage

Adapted from Levangie and Norkin 2001; Takala and Virtanen 2000)

Changes in the biosynthesis of collagen and in the extracellular matrix are thought to contribute to hypermobility and impaired tensile strength leading to tissue damage, overuse injuries and a predisposition to injury (Grahame 2010). Patients with JHS have recurrent problems throughout their lives, suffering from severe muscle deconditioning and requiring prolonged rehabilitation (Russek 2000; Simmonds 2003; Grahame and Hakim 2006). Prolonged rehabilitation may result from a lack of recognition of the condition and because many treatment approaches are ineffective. Questions relating to treatment effectiveness contributed to the evolution of this study.

1.4 The research journey and the evolution of the study

This research journey has been influenced by a breadth of clinical experience, combined with working in a variety of countries and teaching sports activities to primary aged school children. My clinical experience as a physiotherapist has included working in rehabilitation units, critical care, primary care and sports injury clinics with adults and children of different ethnic backgrounds. The research idea evolved as a result of observing different populations in the United Kingdom (UK), Middle East and Africa.

In some locations as the only available physiotherapist I observed a group of patients who presented with multisite musculoskeletal pain. These patients were more likely to re-attend for treatment either for the same initial problem or for a subsequent ‘injury’. In addition they responded slowly to treatment interventions. This led me to contemplate what made these patients more

'prone' to their musculoskeletal injuries. The next observation was that some patients presented with impaired coordination or biomechanical dysfunction which in some cases appeared to be global. The global nature of the impaired coordination led me to believe that biomechanical dysfunction may be contributing to the repetitive nature of the condition. It was not until I was introduced to hypermobility and JHS that I began to appreciate the relevance of these observations.

Whilst studying for an MSc in neuromusculoskeletal physiotherapy I was introduced to joint hypermobility syndrome (JHS) (Grahame 2003d). The condition was described as a multisystemic disorder in which patients showed a susceptibility to musculoskeletal injuries. Other factors including enhanced pain perception, proprioceptive impairment and autonomic dysfunction were also described (Sacheti et al 1997; Gazit et al 2003). I was particularly struck by the description of hypermobile patients re-attending clinics (Hudson et al 1998) as prior to this lecture my impression had been that people with hypermobility were less susceptible to musculoskeletal injuries.

From 1993 to 1997 I worked in Nigeria and observed that Nigerian women in the rural setting of the Niger delta were very hypermobile. They spent hours contorted into end range hypermobile positions and were also capable of carrying heavy loads for great distances with considerable grace and rhythm. Anecdotally they did not report back pain. Subsequently I came across a paper by Birrell et al (1994) who examined hypermobility in a rural population in Nigeria and found a high prevalence of hypermobility. In this report hypermobility was recorded with the Beighton score (Beighton et al 1973). Interestingly Birrell and colleagues (1994) reported that hypermobility in their study was not associated with musculoskeletal pain.

Once introduced to JHS in 2003 I began to recognise patients with the syndrome and discussed these findings with colleagues. My impression was that my colleagues thought JHS to be a rare condition. Perhaps a condition only seen in specialist centres and therefore one of limited interest. This led me to contemplate the prevalence of hypermobility and JHS in the clinical setting.

The purpose of the first study I undertook (as a masters student) was to investigate the prevalence of hypermobility and JHS in a female adult population attending physiotherapy clinics. A literature search was undertaken which led to an analysis and synthesis of the literature concerning hypermobility, benign joint hypermobility syndrome (BJHS), soft tissue rheumatism and prevalence using MEDLINE, Pub Med, CINAHL, and EMBASE. For this first study in 2003, a manual analysis of the reference lists of relevant papers and chapters dating from 1984-2003 was also carried out. The study undertaken reported the prevalence of hypermobility and JHS in female Omani patients attending for physiotherapy in a government hospital as 51% and 55% respectively (Clark and Simmonds 2011). The results were similar to those collected amongst non Caucasians at a north

London community hospital (Grahame and Hakim 2004). In addition patients with JHS in Oman were significantly more likely to be re-attending the physiotherapy clinic either for the same musculoskeletal complaint or a subsequent musculoskeletal complaint (Clark and Simmonds 2011). I concluded there was a requirement to observe JHS in other ethnic groups and gain a wider understanding of how this condition impacted on their lives.

In clinical practice I had the opportunity to observe patients with hypermobility and JHS from other ethnic groups attending a private hospital in Oman. I began to recognise a sub group who had more difficulty attempting to perform therapeutic exercises. They had difficulty coordinating movements required for therapeutic exercises. This led me to contemplate whether the poor movement patterns were as a result of pain, reduced muscle strength, lack of physical fitness and/or deconditioning.

Pain and in particular back pain is a major feature in those with JHS. There is evidence to suggest that localised motor control and movement impairments are secondary to the presence of low back pain (Hodges and Moseley 2003). It might also be suggested that long term movement impairments contribute to deconditioning. There is anecdotal evidence that deconditioning is considered to be a feature in patients with hypermobility and JHS (Russek 2000; Simmonds 2003). The term 'decondition' is defined as 'a loss of physical fitness' (M-WD 2010). There are four components to physical fitness which include cardiovascular fitness, body composition, muscle strength and endurance (Blair 2001). My impression was that a combination of aberrant connective tissues and multisystemic symptoms including pain were contributing to deconditioning and localised motor control impairments. However, this did not explain the observation that poor coordination and impaired motor control were often global.

In 2004 I was introduced to the similarities in functional difficulties reported by children with JHS and dyspraxia/DCD (Kirby 2004). It was then that I reflected whether the poor coordination and motor control impairments observed in some adult patients with JHS were not just as a result of pain or deconditioning but also as a result of inherent coordination difficulties like those associated with dyspraxia/DCD.

1.5 Dyspraxia/Developmental Coordination Disorder (DCD)

Dyspraxia/DCD is the term primarily given to describe children who are noted to experience difficulties with fine and gross motor control. These functional difficulties are noted to significantly affect their activities of daily living and occur in the absence of any other medical condition (APA 1994). Other terms that are also in use are clumsy child syndrome, (Gubbay 1975), sensory integrative dysfunction (Polatajko et al 1991), developmental dyspraxia (Ayres 1975) or under the

International Statistical Classification of Diseases and related health problems 10th revision (ICD-10) (WHO 1992; WHO 2007) a Specific Developmental Disorder of Motor Function (SDDMF). Motor coordination deficits in the form of the term apraxia were first discussed in the literature by Orton (1937). They were introduced in the Diagnostic and Statistical Manual of Mental Disorders (Revised 3rd edition) (DSM-III) in 1987 (APA 1987). The term Developmental Coordination Disorder (DCD) was endorsed at an international consensus meeting in London, Ontario in Canada, (Polatajko et al 1995). For consistency the combined term dyspraxia/DCD will continue to be used.

Movement dysfunctions experienced by children with dyspraxia/DCD have been described in a variety of ways. Walton et al (1962) described the movement patterns as inaccurate in terms of force, judgment, amplitude and speed. The terms used by Hall (1988) focused on the failure of the individual to acquire or learn the necessary skills required for fluid coordinated movements. There is agreement that dyspraxia/DCD is a heterogeneous condition with no set characteristics except the lack of movement fluency coupled with motor learning difficulties (Larkin and Hoare 1992; McKinlay 1988; Missiuna 1994; Cermak et al 2002). The movement characteristics seen in children with dypraxia/DCD are as a result of poor integration of action, perception and cognition. To the observer these movement impairments are seen as poor coordination and clumsiness. Children with dyspraxia/DCD demonstrate a heterogeneous spectrum of difficulties as a result of impaired integration of action, perception and cognition. For these children motor control dysfunction is acknowledged to significantly impact on their daily life and occurs in the absence of any known medical disorder (APA 1994; 2000; Cermak et al 2002).

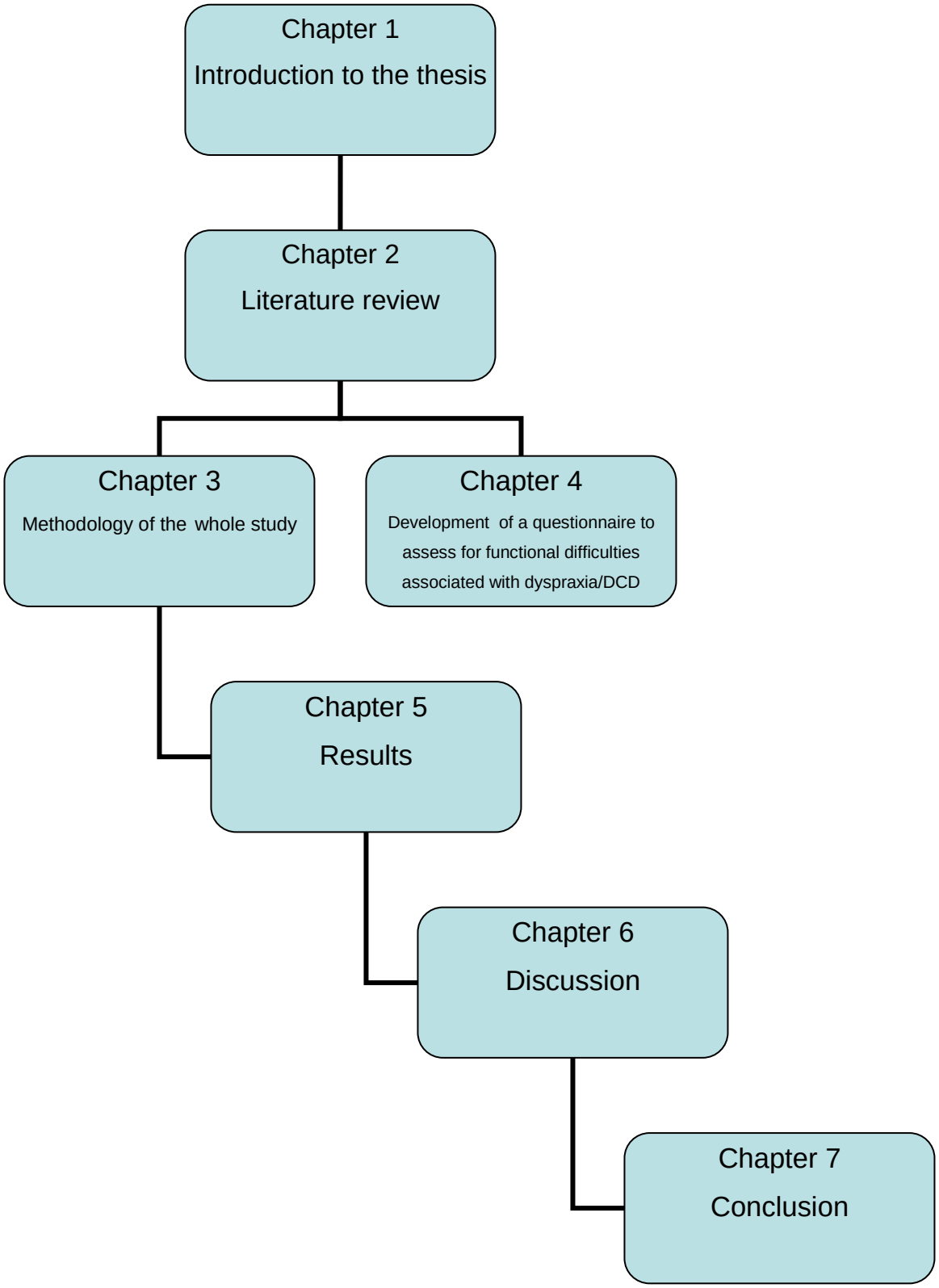
More recently there have been both cross sectional and longitudinal studies demonstrating the persistence of coordination difficulties from childhood to adolescence and adulthood (Rasmussen and Gilberg 2000; Cousins and Smyth 2003; Cantel et al 2003; Kirby et al 2008). In addition children with JHS report similar functional difficulties as children with dyspraxia/DCD (Kirby et al 2005) this includes clumsiness (Adib et al 2005). Dyspraxia/DCD is a condition recognised by some paediatric physiotherapists but rarely recognised if the presenting symptoms are musculoskeletal pain and in particular JHS. To address this gap there was a requirement to carry out a literature review (See chapter 2). The objective of the literature review was to investigate if functional difficulties associated with dyspraxia/DCD were reported in those with hypermobility and JHS.

1.6 Outline of the thesis

This thesis is divided into seven chapters (See figure 1-2). In chapter two the literature review is described and includes reference to the diagnostic criteria. The theoretical concepts related to the

association of these two conditions and the case for aetiological overlap is considered and the research hypotheses and questions are presented. Chapter three describes the rationale for the mixed methods approach, and the overall methodology including a breakdown of the phases and stages of the study. Chapter four focuses on the development of a questionnaire aimed at assessing functional difficulties associated with dyspraxia/ DCD in adults. The development and psychometric properties of the questionnaire are reported. Concurrent validity is not explored, this limitation is acknowledged and the questionnaire is employed in chapter five as an assessment of functional difficulties. In chapter five the multi-factorial nature of JHS is explored, impact on quality of life is reported and the experiences of individuals attending a hypermobility clinic related. In chapter six the key findings of the qualitative and quantitative data are integrated and discussed in the light of previous literature. An outline of how this work contributes to new knowledge in health care is revealed in this chapter. Chapter seven presents the conclusions and broader implications for practice, education and research. Finally the appendices provide additional material to support this thesis.

Figure 1-2 Over view of the chapters and contents of the thesis



Chapter 2

2 LITERATURE REVIEW

2.1 Introduction

An initial review was undertaken to explore literature relating to JHS, hypermobility and functional difficulties associated with dyspraxia/DCD. In the following section the diagnostic criteria for hypermobility, JHS (See appendix 1) and dyspraxia/DCD (See appendix 2) are introduced. Data relating to the population and sex prevalence of hypermobility, JHS and dyspraxia/DCD are reported. A case for the aetiological overlap of the conditions is explored in conjunction with the diagnostic criterion and a summary is presented (See table 2-1). The objectives of this thesis and the research questions are presented. The clinical and non clinical implications of the study are considered.

2.2 Background to the literature review

The relevance of the review was to explore the literature in relation to exploring an association between hypermobility, JHS and dyspraxia/DCD. Further literature reviews were carried out to broadly search the literature pertinent to common features of hypermobility, JHS and dyspraxia/DCD with the aim being to explore the case for aetiological overlap. It was anticipated that the searches would include both adult and child studies. This was because hypermobility and JHS have been reported in both adult and child literature, while dyspraxia/DCD has more commonly been described in literature pertaining to children.

An initial search for literature related to hypermobility, JHS and dyspraxia/DCD was carried out using the following data bases: EMBASE, MEDLINE, CINAHL, ASSIA, PsychARTICLES, SPORTDiscus and PsycINFO from 1989 – 2009. The key words used to search each data base included JHS, Benign Joint Hypermobility Syndrome (BJHS), hypermobility, and Ehlers-Danlos Syndrome (EDS) with DCD, dyspraxia, impaired motor development, Clumsy Child Syndrome and coordination. A manual search of the reference lists from each article was conducted. Articles were included for review if they were in peer reviewed journals in addition research, review, editorial articles and short supplements were included. The articles for the literature review were summarised using a summary and concept table (See appendix 3).

2.3 Summary of the review articles

There were nine relevant aticles, one of which was an editorial by Murray and Woo (2001) another was a review written by Murray (2006). Both these papers discuss delayed motor development, hypotonia, hypermobility and musculoskeletal manifestations in the light of research studies identified in the table (Jaffe et al 1988; Tirosh et al 1991; Davidovitch et al 1994; Adib et al 2005). Two studies relating to motor development impairments and hypermobility were longitudinal observational comparison studies in infants and young children in Israel (Jaffe et al 1988; Tirosh et al 1991). Jaffe and colleagues (1988) reported no long term motor delay in infants less than two years old who were hypermobile. Conversely Tirosh and colleagues (1991) reported long term delay in the group of infants who were hypermobile with developmental delay but not in the group who were hypermobile without developmental delay. They concluded that the origin of the symptoms in the children with hypermobility and persisting motor delay might be within the central nervous system (CNS).

The fourth study reported in the review by Murray (2006) was carried out in the UK. This study aimed to characterise the clinical profile of children with JHS aged 3-17 years attending a tertiary referral hospital. The commonest characteristics reported were pain and clumsiness. Other neurophysiological characteristics that were communicated included pain enhancement, gross and fine motor difficulties, speech and learning difficulties and dyslexia. The authors of this study also concluded there was evidence of CNS involvement in children with JHS (Adib et al 2005).

Davidovitch et al 1994 studied first and second grade school children in Israel. They concluded that hypermobility was not associated with any neuromotor deficit. The results of this study may have been influenced by the methodology. Hypermobility was recorded using an unstandardised test. In addition although children with specific learning difficulties attending a special education program were included in the study there was no report of the types of neuromotor deficits experienced by these children. This is an important consideration as in some countries children attending special education programs have a variety of neurological impairments which impact on their tone. Increased tone and in particular spasticity would affect any assessment of hypermobility.

Englebert et al (2005) carried out a study of school children in the Netherlands. The study aimed to assess the relationship between hypermobility and motor delay. They observed children aged 4 – 12 years who were hypermobile. They found that 25% of the hypermobile children were considered to have severe motor delay and 21% were considered at risk of motor delay. In addition in this cohort the mean age of walking was 18 months. The mean age of walking amongst children with JHS attending a tertiary referral hospital was 15 months (Adib et al 2005). In both these studies it

would appear walking was considerably later than the usual average age of 11 – 12 months (Needlman 2000). Both these studies reported on delayed walking. Walking is a motor milestone and milestone delay is discussed within the diagnostic criteria for DCD in the Diagnostic and Statistical Manual of Mental Disorders Fourth Version Text Revised. (DSM-IV-TR) (APA 2000).

The aim of the study conducted by (Kirby et al 2005) in the UK was to ascertain whether children with JHS experienced the same functional difficulties as those reported by children with dyspraxia/DCD. In this case comparison study the children were aged between 8-10 years. Children with JHS were reported to experience similar functional difficulties as children with dyspraxia/DCD. In addition the range of functional impairments was similar to those reported by Adib et al (2005) and included not only functional difficulties in the form of fine and gross motor function but also reading and spelling difficulties.

In both the review by Murray (2006) and the study by Adib et al (2005) readers are made aware of the multisystemic nature of the symptoms presented by children with JHS. In a subsequent study carried out by Kirby and Davies (2007) they compared the reporting of multisystemic symptoms (associated with JHS) between children with dyspraxia/DCD and typically developing children. Children with dyspraxia/DCD were significantly more likely to report symptoms of JHS than typically developing children. These included pain, autonomic nervous system (ANS) and gastrointestinal (GI) symptoms. This study highlighted the multisystemic nature of dyspraxia/DCD and to the researcher's knowledge is the first study to report pain in children with dyspraxia/DCD.

In summary, several of the papers reviewed suggest that hypermobility may be linked to motor delay as a result of CNS dysfunction (Tirosh et al 1991; Murray and Woo 2001; Adib et al 2005; Englebert et al 2005; Murray 2006). It is suggested that the cause of that CNS dysfunction is likely to be as a result of an association with dyspraxia/DCD (Kirby et al 2005; Kirby and Davies 2007). In the next section the diagnostic criteria and prevalence of JHS and DCD is introduced. The case for an aetiological overlap is considered by discussing features common to hypermobility, JHS and dyspraxia/DCD.

2.4 Diagnostic criteria for hypermobility, JHS and dyspraxia/DCD

2.4.1 Diagnostic criteria for hypermobility and JHS

The nine point Beighton score (Beighton et al 1973) is the most widely used system for the recognition of hypermobility in adults and has yet to be surpassed (See appendix 1 figure 1).

Hypermobility is assessed in nine areas with a range of scores from 0-9. The Beighton score was modified from the Carter Wilkinson criteria (1964) and validated for adults by Bird et al (1979). An alternative scale modified from the Beighton score is the Hospital del Mar criteria also referred to as the Barcelona or Bulbena criteria (Bulbena et al 1992). This scale offers a wider view of joint laxity, by including the hip, shoulder, foot and toes, but has not been reported as frequently as the Beighton score. Bulbena et al (1992) found a high correlation between the Beighton score and the Bulbena criteria indicative of high concurrent and predictive validity. The three criteria discussed above were originally introduced for epidemiological studies and as such for identifying hypermobility in populations. They are frequently used in the clinical setting and in research where some confusion has arisen. A high hypermobility score does not indicate a high degree of hypermobility or joint laxity but instead is a record of the number of hypermobile joints from a relatively small sample. One of the limitations of these scoring systems is the limited number of areas assessed and therefore localised hypermobility may be missed. Population studies using the Beighton score (Beighton et al 1973) have shown a variety of cut off scores ranging from 3-5/9 as the benchmark for hypermobility.

The Contompasis scoring system (McNerney 1979) developed at the end of the seventies by a podiatrist showed some quantification of hypermobility. This system not only attempted to quantify the degree of hypermobility using the same joints as the Beighton score but also included hind foot eversion. It used a more comprehensive scoring system, but has not been used widely clinically or in research probably because it is less well known and more time consuming than the Beighton score.

A more comprehensive set of criteria taking into account symptoms associated with JHS has been introduced and is known as the Brighton criteria (Grahame et al 2000)(See appendix 1 figure 2.) This has been used in the diagnosis of JHS in research and specialist centers. The Simple questionnaire to detect hypermobility (Hakim and Grahame 2003a)(See appendix 1 figure 3) is a practical way of diagnosing hypermobility. This questionnaire has been employed alongside a clinical assessment when chronic pain, arthralgias and soft tissue injuries present and has also been employed in epidemiological studies.

2.4.2 Diagnostic criteria for dyspraxia/DCD

Motor coordination deficits as a primary impairment in children were first introduced into the Diagnostic and Statistic Manual for Mental Disorders third edition (DSM-III) (APA 1987), were updated in the fourth edition DSM-IV (APA 1994) and the fourth edition with a text revision as the DSM-IV-TR (APA 2000) (See Appendix 2 figure 1). Clumsiness and motor coordination difficulties were acknowledged in the International Statistical Classification of Diseases and related health

problems 10th revision (ICD-10) (WHO 1992) (See appendix 2 figure 3). Motor coordination difficulties were updated in the ICD-10 (WHO 2007) under the term Specific Developmental Disorder of Motor Function (SDDMF) (See appendix 2 figure 2). In the ICD-10 (WHO 2007), the definition suggests the impairment is related to biological maturation of the CNS and that impairments diminish through life. It is the first time that it is suggested that adults may continue to be affected albeit 'mildly'.

There are two assessment tools commonly employed in the UK for the recognition of dyspraxia/ DCD in children by physiotherapists and occupational therapists. The tests are; the Movement Assessment Battery for Children second edition (MABC-2) (Henderson and Sugden 2007) and the Bruininks-Osteretsky test of Motor Proficiency-2 (BOT-MP-2) (Bruininks and Bruininks 2005). Both are revisions of the earlier tests which were; the MABC first edition published in 1992 (Henderson and Sugden 1992) and the BOT-MP first edition which was first published in 1978 (Bruininks 1978). Both tests require participants to perform a battery of physical tests aimed at assessing functional movement.

Universities in the UK test for DCD using check lists following the Department for Education and Skills (DfES) (2005) guidelines. The guidelines suggest employing writing tasks and the Morrisby manual dexterity test (MMDT) (Morrisby 1955) for assessing for DCD. Kirby and Barnett (2009) report the MMDT has not been tested in adults with dyspraxia/DCD. Both these assessments focus on fine motor skills and do not include gross motor skills or organisation. More recently Kirby et al (2010) published an article describing the development and standardisation of an adult screening tool for dyspraxia/DCD aimed at identifying difficulties and target areas for support in young adults entering further and higher education (See appendix 21).

2.4.3 Prevalence of hypermobility and JHS

In clinical populations presenting with musculoskeletal pain the prevalence of JHS assessed by employing the Brighton criteria (Grahame et al 2000) ranges from 30% - 60%. A higher prevalence amongst female non Caucasians than male Caucasians has been recorded. (Grahame and Hakim 2004; Bravo and Wolff 2006; Clark and Simmonds 2011). In a study of New Zealand Maori females 9% of the Maori population were noted to be hypermobile and 8% of Maori females had features of JHS indicating a population prevalence of 0.75% (Klemp et al 2002). Studies have shown hypermobility (recorded with a score of ≥ 4/9 using either the Beighton score (Beighton et al 1973) or the Simple questionnaire (Hakim and Grahame 2003a) in a variety of populations in females to be between 20% - 57% and in males 25% - 35% (Al-Rawi et al 1985; Pountain 1992; Birrell et al 1994; Verhoeven et al 1999; Hakim et al 2004). This might suggest that the population prevalence of JHS is higher in other populations than that estimated in New Zealand.

Hypermobility recorded in children employing the Beighton score with a cut off of 5/9 indicated the prevalence to be 13% - 16% in the United States of America and the Netherlands (Decoster et al 1997; Rikken-Bultman et al 1997). When a cut off of 4/9 on the Beighton score was employed the prevalence was 27% amongst Icelandic and British children (Qvindersland et al 1999; Clinch et al 2009). A cut off of 5/9 maybe considered more realistic as a measure of hypermobility in children as individual hypermobility scores diminish through life (Grahame 2003a).

2.4.4 Prevalence of dyspraxia/DCD

Prevalence rates of dyspraxia/DCD in children are reported to be between 1.6% - 35% (Keogh 1968; Wright and Sugden 1996; Kadjesjo and Gillberg 1999; Larkin and Cermak 2002; Foulder-Hughes and Cooke 2003; Tsiotra et al 2006; Kourtessis et al 2008; Piek et al 2008; Spironella et al 2009; Piek et al 2009; Loh et al 2009; Lingam et al 2009; Cairney et al 2009). There is discrepancy related to the sex prevalence of DCD. It is commonly reported that there is a greater prevalence amongst boys than girls with a ratio of 3:1 (Wilson 2005; Zoia et al 2006). However, Foulder-Hughes and Cooke (2003) reported a similar prevalence of DCD (7%) between the sexes in 490 children attending main stream schools in the UK. They assessed children using the MABC (Henderson and Sugden 1992) using a cut off of the 5th percentile. Interestingly Cairney et al (2005) reported a higher prevalence amongst girls (10%) than boys (6%) in 590 school children in Canada. They assessed DCD using the short form of the BOT-MP (Bruininks 1978) and employed a cut off score at the 10th percentile. The prevalence rates are as high as 31% - 64% in children born prematurely (Foulder-Hughes and Cooke 2003; Hemgren and Persson 2008). The reason for the wide range in the prevalence rates is mainly due to different interpretations of the ‘constructs’ of dyspraxia/DCD, adherence to the DSM-IV criteria, assessment tools and the different cut-offs in relation to severity (Cermak and Larkin 2002). Table 2-1 shows the prevalence rates reported in a variety of studies.

Table 2-1 Prevalence of dyspraxia/DCD in children recorded using different assessment tools, cut-off criteria and in different countries.

Study and country	Sample size n	Age and sex	Assessment tool (not validated)	Defined Cut – off	Prevalence rates
Kadesjo and Gillberg 1998 Sweden	n=409	7 year olds M 224 F 185	Questionnaire, observational tool and interviews	Moderate Severe Combined	4.6% 2.7% 7.3%
Foulder-Hughes and Cooke 2003 UK	*Pre term n=280 Full term n=210	7 year olds M=151;F=129 M=112;F=98	MABC-MT	5th percentile Preterm Full term	 30.6% 6.7%
Tsiotra et al 2006 Canada and Greece	Canada n=591 Greece n=329	11 years M=322;F=269 M=175;F=154	BOTMP-SF	12th percentile Canada Greece	 8% 19%
Kourtessis et al 2008 Greece	n=354	7-8 years M=204;F160	MABC-MT	5th percentile 15th percentile	1.6% 10.8%
Piek et al 2008 Australia	n=41	4 years M=22;F=19	MAND	15th percentile	34%
Piek et al 2009 Australia	n=398	3-14 years M=192;F=206	MAND	Mild 71-85 Moderate 55-70 Severe <55	17.6% 5% 0%
Spironella et al 2009 Canada	n=340 randomly selected from 2278	9-10 years	BOTMP-SF MABC-MT	15th percentile 15th percentile	12.6% 24%
Loh et al 2009 Australia	n=129 selected from 4,640 letters	10-12 years M=91;F=38	DCDQ MAND	25th percentile 15th percentile	35.6% 35%
Cairney et al 2009 Canada	n=2058	11 years	BOTMP-SF	5th percentile	4.9%
Lingam et al 2009 ALSPAC, UK	n=6990	7-8 years	ADL questionnaire Motor observation Handwriting test Combined	10th percentile 5th percentile 15th percentile Level 2 or <	9.7% 4.6% 18.4% 16.4% 1.8%

DCDQ Developmental Coordination Disorder Questionnaire (Wilson et al 2000) MABC –MT Movement Assessment Battery for Children – Motor Test (Henderson and Sugden 1992); MABC-C Movement Assessment Battery for Children – Checklist (Henderson and Sugden 1992); BOT-MP–SF Bruninks Osteretsky Test of Motor proficiency – Short form (Bruninks 1978); MAND - McCarron Assessment of Neuromuscular Development (MAND) McCarron (1997) ; Avon Longitudinal Study of Parents and Children (ALSPAC)
*Preterm < 32 weeks gestation

Other factors which might also influence prevalence rates relate to the population sizes of the studies, heterogeneous nature of the condition, response rates, nationalities and tests employed. In the table above two of the studies employed methods of assessing dyspraxia/DCD in Sweden

(Kadjesjo and Gillberg 1998) and the United Kingdom (UK) (Lingam et al 2009) the validation of which have not been published.

One of the lowest prevalence rates was reported in the Avon Longitudinal Study of Parents and Children (ALSPAC) (Lingam et al 2009). The aim of the ALSPAC was to calculate the prevalence of dyspraxia/DCD in children aged 7 years in a large UK birth cohort by employing the DSM-IV (APA 2000). Approximately 50% of the live births recorded in this cohort were assessed for coordination at 7-8 years by employing three tests. The first included three sub tests of the Movement Assessment Battery for Children- Motor Test (MABC-MT) which aimed to address criterion A of the DSM-IV (APA 2000). The second was the Level 2 handwriting skills and the third test was a questionnaire related to Activities of Daily Living (ADL). These latter two tests aimed to address criterion B of the DSM-IV (APA 2000) (Lingam et al 2009). A total of 7058 children completed the sub tests of the MABC-MT and a total of 6990 also completed either the ADL questionnaire OR the handwriting test.

A flow diagram is presented in the paper which aims to describe how the children were recruited but there are several stages missing. For example the number of participants recruited who completed all three tests was not reported in the ALSPAC study. In the methodology it is not explained why participants had not completed all three tests. In addition, the assessment tools had not previously been validated as tools for identifying DCD.

In the ALSPAC study the results reported related to ADL, motor coordination and handwriting. The ADL questionnaire identified 9.7% with difficulties, the motor coordination assessment identified 18.4% with difficulties and 16.4% of children did not achieve level 2 hand writing skills. The prevalence of DCD reported was 1.8%. It was not clear how the prevalence of 1.8% was established based on the percentages of children reporting difficulties in the individual tests. It would appear the paper required participants to perform poorly at all three tests which corresponded with criteria A and criteria B of the DSM-IV (APA 2000). However, criteria A and B are inclusive features of dyspraxia/DCD and not exclusive. In addition not all of the 6990 participants had undertaken all three tests.

In summary there were weaknesses in the methodology and data analysis of the above study (Lingam et al 2009) and a lack of transparency in the paper, therefore the prevalence reported in this study should be considered with caution.

It is possible that the perceived difference in the sex prevalence is because boys appear to be referred for intervention more frequently than girls (Wilson 2005), this may be because boys score

lower in fine motor/handwriting activities than girls (Martin et al 2006) and the most frequent reason for referral is poor handwriting and poor fine motor control (Losse et al 1991; Polatajko and Cantin 2006; Barnett, 1994; Smits-Englelsman et al 2003). Although prevalence rates of dyspraxia/DCD have been reported in several countries there is no mention of whether participants were of African, Asian or Caucasian origin. Prevalence studies of Hypermobility and JHS have found a higher prevalence in those with African and Asian origin than Caucasian (Beighton et al 1999; Grahame and Hakim 2004).

It is understood that dyspraxia/DCD persists into adulthood (Cousins and Smyth 2003; Kirby et al 2008). Persistence of coordination difficulties reportedly varies from 30%-80% (Knuckey and Gubbay 1983; Geuze and B€oorger 1993; Losse et al 1991; Cantell et al 1994). Thus prevalence estimations of dyspraxia/DCD in adulthood based on the prevalence rates previously presented (See table 2.1) may range from 0.5% to 28%. It is not clear why some adults continue to show functional difficulties while for others the difficulties resolve. It is suggested this may be as a result of the initial severity of their difficulties, the heterogeneous nature of dyspraxia/DCD or maybe linked to their participation in physical activity (Cantell et al 2003; Cairney et al 2005; Cairney et al 2007).

2.5 Common symptoms

In this next section the intention is to explore the common symptoms of hypermobility, JHS and dyspraxia/DCD both in terms of epidemiological and clinical features and by reviewing the proposed physiological mechanisms. The terms ‘co morbid’ and ‘overlapping’ will be employed in this exploration which includes reference to the diagnostic criteria.

The term ‘co morbid’ is defined (M-W D 2009) as ‘existing simultaneously with and usually independently of another medical condition’. For example asthma and diabetes may be two conditions existing simultaneously but their aetiology is independent. The combination of co morbidities may be used to determine prognoses. The term ‘overlap’ is defined (M-W D 2009) as “having something in common”. This suggests an association between two conditions and a sharing of features and symptoms. In this next section the intention is to report and discuss common features of JHS and DCD highlighted by articles from the literature review.

2.5.1 Genetics and biological markers

Recent studies indicate that JHS and dyspraxia/DCD are both genetically determined. JHS is an inherited disorder and there is a strong genetic component to hypermobility (Hakim et al 2004; Hakim et al 2010) although the biological markers have yet to be identified. It is possible that for

those with JHS there are a variety of causes affecting the connective tissues rather than being monogenetic (Grahame 1999). Although the genetics are still poorly understood, there is a strong family pattern pointing towards an autosomal dominant form of inheritance (Malfait et al 2006; Hakim et al 2010). Until recently the aetiology of dyspraxia/DCD has been poorly understood (Visser 2003). The first genetic study by Martin et al (2006) confirmed DCD as an inherited disorder. In addition this study highlighted the fact that there is a close link between dyspraxia/DCD and another neurodevelopmental disorder Attention Deficit Hyperactivity Disorder (ADHD). To date there are no biological markers for hypermobility, JHS or dyspraxia/DCD. JHS and dyspraxia/DCD are both genetic disorders but there is no evidence to suggest that these conditions share similar genetic origins.

2.5.2 Impaired proprioception and motor delay

Proprioception is defined as '..the perception of the position and movements of the body' (OED 2007). It is sometimes used interchangeably with the term kinaesthesis. Kinaesthesis is defined as 'The sense of muscular effort that accompanies voluntary motion of the body. Also the sense or faculty by which such sensations are perceived' (OED 1989). Some authors differentiate kinaesthesis from proprioception because kinaesthesis does not include other senses for example of equilibrium and balance. For movement that involves the whole body it would be difficult for the brain only to perceive sensation from muscles and joints without also integrating equilibrium (gravity) and balance, therefore for consistency in this section the term proprioception will be employed.

Good proprioception is important in the production of normal movement (See 1.2) where integration of action and cognition are vital if intentional movement is to occur. The integration of proprioception, action and cognition occur in the CNS. It is suggested that proprioceptive information relayed to the CNS relies on information from all the tissues where there are overlapping areas of sensitivity (Erickson 1968; Johansson et al 1991) these include muscle, skin, ligaments, joints, eyes and ears. Impaired proprioception has been reported in those with both DCD and JHS (Hulme et al 1982; Laszlo and Bairstow 1983; Smyth 1994; Hall et al 1995; Coleman et al 2001; Ferrell et al 2004; Deconinck et al 2006).

Proprioception is variable through life and is influenced by exercise in those who are healthy or with conditions such as JHS or dyspraxia/DCD (Visser and Geuze 2000; Ferrell et al 2004; Tsang and Hui-Chang 2004). Proprioceptive exercise programs have been found to be beneficial in those with hypermobility and JHS but the benefits are lost if exercise is stopped (Barton and Bird 1996; Ferrell et al 2004). This may indicate a lifelong need for exercise for this patient group. Treatment programs involving proprioceptive exercises for children with dyspraxia/DCD have been reported

with mixed results (Laszlo and Sainsbury 1993; Polatajko et al 1995). This may in part be due to the complex heterogeneous nature of those with dyspraxia/DCD, because it is not clear why some children improve and others do not. It may also relate to type and duration of exercise. Children with dyspraxia/DCD are reported to be less physically active than their peers (Cairney et al 2005). It is possible that exercise programs prescribed therapeutically are not continued and therefore impaired proprioception continues. Children with hypermobility and pain have also been recorded as showing a reduced capacity for exercise the explanation being that this occurs as a result of reduced exercise tolerance and deconditioning (Engelbert et al 2006) It may well be that children and adults with JHS who present with pain are taking less exercise and that this continues to impact on their proprioceptive abilities.

Delayed motor development has been linked to impaired proprioception (Sainburg et al 1993; Sainburg et al 1995). Delayed motor development was discussed earlier (See 2.2) in relation to hypermobility in infants and young children. It is suggested that those with motor delay are inherently less physically active as a result of impaired proprioception. Forsberg (1985) reported that the action of walking in infants was related to the maturation of the proprioceptive system and not as the result of motor action impairment. This indicates the importance of a mature functioning proprioceptive system in order for a child to achieve independent walking. Children with dyspraxia/DCD, hypermobility and JHS report delayed walking (Adib et al 2005; Englebert et al 2005; Polatajko 1999). In summary poor proprioception in children with hypermobility and dyspraxia/DCD may be associated with developmental delay which impacts on reduced physical activity and continuing proprioceptive deficits through life. It would appear that children with JHS and dyspraxia/DCD share these overlapping features. Although developmental delay is recognised in the diagnostic criteria for DCD (DSM-IV-TR APA 2000), it is not reported in the diagnostic criteria for JHS. Impaired proprioception is not mentioned in either diagnostic criterion.

2.5.3 Pain, autonomic and gastrointestinal symptoms

Pain associated with JHS may be regional, localised or widespread (Hakim et al 2010) in most cases it is chronic, progressive and causes considerable concern for patients (Hakim and Grahame 2003a; Gurley- Green 2001). JHS is thought to be a cause or risk factor for musculoskeletal pain and injuries in children (Gedalia et al 1993; El-Garf et al 1998; Murray 2006). Pain was the commonest symptom reported by children with JHS attending a tertiary referral centre (Adib et al 2005), who also reported clumsiness. There is evidence that some adults with JHS report their pain commencing in early childhood. Continuing pain impacts on their ability to function at work, socially and physically as adults (Sacheti et al 1997). It is only recently that pain and physical injury have been mentioned in the literature pertaining to dyspraxia/DCD, where the focus has tended to be on functional impairments (Kirby and Davies 2007; Poulsen et al 2007). In addition Kirby and Davies

(2007) highlighted the multisystemic nature of the symptoms reported by children with dyspraxia/DCD which included those of autonomic dysfunction and gastrointestinal (GI) dysfunction.

Patients with JHS report symptoms identifiable with autonomic dysfunction (Gazit et al 2003; Hakim and Grahame 2004; Bravo and Wolfe 2006). Some of these symptoms include fainting or feeling faint, light headedness, dizziness, and poor concentration. Findings suggest these symptoms arise as a result of cardiovascular autonomic dysfunction in the form of orthostatic hypotension, orthostatic intolerance or postural orthostatic tachycardia syndrome (POTS) (Bravo et al 2010). POTS is reported to be the commonest finding in relation to autonomic dysfunction in patients with JHS (Hakim et al 2009) and may be accompanied by deconditioning. It is interesting to note that children and adolescents with features of autonomic dysfunction also report clumsiness, exercise intolerance and fatigue (Bravo et al 2010). Children with dyspraxia/DCD were significantly more likely to report feeling faint, lightheaded and or dizzy than typically developing children (Kirby and Davies 2007). It is suggested that the associated symptoms reported alongside autonomic dysfunction in those with JHS and dyspraxia/DCD indicate an origin in the CNS rather than the peripheral nervous system.

A significant association between the reporting of GI symptoms and JHS was reported amongst adults with JHS (Hakim and Grahame 2004). These symptoms included; nausea, stomach ache, diarrhea and constipation. GI symptoms have been reported in children with both dyapraxia/DCD and JHS. (Adib et al 2005; Kirby and Davies 2007). Unexplained GI symptoms and hypermobility are more prevalent in patients with fibromyalgia than those without (Sendur et al 2007).

Several studies report on the significant association between hypermobility and fibromyalgia in both children and adults (Gedalia et al 1993; Hudson et al 1995; Acasuso-Dias and Collantes-Estevez 1998; Karaaslan et al 2000). Fibromyalgia is a clinical syndrome distinguished by widespread musculoskeletal pain diagnosed by the reporting of tender points at specific sites (Wolfe et al 1990). To the researcher's knowledge there are no studies reporting on the association between fibromyalgia, JHS and or dyspraxia/DCD. Epidemiological studies have shown that 50%- 70% of patients with fibromyalgia report GI symptoms including functional dyspepsia and irritable bowel syndrome (IBS) (Triadafilopoulos et al 1991). Similarly patients with IBS report a high prevalence of fibromyalgia (Kurland et al 2006). Chronic pain and pain hypersensitivity are common features of JHS, fibromyalgia and IBS. In the cases of fibromyalgia and IBS there are suggestions that pain may be centrally sensitised (Gibson et al 1994; Sarkar et al 2004). Central sensitized pain manifests as pain hypersensitivity, allodynia and hyperalgesia resulting in secondary changes in the brain (Woolf 2011).

In summary it is noted that symptoms of pain, autonomic and GI dysfunction are overlapping features for those with hypermobility, JHS and dyspraxia/DCD. In addition symptom onset is reported in childhood. It is suggested that these symptoms may have a common origin in the CNS. Pain is reported in the diagnostic criteria for JHS, but not mentioned in the diagnostic criteria for dyspraxia/DCD. GI and ANS symptoms are not mentioned in the diagnostic criteria for either JHS or dyspraxia/DCD.

2.5.4 Dyslexia

In the context of this thesis the type of dyslexia discussed is developmental dyslexia, which was first described by Morgan (1896) as 'word blindness'. It is an inherited disorder in which a proportion of the reading related skills are thought to be genetically related, the mode of inheritance is thought to be autosomal dominant (Stein and Talcott 1999), with a firmly established gene location (Fisher et al 1999). Delayed crawling, walking, clumsiness and inability to ride a bike are some difficulties reported by children who subsequently report reading difficulties (Stein and Talcott 1999). In addition hypotonia, poor balance and problems with timing and sequencing are also reported (Fawcett et al 1996). These features indicate impaired integration of perception, action and cognition. These are the mechanisms of movement which are implicated in those with dyspraxia/DCD. Dyslexia is a broad neurodevelopmental term, which has recognised overlapping features in those with dyspraxia/DCD (Kaplan et al 1998). It is only more recently that spelling, reading and learning difficulties have been reported by children with JHS (Adib et al 2005; Kirby et al 2005). Dyslexia appears to be a feature of both dyspraxia/DCD and JHS but is not mentioned in either diagnostic criterion.

2.5.5 Chronic fatigue syndrome (CFS) and physical activity

Chronic fatigue syndrome (CFS) is a relatively common disorder defined as a sensation of abnormally prolonged fatigue (Fukuda et al 1994). The exact pathology is unknown, but the origin is thought to be associated with cytokines, neuropeptides or neurotransmitters within the CNS (Narita et al 2003).The symptoms are multisystemic and include; multi joint and muscle pain, post exertion fatigue, GI symptoms and dysautonomia (Fakuda et al 1994; Afari and Buchwald, 2003; Prins et al 2006). Joint hypermobility is a significant feature for children with CFS (Barron et al 2002), while adults with CFS were significantly more likely to report JHS than controls (Nijs et al 2006). Joint hypermobility is a significant feature for children with CFS (Barron et al 2002), while adults with CFS were significantly more likely to report JHS than controls (Nijs et al 2006). Children with poor coordination have been found to fatigue faster than children without coordination difficulties (O'Beirne et al 1994). Hands and Larkin (2002) suggest fatigue in children with dyspraxia/DCD is

as a result of poor movement patterns resulting in mechanical inefficiency leading to higher energy expenditure.

The mechanisms of fatigue are complex and beyond the scope of this thesis. Suffice to say that fatigue differs in nature and cause depending on the type of activity. However, in maximal exercise reduced neural activity accompanies fatigue. This indicates that failure in neural activity is the important contributor to fatigue (Rowell 2001). The neural components comprise; the central nervous system, peripheral nervous system and the neuromuscular junction. Recently functional magnetic resonance imaging (fMRI) scans of children with dyspraxia/DCD and age matched controls were employed to investigate brain activity. The fMRI revealed that during task orientated fine motor activity children with dyspraxia/DCD activated almost twice as many brain regions as that of their peers to achieve similar motor performance (Zwicker et al 2010). Children with dyspraxia/DCD show differences in the neural pathways and patterns activated within the CNS, it is suggested this may be a contributing factor to fatigue generation in those with dyspraxia/DCD.

It has previously been discussed that the mechanisms that contribute to motor control are the integration of perception, action and cognition (See 1.2). Poor balance and locomotor skills noted in children with dyspraxia/DCD impact on their abilities because of the impaired integration of the mechanisms of movement. This means children have more difficulty performing complex tasks. Therefore achieving skills for example associated with playing football and riding a bike require more effort (Miyahara 1994; Mandich et al 2003). This may explain why children with dyspraxia/DCD are less likely to participate in physical activities or team games (Poulsen et al 2007) which may contribute to reduced cardio-respiratory fitness (Cairney et al 2005; Cairney et al 2007) and deconditioning.

More than half the children attending rheumatology clinics reported not taking part in physical education because of symptoms (Adib et al 2005). Whether reduced participation in physical activities is related to post exercise pain and musculoskeletal injuries or due to poor performance related to impaired motor coordination remains to be investigated, but children and adolescents with symptomatic hypermobility report significantly reduced exercise tolerance compared with their peers (Engelbert et al 2006). Deconditioning is a feature of autonomic dysfunction in particular POTS. It is possible that these multisystemic features also contribute to reduced exercise tolerance, deconditioning and reduced adherence to exercise programs. Chronic fatigue syndrome is linked to JHS, while children with dyspraxia/ DCD report fatigue. Reduced physical activity participation and cardio-respiratory fitness have been reported in children with dyspraxia/DCD and JHS. Fatigue,

chronic fatigue syndrome and reduced cardiac fitness may be overlapping features for those with JHS and dyspraxia/DCD, but are not mentioned in either diagnostic criterion.

A summary of features common to hypermobility, JHS and dyspraxia/DCD is presented (See table 2-1).

Table 2-1 Features common to Joint Hypermobility Syndrome (JHS) and dyspraxia/Developmental Coordination Disorder (DCD)

Features	JHS	Dyspraxia/DCD	Section of discussion
Biological markers	No	No	2.5.1
Inheritance	Yes	Yes	2.5.1
Age of symptom onset	Childhood and adulthood	Childhood	2.5.2, 2.5.3
Symptom overlap			
Impaired proprioception	Yes	Yes	2.5.2
Motor delay	Yes	Yes	2.5.2
Pain	Yes	Yes	2.5.3
ANS dysfunction	Yes	Yes	2.5.3
Gastro intestinal symptoms	Yes	Yes	2.5.3
Condition overlap			
Dyslexia and or difficulties with reading	Yes	Yes	2.5.4
Chronic fatigue syndrome and or fatigue	Yes	Yes	2.5.5
Fibromyalgia	Yes with hypermobility No with JHS	No	2.5.3

*BS Beighton Score

2.6 Research objectives and questions

In the discussion above it would appear there are common features for children with hypermobility, JHS and dyspraxia/DCD. However, these have not previously been described in adults with JHS. It is understood that JHS is a multi-factorial condition and one of the factors to be explored in this thesis were the functional difficulties associated with dyspraxia/DCD. Investigating a functional difficulties associated with dyspraxia/ DCD in patients with JHS required two parts to the study. The first part involved the development and validation of a questionnaire aimed at assessing functional difficulties associated with dyspraxia/DCD in adults. The rationale for which is discussed in chapter four. The second part was to explore the multisystemic symptoms reported by patients with JHS including functional difficulties associated with dyspraxia/DCD and how these might impact on quality of life. This was to be achieved by addressing the following hypotheses and questions using a mixed methods approach with a predominantly quantitative focus and a small qualitative aspect:-

Quantitative hypotheses

1. Exploring functional difficulties in patients with JHS by addressing the following hypotheses (see table 2-2).

Table 2-2 Hypotheses 1-4

Null Hypothesis	Description
1	Patients with JHS are no more likely to report functional difficulties than healthy volunteers.
2	Patients with JHS are no more likely to report functional difficulties related to gross motor function than healthy volunteers
3	Patients with JHS are no more likely to report functional difficulties related to fine motor function and organisation than healthy volunteers
4	Patients with JHS are no more likely to report being poor or very poor at an item of the FDQ-9 than healthy volunteers

2. Exploring the reporting of musculoskeletal pain in patients with JHS

3. Exploring physical activity participation in patients with JHS and healthy volunteers and exploring physical activity participation for those with functional difficulties. This was to be achieved by addressing the following hypotheses (See table 2-3).

Table 2-3 Hypotheses 5-6

Null hypotheis	Description
5.	There is no difference in the time spent engaged in weekly physical activity between patients with JHS and healthy volunteers.
6.	There is no association between the reporting of functional difficulties and the time spent engaged in physical activity for patients with JHS and healthy volunteers.

4. Exploring the reporting of other musculoskeletal and non musculoskeletal features in patients with JHS. This was to be achieved by addressing the following hypotheses (See table 2-4).

Table 2-4 Hypotheses 7-8

Null hypothesis	Description
7	There is no difference in the reporting of dislocations/subluxations between patients with JHS and healthy volunteers at any site
8	There is no difference in the reporting of Gastrointestinal (GI), cardiorespiratory (CR) and Autonomic Nervous System (ANS) symptoms and the condition Chronic Fatigue Syndrome (CFS) between patients with JHS and healthy volunteers.

5. Exploring the health burden reported by patients with JHS by addressing the following hypotheses (See table 2-5).

Table 2-5 Hypotheses 9-11

Null hypothesis	Description
9	There is no difference in the mean physical component summary (PCS) scores of the SF-12 between patients with JHS and healthy volunteers.
10	There is no difference in the mean mental component summary (MCS) scores of the SF-12 between patients with JHS and healthy volunteers.
11	There is no association between the reporting of pain, dislocations/subluxations, functional difficulties, Autonomic Nervous System (ANS) and Gastrointestinal (GI) symptoms in patients with JHS and their PCS scores.

Qualitative research questions

- When and what triggers the onset of aches and pains?

- How do patients with JHS report the nature of their condition and their experiences with the condition?

2.7 Clinical and non clinical implications of the study

As reported earlier (See 1.5) it is only more recently that functional difficulties similar to those recognised in children with dyspraxia/DCD have been portrayed as persisting into adulthood. The International Classification of Disease (ICD-10) under the Classification of Mental and Behavioral Disorders:F80 Disorders of Psychological Development (WHO 2007) briefly mentions mild symptoms persisting into adulthood. The recognition of dyspraxia/DCD in adulthood has not been acknowledged in the Diagnostic Statistical Manual (APA 2000). It was therefore not surprising there were no validated tools for assessing dyspraxia/DCD in adults in a clinical population. The aim of the first part of this study was to develop and validate a tool to assess for functional difficulties associated with dyspraxia/DCD in adults with or without JHS. It was anticipated this questionnaire could be employed for assessment of dyspraxia/DCD in research and clinical practice. In clinical practice it was anticipated the questionnaire would be employed to assess for functional difficulties

associated with dyspraxia/DCD and to guide intervention. To be useful in clinical practice the questionnaire would need to be easily administered and scored.

The second part of the study aimed to explore the multi-factorial manifestations of JHS (including functional difficulties), their impact on quality of life and the experiences reported by patients with JHS. It was anticipated that understanding the diverse nature of symptoms reported by patients with JHS would be important to guide appropriate intervention.

There is evidence to suggest both children with JHS and children with functional difficulties associated with dyspraxia/DCD are less likely to be physically active than their peers (Cairney et al 2005; Englebert et al 2006). Reduced physical activity may result in deconditioning; this has been reported amongst patients with JHS (Russek 2000; Simmonds 2003). It was decided to investigate weekly physical activity participation for adults with JHS and healthy volunteers with functional difficulties. This would enable identification of whether reduced physical activity is a feature in adults with JHS with functional difficulties. This has further clinical implications as reduced physical fitness may contribute to acquired conditions such as; chronic heart disease (Shaper et al 1991; Lee et al 2001), type II diabetes (Sigal et al 2006), obesity (Waller et al 2008) and some cancers (Giovannucci et al 1995).

It has been reported that JHS can be a debilitating condition (Hakim and Grahame 2003b) but there is only one study which has reported on the health burden of 18 patients with JHS using the SF-36 (Ferrell et al 2004). In this current study part of the questionnaire relates to exploring the health burden of patients with JHS. This is achieved by employing the SF-12 a shortened version of the SF-36.

The clinical implications of this study relate to the multi-factorial nature of JHS and the experiences of individuals. It is anticipated that this study will contribute to an acceptance and understanding of this condition and help subscribe to the future management.

2.8 Summary

This chapter began by reviewing the literature relating to JHS and dyspraxia/DCD. The literature reviewed was that pertaining to children and included hypermobility, JHS, hypotonia, delayed motor development and dyspraxia/DCD. The case for aetiological overlap was discussed within the context of features reported in those with hypermobility, JHS and dyspraxia/DCD. There is evidence from the literature these may be overlapping disorders with some important common features. Both conditions are inherited with lifelong features but it is not clear if they show the same population prevalence. Impaired proprioception and delayed walking are recognised in both

conditions. There is evidence to suggest that children with hypermobility, JHS and dyspraxia/DCD report similar functional difficulties, limitations in physical activities and post exercise injury or pain (Adib et al 2005; Kirby et al 2005; Cantell et al 1994). In addition autonomic dysfunction and gastrointestinal symptoms have been reported in children with dyspraxia/DCD and adults with JHS. There is evidence to suggest an important overlap between hypermobility, JHS and dyspraxia/DCD in children. It is hypothesised that this overlap continues into adulthood and this is explored in this thesis.

Chapter 3

3 METHODOLOGY AND RESEARCH DESIGN

3.1 Introduction

This chapter outlines the methodology (philosophical and theoretical considerations), research design and research methods employed to explore the multi-factorial manifestations of JHS. A time line of the study is described in five stages. The method of data collection for this aspect of the study was a questionnaire. The questionnaire was developed in two parts. The first part was aimed at exploring information in relation to the multisystemic nature of JHS and the experiences of patients with JHS attending a hypermobility clinic. This questionnaire is discussed in this chapter. The second part of the questionnaire consisted of questions to assess for functional difficulties associated with dyspraxia/DCD in adults. The development and validation of these questions is discussed in depth in chapter four. Finally the data analysis is discussed within a mixed methods framework by employing a process previously described (Onwuegbuzie and Teddlie 2003).

3.2 Philosophical world view

Identifying a method of appropriately answering research questions and hypotheses is challenging and in part will be determined by a researcher's philosophical world view. An inquirer's views of the ideas they are studying are influenced by their understandings and beliefs (Greene and Caracelli 2003). Beliefs are no doubt founded on experiences and reflection of those experiences. In this case my beliefs and experiences as a trained and practicing physiotherapist have had an impact on my view of the world and the focus and the choice of methodology for this study. I see a requirement to collect evidence that can be quantified and acknowledge that within the context of health and social care research qualitative enquiry is also important. Qualitative data within a quantitative study enables the researcher to enrich the information collected and can be employed to add to or explain the numerical findings.

I am an advocate of lifespan development described by (Datan and Reese 1977; Baltes et al 1980). Within this context there is an understanding that an individual is constantly changing and that these changes occur as a result of the circumstances in which they live. An individual's life time development is influenced by changes from conception to death involving the interaction of

biological, psychological, historical and sociological factors. These changes are as a result of the individual interacting within their environment and adjusting to both internal and external influences occurring sequentially. This world view which arises out of actions, situations and consequences is best described as a pragmatic world view (Creswell 2009). Within this context it is acknowledged that the data collected for this study only captures a snap shot of the lives of the participants and is therefore a limitation. However, resources for research are not finite and researchers need to identify the best use of resources within methodological and ethical limitations. The considerations discussed above have contributed and influenced the pragmatic approach taken by the researcher for this study.

Pragmatism as a paradigm in research supports the use of both qualitative and quantitative research in the same study, presenting the researcher with a practical approach to answering research questions while allowing the researcher to study a topic pertinently (Teddlie and Tashakkorie 2003). In this study the quantitative data collected in the questionnaire contributes to understanding relationships. The qualitative data collected in the open questions in the questionnaire enable a deeper sense of appreciation of those relationships. Pragmatism belongs to a culture of commonsense (Sleeper 1986) and supports the use of mixed methods research. Mixed methods as a research concept is there to facilitate the researcher to gain a more superior comprehension of a topic than would be possible if only one methodology was used.

Having stated my world view, within this project I understand that my experiences may contribute to biases and therefore trustworthiness in this study. Trustworthiness is a term used in qualitative research and relates to the reliability and validity of the research and includes the terms credibility transferability, dependability and confirmability (Rolfe 2006). Credibility and transferability correspond to the concepts of internal and external validity and are discussed later (See 6.3). Dependability and confirmability are aspects which deal with the consistency and objectivity of the study.

Dependability is defined as the reliability of the data findings (Rolfe 2006; Taylor 2007) and relies on the researcher clearly defining the methodology and data analysis involved in the study. This chapter provides evidence of the methodology utilised in this study and the data analysis strategies. Confirmability is defined and relates to the presentation and objectivity of the data (Rolfe 2006; Taylor 2007). This relies on the researcher identifying and putting strategies in place to limit bias. To limit bias involves the researcher documenting their stance in the research and showing continuing dialogue with colleagues, supervisors and field experts through the research process and documenting presentations of the research findings. In the introductory chapter I discussed my stance in this study in addition a field diary was kept and referred to when analysing the data. All

the qualitative data was peer reviewed by an expert in the field of JHS. Qualitative data analysis was discussed with supervisors who were informed of the overall research progress in regular meetings (See appendix 4**)** and presentations of the research findings are documented (See appendix 5**)**.

The overall study objective was to explore the multi-factorial nature of JHS. Details of the hypotheses and questions have been previously presented within a mixed methods context and can be viewed (See 2.6).

3.2.1 Mixed methods research

Mixed methods research as a methodology requires an explanation, because the mixing of the methods is particular for each study. It is not the intention in this chapter to discuss this topic in detail but to give the reader an overall picture of mixed methods as it has been used in this study.

Mixed methods research has been referred to as the third paradigm or third methodological movement (Teddlie and Tashakkori 2003; Johnson and Onwuegbuzie 2004). The other research movements are defined as quantitative and qualitative. It is suggested that the term mixed methods designs (MMD) (which is the term that will continue to be used in this thesis) is used as a general term to cover mixed method research and mixed model research (Teddlie and Tashakkori 2003). Mixed method research studies involve the collection and analysis of quantitative and qualitative data either sequentially or concurrently. They are often only marginally mixed but both sets of data are required to answer the research hypotheses and questions and there is often a single paradigm. Alternatively the mixing may be more global. In the case of mixed model research where there is mixing in many or all of the stages of the study, to enable the answering of each research question depending on the paradigms and inferences corresponding to different world views. This study utilised mixed method research within a MMD.

3.2.2 Mixed methods design

It was anticipated that by utilizing MMD in which both quantitative and qualitative data were collected, analysed and integrated would enable the answering of questions that the other methodologies on their own may not be able. It was also anticipated this method would provide stronger inferences if the data converged, or the opportunity to offer diversity if the data were divergent as has previously been discussed within the mixed methods literature (Tashakkori and Teddlie 1998). The use of triangulation has been reported as a method by which to combine sources and to add to the usefulness of MMD (Jick 1979; Greene et al 1989). Creswell (2002) described the method and usefulness of triangulation and suggested collecting quantitative and

qualitative data, merging the data and then using the integrated results to answer the research questions. In this study triangulation was used to enable the discussion of inferences that confirmed or refuted each other. Further analysis of the data may be facilitated by transformation. Transformation of data is referred to using the terms 'qualitising' and 'quantitising'. These terms were defined by Tashakkori and Teddlie (1998) although the idea 'to convert data into primitive quantities' was previously described by Miles and Huberman (1994p11). Qualitised data is data collected quantitatively, converted into narratives and analysed qualitatively. Quantitsed data is data collected qualitatively and converted into numerical codes that can be statistically analysed.

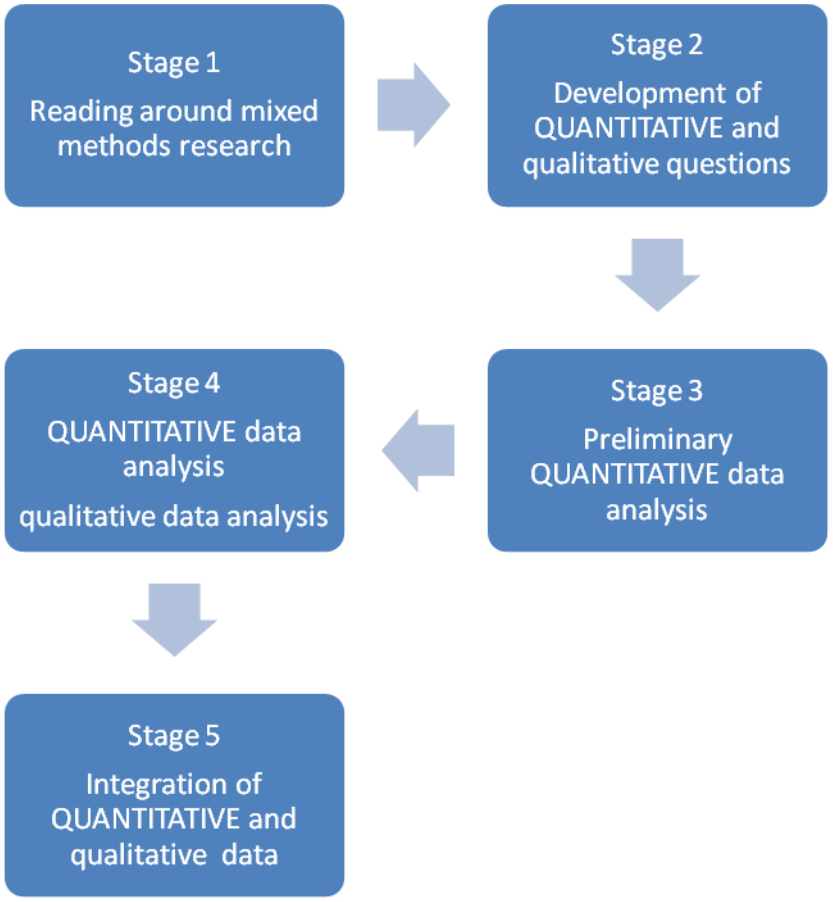
For this study the benefits of using MMD were to confirm a quantitatively derived hypothesis and explore features that were important to patients with JHS. This method of conducting research is similar to a clinical examination in which both subjective (qualitative) and objective (quantitative) information is collected, analysed and from which inferences are made.

3.2.3 Choosing a mixed methods design

There are many ways of designing a MMD study, some of which incorporate practical decisions. For example data collected in phases (sequentially) will take longer to gather than data collected at the same time (concurrently). Another factor will be the weighting given to each methodology. This may be equal or it might be preferred for one method to dominate another. A more complex issue arises when considering how the questions and the data analysis are to be mixed. This consists; a) connecting the data, this means mixing quantitative and qualitative in the first and second phases of the data collection, b) integrating the data by merging the different data sets; and c) embedding the data in which the researcher uses the secondary form of data to support data from the larger primary study.

With these designs in mind it seemed appropriate to use a concurrent nested strategy because the secondary (smaller) *qualitative* method was to be nested in the primary (larger) *QUANTITATIVE* method and the mixing of the two methods were to be used to integrate information and compare between the data sets in order to gain perspectives at different levels. There were five stages for this study. Within each stage there was an element of development, analysis or integration of either or both the quantitative and qualitative aspects (see figure 3-1).

Figure 3-1 Overview of the stages of the mixed methods process and relationship of the methodologies



3.3 Stages of the study

The overall design of the study has been divided into five stages. The design of the study reflects the research activity in relation to the summarised development and progression of the overall project and the dates (See table 3-1). In the discussion that follows the research activity within each stage is described.

Table 3-1 Overview of the study in relation to stages, research activity and dates

Stage	Research activity	Dates
Stage one	• Literature reviews, discussion and correspondence with supervisors and field experts • Development of the research question • Development of the methodology • Writing of the research protocol • National Ethics submission and approval • Permission for questionnaire to be sent to other groups	Oct 2007 – May 2009
Stage two	• Development of the health and activities questionnaire with quantitative validated questions • Development of the non validated functional difficulties questionnaire • Development of qualitative questions • Pilot study *(sample 1) • Test re-test **(sample 2) • Data analysis	April 2008 – April 2009
Stage three	• Application for a research passport • Pilot study ***(sample 3) • Continuation of the study ***(sample 3)	Feb 2009 – Aug 2009
Stage four	• Quantitative data analysis • Qualitative data analysis • Comparison group ****(Subgroup of sample 4)	Sept 2009 – May 2010
Stage five	• Data analysis • Writing up of final report	June 2010 - Dec 2010 Jan 2011 – Sept 2011

*Sample 1 convenience sample of employees and their families from an international company
**Sample 2 convenience sample from staff and employees of an international company and students of a university
***Sample 3 patients with JHS attending a hypermobility clinic
****Subgroup of sample 4 a convenience sample of staff and students from a university without pain.
.

3.3.1 Stage 1 initial development

The aim of the first stage of the study was to carry out literature reviews relating to JHS and dyspraxia/DCD to inform the development of the research question. The initial literature search focused on exploring an association between hypermobility, JHS and dyspraxia/DCD the results of which have been discussed (See 2.3-2.6). Further literature searches and discussions with colleagues and researchers were carried out to enlighten the researcher on the different methodological designs and outcome measures that could be employed for this project (See 3.2).

3.3.1.1 Methods and populations

In the first stage of this project consideration was given to identify suitable methods of collecting data and sample groups. The methods initially considered were based on the current diagnostic criteria and tests. These included the Brighton diagnostic criteria (Grahame et al 2000) for the diagnosis of JHS in adults, the Beighton score (Beighton et al 1973) for identifying hypermobility in children and adults and the Simple Questionnaire (Hakim and Grahame 2003a) for identifying hypermobility in adults. Consideration was given to collecting data relating to the functional difficulties associated with dyspraxia/DCD. Two commonly used tests for identifying dyspraxia/DCD in children and young adults are; the MABC-2 (Henderson and Sugden 2007) and BOT-MP-2 (Bruinicks and Bruinicks 2005). Both tests require participants to carry out a battery of physical tests in order to assess for functional impairment or proficiency. Early on in this study it was realised that these tests might not be appropriate. This was because it would not be possible to establish if a poor score was related to functional difficulties associated with dyspraxia/DCD or musculoskeletal pain associated with JHS. In addition although a functional test would give an indication of current functional difficulties it would not be possible to distinguish if these were acquired or as a result of functional difficulties associated with dyspraxia/DCD.

Furthermore to explore the multi-factorial manifestation of JHS required a case comparison study. It became apparent that the best way to access this data would be through a questionnaire.

A questionnaire was devised for the purposes of this study and is referred to as the Health and Activities Questionnaire this consisted of two parts. The first part was comprised of validated questions from previous questionnaires and open ended questions. The aim of these questionnaires and questions was to explore the multifactorial nature, impact on quality of life and experiences of patients with JHS. The rationale for the questions included will be discussed later in this chapter. The second part was a newly developed questionnaire aimed at assessing functional difficulties associated with dyspraxia/DCD. The development and the analysis relating to this questionnaire are discussed in chapter four.

The next consideration was accessing participants with JHS. It was decided to investigate the possibility of carrying out the study in a hypermobility clinic in which participants would already have a diagnosis of JHS. The hypermobility clinic with which the researcher was most familiar with was that in a London teaching hospital. Agreement was reached for the study to take place in this location.

Another consideration was accessing a comparison group. Initially it was decided to contact an international company who were accessible to the researcher. Data from the first pilot study which included respondents from an international company revealed that the average age of respondents

was considerably older than the participants from the hypermobility clinic and there were more males. In order to establish a closer age and sex matched population permission was sought to approach employees and students of a university in the south of England. It was anticipated that it might be difficult to match similar educational achievement between the groups but this could be controlled for in the analysis.

3.3.1.2 Ethics and permission

Within the first stage of this research project a research protocol was written and submitted along with the ethics application on the15/01/09. This was reviewed by the National Hospital for Neurosurgery and Neurology and the Joint Institute of Neurology Research Ethics Committee (NHNNJIN REC) on 19/02/09 at the National Hospital for Neurological diseases, Queen Square, London. In attendance were the researcher and principal investigator. Approval was subsequently granted in a letter dated 05/03/09 (ref 09/H0716/5) (See appendix 6).

Permission was sought and given for the questionnaire to be sent out via an email distribution list to employees and their families from Damascus Shell Club (See appendix 7). Permission was also sought and granted by the Health and Social Care Research Governance Group at Bournemouth University to approach staff and students of the university (See appendix 8).

3.3.2 Stage 2 development of the health and activity questionnaire

Stage two of this study was carried out in parallel with stage one and the focus of this stage was the development of the Health and Activities Questionnaire (HAQ). Questionnaires can be an inexpensive, relatively non-invasive and in some cases readily available tool for collecting data from a number of people in different populations (Nilsson et al 2008). A questionnaire was chosen for this study based on the practical considerations discussed earlier. Questionnaires may be used as tools for collecting both quantitative and qualitative data.

3.3.2.1 Content validity of the Health and Activity Questionnaire (HAQ)

In this next section the focus of the discussion is on the HAQ which was developed to explore the multifactorial nature of JHS, the impact on quality of life and experiences reported by those with JHS. It is understood there are no standard procedures appropriate for demonstrating content validity, however what is important is that the content measures what it is intended to measure (Wilkin et al 1992). In this next section the discussion focuses on the rationale for including the questions in the questionnaire. Content validity of any questionnaire is enhanced by demonstrating reference to existing literature, showing the instrument covers topics previously recognised as important and that a number of previously validated instruments have been used to generate the

questions (Wilkin et al 1992). In the following section the aim is to demonstrate these properties. In addition during the development of this aspect of the questionnaire field experts (a consultant rheumatologist, two physiotherapists and two occupational therapists) were consulted to establish if the questions in the questionnaire were appropriate in relation to current understanding. Three patients with JHS were consulted in relation to the open ended questions all of whom completed the full questionnaire and made suggestions.

3.3.2.2 Assessing quality of life – The SF-12 (Ware et al 1996)

In this study one of the research questions related to investigating the quality of life or health burden of patients with JHS and comparing this with healthy volunteers. For this aspect of the questionnaire there was a requirement to find a quality of life measure that could be used to report on quality of life in populations with or without musculoskeletal pain. The tool chosen was the SF-12 medical outcomes score (Ware et al 1996). This is a generic health survey measuring both physical and mental health quality of life.

The SF-12 is a shortened version of the SF-36 (Ware et al 2000) and uses a scoring algorithm converting raw scores into two component summary scores (mental and physical) ranging from 0-100 where higher scores indicate better health and the mean score of a healthy population equates to approximately 50 (Ware et al 1995). The SF-12 was chosen for this study following a review of other available tools for assessing quality of life. This was because it could be used for populations who were either healthy or had multiple symptoms (Ware 2000; Ware et al 1996). The SF-12 was chosen in preference to the SF-36, because it was shorter and therefore would be less burdensome to participants. Importantly the SF-12 correlates well with the SF-36 (Ware et al 1996) and has been shown to have good internal consistency, validity and responsiveness for those with musculoskeletal pain (Luo et al 2003). The questions relating to the SF-12 within the Health and Activity Questionnaire are numbered 29-40 (See appendix 9).

3.3.2.3 Assessing JHS – The Brighton criteria (Grahame et al 2000)

The Brighton Criteria (Grahame et al 2000) is the validated tool used in clinical practice for the identification and diagnosis of JHS (See appendix 1 figure 2). The aim of adding the questions relating to the Brighton criteria (Grahame et al 2000) were two fold. The first reason was to set the inclusion and exclusion criteria for participants in the case comparison part of the study. The second reason was to collect data relating to JHS.

The Brighton criteria had previously been validated for use in clinical examination, as such a couple of questions have been re-worded for this study in consultation (R. Grahame personal

communication May 12, 2009). These questions were cross checked with the clinical data from the medical notes of patients with JHS. The questions may be viewed as 13-17 and 41-43 (See appendix 9)**.** A pain chart was employed to assess the number of pain sites reported for three months or more. In addition this pain chart was used to report if pain was from one or multiple sites and whether this equated with widespread pain. Widespread pain is defined as spinal pain and pain in at least two contra lateral quadrants (Wolfe et al 1990).

3.3.2.4 Assessing hypermobility – The simple questionnaire (Hakim and Grahame 2003a)

The Simple Questionnaire is employed for assessing hypermobility in a non clinical population. The Simple Questionnaire has been shown to have a sensitivity of 84% and specificity of 80-89% in correctly identifying hypermobility in cases and controls (Hakim and Grahame 2003a) (See appendix 1. Figure 3).The Simple Questionnaire (Hakim and Grahame 2003a) was employed in the Health and Activity Questionnaire to record hypermobility. Hypermobility is more commonly recorded in the Brighton criteria by applying the Beighton score (Beighton et al 1973) (the Beighton score could not be used in this study as this requires a clinical examination). The responses to the Simple Questionnaire were cross checked with the Beighton scores in the medical notes of patients with JHS. The questions relating to the Simple Questionnaire may be viewed as 13-17 in the Health and Activities Questionnaire (See appendix 9).

3.3.2.5 Assessing physical activity participation

The aim of the physical activity questions were to ascertain if participants with or without JHS and or DCD reported spending more or less time involved in physical activity and which activities they were involved in. It was not the intention in this study to develop a tool for measuring physical activity.

There is no standardised method for assessing physical activity in a general population (Kutze et al 2008), let alone in a population with musculoskeletal pain or functional difficulties. It was understood that the development of appropriate questions to ascertain duration, types and frequency of physical activity in this questionnaire would be a challenging task. It has been hypothesised that questionnaires for measuring physical activity need to take into account intensity, duration, and frequency in order to record activity expenditure although it remains unclear whether physical activity questionnaires correlate with activity expenditure (Nilsson et al 2008). It might be suggested that activity expenditure is likely to be dependent on many factors that are beyond the scope of this study.

It was decided to take a practical approach and to record types of activity, frequency and duration. In relation to duration it was decided to analyse the data based on the United Kingdom government's recommendations for physical activity (Health Survey for England (HSE) 2008a). The recommendations are for adults to be engaged in moderate intensity physical activity for at least half an hour on five days equating to two and a half hours a week. Weekly physical activity duration data would be analysed using the dichotomous variables of; two hours or less versus three hours or more.

The development of the two questions relating to physical activity in this questionnaire and their adaptation from the General Physical Activity Questionnaire (GPAQ) (Armstrong and Bull 2006) is discussed (See appendix 10). They may be viewed in the Health and Activity Questionnaire (HAQ) as questions 5 and 6 (See appendix 9).

3.3.2.6 Demographic questions

A number of demographic questions relevant to this population and the research study for example age, sex, school leaving age, educational achievement, occupation and employment status were included. Age and educational achievement were employed for the inclusion and exclusion criteria. Details of the inclusion and exclusion criteria may be viewed (See 3.3.2.11). Information relating to the inclusion and exclusion criteria relating to dyspraxia/DCD may be viewed (See table 4-2 and 4.3.3). Age, sex and educational achievement questions were to aid with matching for the comparison group. Current employment status was included as this would add context for the qualitative data analysis. The demographic questions may be viewed in the HAQ as questions 1-5 (See appendix 9).

3.3.2.7 Question related to additional conditions

The aim of this next section was to ascertain if participants reported additional conditions and to establish if these were reported any differently amongst participants with or without JHS. An open ended question was used to ask if any conditions were relevant to participants and their comments were invited. These questions related to; symptoms of autonomic dysfunction (dizziness, fainting, light-headedness), cardiovascular system (heart palpitations, shortness of breath, chest pain) and gastrointestinal system (nausea, constipation, diarrhea, stomach ache); neuro-developmental disorders; (dyspraxia/DCD, Attention Deficit Hyperactivity Disorder (ADHD) and dyslexia); fatigue in the form of Chronic Fatigue Syndrome (CFS) and Myalgic Encephalopathy (ME) and fibromyalgia. The rationale for collecting information about these conditions or symptoms was they had previously been described in those with hypermobility, JHS and/or dyspraxia/DCD (Gazit et al 2003; Hakim

and Grahame 2004; Kirby and Davies 2007; Adib et al 2005; Baron et al 2002; Acassuso Diaz and Collantes-Estevez 1998; Karaaslan et al 2000; Martin et al 2006; Kirby et al 2008). It was anticipated that there might be overlap of these condition in those with hypermobility, JHS and dyspraxia/DCD. This may be viewed as Question 12 (See appendix 9).

3.3.2.8 Question relating to accessing health professionals and treatment

The aim of these questions was to ascertain the regularity with which patients attended health professionals and the type of treatment they received. While patients were filling out the questionnaire some discussed the fact that they no longer visited health professionals because their symptoms were not taken seriously. In addition with regards to treatment received often they had had so many treatments they did not know where to begin to answer this question. These two questions were not relevant for the comparison group and therefore were not included. They were not analysed any further in this study. These questions were 8 and 10. (See appendix 9).

3.3.2.9 Open ended qualitative questions

The open ended questions were only included in the questionnaire for the patients with JHS, this was because the comparison group would be those without pain.

The first open ended question was 'Can you recall an event that triggered the onset of your aches and pains? If YES please explain'. The aim of this open ended question was to explore if participants with JHS recalled an event that triggered the onset of their symptoms. This question was included in a previous unpublished study (Clark 2004) and was also suggested by patients with JHS (see 3.3.2.1). Anecdotal evidence amongst field experts has suggested that those with JHS often report an event that triggered their symptoms and that these events might be associated with a period of unaccustomed activity (Grahame 2003c). Interestingly Sacheti et al (1997) and Adib et al (2005) had reported children and adults with JHS reporting aches and pains starting in childhood. This question can be viewed as question 9 (See appendix 9).

The second open ended question was 'Is there any other information you wish to add?'

This question was asked at the end of the questionnaire (See appendix 9). The aim of this question was to capture additional information that patients with JHS wished to contribute.

3.3.2.10 Face validity

Face validity is a subjective criterion which indicates whether the instrument appears to be assessing the desired qualities. The judgment of face validity may be measured by one or more experts but there are no numerical methods of measurement (Streiner and Norman 1989).

Both parts of the HAQ (which included the Functional Difficulties Questionnaire (FDQ-9) see chapter four) were reviewed by volunteers who consisted of three English teachers, two researchers and three people with a diagnosis of JHS. Comments and feedback from the English teachers and researchers related to the layout of the questionnaire and clarity of wording. There was one change in the physical activity part of the questionnaire. The change involved including the category of half an hour physical activity a week and this change is reported (See appendix 9). The lowest category before this had been one hour. The suggestions from these participants contributed to wording and clarity of the questionnaire.

There is limited research relating to the optimum length of questionnaires, but Jepson et al (2005) reported the response rate of questionnaires was optimal at approximately 1,000 words. The aim was to develop a questionnaire of approximately 1000 words in order to maximise the response. In addition if it was not to be a burden for participants, it needed to be easy to read and to answer. To improve the response rate of the questionnaire advice was also sought from a colleague who had experience in marketing and surveys this resulted in the format of the current HAQ for patients with JHS (See appendix 9).

The advice of the three English teachers and three volunteers with JHS and two researchers was also sought in relation to the information sent to patients attending a hypermobility clinic and general practitioners (GP). These included participant information sheets (See appendix 11), letters of invitation (See appendix 12) and consent forms (See appendix 13). In addition with the patient's permission a letter was sent to each general practitioner (GP) informing them of their patient's participation in the study (appendix 14). Advice was also sought on the email invitations (see appendix 15) and questionnaires sent out either as an attachment or as a survey monkey (www.surveymonkey) (see appendix 16) inviting participants to take part. These were sent to students and staff of a university and employees and their families of an international company.

3.3.2.11 Inclusion and exclusion criteria for patients with JHS and healthy volunteers

Questions which took into account the DSM-IV-TR (APA 2000), the Leeds consensus statement (LCS) (Sugden 2006), the Brighton criteria (Grahame et al 2000) and the Simple questionnaire (Hakim and Grahame 2003a) were embedded in the questionnaire. These provided the bases for the inclusion and exclusion criteria for this study.

Patients with JHS from a hypermobility clinic

Inclusion criteria:

- Patients attending the hypermobility clinic of a London teaching hospital who were diagnosed with JHS by one of two consultant rheumatologists and who fulfilled the

requirements of JHS* using the Brighton Criteria (paper version of the questionnaire). [This identified the participant group to be studied]

- Aged 18-65 years [musculoskeletal pain outside these ranges is more likely to be related to other pathologies].
- Details of secondary or tertiary educational achievement [this was in accordance with the DSM-IV-TR (APA 2000) recommendations and advice from the LCS (Sugden 2006) which suggest that where the IQ cannot be measured intellectual ability might be established through national tests].
- No previous neurological history [this is accordance with the DSM-IV-TR (APA 2000). Details of neurological history were taken from the patients notes. Dual developmental diagnoses were recorded in the questionnaire but were not exclusive].

Exclusion criteria:

- Patients attending the hypermobility clinic without a diagnosis of JHS or who did not fulfill the requirements of the Brighton criteria as recorded in the HAQ.
- Below the age of 18 years or above 65 years
- If no details of educational qualifications were given [this was in accordance with the DSM-IV-TR (APA 2000) recommendations and advice from the LCS (Sugden 2006) which suggest that where the IQ cannot be measured intellectual ability might be established through national tests].

Comparison study group inclusion and exclusion criteria

Inclusion criteria:

Aged between 18-65 years [Similar age to the study group].

- Achievement of secondary or tertiary education [this was in accordance with the DSM-IV-TR (APA 2000) recommendations and advice from the LCS (Sugden 2006) which suggest that where the IQ cannot be measured intellectual ability might be established through national tests].
- No neurological history [this is accordance with the DSM-IV-TR (APA 2000). Participants were asked if they had any condition which had affected the brain or nervous system and examples i.e. stroke. If participants responded yes or did not respond to the question they were excluded. Dual developmental diagnoses were recorded in the questionnaire but were not exclusive].

Exclusion criteria:

- Participants younger than 18 or over 65 years or who did not record their age [age was important for data matching].

- Participants who reported musculoskeletal pain in the last 6 months requiring the attention of a health professional or who did not respond to this question [to identify health volunteers without pain]
- Participants who would have a diagnosis of JHS or the JHS phenotype without pain (one major criteria and two minor criteria or four minor criteria - excluding pain)[to identify those without JHS* or the phenotype].
- Participants who reported a previous neurological history or who did not respond to this question [this is accordance with the DSM-IV-TR (APA 2000).

***** JHS diagnosed if responders reported either 2 major criteria or 1 major criterion and 2 minor criteria or 4 minor criteria. In accordance with the Brighton Criteria (See appendix 1 figure 2). Hypermobility considered a major criteria if there were two positive responses to the Simple questionnaire (See appendix 1 figure 3). Hypermobility considered a minor criterion if there was a positive response to either Q13 or Q14 (See appendix 9) (This would enable exclusion of those with the JHS phenotype).

3.3.2.12 Pilot study 1 Participants from an international company

A pilot study is a feasibility study which is used to test the logistics and to gather information (Altman et al 2006). The pilot study in this instance was carried out to test the logistics and to gather information relating to face validity. The HAQ was piloted by employees and their families of an international company. The data from the pilot was utilised as part of the validation process for the Functional Difficulties Questionnaire (FDQ-9) (See 4.5.1).

Recruitment of participants for Pilot 1 was conducted between March and April 2009 following favourable ethical approval for the study and permission (See 3.5.1). Participants were employees and their families from an international company who were sent an email. The email was written as an invitation to the study; a participant information sheet (See appendix 15) and HAQ (which was similar to the one employed in the hypermobility clinic without the title - Hypermobility Clinic (See appendix 9) were included as two separate attachments. Participants were informed that their participation in the study was voluntary and that by answering the questionnaire they were giving their consent to take part.

All questionnaires that were returned were saved on a pass word protected computer, allocated a code and printed. The questionnaires were printed to make it easier to load data on to SPSS. A unique reference code was given sequentially in the order in which responses were received. For example C 12 related to participant 12. Data from the questionnaires was then entered on to SPSS.

3.3.2.13 Face validity for the health and activity questionnaire

As discussed previously the purpose of this pilot study was to explore face validity of the questionnaire and improve on it where possible. Participants were invited to add their comments about the questionnaire. From a total of 24 respondents one participant ticked two boxes in relation the SF-12 questionnaire (Ware et al 1996). One participant reported not understanding what 'double jointed' was in the Simple questionnaire (Hakim and Grahame 2003a).These two questionnaires have previously validated and no change was made. A decision was made to review all questions early on in the clinical pilot study in case there were difficulties with these particular questions. Overall the combined completion rate for the questionnaire was over 99%.

3.3.2.14 The Health and Activity Questionnaire (HAQ) for the comparison group

The HAQ underwent a minor revision for the comparison group this led to the removal of the question relating to school leaving age. This question was not thought to be necessary, if educational achievement and occupation were recorded. In addition two extra questions at the beginning of the questionnaire were used to establish the exclusion of those with musculoskeletal pain and JHS from the study. The revision was subsequently transcribed to a survey monkey for the comparison group (See appendix 16).

3.3.3 Stage 3 clinical data collection

3.3.3.1 The investigator file

The investigator file consisted of two folders; the first, a 'set up file' which had details regarding the set up of the research study, the second a 'file in progress' related and was for the documentation of minor changes which were recorded in a summary amendment log, the patient master log and field diary. In this study the minor changes that were documented and related to the presentation of the questionnaire not the content. These amendments were made for the following reasons; a) requests from participants with specific needs who were attending the hypermobility clinic; b) transcription of the paper based questionnaire to a survey monkey for the comparison group; c) to allow participants the flexibility of being able to ask the researcher questions in the clinic and to take the questionnaire home and forward it to the researcher at the university with the appropriate consent form. In addition within the 'file in progress' were details of the patient master log and field diary.

3.3.3.2 The hypermobility clinic

A security pass was issued to enable access to relevant areas in the hospital and the administration building where the consent forms were stored in a locked filing cabinet. After accessing the new email address training was received by clinic staff on how to access the patient record system.

The principal investigator introduced and supervised the researcher during the data collection phase in the hypermobility clinic. The hypermobility clinic ran from 08.30 – 12.30 and was attended by one or two consultants twice a week. The researcher attended from 08.00 in preparation for patients with JHS arriving for the early appointments. Administrative activities were carried out after 13.00, this included writing up data for the study diary, the participant log, sending out letters of invitation and participant information packs, GP letters and the filing of consent forms.

The clinic staff were made aware of the research project and the names of the consultants with whom the researcher was working alongside. They were proactive in alerting the researcher to the arrival of patients attending the hypermobility clinic. The location of the hypermobility clinic was in a busy out- patient clinic area in which patients were attending appointments to see a variety of consultants in different disciplines. At either end of the morning there was generally sufficient seating for patients and their accompanying visitors. For a couple of hours in the middle of the morning the clinic could be so busy that there was insufficient seating for all. These factors meant that more time was spent talking with patients with JHS who attended the clinic at either end of the morning. Most patients with JHS were given the opportunity to discuss the study with the researcher and ask questions. On the information sheet participants were given the phone number of the research administrator as a contact and the email of the researcher if there were any queries.

Registration details of patients attending the hypermobility clinic were entered on to a sheet designated as the patient master log. The aim of this log was to record the patients name, unique study code, date of birth, clinic appointment date, the date the patient information pack was sent, date of consent and the record of the letter sent to the GP. There was space to record comments. The unique codes were simple. The first eight participants started with a double P and a subsequent number. After collecting data from the first eight participants the recruitment and consent process were discussed with the principal investigator and the research administrator from the hospital research and development unit. There were no changes made to the process and the data collection continued. Subsequently participants were allocated a single P and sequential number. Where participants were added to the clinic list, they were allocated a code PE and a corresponding number related to where they would appear on the clinic list. This made the locating of participants at relevant clinics easier to trace than if their details had been added to the end of the participant list which might be for a subsequent clinic.

3.3.3.3 Consent

Most consent forms were signed in the clinic by the participant and the researcher together. Consent forms were then photocopied, one copy was given to the participant, another copy filed in the participant's notes and the original filed in the research study consent form folder and kept in a locker in the administration building. Occasionally participants wanted more time to think about the study and on these occasions they sent the consent form and completed questionnaire through to the researcher. Consent forms were then copied and a copy of the consent form was posted to the participant. On a few occasions where participants had only initialed the boxes instead of signing their full name the consent forms were sent out to the participant with a letter of explanation and a stamped addressed envelope for the return of the consent form.

3.3.3.4 Field diary

The aim of the field diary was to record; a) events during the time of the data collection in the hypermobility clinic; b) thoughts and ideas during the data collection and c) observations and significant interactions with participants and consultants. This field diary was accessed during the data analysis. The following extract was taken from the field diary and enables a broader understanding about the patient population attending the hypermobility clinic.

> 'The hypermobility clinic is run as part of the rheumatology specialism at a London teaching hospital. It is attended by two consultant rheumatologists. From January to June 2009 a total of 363 patients attended the clinic of which 207 were new patients. The patients were referred from all over the country, this included Wales and Cornwall in the west, Kent in the East, and Manchester in the north and 'everywhere' in between. The patient population was predominantly female 304/363 (83.7%), with the number of male patients during this time as 59 (16.3%). The average age of the 363 patients attending the clinic was 33 years. (Grahame 2009). Presentation to the Arthritis Research Council at University College London [21st July 2009]).' (Field Diary CC 21/7/2009).

3.3.3.5 Recruitment for the pilot and continuation of the study in the hypermobility clinic

Pilot studies are used in social science research to run small scale versions of the major study (Polit et al 2001) and to pre-test the research instruments (Baker 1994). The purpose of this pilot study was to test the logistics and feasibility of the main study in a hypermobility clinic.

Data collection for the pilot study in the hypermobility clinic was conducted between May and June 2009. Potential participants for the study were accessed using the patient record system. The initial screening confirmed that participants who were sent a participant information pack (PIP) were

between the ages of 18-65 years (this was part of the inclusion criteria). The attendance lists constantly changed therefore where possible clinic lists were accessed several times in order to keep up with the changes. Potential participants were sent a participant information pack by post 8-14 days prior to their hospital appointment. Participants who had not received a participant information pack when they attended the clinic were given the option of receiving an information pack. The information pack consisted of a letter of invitation to the study, an information sheet, consent form and questionnaire (See appendices 9, 11,12 and13). All participants who were sent or given a patient information pack were recorded in the patient master log.

The data from the questionnaires was loaded into SPSS within 48 hours of the researcher receiving the completed health and activities questionnaire. Qualitative data was initially entered on to SPSS and subsequently transcribed to a word document. The researcher was actively involved in checking questionnaires in order to ascertain if there were any difficulties that required addressing. The number of completed questionnaires received from patients from the hypermobility clinic on the 16th June was 22. The hypermobility clinic was cancelled on the 18th June giving a week between clinics. The natural break in the data collection enabled the researcher a chance to analyse some of the data and to see if the questionnaire required any further revisions. After this analysis it was anticipated that the data being collected would enable the research questions and hypotheses to be answered. No further changes were required for the questionnaire. This information was conveyed to the principal investigator and supervisors. The data collection continued until the end of July which was when the participant number predicted by the sample size calculation had been met.

3.3.3.6 Calculating sample size

The end of the data collection phase in the hypermobility clinic was determined by meeting the sample size requirement. In order to calculate a sample size for this study, it was decided to use the SF-12. The requirement was to find the optimum number of patients with JHS and participants in a comparison group without JHS required to show a difference in the score of the SF-12. The score of the SF-12 is divided into the physical component summary (PCS) score and the mental component summary (MCS) score. It had previously been reported that a difference of 5 points on the SF-12 scoring system was the lowest score associated with a perceived clinical difference in clinical and population studies (Bjorner et al 2007). The minimum clinically important difference is based on the concept that this is the smallest difference in which patients would perceive a beneficial difference, in the absence of any side effects or excessive changes in health management (Jaeschke et al 1989). There were no previous studies in which the SF-12 had been reported in patients with JHS. It is suggested in this instance that data from a previous study may be employed (Petrie and Sabin 2005). The data for this calculation was therefore taken from a previous study in which participants reported chronic low back pain (Baldwin et al 2007) as this study was one that most closely

mirrored the current study. The PCS scores from the chronic low back pain study were employed for the sample size calculation.

In this instance Lehr's formula for calculating sample size was employed (Lehr 1992). The assumed standard deviation of the observations in two groups was taken as 10.16. This was the average standard deviations taken from two groups in a chronic low back pain study one group who had no lasting pain and the other reported multiple episodes of pain (Baldwin et al), a 5% 2−sided significance level, and a power of 90% the sample size was calculated at 88 per group. Assuming an 80% response rate for the questionnaires the aim was to send out 110 participant information packages to the patients with JHS attending a hypermobility clinic.

In practice the response rate to the questionnaire was less than had initially been anticipated, it was 60% instead of 80% and therefore the total number of patient information packs sent out were 154 of whom 114 recipients attended the hypermobility clinic and 97 patients with JHS completed the questionnaire. Patients with JHS who did not fulfill the inclusion criteria were 7 this left a sample of 90.

3.3.4 Stage 4 Comparison group study

The aim of the next stage of the study was to decide how to obtain information from a comparison group without JHS in order to answer the hypotheses and research questions. It was decided that to address the construct validity of the functional difficulties questionnaire (FDQ-9) an additional question was required. This is discussed in depth in section 4.3.4. In addition as previously mentioned data from the first pilot study indicated that the age and gender difference between participants from an international company and patients with JHS from a hypermobility clinic were markedly different. It was anticipated that by accessing staff and students at a university might enable a closer age and gender match. Permission from Research Governance at a school of health and social care for a survey to be sent out to staff and students of a university had been granted (See appendix 8).

3.3.4.1 Recruitment of the comparison group

Data collection for the comparison group was conducted in May 2010. Participants were recruited by sending an email inviting participants to take part in a health and physical activities survey. Information about the study was included in the main body of the email and a web link was provided for a survey monkey (http://www.surveymonkey.com).

3.3.4.2 Storing and managing data for all the study groups

All data was stored on password protected computers. The data was entered into SPSS version 16. Descriptions of the codes used for the first pilot study and study group in the hypermobility clinic have been discussed. Participants involved in the test re-test part of the study were identified using their date of birth. For the comparison group each participant had a code for example the comparison group code was either CUSF or CUST followed by a number. The letter code was related to the email addresses used. The numbers were allocated in relation to the numerical order in which the data was received.

3.3.5 Stage 5 data analysis

The data analysis associated with the validation of the questionnaire is described in chapter four. The analysis of the mixed methods data collected for the case comparison aspect of this study was guided by a seven stage process described by Onwuegbuzie and Teddlie (2003). This process was as follows a) data reduction, b) data display, c) data transformation, d) data correlation, e) data consolidation f) data comparison, g) data integration.

3.3.5.1 Quantitative data reduction and display

Quantitative data from the questionnaire was analysed using SPSS version 16. Data was displayed using graphs and tables. Critical P was set at 0.05.

Numerical data were described in terms of means, standard deviations (SD), standard error of the mean (SE) and 95% confidence intervals (CI). Numerical data was assessed for normal distribution. The size of sample for which non normality and unequal variances can be ignored varies but Bland (2000) suggested 50+ in each group. Ruxton (2006) suggested using the unequal variance *t*-test unless the sample sizes were identical. In this study where Levene's test was significant indicating unequal variances an unequal variance *t*-test was used to analyse the mean differences between constructs and where the group size was < 50 a Mann-Whitney U test was performed to confirm the findings. Where Levene's test was not significant indicating equal variances an equal variance *t*-test was used in the analysis.

Categorical data was described in terms of frequencies and analysed using the Pearson Chi square test and displayed using 2 x 2 and 2 x 3 tables. The chi square statistic, *p* value and odds ratios were calculated with the 95% CI. Relative risk was also calculated. Risk refers to the increased (or decreased) risk of a factor. A relative risk of one indicates that there is no difference between the groups, while a risk of 2 indicates the condition of interest is twice as likely to have the impairment. It was decided to present data in relation to 'relative risk' as well as well as odds ratios whilst

acknowledging that odds ratios tend to exaggerate the probability of an impairment if the condition being investigated is above 10% (Grimes and Schulz 2008). Where numbers were below 5 a Fisher's Exact test was used for comparing proportions. Calculations for the Fisher's Exact are one sided, but where the marginal totals are different it is important to get a two sided test (Bland 2000) To calculate a two-sided probability it is recommended to double the one sided probability (Armitage and Berry 1994).

Multiple linear regression analysis was used to examine the relationship between a single outcome variable to two or more explanatory variables. A description and validity of the regression model was reported in relation to variance inflation factors and averages and tolerances. Variance inflation factors close to 1, variance inflation averages not substantially greater than one and tolerances well above 0.2 would indicate that co-linearity was not a problem and there was no biasing of the regression model. These were reported in the results (Chapter 5). The R^2 represented the proportion (as a percentage) of the variability explained by the model (Field 2005).

Logistic regression was used to examine the relationship between a binary outcome and a number of explanatory variables. An analysis of each model was described, in which the Hosner and Lemeshow and Wald statistics were reported. The Hosner and Lemeshow statistic has a chi-square distribution and indicates how well the model fits with the explanatory variable (a non significant result indicates good prediction). The Wald statistic tests the significance of independent variables to the regression model. Where the Wald statistic was found to be non significant variables would need to be dropped from the model. To limit type II errors (false negatives) in the model it has been suggested that the ratio of sample population to explanatory variables be set at a minimum ratio of 10 to 1 with a sample size of about 100 (Tabachnick and Fidell 1996; 2001; Petrie and Sabin 2005; Field 2005).

3.3.5.2 Qualitative data reduction and display

Qualitative data from the questionnaire were loaded into word documents and read through a number of times in order to familiarise the researcher with the data. It was anticipated that this familiarisation of the text would enable patterns to be recognised within the data. The qualitative data collected in relation to exploring engagement in physical activity was collected from both patients with JHS and healthy volunteers. It was analysed using content analysis in which themes and patterns were identified. The themes and subthemes related to the type of physical activity while the patterns incorporated the frequency and duration of physical activity (See appendix 20) this was a method previously described (Patton 2002 p 452).

The qualitative data relating to the question ‘Can you recall an event that triggered the onset of your aches and pains?’ was collected only from patients with JHS. The data was analysed after reading and re-reading the text and dividing the text into meaning units. These were categorised and coded into meanings relevant to the question and the views of patients with JHS. These then formed themes and subthemes. This method has previously been described (Patton 2002 p454) using the terms ‘indigenous concepts and practices’. The use of meaning units for the analysis of this data was thought to best fit this analysis as it was assumed that patients with JHS had an innate understanding of their aches and pains. The inductive coding, categories and themes can be viewed (See appendix 17).

The qualitative data for the next part of the study came from the open ended question at the end of the questionnaire which was; ‘Is there any other information you wish to add?’ The qualitative data analysis in this section was based on the code and coding methods described Miles and Huberman (1994 p55). This method was chosen to enable coding of a breadth of information. The codes were grouped into broader categories that most accurately reflected the context. A thematic frame work emerged in which there were themes and subthemes. Expert advice was sought from supervisors throughout the process. In addition advice was sought from a field expert not involved in the study in order to validate the process and findings. Further details of the analysis may be viewed (See appendix 18).

3.3.5.3 Data transformation

Transformation of the data may involve either quantitising or qualitising data. Quantitising is a process in which qualitative data is transformed in to quantitative data (Sandelowski 2000). In this study the numbers of patients with JHS who reported functional difficulties both as an adult and as a child who reported on events that triggered their pain was described and compared using descriptive statistics. Qualitising is a process by which quantitative data is transferred into qualitative data (Sandelowski 2000). This involves extracting information using another dimension and can also be used to confirm interpretations. This latter type of transformation was not used in this study.

3.3.5.4 Data correlation and consolidation

Where additional information was considered useful in explaining a phenomenon qualitative data was quantitised and comparisons were made between the proportions. In particular this related to the themes generated by patients with JHS who reported events triggering the onset of their aches and pains. In this case the proportions of patients with JHS who reported functional difficulties both

as a child and as an adult were compared with those who reported no functional difficulties. This data was analysed in relation to a theme was described and analysed using the Fisher's Exact test.

3.3.5.5 Comparison and integration

The researcher anticipated that the comparison and integration of some of the qualitative and quantitative data would increase understanding. In this instance qualitative and quantitative data were integrated. In particular this related to the themes generated by patients with JHS when they described aspects of their condition. Multiple regression analysis was carried out to examine the relationship between a single outcome variable generated from the quantitative data (employing the physical component summary score of the SF-12) and explanatory variables generated from qualitative data (See section 5.9.5) The rationale for this analysis and discussion are reported (See 6.5).

3.4 Summary of the methods chapter

This chapter has provided a detailed description of the philosophical and theoretical methodological approach, the design, stages and the process by which the study was undertaken. The rationale for the design and the choice of the validated quantitative questions and the qualitative questions is presented. Ethical considerations and recruitment of the different sample populations is discussed. An additional questionnaire aimed at assessing functional difficulties aligned with the concept dyspraxia/DCD constituted the second part of the HAQ. The development and validation of these additional questions was a key focus for this study and was explored and discussed in chapter four.

Chapter 4

4 DEVELOPMENT OF THE FUNCTIONAL DIFFICULTIES QUESTIONNAIRE

4.1 Introduction

This chapter discusses the development and psychometric properties of a questionnaire aimed at assessing functional difficulties associated with dyspraxia/Developmental Coordination Disorder (DCD) in adults. The concept of dyspraxia/DCD used in this study is derived from the definition in the International Classification of Mental and Behavioural Disorders (ICD-10) (WHO 2007). In this definition it is reported that impairments in motor coordination are those noted in the absence of a congenital or acquired neurological disorder that occur in childhood and which may continue into adulthood in a milder form (WHO 2007). This chapter begins with a description of the items used to describe dyspraxia/DCD and information relating to common standardised assessment tools used for the assessment of dyspraxia/ DCD.

A variety of sources were employed to guide the development of this questionnaire which included; the Diagnostic and Statistical Manual of Mental Disorders 4th edition text revised (DSM-IV-TR) (APA 2000); the definitions reported in the ICD-10 (WHO 1992; 2007); previous questionnaires and an observational study (Wilson et al 2000; Cousins and Smyth 2003; Kirby et al 2005; Henderson and Sugden 2007; Kirby et al 2010). An initial item pool of 13 questions was assessed by an expert panel for face and content validity and the number of questions was reduced to nine. The nine items were then cross referenced with the International Classification of Functioning, Disability and Health (ICF) (WHO 2001) in order to verify that they formed part of the standard language and framework relating to health.

Data were analysed in four sample groups. Principal axis factoring was employed to explore the underlying factor structure of the nine items. Test-retest reliability and internal consistency were analysed. Construct validity of the concept of dyspraxia/DCD was assessed by employing the known groups method and concurrent validity was discussed. The diagnostic accuracy of the questionnaire was explored by using a receiver operating characteristic (ROC) curve with self-report dyspraxia as the reference standard. Two methods were employed to establish an optimal cut-off score. The discussion considered reliability and validity, limitations and the requirement for future work. The implementation of the questionnaire in clinical practice was reviewed along with the clinical implications.

4.2 Background information

DCD manifests as abnormal difficulties in learning, planning and execution of motor skills. The mechanisms underlying these motor skill impairments arise from impaired integration of action, perception and cognition, which are the requirements for coordinated movements (Shumway-Cook and Woollacot 2001). Motor skill impairments associated with dyspraxia/DCD are summarised in the ICD-10 (WHO 1992; 2007) and referred to as Specific Developmental Disorder of Motor Function (SDMF) (See table 4-3) and in criteria A and B of the DSM-IV-TR (APA 2000) (See table 4-2). The mechanisms underlying motor skill impairments and the diagnostic criteria underpin the development of the questionnaire discussed in this chapter. The motor skill impairments observed in those with dyspraxia/DCD for example 'clumsiness', are such that they affect activities of daily living but are not as a result of any known neurological or medical disorder or intellectual delay (Polatajko et al 1995; APA 2000; WHO 2007). Although dyspraxia is a term that has been commonly employed to describe these motor impairments, the term DCD was endorsed in 1995 at an international consensus meeting in London, Ontario, Canada, (Polatajko et al 1995). DCD and dyspraxia are terms that are considered synonymous and will be employed together in this chapter.

Dyspraxia/DCD is assessed primarily in children by employing standardised tests to assess motor abilities either using motor tests or questionnaires. These tests have been developed in a variety of ways. The Bruininks Oseretsky Test of Motor proficiency (BOTMP) (Bruininks 1978) was originally developed based on observations of children's motor proficiency. Developers of the Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson et al 2000) reviewed a number of commonly employed questionnaires. More recently the Adult Developmental Coordination Disorder/Dyspraxia Checklist (ADC) (Kirby et al 2010) was developed by addressing criteria B of the DSM-IV-TR (APA 2000).

In practice in the UK one of the most common standardised assessment tools employed for assessing dyspraxia/DCD is the Movement Assessment Battery for Children - Motor Test) (M-ABC-MT) (Henderson and Sugden 1992). Other tests include the Bruininks Oseretsky Test of Motor proficiency (BOTMP) (Bruininks 1978); the McCarron Assessment of Neuromuscular Development (MAND) McCarron (1997) and the DCDQ (Wilson et al 2000) (See table 4-1).

The MABC (Henderson and Sugden 1992) has two parts; a checklist and a motor test and these have been employed worldwide in research (Crawford et al 2001; Geuze et al 2001; Chow et al 2001). The MABC-Checklist (MABC-C) consists of a series of questions devised to be answered by teachers who have concerns about a child's coordination. The MABC-Motor Test (MABC-MT) consists of a battery of physical tests carried out by clinicians. The MABC-MT has been employed

as a reference tool in order to assess the diagnostic accuracy of other assessment tools (Tan et al 2001; Wilson et al 2009). However, there are limitations in relation to the validity of the MABC-MT. For example van Waelvelde et al (2004) explored aspects of concurrent validity and although satisfactory concurrent validity was achieved for one age band, this was not established through all the age bands or items of the MABC-MT. In addition, van Waelvelde et al (2004) highlighted the lack of discriminative power for some aspects of the MABC-MT. More recently following a comprehensive review of the psychometric properties of the MABC-MT Venetsanou et al (2010) reported they found insufficient evidence to suggest that the MABC-MT could be considered a 'gold standard' test.

The BOTMP (Bruininks 1978) has been widely employed in North America, where in clinical practice the full scale version is typically administered by a trained psychologist or an occupational therapist (Miller et al 2001). In research studies the short form version of the BOTMP-SF is commonly employed and administered by research assistants (Cairney et al 2005; Tsiotra et al 2006).

The MAND (McCarron 1997) has been employed for screening children with DCD entering developmental skills programs and in research in Australia. The MAND has been referenced against the MABC-MT (Tan et al 2001; Piek et al 2009).

Another commonly used assessment tool is the DCDQ. This questionnaire was developed in Canada in 2000 (Wilson et al 2000) initially as a17 item questionnaire and has undergone a revision to a 15 item questionnaire referred to as DCDQ'07 (Wilson et al 2009). The DCDQ relies on parents completing the questionnaire in relation to their child's abilities. The DCDQ has been referenced against the MAND and MABC-MT. The specificity and sensitivity of these tests have been examined by employing reference tools and in different populations (See table 4-1).

Table 4-1 Sensitivity, specificity and cut-offs for assessment tools employed to screen DCD in children

Study	Number (n) and age (years)of participants	Index Assessment tool	Reference tool	Cut-off	Se	sp
Tan et al 2001	n=26 (4-10 years)	BOTMP – SF	MABC –MT	15th percentile	31%	100%
		MAND	MABC-MT	15th percentile	81%	92%
Schoemaker et al 2003	n=120 (6-11 years)	MABC -C	MABC-MT	DCD 15th percentile DCD 5th percentile No DCD 15th percentile No DCD 5th percentile	85% 65% 79% 62%	55% 66% 65% 66%
Schoemaker et al 2006	n= 110 (4-12 years Control group (n=55) 48M:7F DCD group (n=55) 48M:7F	DCDQ	MABC-C	15th percentile for both questionnaires	82%	84%
Loh et al 2009	n=129	DCDQ	MAND	10th percentile	55%	74%
Wilson et al 2009	n=55	DCDQ'07	MABC-MT	Cut off score 53	85%	71%
DCDQ Developmental Coordination Disorder Questionnaire (Wilson et al 2000) DCDQ'07 (Wilson et al 2009) MABC –MT Movement Assessment Battery for Children – Motor Test (Henderson and Sugden 1992); MABC-C Movement Assessment Battery for Children – Checklist (Henderson and Sugden 1992); BOT-MP–SF Bruininks Oseretsky Test of Motor Proficiency – Short Form (Bruninks 1978); MAND - McCarron Assessment of Neuromuscular Development (MAND) McCarron (1997) Se Sensitivity; Sp Specificity						

The minimum sensitivity and specificity of diagnostic tests recommended by the APA (1985) are 80% and 90% respectively. The MAND is the only assessment tool which achieves this when referenced against the MABC-MT. The DCDQ and the BOTMP-SF do not reach the diagnostic accuracy recommendations of the APA (1985) but are assessment tools which have featured in research internationally (Tan et al 2001; Green et al 2005; Cairney et al 2005; Cairney et al 2008) (See table 2-1).

To summarise: There are a number of assessment tools employed for the identification of dyspraxia/DCD which are employed internationally. These tools have been developed using different methods and employ physical tests and questionnaires that have been referenced against each other. The discrepancies in the tests reflect the differences in the types of functional difficulties assessed, the constructs being examined and the cut-offs employed. It is suggested to develop a questionnaire for assessing dyspraxia/DCD requires finding a common construct and including the

most salient aspects of dyspraxia/DCD. These could be achieved by accessing the definition, diagnostic criteria, existing questionnaires and field experts. While taking into account a suitable tool that could be employed in those with musculoskeletal pain.

4.2.1 Assessing for dyspraxia/DCD in those with musculoskeletal pain

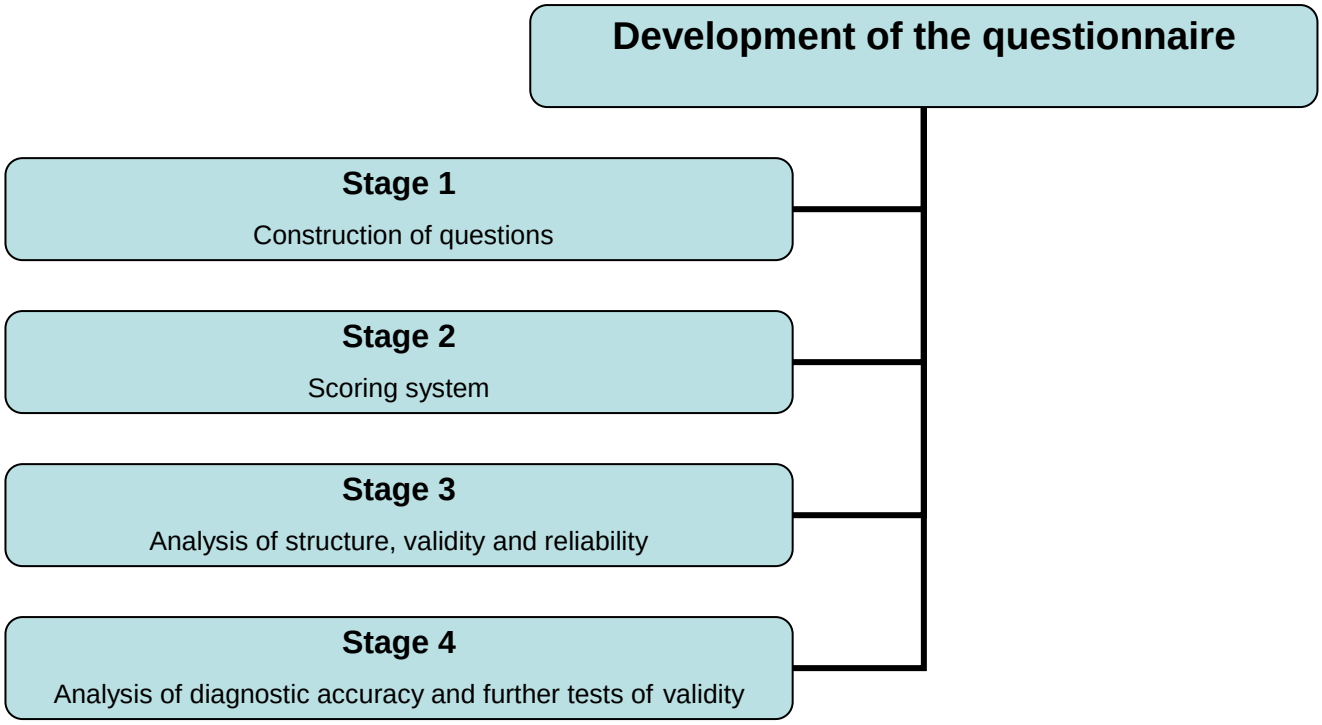
Where participants are observed to have biomechanical dysfunction with accompanying musculoskeletal pain it is argued that physical tests would not be appropriate. This is because for those with musculoskeletal pain it would be difficult to determine whether poor scores were related to coordination difficulties or due to pain. It might therefore be more appropriate to employ questionnaires. Questionnaires have been developed to screen for dyspraxia/DCD in children but these are not appropriate for identifying dyspraxia/DCD in adults as they are generally completed either by a parent or teacher and include child only activities (Henderson and Sugden 1992; Wilson et al 2000). In the absence of a suitable method for identifying dyspraxia/DCD in adults, the objective of this study was to develop a questionnaire to assess for dyapraxia/DCD. This chapter describes the development and initial validation of a scale called the Functional Difficulties Questionnaire-9 (FDQ-9). The purpose of the FDQ-9 was twofold: firstly, to assess for dyapraxia/DCD in adults with and without musculoskeletal pain including joint hypermobility syndrome (JHS) and, secondly, to be used as a tool in clinical practice.

Ethical approval was granted by the National Hospital for Neurosurgery and Neurology and the Joint Institute of Neurology Research Ethics Committee (ref 09/H0716/5) (appendix 5) and internally from Bournemouth University (appendix 6). Permission was granted by Damascus Shell Club for the questionnaire to be sent out via an email distribution list to employees and their families (appendix 7).

4.3 Development of the Functional Difficulties Questionnaire–9 (FDQ-9)

In the following section the stages of the development are described. **Stage one**; construction of the questions; **stage two**; the scoring system; **stage three**; analysis of the structure, validity and reliability and **stage four**; diagnostic accuracy and further tests of validity (See figure 4-1).

Figure 4-1 Four stages relating to the development of the questionnaire



Stage 1 – Construction of the questions

Stage one involves a description of the diagnostic criteria for dyspraxia/DCD and identifies current screening tools and questionnaires. An explanation is given as to how the diagnostic criteria, definition, previous questionnaires and screening tools were employed. Field experts were also consulted during the development of the questionnaire.

4.3.1 The diagnostic criteria and the initial construction of the questionnaire

The diagnostic criteria and definition for dyspraxia/DCD were accessed to identify a starting point for the questionnaire. The diagnostic criteria are recorded in the DSM-IV-TR (APA 2000) (See table 4-2). The definition is published in and the ICD-10 (WHO 1992; 2007) (See table 4-3). In addition a literature search was undertaken to identify questionnaires and checklists in current use.

The DSM-IV-TR (APA 2000) diagnostic criteria were reviewed in conjunction with the Leeds Consensus Statement (LCS) (Sugden 2006) for clarification. The ICD-10 definitions were reviewed in which the term ‘Specific Developmental Disorder of Motor Function’ (SDDMF) is employed (WHO 1992; WHO 2007) (See table 4-3).

The DSM-IV-TR (APA 2000) diagnostic criteria were used as the foundation for the framework of the questionnaire described in this chapter. There are four criteria in the DSM-IV-TR (APA 2000) for the diagnosis of DCD these are listed as Criteria A, B, C and D.

Table 4-2 Summary of the DSM-IV-TR (APA 2000) and the LCS (Sugden 2006)

Diagnostic criteria for Developmental Coordination Disorder DSM-IV-TR (APA, 2000) Including summarised recommendations from the LCS (Sugden 2006)
A. Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (e.g. walking, crawling and sitting), dropping things, "clumsiness", poor performance in sports or poor handwriting. *[Standard tests of motor performance should identify children falling below the 5th percentile, and those between the 5th and 15th percentile should be considered 'at risk' of having DCD].(Sugden 2006)*
B. The activities in Criterion A significantly interfere with academic achievement or activities of daily living. *[Assessment should consider relevant developmental norms relating to activities of daily living, that these should be culturally sensitive and include the views of parents, teachers and children] (Sugden 2006).*
C. The disturbance is not due to a medical condition (e.g. cerebral palsy, hemiplegia or muscular dystrophy) and does not meet criteria for a Pervasive Developmental Disorder. *[That a neurological examination be carried out to exclude major neurological conditions, although it was understood there maybe dual diagnoses such as those already identified with DCD (dyslexia, ADHD, autistic spectrum disorder] (Sugden 2006)*
D. if mental retardation (learning difficulties) is present, the motor difficulties are in excess of those usually associated with it *[Assessment should include a measure of IQ, but where this was not possible to establish intellectual ability through national tests] (Sugden 2006).*

- In summary: Criterion A states that the performance in daily activities requiring motor coordination are substantially below that expected. The LCS suggests that children falling below the 15th percentile should be acknowledged (Sugden 2006).

- Criterion B states that activities (that require motor coordination) significantly affect academic achievement and or activities of daily living. The LCS (Sugden 2006) suggests

the assessment of these activities should be relevant and culturally sensitive therefore the questions for this questionnaire were made relevant to children and adults (See table 4-2).

- Criterion C suggests that the disturbance (in activities) was not as a result of another medical condition (hemiplegia, muscular dystrophy etc.). The LCS (Sugden 2006) makes it clear that this does not include neurodevelopmental disorders for example dyslexia and ADHD, but should include a neurological examination (See table 4-2). As a neurological examination was not practical in this study participants were asked if they had any known neurological disorder.

- Criterion D suggests if learning difficulties were present the motor difficulties were in excess of those associated with the learning difficulties. The LCS (Sugden 2006) suggests if IQ tests were not available intellectual ability could be established through national tests (See table 4-2). In this study participants were asked to report on their highest academic achievement.

The definition used by the ICD-10 WHO (1992) acknowledges difficulties in relation to fine and gross motor tasks and neurodevelopmental delay. The later version of the ICD-10 (2007) definition reflects some of the changes reported in the literature including an understanding that delay or impairments may continue into adulthood (See table 4-3).

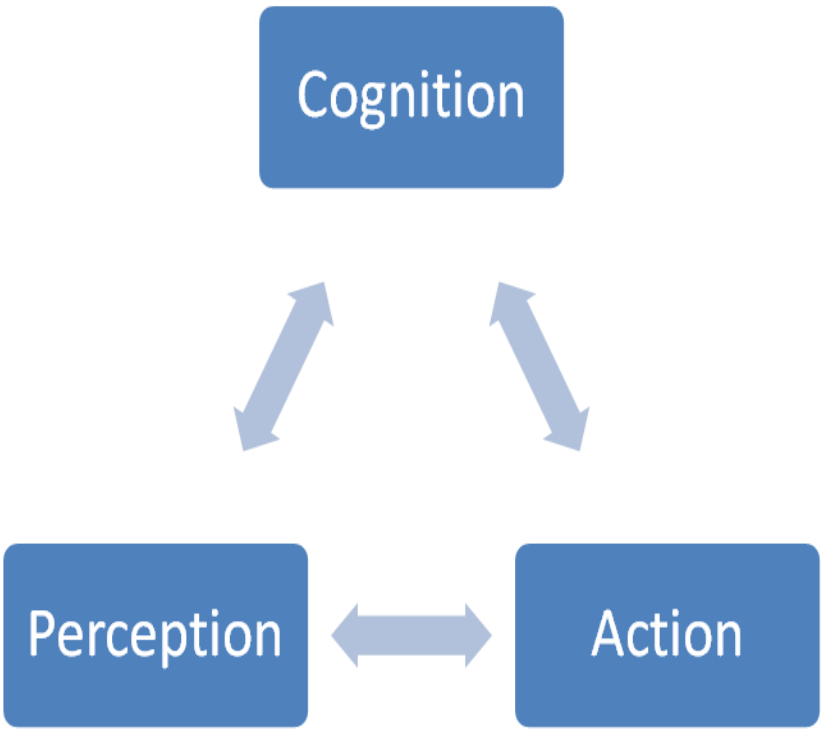
Table 4-3 The definition of specific developmental disorder of motor function (WHO 1992; WHO 2007)

Under the definition SDDMF (WHO 1992) "The child's motor coordination, on fine or gross motor tasks, should be significantly below the level expected on the basis of his or her age and general intelligence. Difficulties should have been present since early in development and they should not be a direct result of any defects of vision or hearing or any diagnosable neurological disorder. Developmental milestones may be delayed and there may be some associated speech difficulties. The young child may be awkward in general gait, being slow to learn to run, hop, go up and down stairs. Likely to be difficulties in learning to tie shoe laces, to fasten and unfasten buttons and to throw and catch balls. Child may also be clumsy in fine and/or gross motor movements, tending to drop things, to stumble, to bump into obstacles and to have poor hand writing. Drawing skills are usually poor and children are often poor at jigsaw puzzles, using constructional toys, building models, ball games and drawing and understanding maps. May show 'soft' neurological signs and immaturities such as mirror movements.
Under the heading 'Disorders of psychological development (F80-F89) (WHO 2007) it is acknowledged; 'The disorders included in this block have in common: (a) onset invariably during infancy or childhood; b) impairment or delay in development of functions that are strongly related to biological maturation of the central nervous system; and c) a steady course without remissions and relapses. In most cases, the functions include language, visuo-spatial skills and motor coordination. Usually, the delay or impairment has been present from as early as it could be detected reliably and will diminish progressively as the child grows older, although milder deficits remain in adult life.'
Under the definition SDDMF (F82) (WHO 2007) 'A disorder in which the main feature is a serious impairment in the development of motor coordination that is not solely explicable in terms of general intellectual retardation or of any specific congenital or acquired neurological disorder. Nevertheless, in most cases a careful clinical examination shows marked neurodevelopmental immaturities such as choreiform movements of unsupported limbs or mirror movements and other associated motor features, as well as signs of impaired fine and gross motor coordination.'

The terms motor coordination, motor skills or motor activity are referred to interchangeably in the ICD-10, ICF and the DSM-IV-TR (APA 2000; WHO 1992; 2001; 2007); in theses and the literature. For example; (Green 2007; Macnab et al 2001). Gross motor skills include activities relating to the whole body i.e. balance, ball skills and team games. Fine motor skills relate to the ability to use hand held tools requiring precision which include hand writing. These are all aspects of motor coordination.

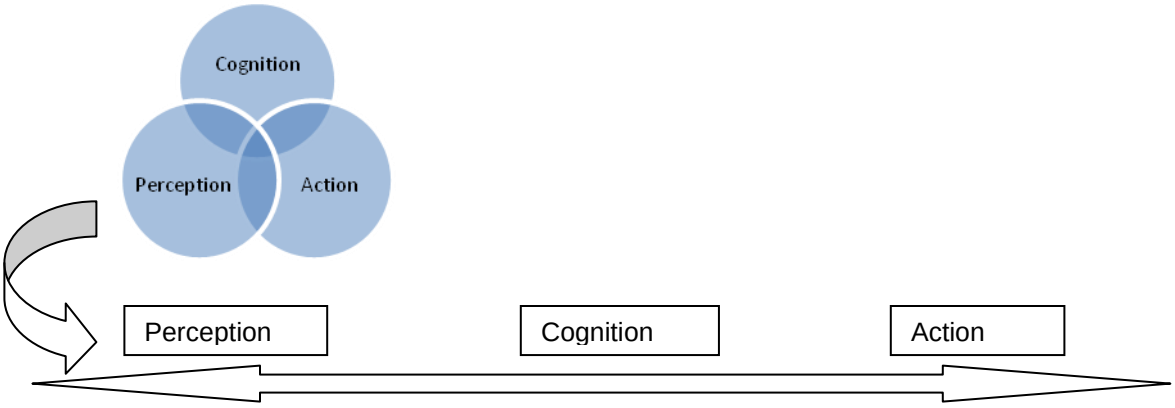
Motor coordination is the ability to coordinate movement. For movement to be coordinated requires the integration of sensory/perceptual information in the central nervous system (CNS) with cognition resulting in action or movement. Therefore the combination of cognition, perception and action contribute to motor control (Shumway-Cook and Woollacott 2001).

Figure 4-2 Motor control process – perception, cognition and action



In figure 4-2 motor control is shown as a process which involves an interaction between perception, cognition and action. From the diagram it would be easy to interpret this as a linear process. However, it is argued that this process is not linear but occurs on an overlapping, multidimensional continuum and therefore might be better conceptualized in figure 4-3. This concept of motor control is well recognised and the theoretical framework forms the basis of current hypotheses relating to motor control (Gordon 1987; Horak and Shumway-Cook 1990; Shumway-Cook and Woollacott 2012).

Figure 4-3 Model of the interaction between perceptual, cognitive and activity processes in relation to motor control



Sensing	Perceiving	Interpreting	Conceptualisation	Strategy/planning	Activation	Execution
Peripheral receptors	Primary and secondary cortex	Higher level processing – parietal, occipital and temporal lobes	Prefrontal cortex	Supplementary motor cortex, basal ganglia and cerebellum	Primary motor cortex, basal ganglia and cerebellum	Motor neurons, muscles and joints

Adapted from Shumway-Cook and Woollacott (2001b; 2012)

The integration of processes relating to motor control are complex. There is a reliance on electrochemical information which is dependent on receptors, pathways and characteristics influencing input (i.e. frequency, duration and intensity). Integration takes place throughout the CNS resulting in action or execution of a movement – motor control. In spite of these complexities there are patterns of motor control impairment that have been recognised in those with dyspraxia/DCD. These patterns of impairment have been summarised as difficulties in carrying out functional activities that are significant enough to affect activities of daily living (APA 2000; WHO 1992; 2007). The patterns of impairment relating to functional difficulties are recognised in the various assessment tools (Bruninks 1978; Henderson and Sugden 1992; McCarron 1997; Wilson et al 2000; Kirby et al 2005; Kirby et al 2010). These functional difficulties may be explained broadly as those associated with gross motor activity, fine motor activity and planning and/or organisation. In conclusion the complexities associated with motor control do not preclude the nature of dyspraxia/DCD as a core motor problem but merely highlight intrinsic factors contributing to heterogeneity. The heterogeneity of dyspraxia/ DCD was previously discussed in relation to the theoretical concepts referred to in the literature (See 1.5).

4.3.2 Current checklists and questionnaires for identifying DCD

A literature search was undertaken using MEDLINE, CINAHL, ASSIA, SPORTDiscus, PsychARTICLES and PsycINFO from 1989 - 2008 and a manual analysis of the reference lists of relevant papers and chapters. The aim was to find questionnaires and checklists already in use. The search terms used were; DCD, dyspraxia and questionnaires, screening tools or check lists. Four questionnaires were identified; the revised check list for the MABC-2(Henderson and Sugden 2007); the Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson et al 2000); the Developmental Coordination Disorder Questionnaire devised by Kirby (which will be abbreviated in this thesis to KDCDQ) (Kirby et al 2005) and the Children Activity Scales (ChAS-P/T) (Rosenblum 2006). It was decided not to use this latter questionnaire because it was aimed at identification of DCD in very young children.

In addition the Adult DCD/Dyspraxia checklist (ADC) was forwarded to the researcher by a field expert (A. Kirby personal communication, Cardiff University, 10th October, 2008).

4.3.2.1 The MABC-2 check list (Henderson and Sugden 2007)

The revised MABC-2 check list (Henderson and Sugden 2007) developed in the UK, focuses on tasks performed in the static environment and tasks where the environment is moving or unpredictable within the context of an education environment. The MABC-2 check list consists of 30 questions which can be scored from 0-3 and includes a 'not observed' option. This checklist is for teachers to fill in as a screening tool for school aged children who are suspected as having dyspraxia/DCD.

4.3.2.2 The DCDQ (Wilson et al 2000)

The DCDQ was developed in Canada by Wilson et al (2000) as a screening tool. The DCDQ is a parent questionnaire aimed at identifying motor problems in children from 8 – 14.5 years (Wilson et al 2000). It has 17 items relating to motor coordination where parents rate their child's coordination on a 5 point Likert scale. Scores =/< 53 indicate motor difficulties in the 15th percentile and are consistent with a diagnosis of dyspraxia/DCD (Wilson et al 2000). In a study by Schoemaker et al (2006) in which the DCDQ was rated against the first MABC-MT (Henderson and Sugden 1992) it showed acceptable validity and reliability.

4.3.2.3 The KDCDQ (Kirby et al 2005)

This was devised as an on line questionnaire in the UK which was used for assessing children reporting functional impairments consistent with dyspraxia/DCD. The questionnaire was used to identify functional difficulties in children who already had a diagnosis of JHS (Kirby et al 2005). This questionnaire consisted of 14 questions related to fine and gross motor function, developmental milestones, concentration and social interaction.

4.3.2.4 The ADC (Kirby et al 2010)

The ADC (Kirby et al 2010) was developed as a self-report questionnaire to examine the characteristics of students (aged 16-40 years) in further and higher education in the UK and Israel. This checklist is divided into three sections the first relating to activities in childhood and the subsequent two sections relating to activities in adulthood. The scoring system uses a four point Likert scale.

The following table (See table 4-4) identifies the skill impairments and questionnaires and diagnostic criteria which mention these impairments.

Table 4-4 Reporting of skill impairments, cross referenced with four questionnaires for the assessment of DCD and the APA and WHO diagnostic criteria

Impairment overview	Skill impairment	Questionnaire reported	Diagnostic criteria reported
Gross motor skills	Ball skills	MABC-2, DCDQ, ADC KDCDQ	ICD-10 (1992)
	Team sport participation	MABC-2, DCDQ, ADC	
	Walking and dynamic balance	DCDQ	DSM-IV-TR (2000) ICD-10 (1992; 2007)
	Obstacle avoidance	MABC-C ADC	ICD-10 (1992)
	Riding a bike/ dynamic balance	MABC-C, DCDQ, ADC, KDCDQ	
	'clumsiness'	MABC, ADC, DCDQ	DSM-IV-TR (2000), ICD-10 (1992; 2007)
Fine motor skills	Handwriting	MABC-C, DCDQ, ADC, KDCDQ	Broadly considered under fine motor skills DSM-IV-TR (2000), ICD-10 (1992; 2007)
	Cutting, using scissors	MABC, DCDQ	
	Doing up buttons and or tying shoe laces	MABC, ADC	
Other skills	Concentration	KDCDQ	
	Reading and spelling	KDCDQ	
	Friendships and spending time alone	ADC, KDCDQ	
	Organisation and planning	ADC	Broadly considered in relation to task and skill achievement DSM-IV-TR (2000), ICD-10 (1992; 2007)
	Driving a car	ADC	

DCDQ Developmental Coordination Disorder Questionnaire (Wilson et al 2000);
MABC–2 Movement Assessment Battery for Children checklist 2nd ed (Henderson and Sugden 2007);
KDCDQ Kirby Developmental Coordination Disorder Questionnaire (Kirby et al 2005);
ADC Adult Developmental Coordination Disorders/Dyspraxia checklist (Kirby et al 2010);
ICD-10 International Statistical Classification of Diseases and Related Health Problems 10th revision (WHO 1992; 2007);
DSM-IV-TR Diagnostic and Statistical Manual Text Revised (APA 2000).

4.3.2.5 Summary of difficulties from table 4-4

Gross motor coordination was addressed in all 4 questionnaires. Ball skills were mentioned in the four questionnaires (Wilson et al 2000; Kirby et al 2005; Henderson and Sugden 2007; Kirby et al 2010) and ICD-10 (WHO 1992) definition, but not in the ICD-10 (WHO 2007) or the DSM-IV-TR (APA 2000). Participation in team sports was included in the questionnaires, but not specifically mentioned in the ICD-10 (WHO 1992; 2007) or DSM-IV-TR (APA 2000). Dynamic balance and walking were mentioned in the questionnaires in different contexts and broadly dealt with in the ICD-10 (WHO 1992; 2007) and DSM-IV-TR (APA 2000). 'Clumsiness' was a term used in all the questionnaires, ICD-10 (WHO 1992; 2007) and DSM-IV-TR (APA 2000).

Fine motor coordination was variously discussed in the diagnostic criteria and questionnaires. Hand writing is specifically mentioned in the DSM-IV (APA 2000) and ICD-10 (WHO 1992) and in all four questionnaires Wilson et al 2000; Kirby et al 2005; Henderson and Sugden 2007; Kirby et al 2010). Doing up buttons, tying laces and cutting were mentioned in 3 questionnaires, and the ICD-10 (WHO 1992), but not specifically in the DSM-IV-TR (APA 2000) or ICD-10 (WHO 2007).

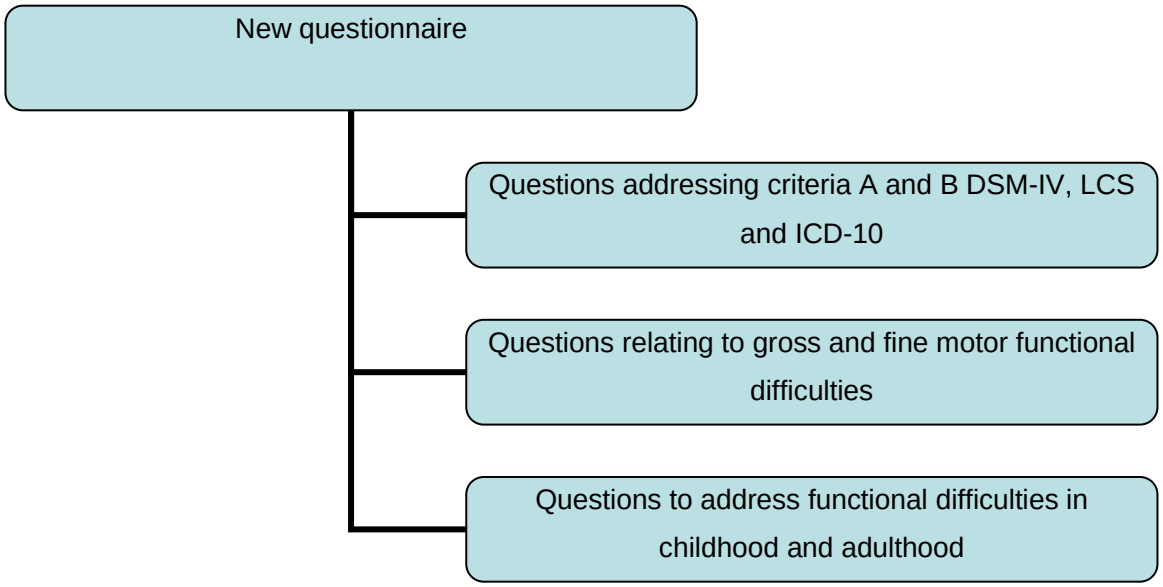
Other skills regarding reading, writing and spelling as well as concentration were asked in one of the questionnaires. These terms are not discussed in the diagnostic criteria or definition (APA 2000; WHO 1992; 2007). These questions are more closely linked to dyslexia and ADHD. An overlap with dyslexia and ADHD has been reported with DCD (Martin et al 2006; Mari et al 2003). Social interaction which is considered in the DCDQ and ADC was not referred to in the DSM-IV or ICD-10 (APA 2000; WHO 1992; 2007). Specific questions relating to organisation were included in the ADC (Kirby et al 2010). Organisation is not mentioned specifically in the other questionnaires or in the diagnostic criteria or definition (APA 2000; ICD-10 WHO 1992; 2007). However, the ability to function in relation to daily activities requires organisation. For example it might be suggested that for a child or adult to manage the task of getting dressed and out of the house to get to school or work requires organisation and planning. Questions relating to driving a car were only asked in the ADC, because this was the only adult questionnaire.

In summary: Common impairments in motor coordination were identified in the diagnostic criteria, definitions and questionnaires. In addition, was the concept that the motor impairments were important enough to interfere with activities of daily living. These aspects needed to be reflected in the development of the new questionnaire.

4.3.3 Conclusions relating to questions that need to be included in the new questionnaire

The questions and frame work for a questionnaire were discussed with field experts and it was suggested that the developing questionnaire required the following (see figure 4-4)

Figure 4-4 Framework for the new questionnaire



The questionnaire would need to be made up with a frame work of questions based on; criteria A and B of the DSM-IV-TR (APA 2000); the LCS (Sugden 2006), (See table 4-2) the ICD-10 (WHO 1992; 2007) (See table 4-3) and previous questionnaires (See table 4-4). These would include the following topics:-

- Ball skills, physical activity and or team game participation.
- Balance could include balance on a bike or other activities where dynamic balance is challenged.
- Driving a car would be appropriate in an adult questionnaire recording if there has been an opportunity for this activity.
- Clumsiness and multi tasking, bumping into objects or tripping.
- Precision movements associated with handwriting, cutting, historically recording difficulties with buttons and tying laces.
- Precision movements in everyday activities may include manual dexterity, sewing, DIY and construction
- How coordination has been rated by others.

- Organisational skills

The questionnaire would also require dividing it into two sections to identify functional difficulties in childhood and in adulthood in recognition of the ICD-10 (WHO 2007) and the theoretical concept of adult dyspraxia/DCD. This was a method previously employed (Kirby et al 2010).

Criteria C and D of the DSM-IV (APA 2000) relate to factors which would exclude a diagnosis of dyspraxia/DCD (See table 4-2). Questions that addressed these criteria in the DSM-IV (APA 2000) including clarification from the LCS (Sugden 2006) would be employed as the exclusion criteria for the questionnaire.

- A history of a current or previous neurological condition would need to be established as part of Criteria C of the DSM-IV-TR (APA 2000). Participants were asked 'Have you suffered from a previous condition which has affected the brain or nervous system i.e. stroke, head injury or multiple sclerosis? These neurological conditions were referred to as they were felt to be more applicable to an adult population. A positive response would mean the participant would be excluded from the study. Cerebral Palsy (CP) was not specifically referred to because it was anticipated that participants who had previously been diagnosed would have been aware through life that they had a neurological condition. It would be unlikely that patients with JHS would have a diagnosis of CP because up to 90% of children diagnosed with CP have some form of spasticity (Odding et al 2006). Spasticity occurs as a result of increased tone and results in reduced range of movement at a joint and therefore hypermobility is unlikely to be a feature associated with CP. The incidence of CP is 2 per 1000 live births (0.002%) and those with mild CP make up less than 10% of this group. Therefore the likelihood of a person in the population with a diagnosis of mild CP is likely to be less than 0.0002% (Odding et al 2006). Hence although the items chosen for the FDQ-9 and in relation to the question 'Have you ever considered yourself to have coordination difficulties?' might pick up some one with mild CP, in practice the likelihood of this happening would be extremely small.

- Those reporting other neurodevelopmental conditions which might overlap with DCD i.e. Dyslexia and ADHD would not be excluded. This was because it has been recognised that there is an overlap between Dyslexia and ADHD with DCD and this is acknowledged by the LCS (Mari et al 2003; Martin et al 2006; Sugden 2006). It is understood that those with either a diagnosis of dyslexia and or ADHD who also have dyspraxia/DCD will report difficulties relevant to these neurodevelopmental disorders as well as coordination or functional difficulties associated with dyspraxia/DCD.

- A history relating to highest educational achievement would be employed instead of assessing IQ. This is suggested by the LCS (Sugden 2006). Those who did not report any secondary school educational achievement would be excluded from the study (Criteria D of the DSM-IV-TR (APA 2000).

The Items proposed for the questions in this study were compared with those used in an observational adult study reported by Cousins and Smyth (2003) who aimed to identify functional difficulties in adults with dyspraxia/DCD. Comparisons were made between self report of motor impairment and observation of the same tasks. There were significant correlations between task performance and self report ratings in relation to: dynamic balance, ball skills, obstacle avoidance, hand writing, construction and manual dexterity (Cousins and Smyth 2003). The items considered for the questionnaire were then cross referenced with the International Classification of Functioning Disability and Health (ICF) (WHO 2001).

4.3.4 Cross referencing functional difficulties with the International Classification of Functioning Disability and Health (ICF)

To establish if the items identified for the questionnaire were part of the standard language and frame work relating to health they were cross referenced with definitions of functional difficulties from the ICF (WHO 2001). The ICF provides a framework for coding aspects of health in a form which permits the sharing of knowledge about health and health care worldwide. The ICD-10 (WHO 1992; 2007) provides an aetiological frame work for the diagnosis of diseases, disorders or health conditions. Used together with the ICF they provide information on diagnosis and functioning as a wider picture for describing the health of people or populations (WHO 2001).

The alphanumeric definitions within the ICF (WHO 2001) were used for classifying aspects of dyspraxia/DCD which were cross referenced with the literature. This reference table may be viewed (appendix 19). It is not intended that this list should be exhaustive but only to serve as examples.

From the combined sources described the researcher selected 13 items. These were deemed to encompass the theoretical concept of dyspraxia/DCD. The 13 items were reduced to nine following discussion with an expert panel. It was decided that functional difficulties related to the use of buttons and shoe laces had been superseded by zips and Velcro and therefore not relevant. There was repetition of information relating to obstacle avoidance and riding a bike as a child and as an adult. The question that related to the ability to manoeuvre a car would be removed as the validity of this question could be affected by restriction in spinal movements and/or pain rather than motor

control associated with dyspraxia/DCD. This led to the removal of these four questions. Nine questions were left which may be viewed in table 4-5.

Table 4-5 Nine items of the Functional Difficulties Questionnaire (FDQ-9). Three items relating to childhood and six items relating to adulthood

Item number	Description
1	**AS A CHILD,** how good was your handwriting?
2	**AS A CHILD,** how good were you at team games that involved balls? i.e. football, netball, basketball
3	**AS A CHILD,** how did others rate your coordination?
4	**AS AN ADULT,** how good are you at avoiding obstacles, like bumping into doors?
5	**AS AN ADULT,** how good are you at organising yourself? i.e. getting ready for work or for a meeting
6	**AS AN ADULT,** how good are you at catching a ball one handed?
7	**AS AN ADULT,** how good are you at balancing on a bike, in a bus or train, or on skis?
8	**AS AN ADULT,** how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?
9	**AS AN ADULT,** how good is your handwriting now?

The questionnaire was to be self report and issues relating to self report were considered during the development.

4.3.5 Self report questionnaires

Children's questionnaires that assess for dyspraxia/DCD are stand alone questionnaires and do not include physical tests and are completed by teachers (Henderson and Sugden 1992; Henderson and Sugden 2007) or parents (Wilson et al 2000). In a previous questionnaire aimed at assessing dyspraxia/DCD in adults the questionnaire was self report (Kirby et al 2010).

Self-report questionnaires are employed widely in healthcare and are a practical method of capturing information from a large number of people. Examples of which are the SF-12 and SF-36 quality of life questionnaires (Ware et al 1996). It should be acknowledged that self-report may be biased or affected by psychological, sociological, comprehension and/or contextual variables (Harrison et al 1996; Lanyon and Goodstein 1997). However, it could be argued that constructs that are perceptual by nature for example ability to perform tasks or the way we feel may be more appropriately measured by self-report (Schmitt 1994; Spector 1994) and this may be considered a more superior method of collecting data relating to ability (Howard 1994). In the study carried out by

Cousins and Smyth (2003) they reported significant positive correlations between task performance and self ratings of performance related to physical tasks in both those who self reported dyspraxia/DCD and those who did not . Concerns about self-report should be considered, but may not be cause for undue concern in the development of questionnaires.

It was acknowledged that bias in the scoring system required consideration.

Stage 2 – Scoring system

The scoring system for the FDQ-9 was influenced by the scoring system in other questionnaires and based on a Likert scale.

4.4 Scoring system

The four questionnaires identified in the literature review were answered in a number of ways. This was in part because they were not just self report questionnaires for example the KDCDQ (Kirby et al 2005) asked a question and allowed the participant to respond either in the present or historically. The MABC-2 check list (Henderson and Sugden 2007) allowed for a variety of answers relating to the quality of ability. The ADC (Kirby et al 2010) was self-report, employed a 4 point Likert score recording frequency of difficulties with higher scores associated with greater motor impairment. The DCDQ (Wilson et al 2000) used a 5 point Likert score with lower scores relating to greater motor impairment.

4.4.1 Introduction to the Likert scale

A Likert scale measures a type of response and is aimed at discovering facts about an event or ability and is often used in questionnaires and in survey research (Likert 1932). Likert scales measure either ends of a scale using positive or negative responses to a statement. Scales have commonly been on a 5 point system using the terms strongly agree, agree, neither agree nor disagree, disagree or strongly disagree, but scales may range from 3 – 11.

4.4.2 Terms used

The terms used in Likert scales relate to the concept being tested. The commonest is that of agreement where the terms mentioned in the paragraph above are used. Other concepts are those of frequency, importance, likelihood and quality. For the FDQ-9 the concept was to ask about perceived quality of functional abilities. The following responses were chosen:

- Very Good = 1, Good = 2, Poor =3, Very Poor =4

4.4.3 Distortions in the scale

It is understood that Likert scales maybe subject to bias for a number of reasons. If respondents:

- Do not use the extreme response categories at either end of the scale

- Choose the middle term ‘neither good nor poor’, because this choice is easier than deciding on one category or another;
- Decide to portray themselves in a more favourable light.

To address these biases in the development of the FDQ, the following decisions were taken:

- A few but relevant responses were chosen
- The middle category was removed to enforce a decision;
- The wording of the statements was considered in addition to making respondents aware that data from all questionnaires would be kept confidential.

4.4.4 Analysis of Likert scale data

There is no common standard for the correct interpretation and analysis of Likert scale data but it is generally accepted that attitude measuring scales should be considered as ordinal data (Field 2005). For example in Likert scales it might be argued that respondents using a scale cannot perceive whether the difference between adjacent levels is equal. It is accepted that adding up data from individual questions gives an overall score, enabling an overview of the responses from the whole questionnaire. The summing of Likert scores from questionnaires using a 4 point Likert scale have been reported in other questionnaires related to functional activity (Casey et al 1997; Wilson et al 2000; Kirby et al 2010). The total scores for the FDQ-9 would range from 9-36 with higher scores indicating greater functional difficulties and may be viewed in table 4-6.

Table 4-6 Nine items of the functional difficulties questionnaire (FDQ-9). These are scored using the terms:- very good = 1; good = 2; poor = 3; very poor 4. Scores range from 9-36

Item	Activities	Very good	Good	Poor	Very poor
1	**AS A CHILD,** how good was your handwriting?				
2	**AS A CHILD,** how good were you at team games that involved balls? i.e. football, netball, basketball				
3	**AS A CHILD,** how did others rate your coordination?				
4	**AS AN ADULT,** how good are you at avoiding obstacles, like bumping into doors?				
5	**AS AN ADULT,** how good are you at organising yourself? i.e. getting ready for work or for a meeting				
6	**AS AN ADULT,** how good are you at catching a ball one handed?				
7	**AS AN ADULT,** how good are you at balancing on a bike, in a bus or train, or on skis?				
8	**AS AN ADULT,** how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?				
9	**AS AN ADULT,** how good is your handwriting now?				
	Total Score				

Stage 3 - Analysis of Structure, validity and reliability

4.5 Data analysis

In this next stage, the recruitment of participants from five sample groups is described. Sex distribution was reported for each sample group and age was described using the mean, standard deviation and range. The methods of analysis are explained and the results presented. This includes an exploration of the structure of the questionnaire, internal consistency, construct validity and test-retest reliability. Data collection from the sample groups took place between March 2009 and May 2010.

4.5.1 Participants and sample groups

- Sample one (S1); was a convenience sample of employees and families of an international company of whom 25 participants completed a questionnaire and one did not meet the inclusion criteria leaving 24 participants (mean age in years (range in years) [SD] 47 (33-60) [8.01]; 11 female).

- Sample two (S2); was a convenience sample of 30 employees and families of an international company and students at a university who filled in a questionnaire twice (mean age in years (range in years) [SD] 31.9 (18-52) [12.25]; 26 female).
- Sample three (S3); consisted of patients attending a hypermobility clinic in a London teaching hospital over a three month period. Of the 97 who completed the questionnaire seven did not fulfill the inclusion criteria. This left a sample of 90 (mean age in years (range in years) [SD] 34.0 (18-61) [9.94]; 83 female).
- Sample four (S4); a convenience sample of 152 staff and students from a university who filled in the questionnaire (mean age in years (range in years) [SD] 36.8 (18-63) [12.88]; female 115). Sample 4 was divided into two subgroups A and B. Subgroup A of sample 4 were those who reported no musculoskeletal pain in the last six months that had required the intervention of a health professional and consisted 113 participants (mean age in years (range in years) [SD] 35.7 (18-63) [13.24]; female 82. Subgroup B of sample 4 were those who reported musculoskeletal pain currently or within the last 6 months that required the intervention of a health professional and consisted of 39 participants (mean age in years (range in years) [SD] 40.2 (21-60) [11.25]; female 33. (Data from Subgroup B of sample 4 were not employed in the analyses because they were a subgroup who had non specific musculoskeletal pain).

The method by which data from the sample groups were employed in the analyses may be viewed (See table 4-7).

Table 4-7 Sample characteristics and tests for reliability and validity

Sample group	Description	Test
Sample 1 (n=24)	Volunteers from an international company	Internal consistency
Sample 2 (n=30)	Volunteers from an international company and students from two undergraduate programs at a university who agreed to complete the questionnaire twice.	Test-retest reliability
Sample 2.1	The same group the first time they answered the questionnaire	Internal consistency
Sample 3 (n=90)	Patients with JHS from a hypermobility clinic	Internal consistency Construct validity
Sample 4 (n=152)	Volunteers from a university some of whom reported musculoskeletal pain	Construct validity Diagnostic accuracy
Subgroup 4A of Sample 4 (n=113)	Healthy volunteers from a university with no musculoskeletal pain	Internal consistency Construct validity

4.5.2 Methods

Patients from S3 were sent a letter of invitation, information about the study, a consent form and a paper questionnaire. They were also given the opportunity to discuss the study with the researcher who was present to take consent. Participants from S1, S2 and S4 were sent an invitation, information about the study and questionnaire by email with a link to the questionnaire on survey monkey (http://www.surveymonkey.com). It was explained to participants that participation was voluntary and that by completing the questionnaire they were giving informed consent to participate in the study.

Participants were excluded if they reported a known neurological condition and if there was no report of secondary school qualifications, this was in fulfillment of criteria C and D of the diagnostic criteria for DCD, DSM-IV-TR (APA 2000) and in consideration of the LCS (Sugden 2006) which states national tests may be used as a bench mark for academic achievement instead of I.Q tests. Participants from subgroup 4A of sample 4 were also excluded if they reported symptoms of JHS as reported in the Brighton Diagnostic Criteria (Grahame et al 2000) and/or if they reported any musculoskeletal pain in the previous 6 months which had required intervention from a health professional.

4.5.3 Face and content validity

Face validity is claimed if the tool measures what it claims to measure to an intelligent audience (Wilkin et al 1992). The advantage of good face validity is that participants are motivated to complete the test thereby improving overall validity. There are no standard procedures to demonstrate either face or content validity. Content validity may be claimed on the grounds that a number of representative judges were employed to generate and select items (Wilkin et al 1992).

Face validity was considered by asking several individuals with different perspectives to examine and complete the scale including three teachers, two researchers (one of whom had adult dyspraxia/DCD) and three volunteers who had JHS. Some focused on clarity while others focused on the relevance of each item to the construct of adult dyspraxia/DCD and all provided feedback. Respondents reported they felt the scale adequately captured the construct of dyspraxia/DCD and found the questions easy to understand. The scale took between one and two minutes to complete, participant's reported being able to recount their abilities as a child with clarity. Sample group 2 (S2) were asked for feedback on the questionnaire and reported finding the questionnaire easy to comprehend and complete.

Content validity is pertinent to tests of attainment or ability (Kline 1999). In this instance the 'representative judges' considered were the literature, diagnostic criteria, definition and field experts who were physiotherapists and occupational therapists working with children with dyspraxia/DCD. The resulting scale, the Functional Difficulties Questionnaire-9 (FDQ-9)(See table 4-6), incorporated a broad spectrum of items relating to gross and fine motor functional activities set in the context of daily activities addressing the concept of dyspraxia/DCD. The questionnaire consisted of 3 questions related to childhood and six questions related to adulthood. Content and face validity are aspects of validity that are difficult to assess and are discussed in section 4.8.3. Further tests of validity and reliability were then explored employing a variety of analyses

4.5.4 Statistical analysis

Data analysis was undertaken using SPSS version 16. Critical P was set at 0.05. There were no missing data for any of the sample groups in relation to the FDQ-9. Since a variety of analyses have been used and in order to aid clarity they have been described alongside corresponding results. These tests have included Principal Axis Factoring which was performed to study the structure of the questionnaire. Cronbach's alpha which was employed to measure the internal consistency of the scale with the average inter-item correlations (Cortina 1993). Hypothesis testing and the known groups method was used to assess construct validity (Cronbach and Meehl 1955; Kline 1999). Test-retest reliability was assessed using the intraclass correlation coefficient (ICC) (Chin et al 1987; McGraw and Wong 1996) and the Bland and Altman method (Bland and Altman 2003). In the next section the data suitability is presented.

4.5.5 Data suitability

To examine the structure of the questionnaire Principal Axis Factoring was explored in data from 257 participants. These participants were from (S1, S2, S3 and subgroup S4A of sample 4). This gave a participant-to-item ratio of almost 30:1, satisfying the criterion of Bryant and Yarnold (1995) that the ratio should be no lower than 5:1. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA=0.794) was well above the acceptable limit of 0.5 and indicated a good test (Hutcheson and Sofoniou 1999). Bartlett's test of sphericity was highly significant, indicating that items were interdependent (chi square = 749.187, $p < 0.001$). This indicated that correlations between items were sufficiently large to explore the dimensionality of the scale. An oblique rotation (Direct Oblimin) was chosen to allow for correlation between factors. The number of factors to retain was evaluated using: a) Kaiser's Eigenvalues exceeding unity extraction criterion (Kaiser 1960); b) scree plot analysis; c) parallel analysis and d) interpretability of the resulting factor structure. It has been argued that the cut-off point for selecting factors should be at the point of inflexion on the scree plot (Cattell 1966). This is where the slope of the curve changes dramatically from being nearly vertical to being horizontal. The scree plot provides a fairly reliable criterion selection in

samples over 200 participants (Stevens 2002) therefore this was a reliable criterion for this study and the plot and can be viewed (See figure 4-5).

Figure 4-5 Scree plot for exploring factors (components) with Eigenvalues in combined sample groups (S1, S2, S3 and subgroup 4A of sample 4, n=257)

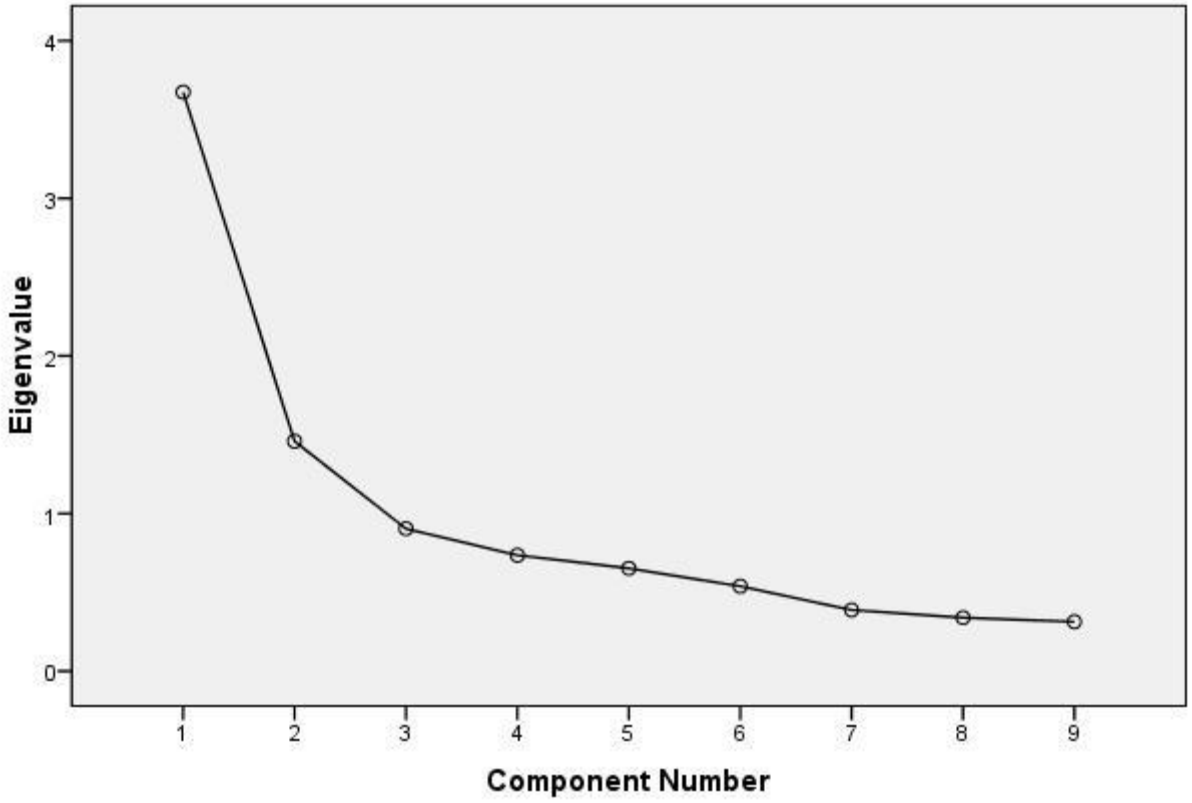


Table 4-8 The total variance and percentage variance explained for the factors identified (n=257)

	Initial Eigenvalues			
Factor	**Total**	**%of variance**	**Mean random**	**95th percentile**
1	3.674	40.821	1.296207106	1.385151223
2	1.459	16.206	1.194301081	1.258955825
3	0.904	10.039	1.117042519	1.170490342
4	0.735	8.168	1.052546524	1.099012722
5	0.652	7.242	0.993067344	1.034093948
6	0.538	5.980	0.931947490	0.975695747
7	0.387	4.303	0.872329745	0.918832595
8	0.339	3.765	0.811075138	0.860900359
9	0.313	3.477	0.731483052	0.795369647

Using the first three criteria a two factor solution emerged (See table 4-9) accounting for 57% of the cumulative variance. On the scree plot (See figure 4-5) the point of inflexion occurred at the third data point (factor) therefore this indicated the two factors to the left of this point should be extracted. A minimum loading of 0.32 was used as a selection criterion (Tabachnick and Fidell 2001). All items loaded > 0.32. Two items cross loaded on both factors (Items 5 and 8) but in each case only one loading was > 0.32 (See table 4-9)

Table 4-9 Summary of Exploratory Factor Analysis with Principal Axis Factoring oblique rotation (Direct Oblimin) for the nine items (n=257)

Item and description	Factor 1	Factor 2
1 Child hand writing	-0.04	**0.56**
2 Child games	**0.69**	-0.05
3 Child coordination	**0.75**	-0.04
4 Adult obstacles	**0.60**	0.13
5 Adult organisation	0.22	**0.35**
6 Adult ball games	**0.80**	-0.08
7 Adult balance	**0.70**	0.01
8 Adult fine motor	**0.35**	0.30
9 Adult hand writing	-0.08	**0.94**

Loadings of every item ≥ 0.32 are presented in bold typeface

Results

Inspection of the items indicated that Factor 1 (items 2, 3, 4, 6, 7) related to 'Gross motor skills' and explained approximately 41% of the variance and Factor two (Items 1, 5, 9) related to 'Fine motor skills with organisation' and accounted for approximately 16% of the variance. Item A8 (adult fine motor) cross loaded (0.35 on Factor 1 and 0.30 on Factor 2).

Factor 1; gross motor skills, was a sub group previously identified in children (Wilson et al 2000) who may also have low postural tone and proximal joint instability (Bundy 2002). Factor 2; fine motor and organisational skills in which fine motor difficulties in particular poor handwriting have previously been identified (Wilson et al 2000; Bundy 2002).

Cronbach's alpha for Factor 1 was 0.832 (corrected item-total correlations range = 0.564-0.675 and mean inter-item correlation > 0.5). No items would improve Cronbach's alpha if deleted. Cronbach's alpha for Factor 2 was 0.639 (corrected item-total correlations range = 0.337-0.550 and mean inter-item correlation = 0.5. No items would meaningfully improve Cronbach's alpha if deleted.

Adding item 8 to Factor 1 resulted in a marginal reduction of Cronbach's alpha from 0.832 - 0.828. Whereas adding item 8 to Factor 2 resulted in a marginal improvement of Cronbach's alpha from 0.639-0.660.

Although Factor 2 had lower internal consistency it was retained as fine motor skills have been an important feature in identifying children with dyspraxia/DCD (Rosenblum 2006). Item 8 (**AS AN ADULT,** how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors) cross loaded it is suggested this is because such activities could challenge both gross and fine motor skills.

Although the Factor analysis broadly supported two Factors, cross loadings for items 5 and 8 perhaps reflect the fact that the underlying mechanisms of motor skill difficulties characteristic of those with dyspraxia/DCD are multifaceted arising from global impairment in motor skills. For this reason, it was felt it made better conceptual sense to include all 9 items to form a total FDQ-9 score rather than using two separate subscale scores.

4.5.6 Internal consistency

Tests that measure internal consistency examine the extent to which individual items correlate with each other and with the overall scores. Internal consistency is measured by employing Cronbach's alpha.

Participants

Internal consistency was carried out employing data from samples S1, S2, S3 and Subgroup 4A of sample 4 (n=257)

Methods

There is controversy relating to acceptable values for Cronbach's alpha, but for tests of ability 0.7 is considered suitable (Kline 1999). It is also acknowledged that the value of Cronbach's alpha is dependent on the number of items on the scale, for example the larger the number of items the higher the value of alpha. This may occur even when the inter item correlations are low. Therefore it is important to report the average inter item correlations along with Cronbach's alpha (Cortina 1993). Average inter item correlations of > 0.5 are considered acceptable (Field 2005).

Results

Cronbach's alpha for this nine item scale was 0.813. This indicated an acceptable value for alpha. The mean inter item correlation was 0.51. Corrected item-total correlations ranged from 0.296 – 0.612 with eight of the nine items possessing corrected item-total correlations of > 0.4. Item one was poorly correlated with the total score (0.292). However, deletion of this item resulted in only marginal improvement of Cronbach's alpha (0.819) (See table 4-10).

Table 4-10 Cronbach's alpha, corrected item correlation and Cronbach's alpha if the item was deleted for the nine items. Data for this analysis included sample 1, sample 2, sample 3 and subgroup 4A of sample 4 (n=257)

Item and description	FDQ-9 n=257 All sample groups Cronbach's alpha 0.813	
	Corrected item-total correlation	Cronbach's alpha if item deleted
1 Child hand writing	0.292	0.819
2 Child games	0.547	0.790
3 Child coordination	0.609	0.783
4 Adult obstacles	0.596	0.783
5 Adult organisation	0.409	0.806
6 Adult ball games	0.612	0.781
7 Adult balance	0.597	0.783
8 Adult fine motor	0.484	0.798
9 Adult hand writing	0.437	0.803

4.5.7 Construct validity and between group differences

Construct validity is tested by evaluating hypotheses in relation to the measure. This might involve confirming or refuting hypotheses (Cronbach and Meehl 1955). Construct validity involves collecting verifiable evidence to support the inference that a measure has meaning and is the most important approach to validity where there is no bench mark test (Wilkin et al 1992; Hays et al 1998; Kline 1999). The term 'construct' is similar to the term 'concept' (Kline 1999) and should be explained. The construct or concept of dyspraxia/DCD relates to impairment in motor coordination in the absence of a congenital or acquired neurological disorder that occurs in childhood and which may continue into adulthood (See 4.1). Construct validity of the Functional Difficulties Questionnaire (FDQ-9) was explored in relation to this concept by employing the known groups method. It was expected that individuals who reported experiencing coordination difficulties in everyday life as an adult and as a child or who self-reported dyspraxia would score more highly on the FDQ-9 than those who reported no coordination difficulties or dyspraxia.

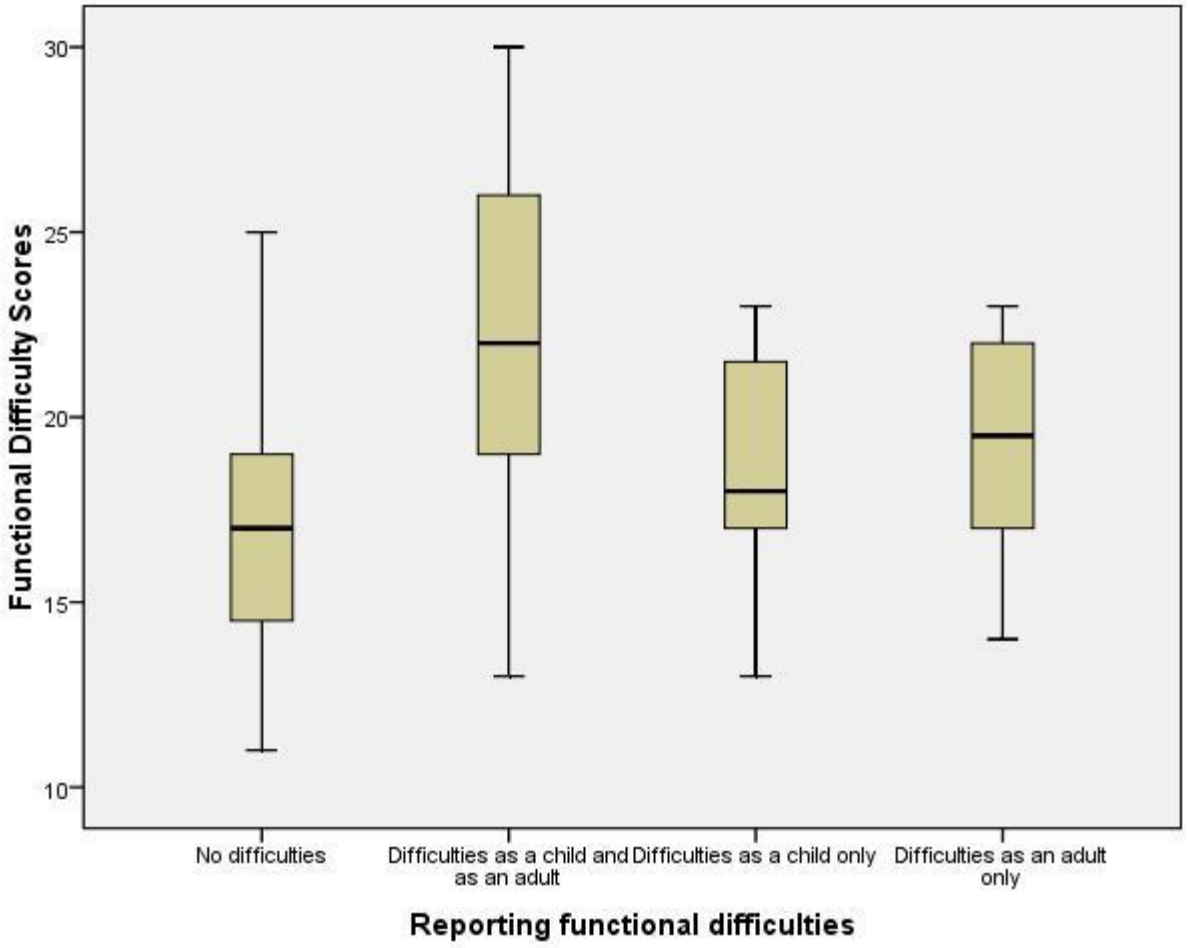
Participants

Construct validity was carried out employing data from S4 (n=152) because this group had been asked questions relevant to construct validity.

1. Methods

Participants from S4 (staff and students of a university) were asked an additional question - 'Have you ever considered yourself to be 'clumsy' or uncoordinated in your everyday life?' Responses were divided into the constructs; 'yes difficulties as a child and as an adult'; 'yes difficulties as a child only'; 'yes difficulties as an adult only' or 'no difficulties'. Box-and-whisker plots are presented for the four constructs versus the Functional Difficulties Scores (FDS). This data is presented in figure 4-6.

Figure 4-6 Box-and-whisker plots for participants who reported functional difficulties in four sub groups of Sample 4 (n=152) and their FDS score



For each group the median, range of functional difficulty scores, Lower Quartile (LQ), Upper Quartile (UQ) and Inter Quartile Range (IQR) were reported.

- Those who reported 'no' difficulties (n=92) the median scores were 17, with a range of 11 – 25, LQ 14, UQ 19 and IQR 5. This would indicate that 75% of participants reported scores of 11-19. A score of 11 would broadly indicate reporting being 'very good' at 7/9 items and 'good' at 2/9 items. A score of 19 would broadly indicate reporting being 'good' at 8/9 items and 'poor' at 1/9 items.
- Those who reported 'difficulties as a child and as an adult' (n=36) the median scores were 22 with a range of 13 - 30, LQ 18, UQ 26 and IQR 8. This would indicate that 75% would report scores of 18 -30. A score of 18 would broadly indicate being 'good' at all 9 items, while as score of 30 would broadly indicate being 'poor' at 6/9 items and 'very poor' at 3/9 items.
- Those who reported difficulties 'as a child only' (n=12) the median scores were 18 with a range of 13 – 23, LQ 17, UQ 21 and IQR 4. This group align to the theoretical construct that not all children who report coordination difficulties in childhood continue to have difficulties in adulthood (Losse et al 1991; Cantell et al 1994).
- Those who reported 'difficulties as an adult only' (n=12) the median scores were 19 with a range of 14 – 23, LQ 14, UQ 22 and IQR 5. It is suggested that participants in this group who appear to acquire functional difficulties in adulthood do not have dyspraxia/DCD. It may be important to investigate this group further but is beyond the remit of this chapter in which the focus is on those who report difficulties in childhood and adulthood in line with the concept of dyspraxia/DCD in this study.

1. Methods

In the following analysis the known groups method was employed to investigate a hypothesis. It was anticipated that those who reported 'difficulties both as a child and as an adult' (n=36) would have a higher FDS than those who reported having 'no difficulties' (n=92). An independent samples unequal variance *t*-test was used to compare the mean FDQ-9 scores for these two groups. A Mann-Whitney U test was used to confirm this result.

1. Results

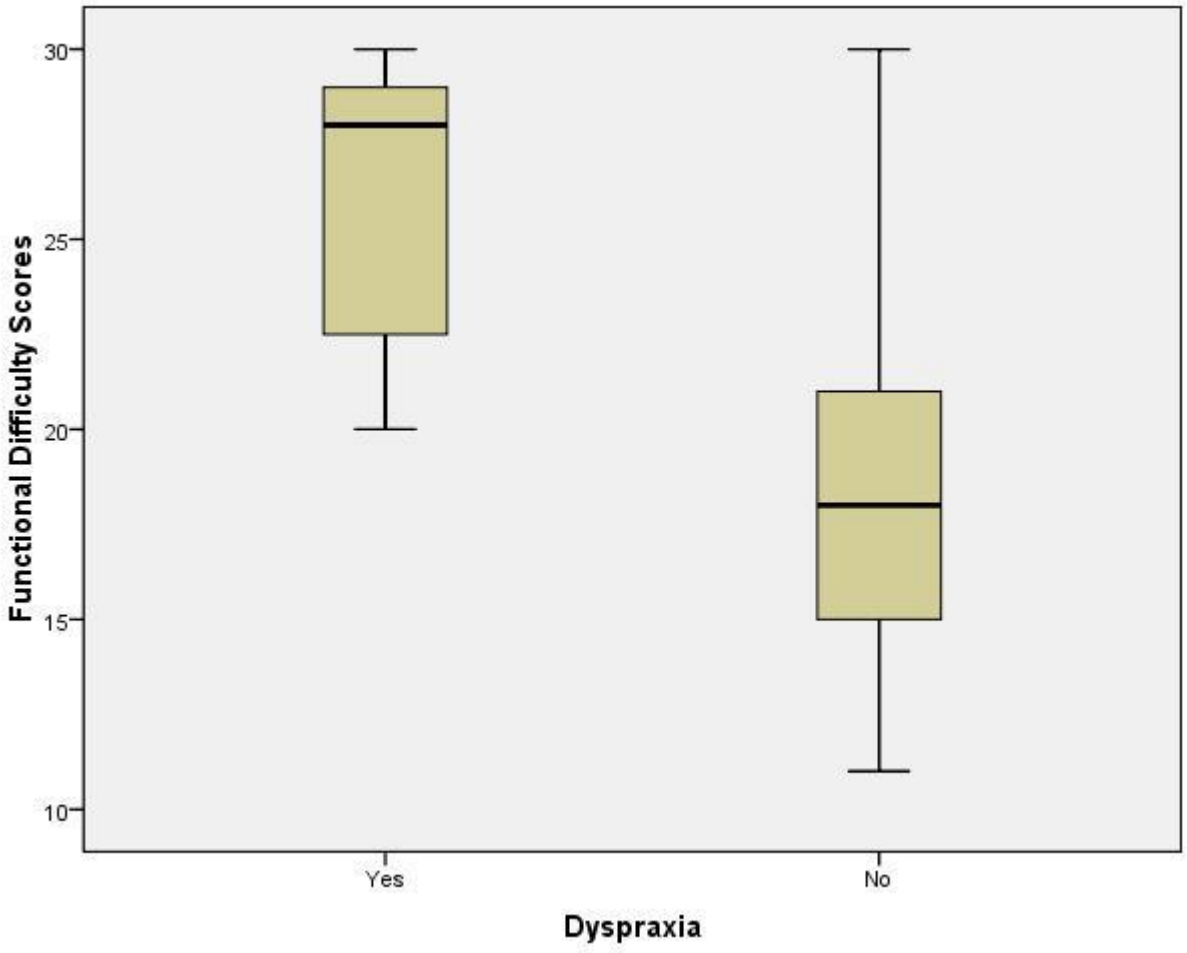
The mean score of those reporting 'no difficulties' (16.77 SD3.099) was significantly lower than those who reported 'yes difficulties both as a child and as an adult' (22.22 SD 4.517). Levene's test, $p < 0.05$ therefore unequal variances were assumed, t (48.45) = 6.653, $p < 0.001$ (two tailed). This result was further confirmed by employing the Mann-Whitney U test. Participants who reported 'yes difficulties both as a child and as an adult' reported significantly higher total scores than participants who reported 'no difficulties' $U = 531.000$, $p < 0.001$ (two tailed). The mean differences between the groups were -5.450 [95% CI – 3.804 to – 7.097]. This is a statistically significant difference and the

hypothesis was upheld.

In addition a difference of five points is likely to be clinically important. On average participants who reported ‘difficulties as a child and as an adult’ broadly recorded scores relating to being ‘poor’ in 4/9 items, indicative of reporting functional difficulties in four items . On average participants who reported ‘no difficulties’ broadly recorded scores relating to being ‘good’ in 8/9 items and ‘very good’ in 1/9 items, indicative or reporting no functional difficulties.

Participants from S4 were given the opportunity to self-report dyspraxia. The term dyspraxia was employed instead of DCD as the term DCD has only more recently been recognised (Polatajko et al 1995) and a diagnosis is usually confirmed in the first decade of life which would have been before the term DCD was in common use. A diagnosis of dyspraxia/DCD has only more recently been available for adults by employing the ADC (Kirby et al 2010) but this questionnaire was not published until after the data collection in this study. The data relating to self-report of dyspraxia versus FDS is presented in figure 4-7.

Figure 4-7 Box-and-whisker plots for participants who either self reported dyspraxia or did not by showing their Functional Difficulties Score (FDS) in Sample 4 (n=152)



For both groups the median, range of FDS, Lower Quartile (LQ), Upper Quartile (UQ) and Inter Quartile Range (IQR) are reported.

- Those who self-reported dyspraxia (n=7) the median FDS were 28, with a range of 20 – 30, LQ 22, UQ 29 and IQR 7.
- The range of FDS were smaller than that noted in those who did not self-report dyspraxia and indicate that all participants who self-reported dyspraxia broadly reported being 'poor' in at least 2/9 items.
- In addition 75% of participants report being 'poor' at 4/9 or more items. None of the participants reported being 'good' or 'very good' at all of the 9 items.
- Those who did not self-report dyspraxia (n=145) the median FDS were 18 with a range of 11 - 30, LQ 15, UQ 21 and IQR 6.
- These results indicate 25% of participants reported being 'good' or 'very good at all 9 items.
- In addition 25% of participants had FDS of between 21 and 30. Scores of 21 or more

indicate being ‘poor’ in at least 3/9 items. FDS of 30 indicate being ‘poor’ in 6/9 and ‘very poor’ at 3/9 items.

- Those with high FDS may be indicative of participants who were not assessed in their early years for dyspraxia/DCD. This is a group that has been previously identified and discussed (Kirby et al 2008).

2. Methods

In the following analysis the known groups method was employed to investigate a hypothesis. It was anticipated that those who self-reported dyspraxia (n=7) would have higher FDS than those who did not self-report dyspraxia (n=145). An independent samples equal variance *t*-test was used to compare the mean FDQ-9 scores for these two groups. A Mann-Whitney U test was used to confirm this result.

2. Results

The mean scores of those self reporting dyspraxia (25.86, SD 4.100) were significantly higher than those who did not self-report dyspraxia (18.06, SD3.777), Levene’s test, $p > 0.05$, therefore equal variances were assumed $t(150) = 5.314$, $p = 0.02$ (two tailed). This result was further confirmed by employing the Mann-Whitney U test. Participants who reported dyspraxia reported significantly higher total scores than participants who did not report dyspraxia, $U = 83.000$, $p < 0.001$ (two tailed). The mean differences between the groups were 7.795 [95% CI 3.998 to – 11.593]. These results indicated a statistically significant difference and the hypothesis were upheld. In addition a mean difference in the scores of 8 points is likely to be clinically important. On average those participants who self-reported dyspraxia broadly recorded scores relating to being ‘poor’ in 7/9 items indicative of reporting functional difficulties in the majority of items. On average those who did not self-report dyspraxia broadly recorded scores relating to being ‘good’ at 9/9 items and therefore did not report any functional difficulties.

4.5.8 Test- retest reliability

Test-retest reliability is the reliability of a test over time. This is measured by analysing data taken from a group of participants who took the test on two occasions.

Participants

Test-retest reliability employed data from sample S2 (n=30) because this participant group took the test on two occasions.

Methods

The questionnaire was administered twice to this sample over a period of six weeks.

Test-retest reliability was assessed using the intraclass correlation coefficient (ICC) (Chin and Burney 1987; McGraw and Wong 1996) and the Bland and Altman method (2003).

The ICC is a relative measure of reliability in which an ICC of 0 indicates no reliability and an ICC of 1 indicated perfect reliability. The fundamental interpretation of an ICC is on the understanding that it is based on the proportion of variance that is attributable to the objects being measured (McGraw and Wong 1996). The model of choice should reflect that variance. In this study a two way random effects model with average measure reliability and absolute agreement (ICC2,1) was chosen. This was because the data was from a sample of participants in which the variability of the raters was considered relevant. A correlation of 0.8 is a minimum figure (Kline 1999).

The Bland and Altman method involves calculating the 95% limits of agreement of the mean and standard deviations (SD) of the two groups (test 1 and test 2). The mean difference plus or minus 1.96 SD are plotted and it is expected that 95% of the cases should lie between these limits. The 95% limits of agreement rely on two assumptions the first that the differences are constant throughout the range and that the differences are approximately normally distributed.

Results

The mean total score for administration 1 was 16.17 (4.19) and for administration 2 it was 16.23 (3.82). The mean difference was -0.07 [95% CI -0.48 to 0.35].

The test-retest ICCs for each of the questions ranged from 0.75-1.00 with all questions demonstrating significant correlations (all *ps* < 0.001). When the total scores were analysed, the ICC two way random effect (absolute agreement) average measure model was 0.96 [95% C.I. 0.92 to 0.98]. Only one item was below 0.83 which was Item 8 (**AS AN ADULT,** how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors). One scored a perfect 1.00 this was item 1 (**AS A CHILD,** how good was your handwriting?) (See table 4-11).

Table 4-11 Intraclass Correlation Coefficient (ICC) [ICC 95% Confidence Interval (CI)] between individual items of the Functional Difficulties Questionnaire (FDQ-9) as a measure of test-retest reliability data from sample two (n=30)

Activity	A1 Child hand writing	A2 Child games	A3 Child co-ordination	A4 Adult obstacle avoidance	A5 Adult organisation	A6 Adult ball games	A7 Adult balance	A8 Adult DIY	A9 Adult hand writing
Intraclass correlation (single measure) [95% CI]	1.000** [1.000-1.000]	0.921** [0.841-0.961]	0.855** [0.722-0.929]	0.946** [0.889-0.974]	0.859** [0.714-0.932]	0.913** [0.827-0.958]	0.853** [0.713-0.927]	0.752** [0.541-0.874]	0.903** [0.807-0.953
** p < 0.001 Two way random effect model (absolute agreement)									

The limits of agreement (calculated using the mean difference ± 1.96 SDs) were -2.2 [95% CI -2.60 to -1.80] units to 2.1 [95% CI 1.80 to 2.70] units with a total width of 4.3 units. To check the assumptions of the limits of agreement were met (i.e. mean and SD constant through range of total scores and differences were approximately normally distributed) two charts were produced. A scatter plot of the difference against the mean of the two measurements with the limits of agreement depicted (figure 4-8) and a histogram of the difference (Figure 4-9).

Figure 4-8 Histogram of the differences between the 2nd test and the 1st test of the Functional Difficulties Questionnaire (n=30)

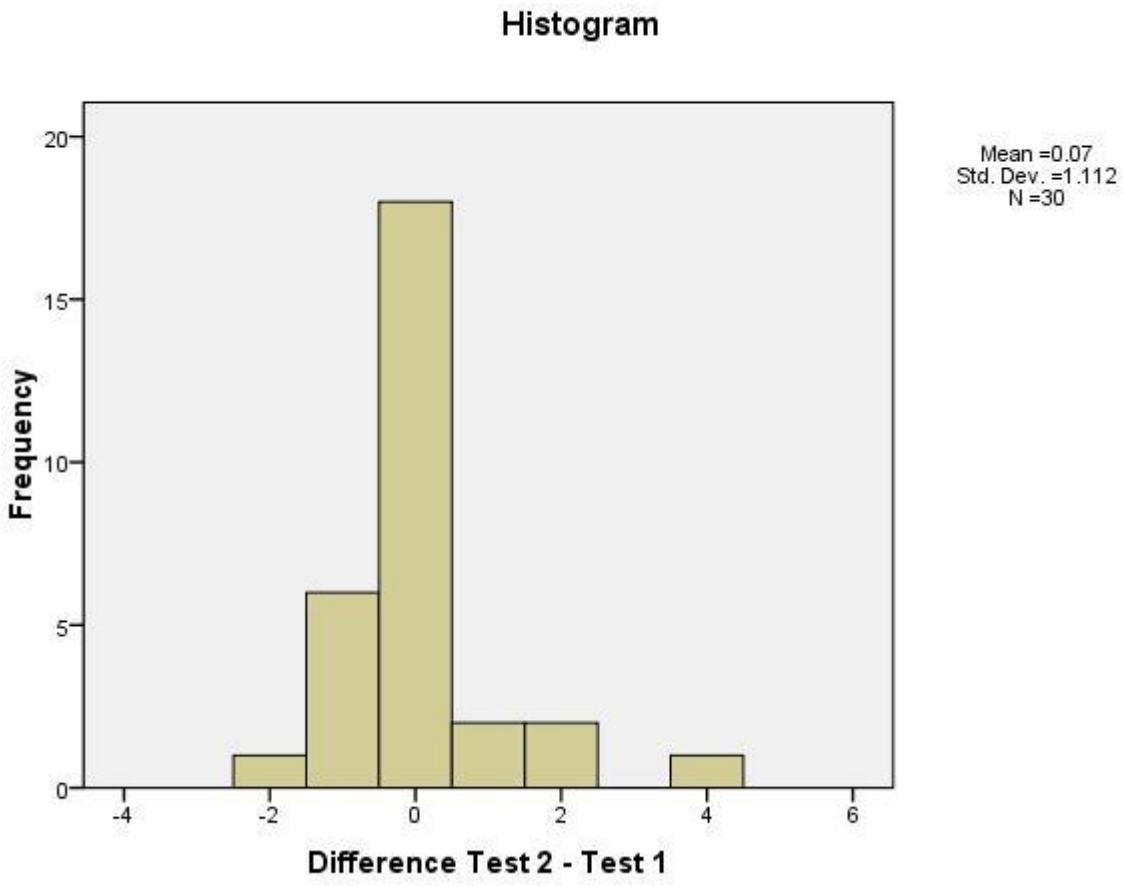
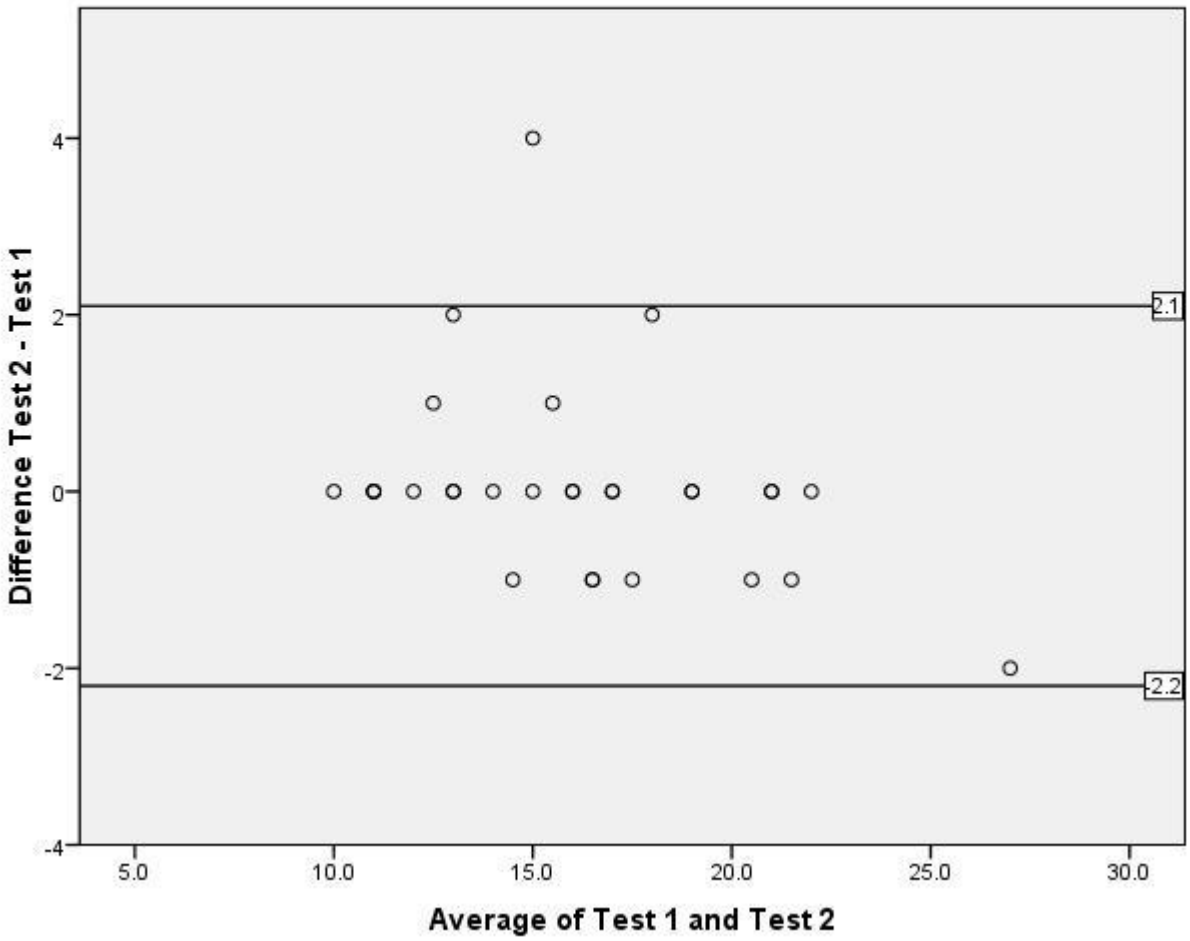


Figure 4-9 Simple scatter diagram of the difference between the scores from the first and second tests versus the averages of the scores for the two tests of the Functional Difficulties Questionnaire. Limits of agreement set -2.2 and 2.1. Sample 2 (n=30)



In the scatter plot about 95% of the points should lie within the limits of agreement. In this graph there are some overlapping points and 96.7% of the cases lay within the limits of agreement and equal divergence is observed. From the histogram the differences in the means were noted to be from an approximately normal distribution. Test-retest total scores are assumed to be from the same distribution when the differences have a mean of zero and 95% of the differences lie within

the 95% limits of agreement (Brazier et al 1992). In this study the mean difference of the scores was 0.07 [95% CI -0.35 - 0.48] which implies that a person with a test score of 16 might score 15 on retesting. This difference is unlikely to be clinically significant. The range reported for the limits of agreement is likely to be clinically significant.

The results of the ICC and the Bland and Altman method indicated good test-retest reliability.

Stage 4 – Analysis of diagnostic accuracy and further tests of validity

Data were presented in order to explore the diagnostic accuracy of the FDQ-9, sensitivity and specificity were reported and a cut-off score established. This cut-off score was employed to further explore construct validity of the FDQ-9.

4.6 Diagnostic accuracy of the FDQ-9 and further tests of validity

The diagnostic accuracy was assessed by employing a receiver operator characteristic (ROC) curve analysis. The aim was to determine the sensitivity and specificity of the FDQ-9 to assess dyspraxia/DCD in adults using self-report dyspraxia as the reference standard. The accuracy of the test and the specificity and sensitivity were reported. A cut-off score was identified by employing two methods; the first is that which balances sensitivity and specificity and the second employed the Youden index (Youden 1950). A checklist is provided which aimed to verify that the essential elements had been included in relation to the Standards for Reporting of Diagnostic Accuracy (STARD) (Bossuyt et al 2003) (See appendix 22)

4.6.1 Assessing diagnostic accuracy

Participants

Diagnostic accuracy employed data from sample S4 (n=152) as this sample group self-reported dyspraxia.

Methods

The accuracy of a test to discriminate cases with or without a condition may be evaluated using a Receiver Operating Characteristic (ROC) curve analysis (Metz 1978; Zweig and Campbell 1993). In this study the ROC curve was employed to discriminate cases self-reporting or not self-reporting dyspraxia. The accuracy refers to the amount of agreement between the index test and the reference standard. The reference standard employed was the self-report of dyspraxia. The index test was the FDQ-9. The number of participants who self-reported dyspraxia (n=7). To establish the diagnostic accuracy of the ROC curve analysis the area under the curve (AUC) was assessed. A

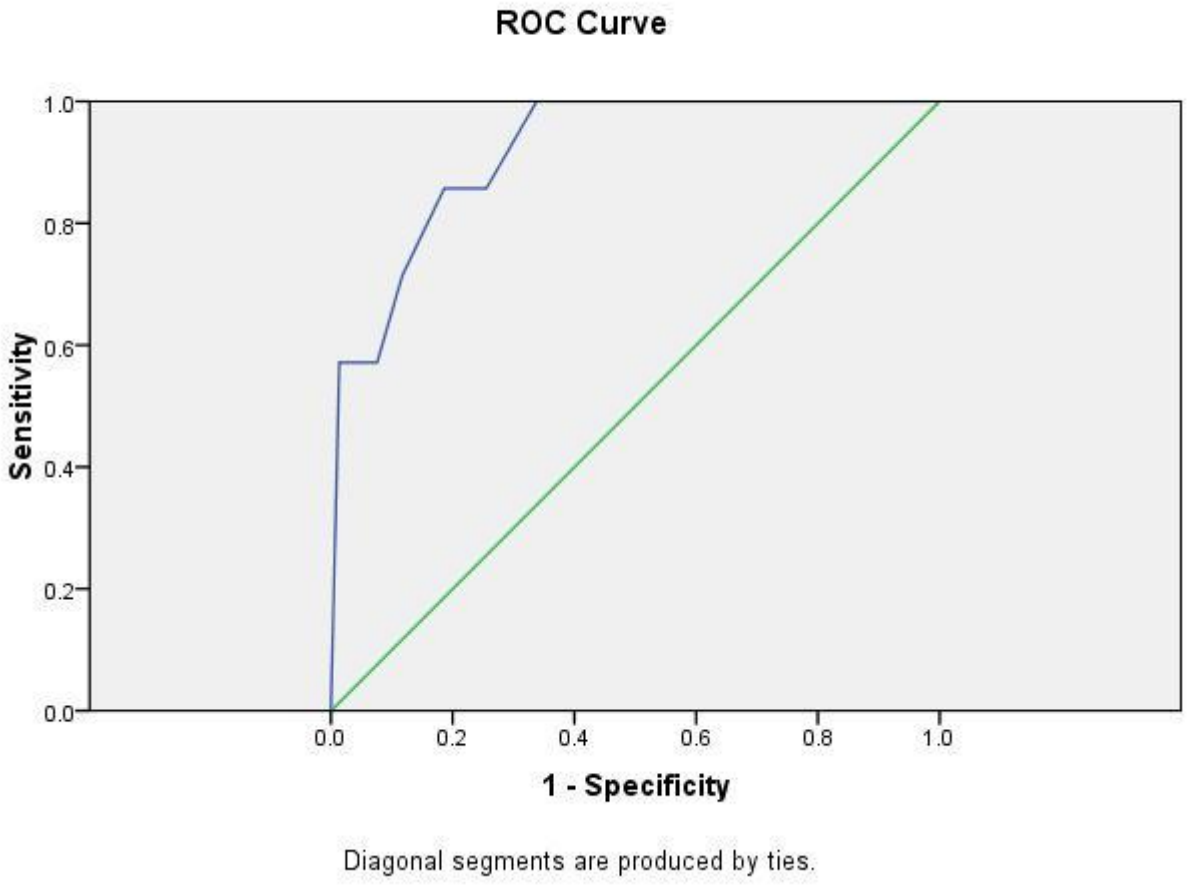
perfect test will have an AUC of 1.0. Tests may be defined as >0.9 (high accuracy); 0.7-0.9 (moderate accuracy); 0.5-0.7 (low accuracy) (Swetts 1988).

In addition there was a requirement to establish a cut-off point at optimal sensitivity and specificity. Determining the optimal cut-off points was explored by employing two methods. The first assumes the best cut-off point for balancing sensitivity and specificity and is the point on the curve closest to the (0,1) point . In this method the minimal value for $(1\text{-senstivity})^2 + (1\text{-specificity})^2$ is the cut-off point (Perkins and Schisterman 2006). The second method is calculated using the Youden index (*J*). Where *J* = maximum (sensitivity + specificity -1) (Youden 1950; Perkins and Schisterman 2006).

Results

The area under the curve was 0.918 [95% CI 0.837 – 1.000] with a standard error of 0.042 ($p < 0.001$). This meant a randomly selected individual who self-reported dyspraxia would have a test score (FDS) higher than that of a randomly chosen individual who did not report dyspraxia 92% [95%CI 84% - 100%] of the time. This represents a diagnostic test with high accuracy (Swetts 1988) and may be viewed (See figure 4-10).

Figure 4-10 Receiver Operating Characteristic (ROC) curve using the total scores of the FDQ-9 and those who self-reported dyspraxia. The sample group were S4 staff and students from a university (n = 152).



To calculate a cut-off score two methods were employed. The first method involved balancing sensitivity and specificity and involved finding a minimal value, the second involved calculating the Youden index maximum score. A minimal value of 0.055 [95%CI 0.023 – 0.100] was calculated in which sensitivity and specificity were balanced. The cut-off occurred with an FDS of 21.5. A review of the 95% CI meant that this cut-off score could range from 20.5 – 22.5. The sensitivity and specificity of 20.5 would be 86% [95%CI 78% -94%] and 75% [95%CI 67% - 83%] respectively. The sensitivity and specificity of 22.5 would be 71% [95% CI 63% - 79%] and 88% [95% CI 80% - 96%] respectively. The Youden index maximum score was 0.671 [95%CI 0.589 – 0.753] and this occurred at a cut-off point of the FDS of 21.5. A review of the 95% CI indicated cut-off scores could range from 19.5 – 22.5. The sensitivity and specificity at a cut-off of 19.5 would be 100% [95%CI

92% - 100%] and 66% [95% CI 58% - 74%] respectively. The sensitivity and specificity at a cut-off score of 22.5 were recorded above.

The coordinates of the curve and associated sensitivity and 1 - specificity are presented (See table 4-12). Based on the two methods described above a cut-off score of FDS 21.5 were achieved. Based on a pragmatic approach as there are no half measures in relation to the FDS especially when used in the clinical setting the appropriate cut-off score would be an FDS of 22.

Table 4-12 Coordinates of the curve (Functional difficulties scores), Sensitivity and 1-Specificity

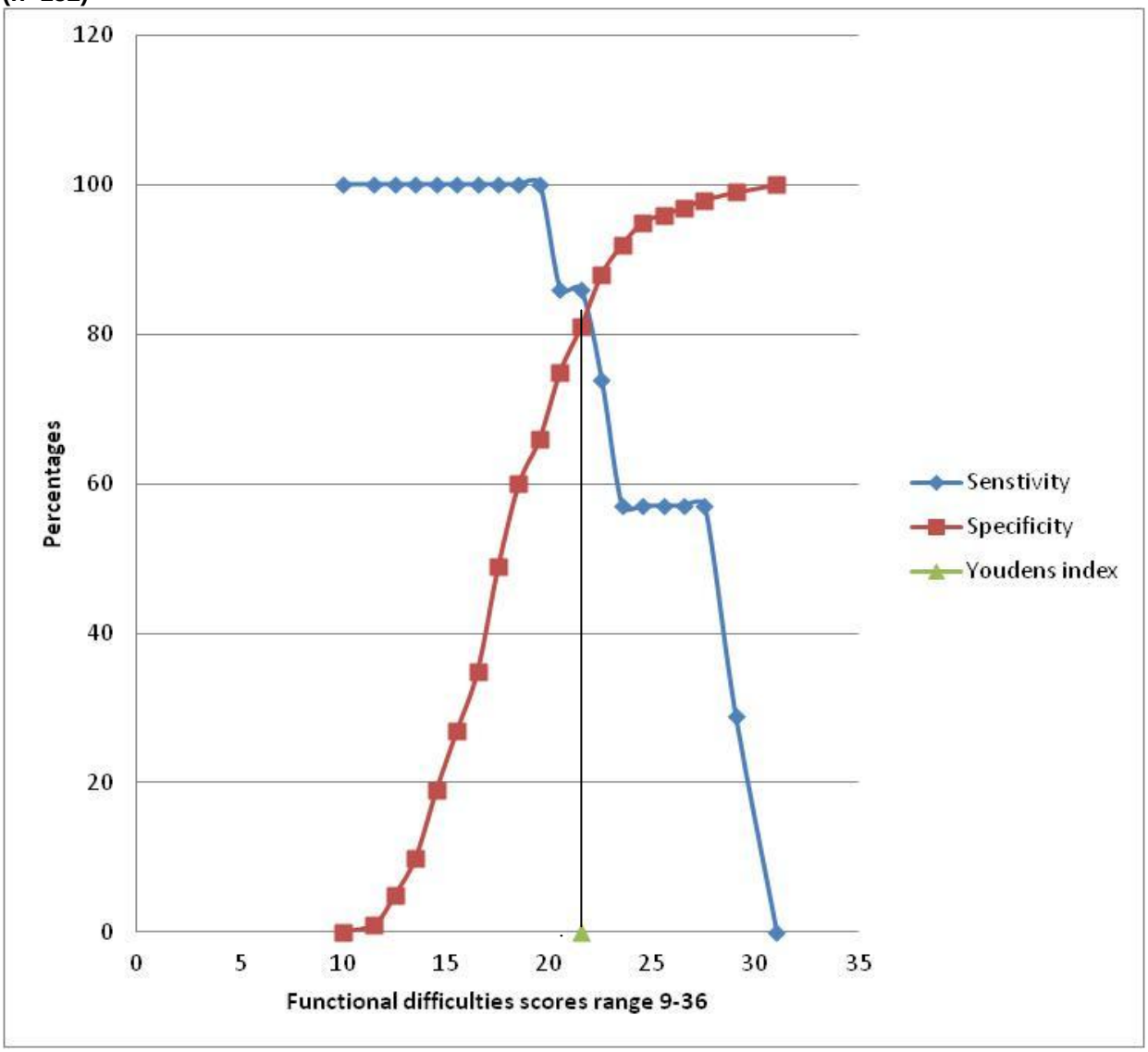
Functional difficulty scores	Sensitivity	1-Specificity
10.0	1.000	1.000
11.5	1.000	0.986
12.5	1.000	0.945
13.5	1.000	0.897
14.5	1.000	0.814
15.5	1.000	0.731
16.5	1.000	0.648
17.5	1.000	0.510
18.5	1.000	0.407
19.5	1.000	0.338
20.5	0.857	0.255
21.5	0.857	0.186
22.5	0.714	0.117
23.5	0.571	0.076
24.5	0.571	0.055
25.5	0.571	0.041
26.5	0.571	0.028
27.5	0.571	0.014
29	0.286	0.007
31	0.000	0.000

The **sensitivity** of a test relates to the proportion of individuals with a condition who are correctly identified by the test. In this case 86% [95% CI 78% - 94%] of those with a cut-off score of FDS 22 would be correctly identified by the test.

The **specificity** is the proportion of the individuals without the condition who are correctly identified by the test. In this case 81% [95% CI 73% - 89%] of those with a cut off score of FDS 22 would be correctly identified as not having the condition and the graph may be viewed (See figure 4-11).

The results of the two methods described above suggested a cut-off score of FDS 22. This score achieved the sensitivity recommended by the APA (1985), but the specificity was less than that recommended.

Figure 4-11 Graph of sensitivity and specificity with a maximum Youden index in sample 4 (n=152)



The proportion of true positives, true negatives, false positives and false negatives employing a cut off score of 22 were presented in table 4-13.

Table 4-13 Proportion reporting a true positive, true negative result, false positive and false negative result when the cut off for the FDQ-9 was 22 (n=152)

Total score	Dyspraxia	No dyspraxia	Total
≥ 22	6	28	34
< 22	1	117	118
Total	7	145	152

Prevalence = (7/152) x 100 = 4.6% [95%CI 0% - 13%]

Sensitivity = 6/7 =86% [95% CI 78% - 94%]

Specificity = 117/145 = 81% [95% CI 73% - 89%]

Positive predictive value = (6/34) x 100 = 18% [95%CI 10% - 26%]

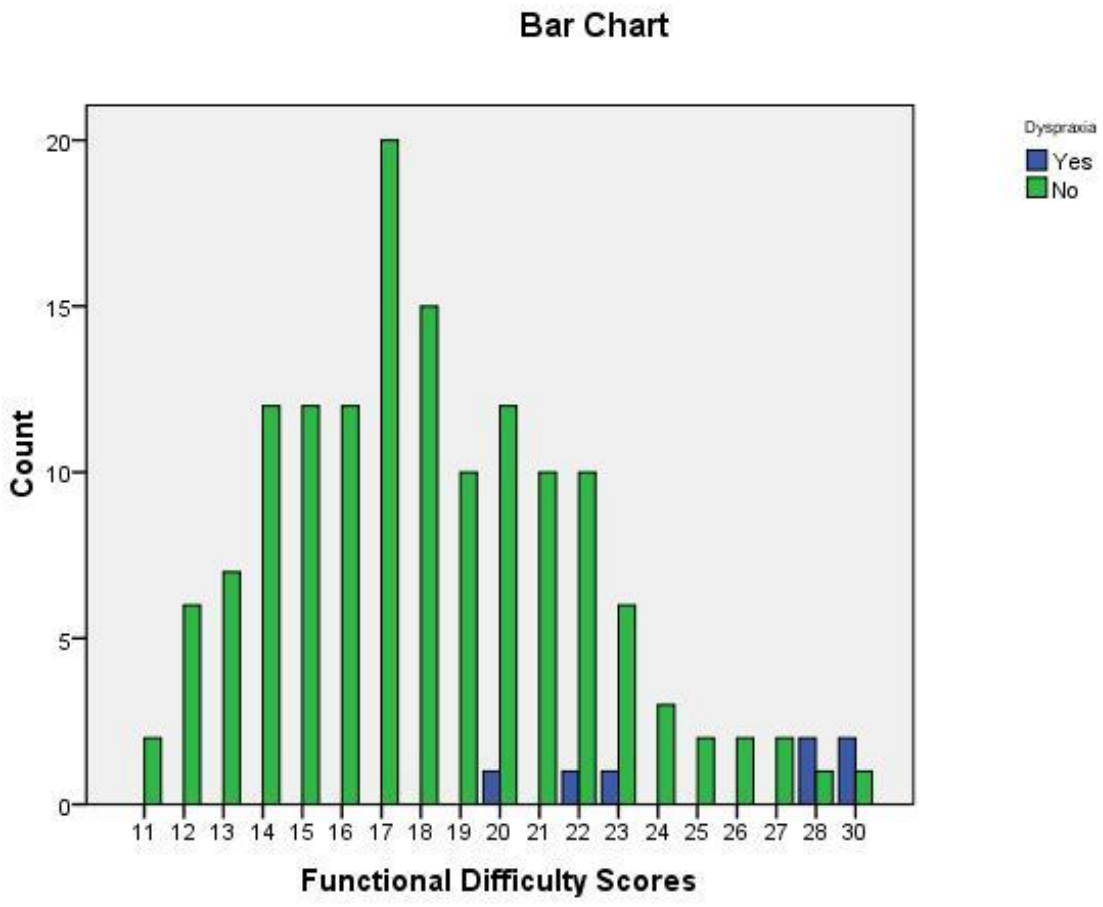
Negative predictive value = (117/118) x 100 = 99% [95% CI 91% - 100%]

The positive predictive value is the proportion of subjects with a positive test who are correctly diagnosed. However, this statistic is dependent on prevalence. The higher the prevalence of a condition in the group tested the higher the PPV. It is therefore appropriate to calculate the positive likelihood ratio which is independent of the prevalence calculation. The positive likelihood ratio indicates the odds of a condition increase when the test is positive. In this study this equated to (sensitivity / 1- specificity) = 4.61 [95% CI 3.93 – 5.38]. The likelihood ratio was high which suggests this test provides useful information (Petrie and Sabin 2005).

Exploring the results of the index test (FDS) and the reference standard (Dyspraxia)

It is suggested that to address the quality of the reporting of diagnostic accuracy researchers should consider the STARD checklist (Bossuyt 2003). This checklist is summarised in a table (appendix 22). In item 19 of the STARD the recommendation is to report a cross tabulation of the index test and the reference standard, this is presented in Figures 4-7 and 4-12. Presenting this data enabled the distribution of continuous data to be viewed and reported.

Figure 4-12 Bar chart showing the continuous results of the functional difficulties scores and the reference standard in Sample 4 (n=152). Self report dyspraxia (n=7) no self report dyspraxia (n=145)



The bar chart demonstrates the continuous distribution of FDS from participants in S4 (n=152).

- FDS ranged from 11 - 30. FDS of 11 indicated being 'very good' at each of the 7/9 and 'good' at 2/9 items respectively.
- FDS of 30 indicate being 'very poor' at 3/9 items and 'poor' at 6/9 items respectively.
- There was a trend for a higher percentage of participants who did not self-report dyspraxia to have scores that span the range.
- Participants who did self-report dyspraxia tended to have higher scores indicating more functional difficulties. All participants who self-reported dyspraxia recorded FDS ≥20 indicating functional difficulties in 2/9 items or more.

- There were a number of participants who did not self-report dyspraxia who recorded high FDS. It is suggested that this group with high FDS may have had functional difficulties in childhood which continued into adulthood but were not assessed for dyspraxia/DCD in their early years. As mentioned previously (See 4.5.7) this is a group that has been previously identified and discussed (Kirby et al 2008).

4.6.2 Criterion, concurrent and predictive validity

Criterion validity by definition is where a measure is validated against a criterion and the new measure should be demonstrably superior to the criterion measure. This might be in terms of practicality, economically or less time consuming. There are two types of criterion validity; concurrent and predictive. Concurrent requires that the test and criterion test to be carried out at a similar time. Predictive validity is where scores from a tool predict the outcome of a theoretically sound construct. Testing for predictive validity occurs after the well established measure has been administered (Wilkin et al 1992; Hays et al 1998) and for that reason was not considered in this thesis.

Concurrent validity is demonstrated if two tests with the same variable are shown to correlate highly. Concurrent validity was not previously considered in relation to the Adult Developmental Co-ordination Disorders/Dyspraxia Checklist (ADC) (Kirby et al 2010) as the standardisation of the ADC was only published after the data collection had been completed for this study. Concurrent validity was subsequently considered in relation to the ADC (Kirby et al 2010). The developers of the ADC should be recognised for their pioneering work in relation to assessing dyspraxia/DCD in adults. However, there were limitations identified in the published psychometric properties of the ADC checklist (Kirby et al 2010). These limitations are discussed and the questions making up the 40 item questionnaire are presented (See appendix 21).

Conclusions relating to the psychometric properties of the ADC were as follows:

- The factor structure of the questionnaire was not explored which has implications in relation to the scoring of the questionnaire. The lack of published data relating to test-retest reliability and internal consistency indicate that the reliability of the ADC has not been established. It is suggested that tests which are not reliable cannot be considered to be valid Kline (1999). Construct validity was explored and significant between group differences between 38/40 items of the questionnaire were reported. Concurrent validity was inferred but not with a tool that was measuring the same variable.

It is anticipated that in the future more data will be presented which explores the structure of the ADC, establishes reliability and further tests of validity. It would therefore be prudent to consider how the FDQ-9 might be correlated with the ADC.

In addition to correlating the total scores of the questionnaires it would be useful to correlate the individual items of the FDQ-9 with the ADC. An exploration of how the 9 items of the FDQ-9 could be compared with 38 items of the ADC is presented (See table 4-14). It was decided to employ the 38 items instead of 40 items as two items of the ADC were not found to be discriminatory (See appendix 21.

Table 4-14 Comparison questions to be correlated between the Functional Difficulties Questionnaire (FDQ-9) and the Adult Developmental Co-ordination Disorders/Dyspraxia Checklist (ADC) (Kirby et al 2010)

FDQ-9	ADC A=Child B & C = Adult
Q1 As a CHILD how good was your handwriting Q9 As an ADULT how good is your handwriting now?	A5 Have difficulty writing neatly (so others could read it) A6 Have difficulty writing as fast as your peers B4 Have difficulty writing neatly when having to write fast B5 Writing as fast as your peers B7 Copying things down without mistakes C6 Do others find it difficult to read your writing
Q2 As a CHILD were you good at team games that involved balls? i.e. football, netball, basketball	A4 Have difficulty playing team games, such as football, volleyball, catching or throwing balls accurately C9 Avoid team games/sports
Q3 As a CHILD how did others rate your coordination	A2 Have difficulty with eating without getting dirty A10 Have others commented about your lack of co-ordination or called you clumsy
Q4 As an ADULT how good are you at avoiding obstacles, like bumping into doors	A7 Bump into objects or people or trip over things more often than others C3 Would you say you bump into things, spill or break things C12 If you are a driver, do you have difficulty parking a car C18 Do you have difficulties with distance estimation (e.g. with regard to parking, passing through objects
Q5 As an ADULT how good are you at organizing yourself? i.e. getting ready for work or for a meeting	A9 Have difficulties with organising/finding things in your room B8 Organising/finding things in your room B9 Finding your way around new buildings or places B10 Have others called you disorganised C2 Do you lose or leave behind possessions C4 Are you slower than others at getting up in the morning and getting to work or college C13 Do you have difficulty preparing a meal from scratch C14 Do you have difficulty packing a suitcase to go away C19 Do you have difficulty planning ahead
Q6 As an ADULT how good are you at catching a ball one handed	A4 Have difficulty playing team games, such as football, volleyball, catching or throwing balls accurately
Q7 As an ADULT how good are you at balancing on a bike, in a bus or train or skis?	A3 Have difficulty learning to ride a bike compared to your peers C3 Do you have difficulty with performing two things at the same time
Q8 As an ADULT how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?	A1 Have difficulty with self-care tasks B1 Do you currently have difficulty with self care tasks B3 Hobbies that require good co-ordination C7 Do you avoid hobbies that require good co-ordination C15 Do you have difficulty folding clothes to put them away neatly A8 Have difficulty playing a musical instrument (e.g. violin, recorder)
9 questions	32 questions
There were five questions without a match	C1 Do you have difficulties with sitting still or appearing fidgety C8 Do you chose to spend your leisure time more on your own than with others C5 Did it take you longer than others to drive C10 If you do a sport, is it more likely to be on your own C 16Do you have difficulty managing money C 20Do you feel you are losing attention in certain situations
Scoring: **ADC:** 40 questions scored using 4 point Likert scores for each question with a range of 40-120. Higher scores indicate greater functional difficulties **FDQ-9:** 9 questions scored using 4 point Likert scores for each question with a range of 9-36. Higher scores indicate greater functional difficulties	

There were a total of 32 items out of 38 from the ADC that could be correlated with the nine items of the FDQ-9. Out of the six questions of the ADC that could not be correlated two referred to individuals preferring their own company; this is not identified in the diagnostic criteria or definition for dyspraxia/ DCD (DSM-IV-TR APA 2000; ICD-10 WHO 1992: 2007). One question asked about difficulties with sitting still and another was in relation to losing attention, these aspects are not identified in the diagnostic criteria or definition for dyspraxia/DCD (DSM-IV-TR APA 2000; ICD-10 WHO 1992: 2007). Managing money may be an aspect of daily living, but may also be related to dyscalculia and is not a specific difficulty recognised in the diagnostic criteria or definition for dyspraxia/DCD (DSM-IV-TR APA 2000; WHO 1992: 2007). The item C5 in the ADC relating to learning to drive might need to be optional as some participants may not have had an opportunity to drive a car.

Concurrent validity has been discussed and how it might have been explored with the ADC if it was considered as a good benchmark test. The psychometric properties of the ADC have not been fully evaluated in order to establish if this is or is not a good bench mark test. In addition there are no other questionnaires available at present that assess for dyspraxia/DCD in adults. Where there is no benchmark test with which to determine concurrent validity it is suggested that a different line of reasoning be employed (Kline 1999). Where there are no other benchmark tests then concurrent validity tests are best regarded as aspects of construct validity (Kline 1999). At the time of the data collection for this PhD study there were no bench mark tests for assessing dyspraxia/ DCD in adults. Further tests of construct validity were considered by employing the cut-off score previously determined at FDS 22. These tests are presented below.

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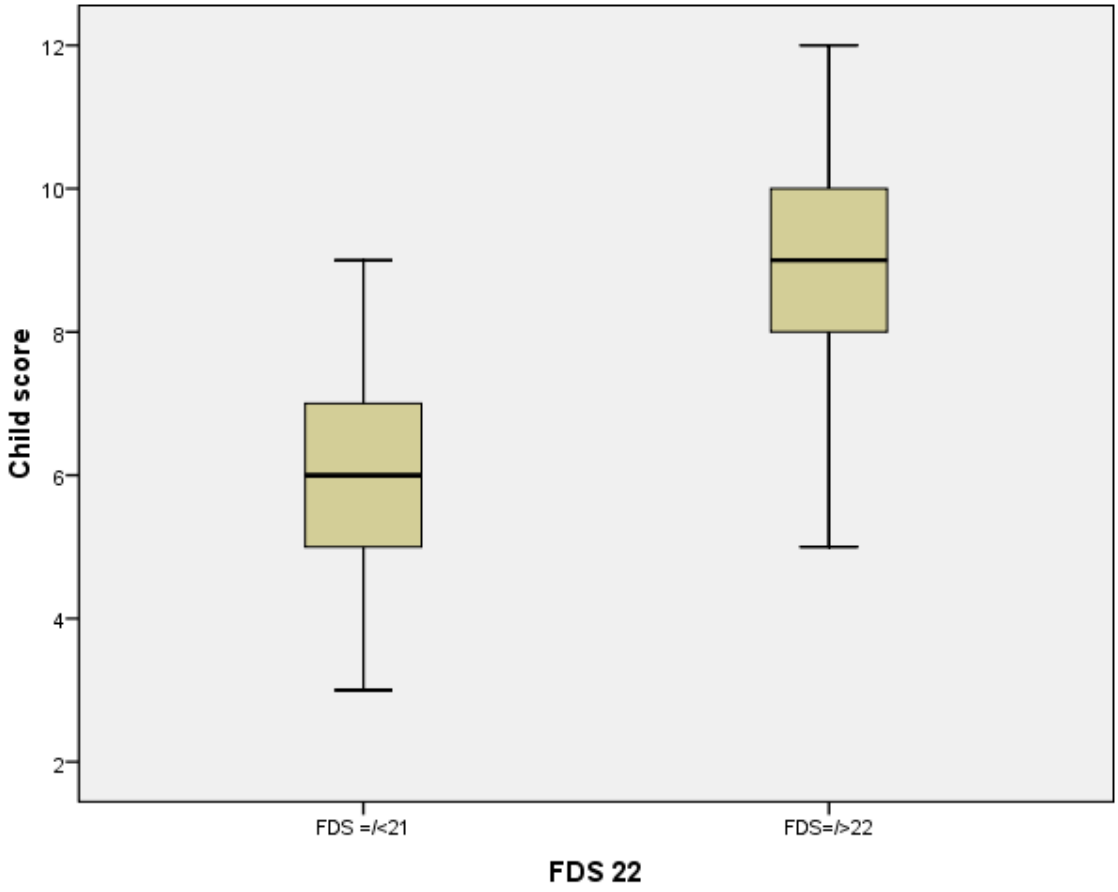
4.6.3 Construct validity explored further employing an FDS cut-off score of 22

Construct validity involves collecting verifiable evidence to support the inference that a measure has meaning and is the most important approach to validity where there is no bench mark test (Wilkin et al 1992; Hays et al 1998; Kline 1999). As discussed previously (See 4.1 and 4.5.7) the concept of dyspraxia/DCD relates to functional difficulties that occur in childhood and may continue in adulthood (WHO 2007). It was decided to test this concept further using the cut-off FDS 22 determined by the ROC curve analysis (See section 4.6.1). It was expected that participants who reported scores FDS ≥22 would be more likely to report functional difficulties both as a child and as an adult than those who reported FDS <22. Data from sample 4 relating to the three items of the FDQ-9 associated with childhood are presented in figure 4-13. Data relating to the six items associated with adulthood are presented in figure 4-14.

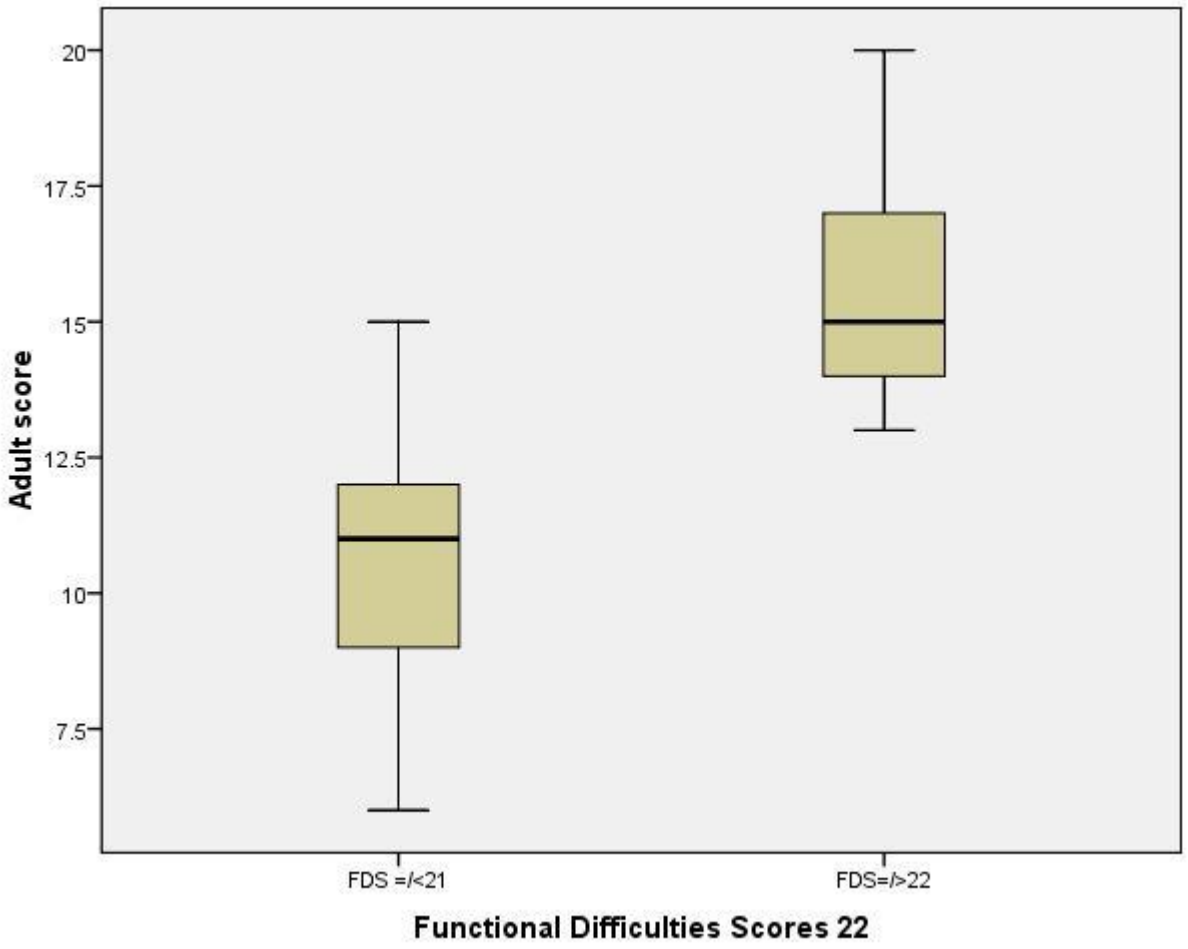
Figure 4-13 Box-and–whisker plots of child scores of the FDQ-9 for participants in two groups FDS ≥22 and FDS<22 in sample 4 (n=152)



For each group the FDS median, range, Lower Quartile (LQ), Upper Quartile (UQ) and Inter Quartile Range (IQR) were reported.

- Those with FDS <22 (n=119) the median scores were 6, with a range of 3 –9, LQ 5, UQ 7 and IQR 2. A score of 6 is indicative of broadly being 'good' in all three items. A quarter of participants reported scores of 7-9 indicative of being 'poor' in 1–3 items.
- Those with FDS ≥ 22 (n=33) the median scores were 9 with a range of 5-12, LQ 8, UQ 10 and IQR 2. A score of 9 is indicative of broadly being 'poor' in 3 items. Three quarters of participants reported scores of 8-12 broadly indicative of reporting being 'poor' in 2 items to 'very poor' in 3 items.

Figure 4-14 Box-and–whisker plots of adult scores of the FDQ-9 for participants in two groups FDS ≥22 and FDS<22 in sample 4 (n=152)



For each group the FDS median, range, Lower Quartile (LQ), Upper Quartile (UQ) and Inter Quartile Range (IQR) were reported.

- Those with FDS <22 (n=119) the median scores were 11, with a range of 6 –15, LQ 9, UQ 12 and IQR 3. A score of 11 is indicative of broadly being ‘good’ in five items and ‘very good’ in one item. A quarter of participants reported scores of 12-15 indicative of broadly being ‘good’ in 6 items to being ‘good’ in 3 items and ‘poor’ in 3 items.
- Those with FDS ≥ 22 (n=33) the median scores were 15 with a range of 13-20, LQ 14, UQ 17 and IQR 3. A score of 15 is indicative of broadly being ‘good’ in 3 items and ‘poor’ in 3 items. Three quarters of participants reported scores of 14-20.

Data relating to the child scores and the adult scores of the FDQ-9 were analysed separately to identify whether participants in the FDS ≥ 22 group would score more highly in both the child scores and adult scores than those in the FDS < 22 group.

Assessing the between group differences in the child scores between using FDS 22 cut-off

Methods

Using the known groups method it was anticipated that those from sample 4 (n=152) who reported FDS ≥ 22 (n=33) would have a higher child score than those with FDS <22 (n=119). An independent samples equal variance *t-test* was used to compare the mean child scores of the FDQ-9 for these two groups. A Mann-Whitney *U* was used to confirm this result.

Results

The mean child scores of those recording an FDS ≥ 22 (8.82 SD 1.229)[95% CI 8.291 -9.349] were significantly higher than those who reported an FDS < 22 (5.92 SD 1.556)[95% CI 5.700 - 6.141]. Levene's test, $p > 0.05$ therefore equal variances were assumed, t (150) = 2.894, $p < 0.001$ (two tailed). This was further confirmed by employing the Mann-Whitney U test, $U = 253.000$, $p < 0.001$. The mean differences between the groups were 2.894 [95% CI 2.387 – 3.401]. This is a statistically significant result and the hypothesis was upheld.

In addition a difference of three points is likely to be a clinically important difference.

- On average participants in the FDS ≥ 22 group broadly recorded scores relating to being 'poor' in at least 3/3 items in childhood, indicating the reporting of functional difficulties in childhood.
- On average participants in the FDS < 22 group broadly recorded scores relating to being 'good' in 3/3 items, indicating no functional difficulties in childhood which suggests this group do not have dyspraxia/DCD.

Assessing the between group differences in the adult scores between using FDS 22 cut-off

Methods

It was anticipated that those from sample 4 (n=152) who reported FDS ≥ 22 (n=33) would have a higher adult score than those who reported FDS < 22 (n=119). An independent samples equal variance *t-test* was used to compare the mean adult scores of the FDQ-9 for these two groups. A Mann-Whitney U was used to confirm this result.

Results

The mean adult scores of those reporting an FDS ≥ 22 (15.58 SD 1.821) [95% CI 14.959 – 16.201] were significantly higher than those who reported an FDS < 22 (10.82 SD 2.040)[95% CI 10.453 –

11.187]. Levene's test, $p > 0.05$ therefore equal variances were assumed, t (150) = 12.104, $p < 0.001$ (two tailed). This was further confirmed by employing the Mann-Whitney U test, $U = 117.500$, $p < 0.001$. The mean differences between the groups were 4.752 [95% CI 3.976 – 5.528]. These results indicated a statistically significant difference and the hypothesis were upheld.

In addition the difference of five points between the groups is likely to be a clinically important.

- On average participants in the FDS ≥ 22 group broadly recorded scores relating to being 'poor' in at least 3/6 items and good in 3/6 items in adulthood indicating reporting functional difficulties in adulthood.
- On average participants in the FDS < 22 broadly recorded scores relating to reporting being 'good' in 5/6 items and 'very good' in 1/6 items indicating reporting no functional difficulties in adulthood. This would indicate that participants in this group do not have dyspraxia/DCD that persists into adulthood.

Assessing the relationship between each item of the FDQ-9 employing the cut-off FDS 22

To explore construct validity further it was decided to assess the relationship between each item of the FDQ-9 in two different samples by employing the cut-off FDS 22 identified following the ROC curve analysis (See section 4.6). The sample groups chosen were S3 patients with JHS and Subgroup S4A, healthy volunteers. This was to explore the relationship between each item of the FDQ-9 in one group who reported musculoskeletal pain and another group who did not report musculoskeletal pain.

Participants

Construct validity employed data from the following samples; S3 (n=90) and Subgroup S4A of sample 4 (n=113)

Methods

Construct validity of the FDQ-9 was further explored using the known groups method. It was expected that individuals from the S3 and Subgroup S4A samples who reported a FDS of ≥22 would be more likely to report being 'poor' or 'very poor' at each of the nine items of the FDQ-9 than those who reported FDS <22. Pearson's chi-square test was employed.

The data for S3 and Subgroup 4A of sample 4 are presented in Table 4-15 and Table 4-16 respectively.

Table 4-15 Percentage of patients with JHS with FDS ≥ 22 or FDS < 22 who reported being poor or very poor at each activity in sample 3 (n=90)

Activity	FDS ≥22 n=50	FDS <22 n=40	Chi square	*p* 2-sided
A1 As a child how good was your handwriting	48%	20%	7.603	<0.01*
A2 As a child were you good at team games that involved balls? i.e. football, netball, basketball	74%	22.5%	23.587	<0.001**
A3 As a child how did others rate your coordination	62%	25%	12.266	<0.001**
A4 As an adult how good are you at avoiding obstacles, like bumping into doors	71%	29%	28.621	<0.001**
A5 As an adult how good are you at organizing yourself? i.e. getting ready for work or for a meeting	42%	12.5%	9.414	<0.001**
A6 As an adult how good are you at catching a ball one handed?	84%	32.5%	24.800	<0.001**
A7 As an adult how good are you at balancing on a bike, in a bus or train or skis?	76%	21%	23.223	<0.001**
A8 As an adult how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?	50%	20%	8.612	<0.01*
A9 As an adult how good is your handwriting now?	56%	22.5%	10.301	<0.001**

*$p < 0.01$, **$p < 0.001$

Table 4-16 Percentage of healthy volunteers with FDS ≥22 or FDS <22 who reported being poor or very poor at each activity in subgroups S 4A of sample 4 (n=113)

Activity	FDS ≥22 n=21	FDS <22 n=92	Chi square	*p* 2-sided
A1 As a child how good was your handwriting	47.6%	18.5%	7.984	<0.01*
A2 As a child were you good at team games that involved balls? i.e. football, netball, basketball	66.7%	31.5%	8.959	<0.01*
A3 As a child how did others rate your coordination	66.7%	14.1%	25.950	<0.001**
A4 As an adult how good are you at avoiding obstacles, like bumping into doors	66.7%	13%	27.752	<0.001**
A5 As an adult how good are you at organizing yourself? i.e. getting ready for work or for a meeting	38.1%	4.3%	20.515	<0.001**
A6 As an adult how good are you at catching a ball one handed?	66.7%	23.9%	14.396	<0.001**
A7 As an adult how good are you at balancing on a bike, in a bus or train or skis?	42.9%	9.8%	13.966	<0.001**
A8 As an adult how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?	33.3%	5.4%	14.020	<0.001**
A9 As an adult how good is your handwriting now?	57.1%	21.7%	10.557	<0.001**

*$p < 0.01$, **$p < 0.001$

Results

These results indicated a statistical difference (all *p values* < 0.01) between the groups for each of the nine items of the FDQ-9 and the null hypotheses were upheld. This indicated that at a cut-off score of FDS 22 there were significant differences in the functional difficulties between these groups. Participants with FDS ≥22 were significantly more likely to report being 'poor' or 'very poor' at all items than those with an FDS <22. This finding was consistent in both sample groups, S3 - patients with JHS (See table 4-15) and Subgroup S4A of sample 4 healthy volunteers with no musculoskeletal pain (See table 4-16).

Summary

These results indicate that those who report FDS ≥ 22 were significantly more likely to report functional difficulties both in childhood and adulthood than those who reported FDS <22. This finding was similar for patients with JHS and healthy volunteers. On average participants with an FDS ≥ 22 report functional difficulties in three items in childhood and three items in adulthood indicating functional difficulties in childhood and adulthood. On average the FDS ≥ 22 group report

'functional difficulties as a child and as an adult' which aligns to the concept of dyspraxia/DCD defined in the ICD-10 (WHO 2007) (See section 4.1). On average participants with an FDS <22 report no functional difficulties either in adulthood or childhood and this indicates this group do not align to the concept of dyspraxia/DCD defined by the ICD-10 (WHO 2007).

4.7 Additional results

4.7.1 Number of participants who self-reported Attention Deficit Hyperactivity Disorder (ADHD), Dyspraxia/DCD and Dyslexia

ADHD and dyslexia are considered to have overlap with dyspraxia/DCD. It is understood that participants with dyspraxia/DCD might have dual diagnoses and therefore data relating to self-report of these conditions was collected. This data was collected in sample groups (S1, S3 and S4). It was not collected in S2 where the focus was in collecting data for test-retest reliability of the FDQ-9. In table 4-17 the descriptive data for the percentage of participants who self-reported these conditions is presented.

Table 4-17 Data relating to the number of individuals who reported a previous diagnosis of Attention Deficit Hyperactivity Dsorder (ADHD), dyspraxia and Dyslexia in three sample groups

Sample	ADHD	Dyslexia	Dyspraxia/DCD
S1 n=24	1 (4%)	1 (4%)	0 (0%)
S3 n=90	3 (3%)	14 (16%)	8 (9%)
S4 n=152	0 (0%)	15 (10%)	7 (5%)

Sample group S3 (patients with JHS) reported ADHD, Dyslexia and DCD/dyspraxia. Sample groups (S4) staff and students from a university reported dyslexia and dyspraxia/DCD but no ADHD. One participant from sample group S1 (individuals from an international company) reported both dyslexia and ADHD but no dyspraxia/DCD.

4.7.2 Participants recording a cut off score FDS ≥ 22

In section 4.6.1 a ROC curve was employed to assess the diagnostic accuracy of the FDQ-9 in assessing for dyspraxia/DCD in adults. The reference standard was the self-report of dyspraxia and a cut-off of FDS 22 was recorded. In sections 4.6.3 and 4.6.4 data were presented on the construct of those with a score of FDS ≥ 22. On average those reporting FDS ≥ 22 reported functional difficulties both as a child and as an adult. On average those reporting FDS < 22 did not report functional difficulties as an adult or as a child. Descriptive data is provided on the number and percentage of participants in the sample groups who recorded an FDS ≥ 22 (See table 4-18).

Table 4-18 Number of participants who reported a ≥FDS 22 and the sex ratios in four sample groups

Sample	FDS ≥ 22	F:M
S1 n=24 11F: 13M	1 (4%)	0 : 1
S2 n=30 26F: 4M	3 (10%)	3 : 0
S3 n=90 83F: 7M	50 (56%)	48 : 2
S4 n=152 115F: 37M	37 (24%)	33 : 4

In S1 (n=24) (participants from an international company) with an equal proportion of males and females. Only one male participant recorded an FDS score ≥22 indicating a prevalence of 4%. No participant in this group self-reported dyspraxia.

In S2 (n=30) (participants from an international company and students from a university). This population consisted primarily of females 10% recorded an FDS ≥22. Data relating to self-report dyspraxia was not collected for this group.

In S3 (n=90) (patients with JHS from a hypermobility clinic). This population consisted primarily of females; 56% recorded an FDS ≥22. Self-report dyspraxia was reported by 9% of this group.

S4 (n=152) (staff and students from a university some of whom had pain). This population consisted primarily of females; 24% recorded an FDS ≥22. Self-report dyspraxia was reported by 5% of this group.

4.8 Discussion

The aim of this part of the thesis was to develop a questionnaire to assess for dyspraxia/DCD and the initial validation of the Functional Difficulties Questionnaire (FDQ-9).

The FDQ-9 is a nine item questionnaire in which respondents are required to relate their functional abilities of fine and motor skills and organisation in childhood and adulthood. The development of the FDQ-9 drew upon a number of sources; (i) diagnostic criteria, DSM-IV (APA 2000); (ii)the definitions reported in the ICD-10 (WHO 1992; 2007); (iii) previous questionnaires (Wilson et al 2000; Kirby et al 2005; Henderson and Sugden 2007; Kirby et al 2010); (iv) an adult observational study (Cousins and Smyth 2003) and (v) an expert panel. The items identified were cross referenced with the ICF (WHO 2001) in order to verify they formed part of the standard language and framework relating to health. Experts and respondents reported that the FDQ-9 was simple to complete and easy to understand and adequately captured the constructs central to dyspraxia/DCD. The discussion will now address the sample populations, findings, limitations, future research requirements and implications.

Sample populations

Four sample groups were employed for this study. Sample groups S1, S2, and S4 were convenience sample groups and might not be representative of an entire population. S3 was a sample group of participants attending a hypermobility clinic.

- Samples S1 and S4 were responding to an email invitation to complete a questionnaire. The questionnaire was titled a 'Health and Activity Questionnaire' and was part of a larger study (the results of which are presented in chapter 5). The 'Health and Activity Questionnaire' took between 10 – 15 minutes to complete.
- Sample 4 consisted of two subgroups; subgroup S4A consisted of participants who reported no musculoskeletal pain and subgroup S4B consisted of participants who reported musculoskeletal pain. Subgroup S4B was not employed in the analysis.
- Sample S2 were those who answered the questionnaire twice, in this group participants were sent the FDQ-9, the inclusion and exclusion criteria and questions related to face validity.
- S3 was recruited by invitation on attendance a hypermobility clinic, they received a paper version of the questionnaire and offered help in filling it out.

The sample groups had a gender bias with only S1 having similar numbers of male and female respondents and there was a sample size variation. Sample groups (S2, S3 and S4) all had more females than males. The lack of male participants may be a limitation of this study as dyspraxia/DCD is thought to be more prevalent in male than female children (Wilson 2005), although there are studies to refute this case (Foulder-Hughes and Cooke 2003; Cairney et al 2005). This might indicate that dyspraxia/DCD is under represented in this study. It was not surprising to find more female participants in S3 (patients with JHS) as hypermobility and JHS are noted to be more prevalent amongst females than males (Al-Rawi et al 1985; Beighton et al 1999; Grahame and Hakim 2004). It is not clear why there were more female responders in S2 and S4 (staff and students from a university). It is suggested it might be related to computer usage as adult females are more likely to engage in surveys and questionnaires while males are more likely to engage in computer games (Li and Kirkup 2007).
To address these limitations future studies are required in randomized samples with equal gender representation.

Sample bias

Surveys and questionnaires are a common method of gaining information in health and social care, but response biases may affect the quality of the data collected and need acknowledging. There are three main reasons for non response to questionnaires sent out either electronically or by paper. This includes; (i) individuals not willing to participate in a study; (ii) the investigator being unable to contact participants and (iii) communication barriers i.e. lack of computers or literacy (Bowling 2005). In this study in relation to willingness to take part it might also be suggested that participants may have been further biased by the topic title a 'Health and Activity Questionnaire'. In relation to contacting participants it was understood that students at the university could elect not to receive surveys and this would affect participant availability. Communication barriers may be of less concern as staff and students at the university and in the international company had access to computers. Participants at a hypermobility clinic all received a paper copy of the questionnaire and were offered assistance to fill in the questionnaire. The inclusion criteria for this study required participants to record success in a national examination and therefore a certain attainment of literacy was part of the inclusion criteria.

Content and face validity

Content validity relies on the adequacy with which the domain has been defined and sampled. In the introduction the definition of dyspraxia/DCD is summarised (Section 4.1) and the sources that were drawn upon for the development of the questionnaire were described thus addressing aspects advocated by Wilkin et al (1992). Content and face validity are aspects of validity which should be considered in the development of an assessment tool but if a test is to be considered valid it must have sufficient reliability. Reliability in this study was considered in relation to the structure of the questionnaire, internal consistency and test-retest reliability.

Structure & Internal consistency

Principal Axis Factoring was employed to explore the structure of the questionnaire. The number of Factors retained was evaluated using four methods. This resulted in a two Factor solution which accounted for 57% of the cumulative variance and related to two theoretical constructs of dyspraxia/DCD; namely gross motor and fine motor activities. Two items cross loaded (5 & 8) (See table 4-9). This was expected as motor skills often require the integration of these domains: For example a complex task such as sewing requires proximal stabilization for the position of the upper limb (gross motor control) ability to manipulate a needle and material (fine motor control) and the planning required for the required needlework (organisation). Although statistically the Factor analysis revealed two factors, in practice these are far from being isolated constructs in motor control and it was considered to make conceptual sense to include all items to form a

single score. This score was the Functional Difficulties Score (FDS).

Internal consistency of a questionnaire relies on combining answers into a single score, and for that score to demonstrate co variation. If a test is to be valid then internal consistency must be high, above 0.9 for ability tests and not below 0.7 (Kline 1999). The value of Cronbach's alpha depends on the number of items in the scale. It is possible to get a large value of alpha if there are lots of items in a scale, but this may not mean the scale is reliable (Cortina 1993). Therefore to ascertain the value of internal consistency the mean correlation between items should also be reported.

Cronbach's alpha for the whole questionnaire was 0.81 the mean correlation between items were 0.51 and no items would improve Cronbach's alpha if deleted indicating acceptable internal consistency.

Test-retest reliability

The objectives of any tool are to reduce measurement errors, and therefore reliability is an important element to be considered. A questionnaire's test-retest reliability relates to the consistency of the phenomenon that is being measured over time. This was analysed in two ways. Initially the ICC was calculated for each of the nine activities, the combined ICC was 0.923 [95% CI 0.877 0.958] which indicated high reliability (George and Mallory 2003) (see table 4-11). The ICC is a better test than a paired *t*-test or correlation because a high ICC can only occur if there is no bias and if the data is in good agreement. It is acknowledged that high ICCs can be inflated by sample heterogeneity Streiner and Norman 1995).

Good test-retest reliability of the FDQ-9 was confirmed by the Bland and Altman (2003) approach which focuses on the basic question of whether repeated measurements would agree sufficiently closely. It was reported that over 95% of the cases were within the limits of agreement and that there was equal divergence (See figure 4-9). In this study the mean differences of the scores was 0.067 [95% CI 0.482 – 0.342] which implies that a person with a test score of 16 might score 15 or 17 on re-testing. A one point difference is not likely to be clinically important.

There is controversy regarding the time interval between tests, because it has been argued that scores may be inflated if subjects remembered their responses. In addition it might be argued that recall of childhood activities may be inaccurate. McKelvie (1991) proposed that test- retest reliability is not inflated due to memory effects. In addition recall of childhood difficulties have been reported in other questionnaires for example the ADC (Kirby et al 2010). It is argued that the effect of recall on responses may be related to association. In this study there was a perfect ICC between the test-retest responses for item 1 (AS A CHILD how good was your handwriting?). This may be because a

significant emphasis is placed on handwriting as a child and so difficulties in relation to this activity are well remembered. In this study there were no notable differences in the ICC scores of items recorded either as a child or as an adult. It is suggested that recalling past difficulties as a child were not a concern in this study.

Reliability in relation to internal consistency and test-retest are essential for the validity of a test (Kline 1999). Construct and concurrent validity are measureable and are now discussed.

Construct validity

Construct validity is explored by evaluating hypotheses and collecting verifiable evidence to support the inference that a measure has meaning (Wilkin et al 1992; Hays et al 1998; Kline 1999). To explore the construct being examined requires an explanation of that construct or concept. As previously discussed (See section 4.1) the concept of dyspraxia/DCD relates to impairments in motor coordination in the absence of a congenital or acquired neurological disorder that occurs in childhood and may continue into adulthood. (All participants who reported a neurological condition were excluded from the study). In this chapter construct validity was explored by employing the known groups method and was initially examined in the S4 sample group. Construct validity was further explored by employing a cut-off score and evaluating hypotheses using the known groups method in S3, S4 and Subgroup S4A of sample 4.

The FDQ-9 distinguished between groups in expected ways – participants reporting coordination difficulties ‘both as a child and as an adult’ scored significantly more highly on the FDQ-9 than those who reported ‘no’ difficulties. The result was statistically significant and there was a clinically important difference. On average participants who reported difficulties ‘both as a child and as an adult’ reported being ‘poor’ in 4/9 items and ‘good’ in 5/9 items. On average participants who reported ‘no’ difficulties did not report being ‘poor‘ in any items instead they reported being ‘good’ or ‘very good’ in all items. Similarly, participants who self reported dyspraxia scored significantly more highly than those who did not self report dyspraxia. There was again a clinically important difference as those who self- reported dyspraxia on average reported being ‘poor’ in 7 items. On average those who did not self-report dyspraxia reported being ‘good’ in all 9 items. It was appreciated that one of the limitations in this study in relation to construct validity was the small number of participants self-reporting dyspraxia. In addition no data was collected on the verification of the self-report of this diagnosis.

Individual items of the FDQ-9, child only scores and adult only scores were examined when a cut-off score FDS 22 was applied (See section 4.6). On average participants with FDS ≥22 reported difficulties both as a child and as an adult while participant with FDS < 22 reported no functional

difficulties. These results indicate between group differences in functional difficulties that are well established in children with dyspraxia/DCD (May Benson et al 2002; Wilson et al 2000) and confirm their continuation into adulthood. This corroborates the work of Cousins and Smyth (2003) and Kirby et al (2008).

Criterion and concurrent validity

Criterion validity is where an existing measure is compared and found to be superior to the criterion measure. There are two types of criterion validity; concurrent and predicative validity. Concurrent validity is applicable to this questionnaire because this is a new tool assessing a condition which has only recently been described in adults. Concurrent validity was considered but was not analysed and is a limitation for this PhD. Concurrent validity is demonstrated if two tests carried out at the same time with the same variable are shown to correlate. Concurrent validity is only useful if there is a good benchmark test. As there are still no good benchmark tests concurrent validity is best regarded as aspects of construct validity (Kline 1999). Construct validity was presented (see 4.5.7; 4.6.3) and has been discussed (see 4.8.6).

Accumulation of evidence relating to validity is a continuous process (Wilkin et al 1992; Hays et al 1998) and future studies are required to address concurrent validity. These could include employing the FDQ-9 in a group of adults in whom data relating to a prior diagnosis of dyspraxia/DCD is known (for example; self-report, interviews). A motor test could then be employed.

It is suggested that the FDQ-9 could be correlated with motor tests in healthy volunteers with no musculoskeletal pain. Of the motor tests commonly in use (MAND McCarron, MABC-2-MT-Henderson and Sugden 2007) and BOT-MP-2 – Bruninks and Bruninks 2005). The latter two have been validated only in adolescents and young adults. These tests assess for current functional or coordination difficulties. They do not assess for historic functional difficulties. Therefore they could not be employed independently to assess the concept of dyspraxia/DCD in adults.

Sensitivity, specificity and cut-off scores

A ROC curve may be employed as a method of assessing whether a particular test provides useful information. In studies of diagnostic accuracy the results form one test are compared with the results of a reference standard and an optimal cut-off for a test may be established. There are several factors which can jeopardize the validity of diagnostic accuracy, to improve the quality of the reporting of diagnostic accuracy it is suggested that researchers cross reference their data with the STARD checklist (Bossuyt et al 2003). This checklist has been employed to verify that the essential elements have been reported on in this chapter (appendix 22). In this chapter the aim of employing

the ROC curve analysis was to determine the sensitivity and specificity of the FDQ-9 to assess for dyspraxia/DCD using self-report dyspraxia as the reference standard.

The area under the curve (AUC) is reported and reflects how good the test is at distinguishing between those with or without the condition. The AUC serves as a measure that is independent of prevalence which summarizes the discriminative ability of a test at different cut-offs (Swetts 1988). In this study the AUC was > 0.9 indicating high accuracy. The sample group (S4) was employed for this analysis in which the scores of the FDQ-9 were compared with participants who self-reported dyspraxia.

Two methods were employed for identifying the optimal cut-off scores of the ROC curve. These included; the point on the curve closest to the (0,1) point that bests balances the sensitivity and specificity and by employing the Youden index. These methods revealed the same cut-off score of FDS 22 which yielded a sensitivity of 86% [95% CI 78% - 92%] and a specificity of 81% [95% CI 73% - 89%].

The recommendations of the APA (1985) are for a test to achieve a sensitivity of 80% and a specificity of 90%. This would indicate that although the FDQ-9 has adequate sensitivity, it does not achieve adequate specificity. However, it is argued that other observational tests and questionnaires employed for identifying dyspraxia/DCD in children also do not achieve the specificity and sensitivity recommendations of the APA (1985) See table 4.1. It is suggested where it is important not to miss a diagnosis and especially in a condition which can be treated a test with a higher sensitivity is needed. If having a test with a high number of false positives would be detrimental then a test with a high specificity is recommended. In relation to the diagnosis of dyspraxia/ DCD which is 'treatable' the cut-off score with sensitivity around 80% would be appropriate whilst acknowledging the limitations of specificity.

In the results of this paper the positive predictive value (PPV) and the negative predictive value (NPV) of the diagnostic measure were presented. The PPV is the proportion of individuals that were identified with a positive test who have dyspraxia/DCD in this case 18% [95% CI 10%-26%]. The NPV is the proportion of individuals with a negative test result who do not have dyspraxia/DCD in this case 99% [95% CI 91% - 100%]. The PPV is lower in a population with a low prevalence and higher in a population with a higher prevalence. The converse will be true for the NPV. The likelihood ratio for a positive result is the ratio of the chance that a participant would have dyspraxia/DCD if they have a positive result compared with if they do not have the condition. In this study the likelihood ratio was high which suggests this test provides useful information in relation to the reference standard (Petrie and Sabin 2005). The limitation of the diagnostic accuracy of the

ROC curve was in relation to the reference standard which was self-report dyspraxia. This was because no data had been collected which verified how or when this assessment had been made.

Dyspraxia, dyslexia and ADHD

Self report dyspraxia, dyslexia and ADHD were recorded in sample groups S1; S3 and S4 . ADHD and dyslexia were reported by one participant from S1. Dyslexia and dyspraxia were reported in S4 but ADHD was not. It was only in S3 (patients with JHS) that dyspraxia, dyslexia and ADHD were reported. In S3 there was a trend for a higher percentage of participants to report dyspraxia, dyslexia and ADHD than in the other sample groups. This overlap maybe important in furthering our understanding of the neurophysiological nature of JHS. There is evidence of DCD/dyspraxia overlapping with dyslexia and ADHD in children (Kadesjo and Gillberg 1998; Kaplan et al 1998; Pitcher et al 2003). The overlap between dyspraxia and dyslexia has been explored in adults (Kirby et al 2008).

Percentages of participants who reported functional difficulties as a child and as an adult

In section 4.7.data was presented relating to the numbers of participants presenting with FDS ≥ 22. On average participants scoring FDS ≥ 22 were those who reported functional difficulties both as a child and as an adult. On average participants scoring FDS <22 reported no functional difficulties. The percentage of those from each sample group recording a FDS ≥ 22 is discussed in relation to the percentage estimations of dyspraxia/DCD. At this cut-off it should be acknowledged that there are limitations in the sensitivity 86% [95% CI 78% - 94%] and in particular specificity 81% [95% CI 73% - 89%].

The sample sizes in this study were small and in particular the number of male participants in each sample group and therefore the results should be considered within these limitations.

The percentage of participants recording an FDS ≥22 ranged from 4% - 56% across the four sample groups. The two groups in which there were a higher percentage of participants with an FDS ≥22 were those in which participants' recorded musculoskeletal pain. This trend was also noted in the percentage of participants who self-reported dyspraxia (See table 4-17).

The percentage of participants who self-reported dyspraxia/DCD was lower than that reported employing an FDS ≥22. This may in part be related to a sensitivity of 86% resulting in a number of false negatives. Alternatively it may be as a result of the inaccuracy of the reference standard self-report dyspraxia. Or it may be because a diagnosis of dyspraxia/DCD has only been available more recently and is generally diagnosed in the first decade of life (Polatajko et al 1995; Henderson and

Sugden 1992). This would mean that those born before the 1990's would have had less chance of being diagnosed with the condition. In addition Kirby et al (2008) noted in their study that girls were less likely to have received professional help for dyspraxia in their early years than boys. Kirby et al (2008) suggested that this might be because gross motor skill impairments were not noticed in school aged girls as these skill impairments did not affect academic performance. It is acknowledged that boys are referred for intervention more frequently than girls (Missiuna 1994) and this is probably because they have fine motor difficulties which affect their academic performance. Poor handwriting and fine motor control difficulties are the commonest reasons for referral to paediatric services for children with DCD (Losse t al 1991; Barnett 1994; Smits-Engelsman et al 2003; Polatajko and Cantin 2006). This suggests that many girls are not being identified and given appropriate support in their early life. This is an area that requires further investigation.

There are no comparable adult studies with which to compare these results but it is useful to compare these findings with previous studies involving children in order to add context and to understand the results of this study.

As previously acknowledged (See chapter 2 table 2-1) the prevalence of dyspraxia/DCD in children are reported to be between 1.6% - 34% (Keogh 1968; Wright and Sugden 1996; Kadjesjo and Gillberg 1999; Larkin and Cermak 2002; Foulder-Hughes and Cooke 2003; Kourtessis et al 2008; Piek et al 2008; Piek et al 2009; Loh et al 2009). Estimations of persistence of coordination difficulties into adolescence and adulthood reportedly vary from 30%-80% (Knuckey and Gubbay 1983; Geuze and B€oorger 1993; Losse et al 1991; Cantell et al 1994) (see chapter 2 section 2.4). Thus prevalence estimations of dyspraxia/DCD based on the prevalence rates previously acknowledged in adulthood may range from 0.5% to 27.2%.

The percentage of sample groups S1, S2 and S4 reporting FDS ≥22 lie within this estimation 0.5% - 27.2% with S4 at the higher end of the estimation. The percentage of sample group S3 (patients with JHS) reporting FDS ≥22 lies outside this estimation. This is examined further in chapter 5.

4.9 Exploring the potential use of the FDQ-9 in clinical practice

One of the aims of developing this questionnaire was to explore the possibility of employing the FDQ-9 in clinical practice. Participants could complete the questionnaire prior to their examination with a clinician and the clinician could review the scores to identify functional difficulties and in particular persistence of functional difficulties.

It is anticipated that in clinical practice the FDQ-9 would be used as a screening tool to identify specific functional difficulties which would guide intervention. A review of the total scores is seen in table 4-19. A guide to the implications and interventions are also presented (See table 4-20).

Table 4-19 Total scores of the FDQ-9, indications and clinical plan.

Scores	Indication	Clinical plan
< 22	Indicates a few or no functional difficulties	Recognition of possible functional difficulties. Further assessment to determine current functional difficulties identified by the questionnaire
≥22	Indicates a number of functional difficulties	Recognition of the long term nature of the functional difficulties. Further tests needed to assess for current functional difficulties identified by the questionnaire.

Table 4-20 Potential application of the FDQ-9 in practice, a guide to the implications and interventions.

FDQ-9 Items	Implications	Interventions
Q1 As a child how good was your handwriting Q9 As an adult how good is your handwriting now?	Difficulties reported for both questions is indicative of the long term nature of the functional difficulties. Difficulties with handwriting may be as a result of impaired coordination and biomechanical dysfunction, which may contribute to pain, recurrent dislocations and impaired function	Further screening of motor control and functional activities relating to the upper limb. Advice regarding functional impairments i.e.the use of pen holds. Referral to hand therapy team for assessment
Q2 As a child were you good at team games that involved balls? i.e. football, netball, basketball	Difficulties with ball skills and visual spatial awareness. Difficulties with eye hand and eye foot coordination. This may indicate long term reduced physical activity participation	Assess gross motor function Assess current physical activity participation. Ascertain types of physical activity preferred
Q3 As a child how did others rate your coordination	Indicative of the long term nature of the difficulties	Assessment of gross and fine motor function
Q4 As an adult how good are you at avoiding obstacles, like bumping into doors	Difficulties are likely to be as a result of impaired visual spatial awareness	Assessment of eye tracking, and the integration with neck, trunk and limb movements
Q5 As an adult how good are you at organizing yourself? i.e. getting ready for work or for a meeting	Difficulties with organisation may impact on an individual's ability to engage fully in a treatment or exercise program Difficulties of organisation may impact on the ability to pace activity	Awareness of difficulties with planning, organisation and pacing. Support, encouragement and advice required for activity engagement and pacing
Q6 As an adult how good are you at catching a ball one handed	Difficulties highlight eye hand coordination	Assessment of eye hand coordination eye foot coordination. Integration of eye tracking strategies
Q7 As an adult how good are you at balancing on a bike, in a bus or train or skis?	Difficulties highlight impaired dynamic balance Impaired balance and possible risk of falling	Balance assessment to include dynamic, static and balance associated with multi tasking Proprioceptive assessment where appropriate Assessment for integrated eye, neck and spinal movements Vestibular assessment
Q8 As an adult how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?	Difficulties highlight impairments with multitasking Global difficulties in relation to gross and fine motor tasks	Assessment of gross and fine motor difficulties combined with core and either upper quadrant or lower quadrant stability.

It is anticipated that the FDQ-9 should be employed as a screening tool and that where a high score is achieved this would suggest that a person has more functional difficulties than his or her peers. This could then be recorded by a clinician using the following terms.

> *'Participant X reported a score of FDS 22 which indicates several functional difficulties. Difficulties were noted for items 2, 4, 5 and 6. These are indicative of difficulties with ball skills, eye hand coordination, visual spatial awareness, planning and organisation.'*

It may be useful in some cases for clinicians to explore these motor difficulties further, in order to identify relevant treatment programs. Motor difficulties and the mechanisms of motor skill impairments are aspects which are introduced in the undergraduate curriculums for physiotherapists and occupational therapists. These are aspects with which health professionals are familiar. Health professionals may wish to employ physical motor assessment tests for example the MABC-MT-2 and the BOTMP-2 (Henderson and Sugden 2007; Bruninks and Bruninks 2005) which have been normed for young adults. However motor tests have limited use in those with musculoskeletal pain.

It is appreciated that shorter questionnaires with simple scoring systems are easier to use in practice and are less burdensome to administer. The questionnaires currently employed for the diagnosis of dyspraxia/DCD range from 15 – 40 questions. This questionnaire consists of nine questions. It could be argued that a shorter questionnaire could be achieved, for example the DCDQ'07 (validated in children from 5-15 years) identified 3 factors that contributed to 79% of the variance these were; motor control during movement; fine motor and handwriting and general coordination (Wilson et al 2009). An appropriately worded questionnaire might be able to capture these three themes in less than nine questions.

4.10 Conclusion

This chapter described the development and initial validation of the FDQ-9. The findings indicate satisfactory face validity, content validity, internal consistency and test-retest reliability (See 4.5.3, 4.5.6 and 4.5.8). As there was no benchmark test to assess for dyspraxia/DCD in adults at the time of the study concurrent validity was discussed but not analysed and this is a limitation (See 4.6.2). Where there is no benchmark test it is important to collect evidence that infers a measure has meaning (Kline 1999). Construct validity was used to explore that inference by employing the known groups method (See 4.5.7 and 4.6.3). It was noted that the FDQ-9 distinguished between those with no functional difficulties and those reporting difficulties both as a child and as an adult.

Diagnostic accuracy of the test was employed to determine the sensitivity and specificity of a cut-off score using self-report dyspraxia as a reference standard.

The potential use of the FDQ-9 in clinical practice was described in relation to the total scores and for each item (See 4.9).

Further studies are required to address the limitations of the FDQ-9 and to address limitations in relation to test-retest reliability and validity in particular concurrent validity in different samples. The questionnaire will also require auditing in clinical practice to assess its usefulness.

In the light of the limitations presented, the FDQ-9 will be employed in the second part of this study to assess for functional difficulties rather than dyspraxia/DCD. In chapter five the total FDS will be employed; higher scores are taken to indicate the reporting of more functional difficulties. In addition, between group comparisons will be analysed by employing a cut-off score FDS 22. The inference will be that on average participants with FDS ≥22 report functional difficulties in both in childhood and adulthood and on average participants with FDS <22 do not report functional difficulties.

Chapter 5

5 RESULTS: REPORTING ON THE MULTIFACTORIAL MANIFESTATIONS OF JHS

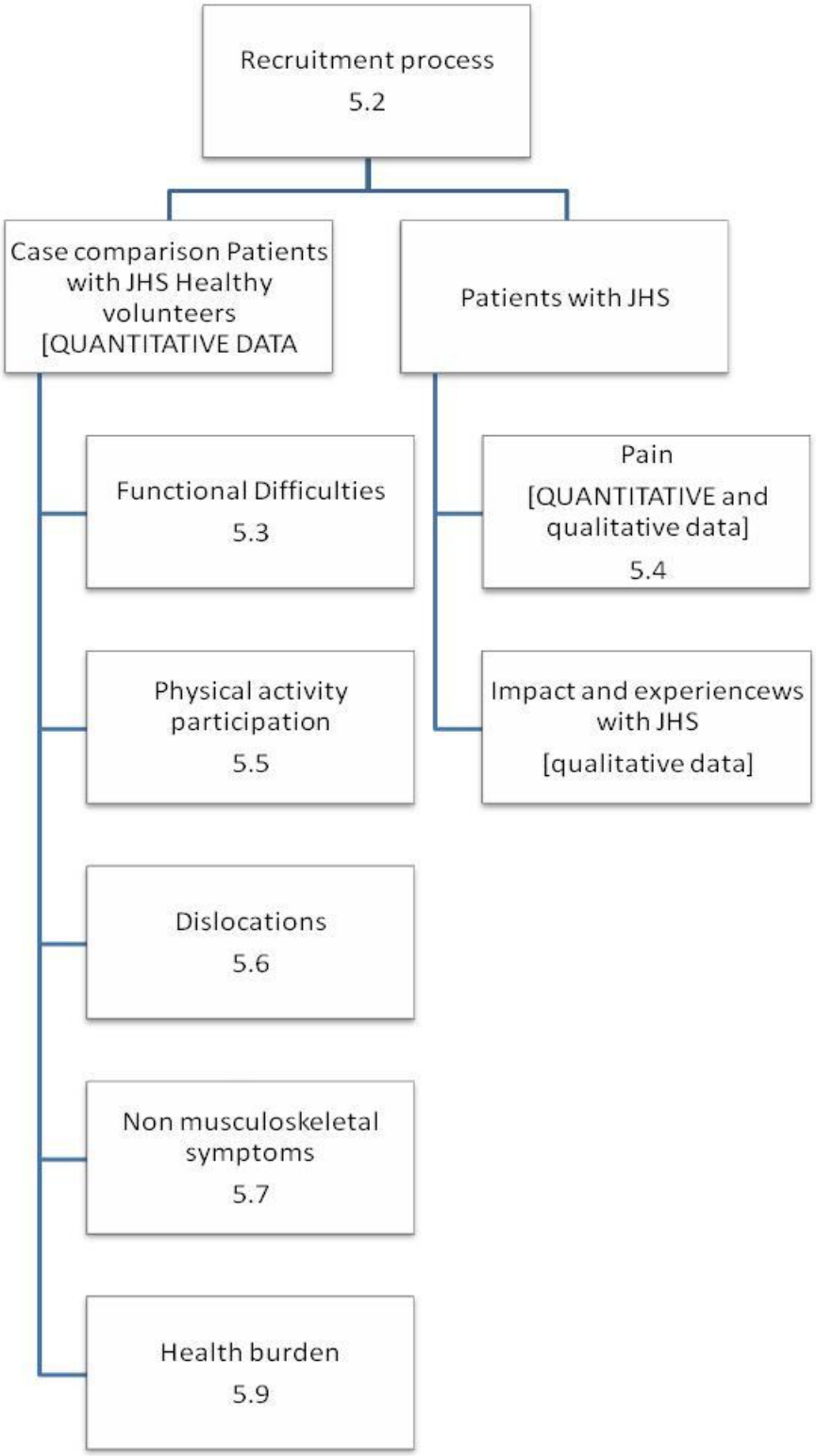
5.1 Introduction

This chapter focuses on the results of the case comparison part of the study aimed at exploring the multifactorial manifestations of JHS and their impact on quality of life. A comparison is made between two groups, referred to in chapter 4 as sample 3 and subgroup S4A of sample 4. Sample 3 were a group of patients with JHS recruited from a hypermobility clinic and will be referred to as 'patients with JHS'. Subgroup S4A of sample 4A was a subgroup of staff and students from a university who reported no musculoskeletal pain or JHS and will be referred to as 'healthy volunteers'. The focus of this chapter was on the reduction, display and analysis of both the quantitative and qualitative data.

This chapter is divided into the following nine sections. In the first section there is a description of the recruitment process for the patients with JHS and the healthy volunteers. Demographic data for the two groups are described and compared in relation to matching the two groups (See 5.2). In the next section the data analysis relates to exploring the reporting of functional difficulties between the two groups (See 5.3). Quantitative and qualitative data only from patients with JHS are employed in the analyses related to the reporting of musculoskeletal pain. (See 5.4). The combined data from patients with JHS and healthy volunteers are compared as physical activity participation is explored in association with the reporting of functional difficulties (See 5.5). Data relating to both groups are used to compare the reporting of dislocations and subluxations (See 5.6). Comparisons are made between patients with JHS and healthy volunteers and the reporting of symptoms and conditions previously recognised in those with JHS (See 5.7). Qualitative data relating only to patients with JHS are displayed and analysed and relates to the nature of the condition and experiences reported by patients with JHS (See 5.8). Quantitative data relating to the SF-12 medical outcomes questionnaire are described and compared between patients with JHS and healthy volunteers (See 5.9).

A summary of the mixed methods data analysis may be viewed (See figure 5-1). In the final section of this chapter there is a brief revision of the key results and findings (See 5.10).

Figure 5-1 Summary of the mixed methods analysis and data presentation for this chapter

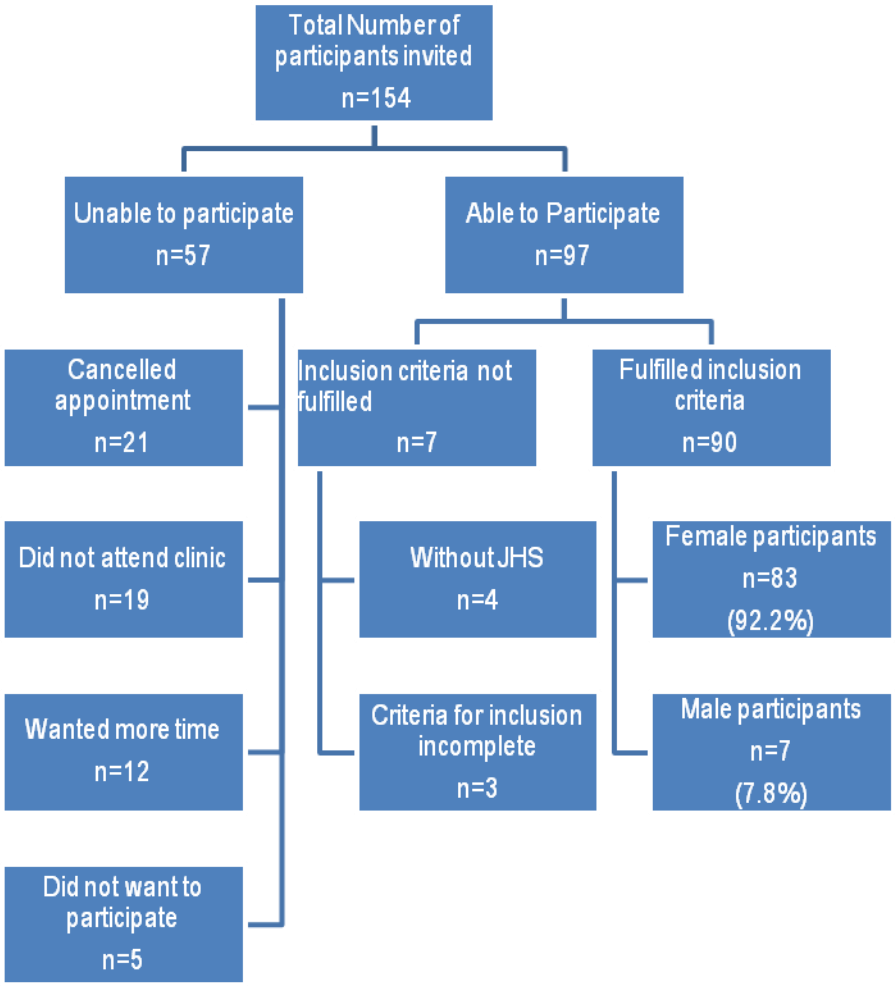


5.2 Matching data for the case comparison aspect of the study

In this part of the study there were two groups; patients with JHS and healthy volunteers. Patients with JHS were patients from a hypermobility clinic attending a London teaching hospital with a diagnosis of JHS. Healthy volunteers were staff and students of a university without a diagnosis of JHS or musculoskeletal pain .

Data was gathered from patients with JHS in a hypermobility clinic between May and July 2009 and loaded into SPSS v 16 and word documents and analysed. A flow diagram illustrates the recruitment process for patients with JHS (See figure 5-2).

Figure 5-2 A flow diagram demonstrating the recruitment of patients with JHS

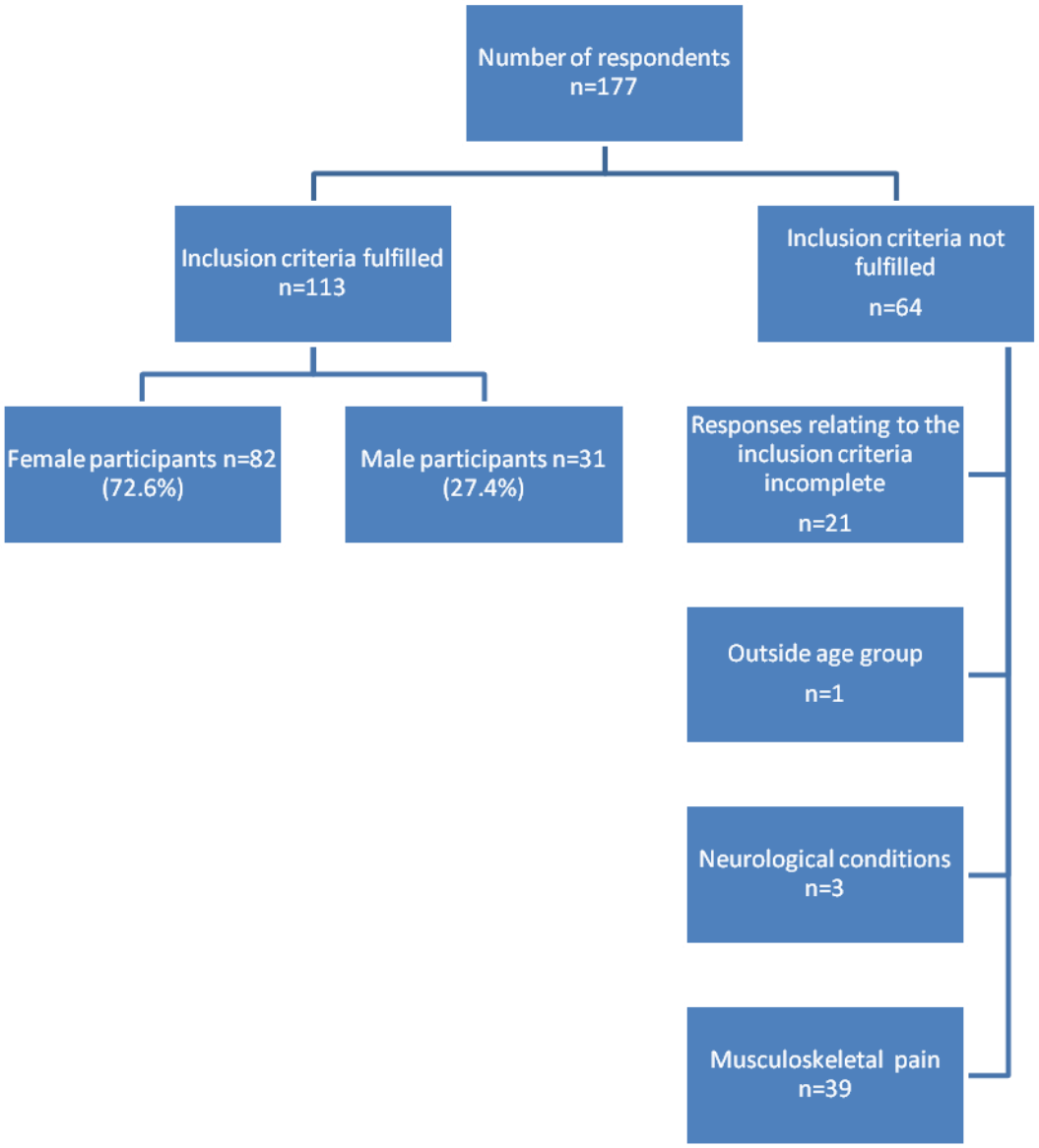


A total of 154 potential attendees for a hypermobility clinic were sent a letter inviting them to participate in the study, 97 participants completed the questionnaire, seven did not fulfill the

inclusion criteria, leaving 90 participants of whom seven (8%) were male and 83 (92%) were female.

Data for the comparison group was collected in May 2010. The comparison group consisted of healthy volunteers from a university setting. A flow diagram illustrates the recruitment process for the healthy volunteers (See figure 5-3).

Figure 5-3 A flow diagram to illustrating the recruitment of healthy volunteers



There were 177 responses received from a survey monkey (www.surveymonkey.com) questionnaire sent out with a link from an email invitation. A total of 64 were excluded because they did not fulfill the inclusion criteria. A total of 113 volunteers fulfilled the inclusion criteria of whom 31(27%) were male and 82 (72%) were female.

It was not possible to match the data from the patients at the hypermobility clinic with the healthy volunteers from a university. To achieve an age and sex match required a larger population than had been anticipated. It might be suggested that matching for age is a limitation in this study, but may not adversely affect the results as JHS is an inherited condition (Hakim et al 2003) and therefore age may not be considered a risk factor as it is in some other acquired conditions.

Conversely sex may be considered to be more important with regard to matching as patients with JHS tend to be predominantly female (Grahame and Hakim 2004). All participants were required to report some form of educational qualification as part of the inclusion into the study (See 3.3.2.11). As this was a study with many variables it was decided to continue with an unmatched control group and adjust within the analysis for age and sex using regression. This is a solution which has been previously suggested (Bland and Altman 1997a).

5.2.1 Data analysis and demographic data

Data analysis was undertaken using SPSS version 16, critical P was set at 0.05. Missing data were reported alongside relevant analyses. Demographic data in relation to sex, age and education were reported. Independent samples *t*-tests were employed to analyse between group comparisons of numerical data. It is suggested that sample sizes for which non normality can be ignored is 50+ (Band 2000). Ruxton (2006) suggests employing Levene's test unless the sample sizes are equal. Therefore Levene's test was employed and where group sizes were <50 a Mann-Whitney U test was reported to confirm the result. Multiple and logistic regression analyses were employed to identify explanatory variables associated with dependent variables and to determine the extent of the associations. Indications of the goodness of fit to the model were presented with each analysis. Pearson's chi square was employed to test associations between categorical data and the odds ratios were calculated. Relative risk was also reported where percentage outcomes were more than 10% this was because odds ratios may exaggerate occurrence (Grimes and Schulz 2008). The qualitative data were sometimes described alongside the quantitative data in order to add context.

Data relating to the mean ages for the participants in the two groups were described. In this instance Levene's test was significant indicating there were unequal variances. Therefore the unequal variance *t*-test was used to analyse the mean age differences between patients with JHS (n=90) and healthy volunteers (n=113).

Data relating to the mean ages of males and females in the two groups were described. Data relating to the mean ages of the female group of patients with JHS were positively skewed. Data for the female healthy volunteers were normally distributed these can be viewed in figures 5-4 and 5-5.

Figure 5-4 Graph to show the age distribution in years amongst female patients with JHS (n=83)

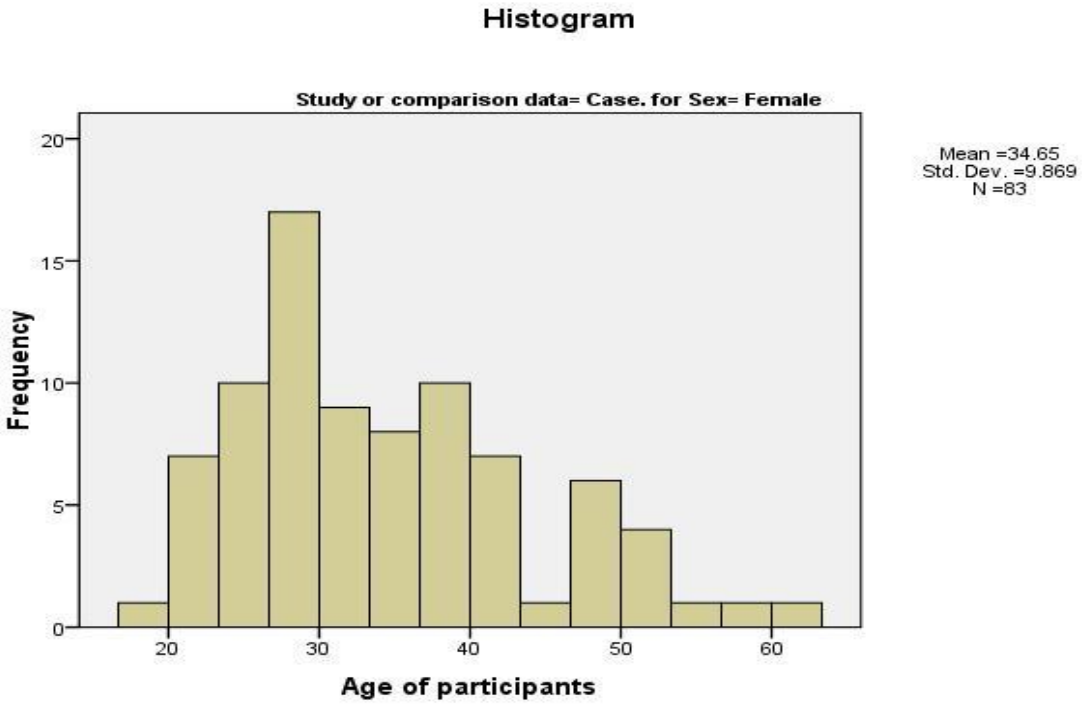
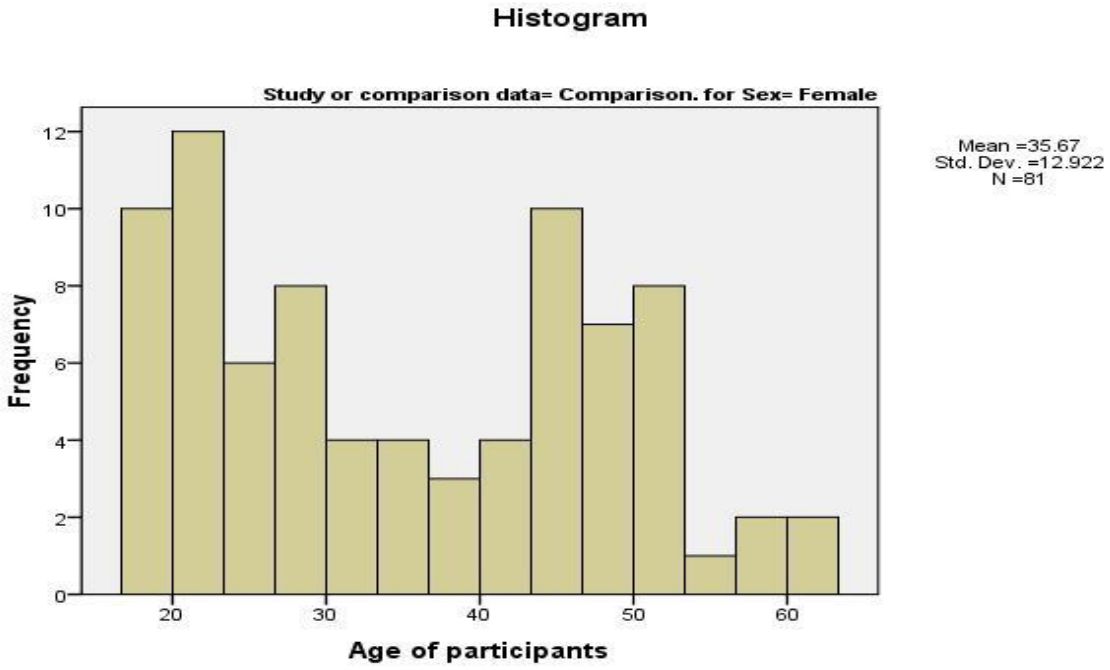


Figure 5-5 Graph to show the age distribution in years amongst female healthy volunteers (n=82)



The male group sizes were both below 50. The mean age scores were described by employing an independent samples *t*-test and the Mann-Whitney U test was used to compare the differences. Data relating to the mean ages between the groups were presented (See table 5-1).

Table 5-1 Mean ages in years, for males and females for patients with JHS (n=90), healthy volunteers (n= 113)

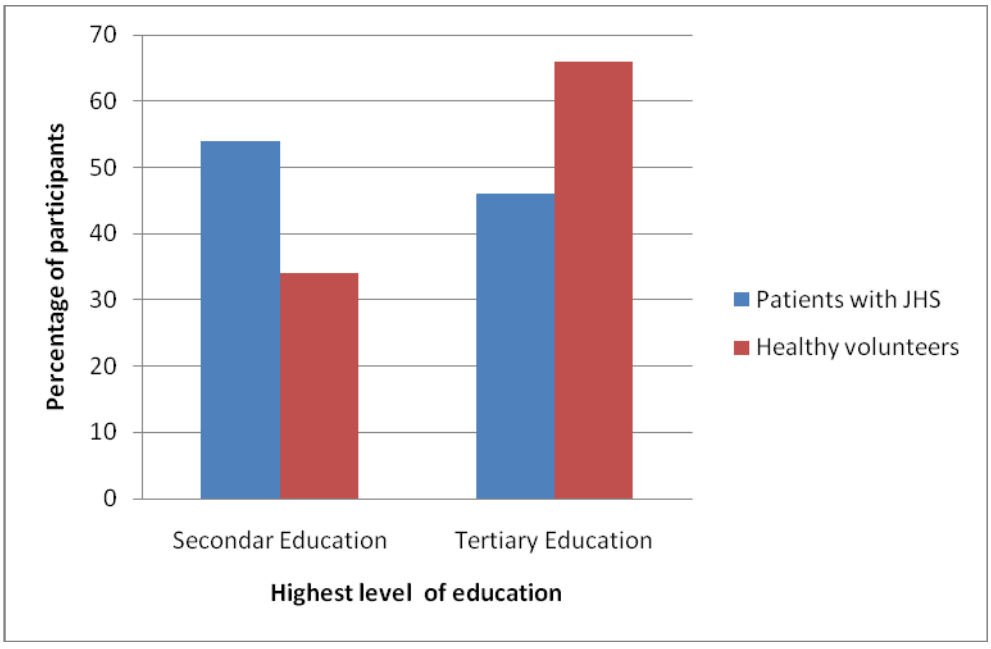
Groups	Mean Age (years)	SE	Difference in the mean ages (years)	95% CI of the difference of the mean	*p* (two tailed)
Male and female age with both groups Unequal variance *t*-test					
Patients with JHS n=90	33.96	1.048	-1.770	-4.979 – 1.439	0.278
HV n = 113	35.73	1.245			
Female age within the groups Unequal variance *t*-test					
Patients with JHS n=83	34.65	1.083	-1.166	-4.705 – 2.372	0.516
HV n = 82	35.82	1.426			
Male age within the groups Mann-Whitney U test					
Patients with JHS n= 7	25.71	2.625	9.770	-17.441 to – 2.098	0.145
HV n = 31	35.48	2.565			

The mean age in years of patients with JHS (M33.96 SD 9.939) was lower than the mean age in years of healthy volunteers (M35.73 SD 13.239). Levene's test, $p < 0.05$, therefore equal variances were not assumed, t (200.346) = -1.088, $p > 0.05$. This was not a statistically significant result. The mean age in years of female patients with JHS (M34.65 SD 9.869) were lower than the mean age in years of female healthy volunteers (M35.82 SD 12.914). Levene's test, $p < 0.05$ therefore equal variances were not assumed, t (151.589) = - 0.651, $p > 0.05$. This was not a statistically significant result. The mean age in years of male patients with JHS (M25.71 SD 6.945) was lower than the mean age in years of male healthy volunteers (M35.48 SD14.283). The Mann-Whitney U test was employed to analyse the difference, U = 69.000, p = 0.145 (two tailed). This was not a statistically significant result. These results indicated there was no statistically significant difference in the ages between the whole groups or when the groups were divided into male and female participants.

5.2.2 Education

Data on the highest level of educational achievement were collected from the questionnaire using mile stones in public exams in secondary and tertiary education. Data were sub divided into categorical data relating to secondary and tertiary education and was presented (See figure 5-6). The Mann-Whitney U test was employed to compare the median scores of the highest level of educational achievement.

Figure 5-6 Educational achievement for patients with JHS (n=90) and healthy volunteers (n=113)



The graph shows 54% of patients with JHS reported their highest level educational achievement was in secondary education. In contrast 66% of healthy volunteers reported their highest educational achievement in tertiary education. A comparison of the median scores showed that on average patients with JHS (*Median* 0.46, SE 0.053) were significantly more likely to have a secondary education as their highest academic qualification than healthy volunteers (*Median* 0.65, SE 0.045), $U = 4071.50$, $p = 0$ .005. This indicated there were statistically significant differences in educational achievement for patients with JHS and healthy volunteers.

5.2.3 Controlling for age, sex, education or group membership

In this next section the Functional Difficulties Score (FDS) which was derived from adding up the scores of the Functional Difficulties Questionnaire (FDQ-9) was employed to control for age, sex, education and/or group membership (healthy volunteers and patients with JHS). The functional difficulties score (FDS) has a range from 9 – 36. It has previously been described (See 4.4.4) and will continue to be referred to in this chapter as the FDS.

It was appreciated that the two groups were not age and gender matched. To control for this a multiple regression analysis was carried out to establish if age and gender were associated with significant changes in the FDS. In addition education and group membership (patients with JHS and/or healthy volunteers) were included in the regression analysis to explore the relationship of these factors with the FDS. The FDS was employed in the analysis as this was important for answering one of the research questions which was to explore the association between the presence of functional difficulties in patients with JHS and healthy volunteers. This data is presented (See table 5-2)

The explanatory variables for this model were age, sex, education and group membership. Age was in years. Sex was divided into the dichotomous variables of females (0) and males (1). Education was divided into the dichotomous variables of secondary education (0) and tertiary education (1). Group membership was divided into the dichotomous variables of patients with JHS (0) and HV (1). The method of regression employed was forced entry, and the combined sample size of the two groups was 203.

Table 5-2 Multiple linear regression analysis to investigate the relationship between the functional difficulties score (FDS) of the functional difficulties questionnaire (FDQ-9) and a number of explanatory variables in patients with JHS and healthy volunteers (n= 203).

	Unstandardised coefficients				95% CI	
	B	**SE**	**t**	***p***	**lower**	**upper**
Age	0.016	0.027	0.600	0.549	-0.037	0.069
Gender	-1.257	0.800	-1.573	0.117	-2.834	0.316
Education	0.191	0.655	0.292	0.771	-1.101	1.483
Group membership (Patients with JHS & Healthy volunteers)	- 4.124	0.640	-6.446	0.001*	-5.385	-2.862

The explanatory variables were [Gender; 0 = female, 1 = male, Group membership; 0 = Patients with JHS, 1 = HV, Education; 0 = secondary education, 1 = tertiary education] *$p < 0.001$

The variance inflation factor (VIF) values were close to 1 and the VIF averages were not substantially greater than 1. Tolerance was well above 0.2, these co linearity statistics confirmed that co linearity was not a problem in this model and there was no biasing of the regression model. The value of R^2 was 0.214 which indicated that 21.4% of the variance was explained by the model. It is acknowledged that there were differences in the percentages of males and females between the two groups which might have a confounding effect nevertheless the only explanatory variable which had a significant effect on the dependent variable was group membership in this regression model.

Group membership was a significant predictor of the FDS, $p < 0.001$. This indicated that those in the healthy volunteer group scored -4.124 [95% CI -5.553 to -2.883] points lower than patients with JHS. This indicated that healthy volunteers had a lower FDS and therefore fewer reported functional difficulties.

5.2.4 Summary related to data matching and the continuing analysis

In this study it was not possible to achieve a combined age, gender and education match between patients with JHS and healthy volunteers. It was demonstrated that there were no statistically significant differences in the mean ages of the females or males between the two groups or the mean ages when the groups were combined. There were significant differences in the median scores in relation to education between the two groups. It was therefore decided to establish if age, sex, education and group membership (patient with JHS or healthy volunteers) would be associated with changes in the FDS. This was important for the research questions. The results of the multiple regression analysis indicated that the only statistically significant association between the dependent variable and the explanatory variables were group membership. The results showed healthy volunteers reported lower FDS than patients with JHS. This chapter continues by exploring this association.

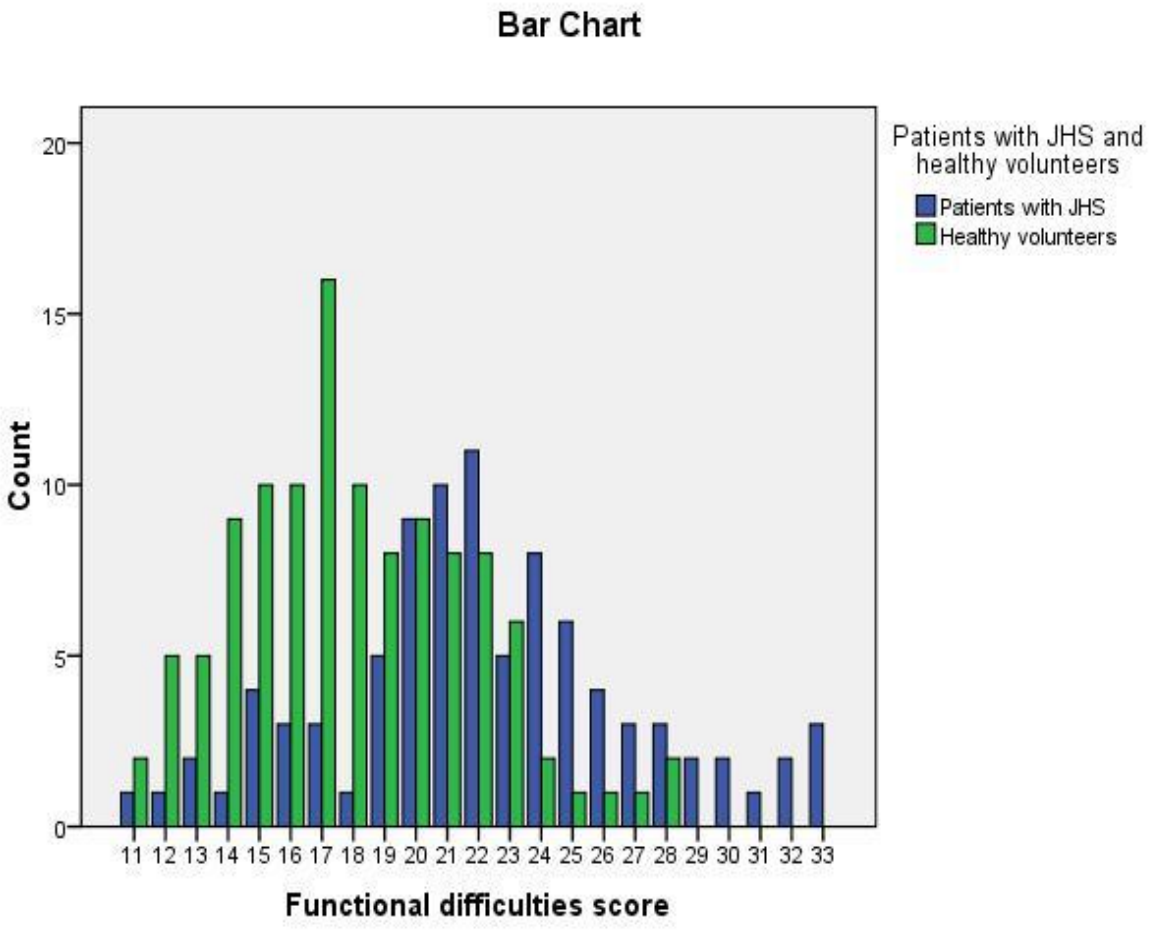
5.3 Investigating differences in the functional difficulties reported between patients with JHS and healthy volunteers

The aim of this next section was to explore the association between functional difficulties in patients with JHS. The reason for studying this association was to explore if patients with JHS reported functional difficulties and if they reported functional difficulties both in adulthood and childhood. It is suggested that functional difficulties as a result of impaired motor coordination may contribute to biomechanical dysfunction which manifests as musculoskeletal pain (See section 1.4). Functional difficulties were explored through four hypotheses.

5.3.1 Describing and comparing the FDS for patients with JHS and healthy volunteers

The following bar chart (See figure 5-7) is presented in order to view and report on the FDS of patients with JHS and healthy volunteers.

Figure 5-7 Bar chart showing the continuous results of the functional difficulties scores for patients with JHS (n=90) and healthy volunteers (n=113)



The bar chart demonstrated the normal distribution of the FDS reported by patients with JHS and healthy volunteers. FDS ranged from 11 – 28 for healthy volunteers and from 11 – 33 for patients with JHS. FDS of 11 broadly indicated a participant reporting being 'very good' at 7/9 items and 'good' at 2/9 items. FDS of 33 broadly indicated a participant reporting being 'very poor' at 6/9 items and 'poor' at 3/9 items. There was a trend for patients with JHS to report higher scores than healthy volunteers. To investigate this observation the following hypothesis was proposed

Null hypothesis 1: Patients with JHS are no more likely to report functional difficulties than healthy volunteers.

Descriptive data is presented and there is a comparison of the mean FDS between patients with JHS (n=90) and healthy volunteers (n=113) (See table 5-3).

Table 5-3 Comparison of the mean FDS, SE, 95% CI of patients with JHS (n=90) and healthy volunteers (n=113). The mean difference, 95% CI of the mean difference

Participants (n)	Mean FDS	SD	95% CI	Mean difference	*p* (two tailed)	95% CI of the mean difference
Patients with JHS (n=90)	22.28	4.897	21.25 – 23.30	4.32	0.001*	3.111 – 5.497
Healthy volunteers (n=113)	17.96	3.734	17.28 – 18.67			

*$p < 0.001$

Data for the FDS for the two groups were normally distributed. Levene's test, $p > 0.05$ indicating the variances were roughly equal therefore the equal variances *t*-test was employed to explore the difference in the mean FDS of the two groups. The mean FDS of patients with JHS (M = 22.28 SD 4.897) were significantly higher than the mean FDS of healthy volunteers (M =17.96 SD 3.734), t (201) = 7.113, $p < 0.001$ (two tailed). This indicated that patients with JHS reported higher FDS than healthy volunteers. This would indicate that on average patients with JHS reported FDS 22.28 [95%CI 21.27 – 23.29] and would broadly report being 'poor' in 4/9 items and 'good' in 5/9 items. On average healthy volunteers reported a score of 17.96 [95%CI 17.28 – 18.64] and would broadly report being 'good' at 9/9 items.

To assess the relationship between the functional difficulties reported by patients with JHS the data was explored employing the cut-off score FDS22. This cut-off score was previously discussed (See 4.6.1 and 4.6.3). A score of ≥FDS 22 inferred that on average participants reported functional difficulties both in childhood and adulthood and a score of FDS <22 inferred that participants on average reported no functional difficulties. The results of this analysis are presented (See table 5-4).

Table 5-4 Comparison of the proportion of those reporting FDS ≥ 22 in the patient with JHS (n = 90) and healthy volunteer (n = 113) groups

Groups	FDS ≥ 22	FDS < 22	Chi square	*p* (2-sided)	Odds ratio [95% CI]
Patients with JHS (n=90) (% within group)	50 (56%)	40 (44%)	30.111	0.001*	5.476 [2.915 – 10.288]
Healthy volunteers (n=113) (% within group	21 (19%)	92 (81%)			

*p <0.001

This indicated the odds of participants reporting an FDS ≥ 22 was 6 [95% 2.9 – 10.3] times greater for patients with JHS than for healthy volunteers. From this contingency table relative risk was also

calculated. Risk refers to the increased (or decreased) risk of a factor of a condition (FDS ≥ 22) being associated with the condition of interest (JHS). It was decided to present the data in relation to 'relative risk' as well as odds ratios. This was because odds ratios tend to exaggerate the probability of a condition if the condition being investigated is above 10% which was the case in this analysis (Grimes and Schulz 2008). There was a 3 times greater probability [95% CI 2.0 - 4.6] of FDS ≥ 22 being reported by patients with JHS than healthy volunteers. This would indicate that patients with JHS were more likely to report average scores indicative of functional difficulties both in childhood and adulthood than healthy volunteers.

Patients with JHS reported statistically significant higher functional difficulty scores than healthy volunteers. In addition there were significantly more patients with JHS who reported an FDS ≥ 22 than healthy volunteers therefore there was evidence to reject the first null hypothesis. The mean difference in scores is likely to be clinically significant. The mean scores reported by the healthy volunteers equated to participants reporting being 'good' in 9/9 items of the FDQ-9. The mean scores of patients with JHS equated to participants reporting being 'poor' in 4/9 items and 'good' in 5/9 items.

5.3.2 Between group differences in functional difficulties

The aim of this next section was to explore the differences between patients with JHS and healthy volunteers in relation to the types of functional difficulties they reported.

Children with functional difficulties associated with dyspraxia/DCD may report functional difficulties that can be classified under the broad terms of fine motor, gross motor or mixed difficulties (Chamber et al 2005). In the Exploratory Factor Analysis reported in the previous chapter (See 4.5.5) two factors emerged which broadly related to gross motor difficulties and fine motor difficulties and organisation. It was decided to investigate if there was a difference in the motor difficulties reported between patients with JHS and healthy volunteers. This was to be explored in two ways. The first was to ascertain if there was a difference in the mean FDS between patients with JHS and healthy volunteers relating specifically to gross motor difficulties and fine motor difficulties. The second was to explore if there were any differences between patients with JHS and healthy volunteers for each of the nine items recorded in the FDQ-9. For this analysis it was decided to compare the differences in the proportions of the two groups who reported being 'poor' or 'very poor' at an item.

Null hypothesis 2: Patients with JHS are no more likely to report functional difficulties related to gross motor function than healthy volunteers

Null hypothesis 3 Patients with JHS are no more likely to report functional difficulties related to fine motor function and organisation than healthy volunteers

Gross motor difficulties included items; 2 Child games; 3 Child coordination; 4 Adult obstacles; 6 Adult ball games and , 7 Adult balance. Fine motor difficulties and organisation included items; 1 Child hand writing; 9 Adult hand writing; 5 Adult organisation and 8 Adult DIY. A comparison of the mean, SD, FDS and 95% CI for gross motor difficulties and fine motor difficulties with organisation for patients with JHS and healthy volunteers is reported. Gross motor scores ranged from 5 – 20 a score of 10 or less indicated participants reporting 'good' or 'very good' at each item. Fine motor and organisation scores ranged from 4 -16 a score of 8 or less indicated participants reporting being 'good' or 'very good ' at each item.

Table 5-5 Describing and comparing the mean gross motor and fine motor and organisation difficulties scores of the FDQ-9, [95% CI] and SD for patients with JHS (n=90) and HV (n=113)

Motor difficulties	Groups	Mean scores	SD	*p* (two-tailed)	95% CI
Gross motor difficulties 2 Child games; 3 Child coordination; 4 Adult obstacles; 6 Adult ball games ; 7 Adult balance	Patients with JHS (n=90)	13.31	3.521	0.001*	12.57 – 14.05
	Healthy volunteers (n=113)	10.27	2.579		9.76 – 10.79
Fine motor difficulties 1 Child hand writing;, 9 Adult hand writing; 5 Adult organisation 8 Adult DIY	Patients with JHS (n-90)	8.82	2.475	0.001*	8.30 – 9.34
	Healthy volunteers (n=113)	7.72	1.887		7.37 – 8.07

*$p < 0.001$

The mean gross motor scores for patients with JHS (M13.31 SD 3.521) [95% CI 12.57 – 14.05] were significantly higher than those reported by healthy volunteers (M 10.27 SD 2.579) [95% CI 9.76 – 10.79]. Levene's test, $p < 0.05$ therefore equal variances were not assumed, t (165.820) = 6.706, $p < 0.001$. The mean difference in the scores was 3.04 [95%CI 2.14 – 3.93]. This is a statistically significant difference. In addition a mean difference in the gross motor scores is likely to represent a clinically important difference. On average patients with JHS would broadly report being 'poor' in 3/5 and 'good 'in 2/5 items. On average healthy volunteers would broadly report being good at 5/5 items and therefore would not report functional difficulties.

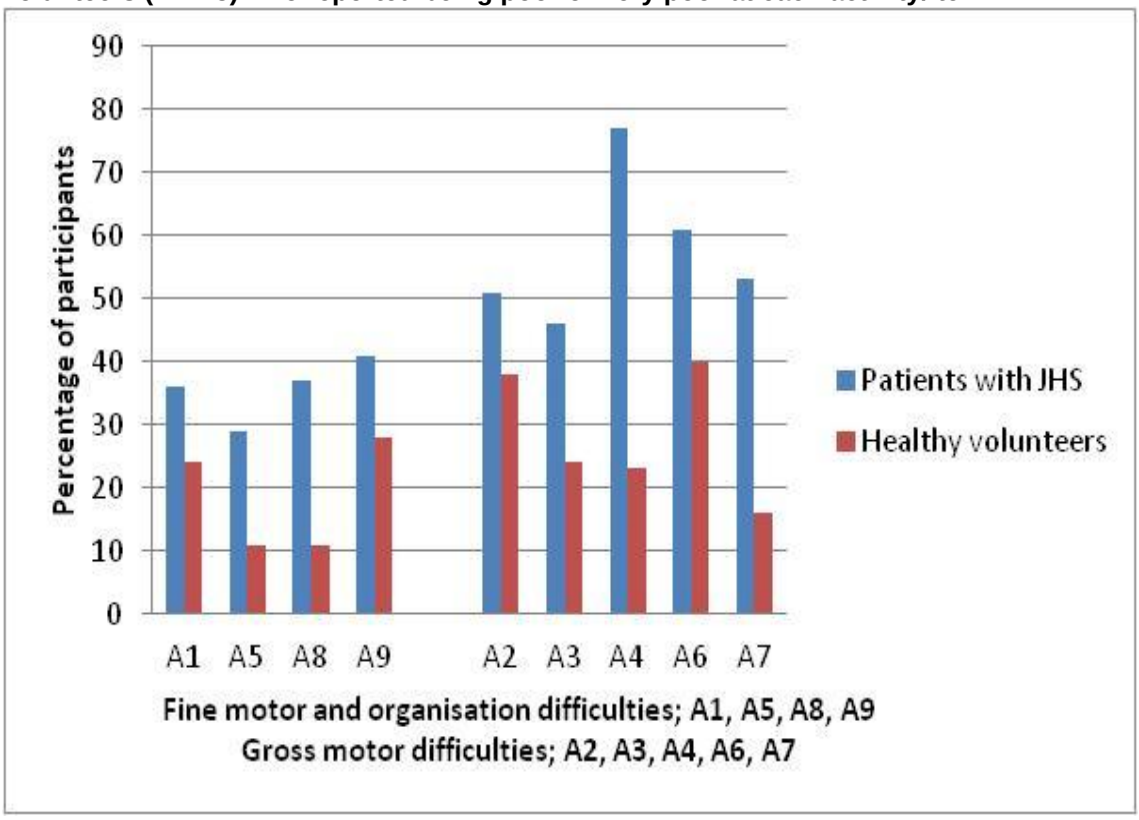
The mean fine motor and organisation scores for patients with JHS (M 8.82 SD 2.475) [95% CI 8.30 – 9.34] were significantly higher than those reported by healthy volunteers (M 7.72 SD1.887) [95%

CI 7.37 – 8.07]. Levene's test was $p < 0.05$ therefore equal variances were not assumed, $t(162.784) = 3.503$, $p < 0.001$. The mean difference in the scores was 1.11 [95%CI 0.482 – 1.729]. This was a statistically significant difference, but might not represent a clinically important difference. On average patients with JHS would broadly report being 'poor' in 1/4 and 'good 'in 3/4 items. On average healthy volunteers would broadly report being 'good' at 4/4 items and therefore not report functional difficulties.

In summary these results indicated that patients with JHS on average had greater functional difficulties associated with gross motor than healthy volunteers which are likely to be clinically important. Although there was a significant different between the groups in relation to fine motor with organisation difficulties this is unlikely to be clinically important.

In the following section the aim was to explore the proportion of patients with JHS and healthy volunteers who report being 'poor' or 'very poor' at each item of the FDQ-9. Data relating to this exploration is displayed (See figure 5-8).

Figure 5-8 Graph showing the percentages of patients with JHS (n=90) and healthy volunteers (n=113) who reported being poor or very poor at each activity/item



A= activity/item.
Fine motor and organisation; A1 = Child hand writing, A5 = Adult organisation, A8 = Adult DIY, A9 = Adult hand writing
Gross motor A 2 = Child games, A3 = Child coordination, A4 = Adult obstacle avoidance, A6 = Adult ball skills and A7= Adult balance

The bar graph shows a comparison between patients with JHS and healthy volunteers in relation to the reporting of being 'poor' or 'very poor' (functional difficulties) at each item of the FDQ-9. There was a trend for a greater percentage of patients with JHS to report being 'poor' or 'very poor' at each item of the FDQ-9 than healthy volunteers. This trend is explored further by addressing the following hypothesis.

Hypothesis 4: Patients with JHS are no more likely to report being poor or very poor at an item of the FDQ-9 than healthy volunteers.

To address this hypothesis a comparison was made between patients with JHS (n=90) and healthy volunteers (n=113) and the reporting of functional difficulties for each item of the FDQ-9. Data was divided into two categorical variables in which the reporting of 'poor' or 'very poor' at an item was considered as a functional difficulty. The reporting 'good' or 'very good' at an item was considered as no functional difficulty. The results are presented in table 5-6

Table 5-6 Comparison of the percentage of patients with JHS (n=90) and healthy volunteers (n= 113) who reported being poor or very poor at any of the nine functional activities recorded in the Functional Difficulties Questionnaire (FDQ-9).

Items	Poor or very poor at activities		Chi square	P (two sided)
	Patients with JHS n, (%) (n=90)	Healthy volunteers n, (%) (n=113)		
1 Child hand writing	32 (36)	27 (24)	3.51	0.069
2 Child games	46 (51)	43 (38)	3.47	0.063
3 Child coordination	42 (46)	27 (24)	10.55	0.001*
4 Adult obstacle avoidance	69 (77)	26 (23)	57.55	0.001**
5 Adult organisation	26 (29)	12(11)	10.99	0.001*
6 Adult ball skills	55(61)	45(40)	17.33	0.001**
7 Adult balance	48 (53)	18(16)	31.94	0.000**
8 Adult DIY	33 (37)	12(11)	19.70	0.001**
9 Adult handwriting	37 (41)	32(28)	3.65	0.056

*$p < 0.01$, ** $p < 0.001$

It was established that there was no statistically significant difference between patients with JHS and healthy volunteers in the reporting of being 'poor' or 'very poor' at the following items; 1 = child hand writing; 2 = child games and 9 = adult hand writing. There were significant differences reported between patients with JHS and healthy volunteers for the following items; 3= child coordination; 4= Adult obstacle avoidance; 5= Adult organisation; 6= Adult ball skills and 7= Adult balance.

The estimated risk of reporting being 'poor' or 'very poor' in at item 3 (coordination as a child) was 1.91 [95% CI 1.3 -2.8] greater for patients with JHS than healthy volunteers. The estimated risk of being 'poor' or 'very poor' at item 4 (avoiding obstacles as an adult) was 3.74 [95%CI 2.5– 5.6] greater for patients with JHS than healthy volunteers. The estimated risk of being 'poor' or 'very poor' at item 5 (organisation as an adult) was 1.76 [95% CI 1.3 – 2.4] greater for patients with JHS than for healthy volunteers. The estimated risk of being 'poor' or 'very poor' at item 6 (ball skills as an adult) was 1.62 [95% CI 1.2 – 2.2] times greater amongst patients with JHS compared with healthy volunteers . The estimated risk of reporting being poor or very poor at item 7 (balance activities as an adult) was 2.37 [95% CI 1.8 – 3.2] times greater amongst patients with JHS compared with healthy volunteers. The estimated risk of being 'poor' or 'very poor' at item 8 (DIY activities as an adult) was 2.03 [95%CI 1.6 – 2.7] times greater amongst patients with JHS than healthy volunteers. This indicated that patients with JHS had a moderate to high risk of reporting difficulties in items 3, 4, 5, 6, 7 and 8.

5.3.1 Summary of functional difficulties reported in patients with JHS

The null hypotheses are summarised (See table 5-7). On average patients with JHS were significantly more likely to report functional difficulties in accordance with the FDQ-9 than healthy volunteers and this result was likely to be clinically important. The estimated risk of Patients with JHS reporting functional difficulties as a child and as an adult were 3 [95% CI 2.0 – 4.6] times greater than healthy volunteers which indicates the long term nature of functional difficulties for patients with JHS. On average patients with JHS were statistically significantly more likely to report gross motor difficulties than healthy volunteers and this result is likely to be clinically important. On average patients with JHS were statistically significantly more likely to report fine motor and organisation difficulties than healthy volunteers but this result is unlikely to be clinically important. Patients with JHS were statistically significantly more likely to report being 'poor' or 'very poor' at 6/9 items from the FDQ-9 than healthy volunteers. The items in which functional difficulties were reported were predominately those that come under the umbrella term of gross motor activities. It is possible that functional difficulties reported in childhood and adulthood may contribute to biomechanical dysfunction and long term musculoskeletal pain. This is explored in section 5.4.6. In addition functional difficulties in particular gross motor difficulties reported in patients with JHS may contribute to reduced physical activity participation and this aspect will be explored (See section 5.5).

Table 5-7 Summary of the null hypotheses used to investigate the differences between patients with JHS and healthy volunteers

Null Hypothesis	Description	Accept/Reject
Null Hypothesis 1	No differences in the functional difficulties scores between patients with JHS and healthy volunteers	Reject
Null hypothesis 2	No differences in the functional difficulties scores for gross motor difficulties between patients with JHS and healthy volunteers	Reject
Null hypothesis 3	No differences in the functional difficulties scores for fine motor difficulties with organisation between patients with JHS and healthy volunteers	Reject
Null hypothesis 4	No differences in the functional difficulties reported for individual items of the FDQ-9 between patients with JHS and healthy volunteers	Accept items;1 child hand writing, 2 child games, 9 adult hand writing. Reject items; 3 child coordination, 4 adult obstacle avoidance 5 adult organisation, 6 adult ball skills,7 adult balance,8 DIY

5.4 JHS and musculoskeletal pain

In this section the aim was to explore musculoskeletal pain in patients with JHS this involved reporting descriptive data in relation to the number and sites of pain. Qualitative text data was examined in relation to the onset of aches and pains.

Quantitative data relating to pain was collected on a pain chart which recorded pain at 17 sites, 14 peripheral and three spinal. The spinal sites were neck, upper back and low back (See table 5-8). Participants ticked a chart if they had had pain at a particular site for ≥ 3 months (See appendix 9 question 18). Reporting pain at multiple sites (four or more) for ≥ 3 months is one of the major features that contribute to a positive diagnosis of JHS in accordance with the Brighton criteria (Grahame et al 2000).

Table 5-8 Descriptive data relating to the number and percentage of patients with JHS (n=90) who reported pain at any site

Region	Site of pain	Proportion of patients with JHS n (%)
Spinal	Low back	75 (83)
	Upper back	51 (57)
	Neck	60 (67)
Upper limb	Shoulder	69 (77)
	Elbow	35 (39)
	Wrist and hand	65 (72)
Lower limb	Hip	69 (77)
	Knee	77 (86)
	Ankle	58 (64)
	Foot	50 (56)

The number of pain sites ranged from 1-17. Eighty four patients with JHS (93%) in this study reported pain in ≥ 4 sites for ≥ 3 months. Chronic widespread pain is defined as spinal pain and pain in at least two contra lateral quadrants for ≥ 3 months (Wolfe et al 1990). The percentage of patients with JHS reporting chronic widespread pain in this category was 77/90 (86%). The commonest sites of pain for patients with JHS in this study were the knee (86%) and the back (83%). The least common sites were the elbow (39%) and foot (56%)

Qualitative data relating to the onset of aches and pains was collected as text data.

5.4.1 The onset of aches and pains

The aim of this next section was to explore the onset of aches and pains described by patients with JHS. It is suggested this is likely to be variable and probably arising from several mechanisms (Grahame 2003a). However, anecdotally many patients have been able to clearly identify features that exacerbate or relieve their pain, and report for example that unaccustomed activity maybe a trigger (Grahame 2003c). Qualitative text data were analysed in response to an open ended question;

> 'Can you recall an event that triggered the onset of your aches and pains?'

5.4.2 Analysis

It was understood that if respondents added their ideas that analysis of the text data would bring meaning to how patients with JHS described the onset of their pain. The data were analysed after reading and re-reading the text and dividing into meaning units which were categorised and coded into meanings relevant to the question. These then formed themes and subthemes. This method has previously been described by Patton (2002 p 454). A description of the analysis is presented (See appendix 17).

The demographics of the patients with JHS and the three themes is presented (See table 5-9). There were 86/90 (96%) responses to the open ended question of these 13/86 (15%) reported 'no' trigger for their pain. Text data for the remaining respondents 73/90 (81%) were analysed. The analysis generated three core themes and a number of subthemes. Each theme is presented and direct quotes are employed to illustrate typical comments within the sub themes. Some patients with JHS contributed to more than one theme.

Table 5-9 Demographics of patients with JHS reporting a trigger to their pain (n=73)

Themes	Reporting theme n= (%)	M/F	Age mean and (range)	Employment	
Long term pain	32 (44%)	1 (M) 31 (F)	34.2 (18-61) years	Fully employed around the home Full time employment Part time employment Unemployed Student Unable to work	6/32 14/32 3/32 5/32 3/32 1/32
Pain and activity	16 (22%)	0 (M)16 (F)	35.1 (21-59) years	Fully employed around the home Full time employment Part time employment Unemployed Student	3/16 6/16 4/16 1/16 2/16
Pain and life events	35 (48%)	3 (M) 32 (F)	36.8 (19-61) years	Fully employed around the home Full time employment Part time employment Unemployed Student Voluntary work	6/35 13/35 7/35 6/35 2/35 1/35

Note: Some patients with JHS contributed to more than one theme

Analysis of the data revealed eight subthemes each theme is presented and direct quotes are employed to illustrate typical comments. The themes and sub themes can be viewed (See table 5-10).

Table 5-10 Themes and subthemes

Themes	Subthemes
Long term pain	• Always had pain • Pain started in childhood • Pain started in adolescence or puberty
Pain associated with activity	• Onset with dynamic activity • Onset with static activity
Pain associated with life events	• Physically traumatic - vehicle accidents or falls • Physically non traumatic – infections and stresses • Pregnancy

5.4.3 Long term pain

Thirty two patients with JHS reported the theme ‘long term pain’. This theme of experiencing long term pain consisted of three sub themes: always had pain; pain started in childhood and pain started in adolescence or puberty. It captured the description of how patients with JHS reported the onset and the long term nature of their aches and pains.

Always had pain was an intriguing theme that emerged in which patients with JHS reported their aches and pains being a feature throughout life *'Always had since birth' (P65).* This statement was not gender specific as one of the male patients with JHS reported *'Have always had them' (P37).*

Pain started in childhood was a theme in which the long term nature of the pain continued this time related to starting in childhood and included childhood memories associated with the onset of pain. For some patients with JHS they related their aches and pains to some form of activity *'No particular event as such but at 8 or 9 when the pains started I was doing a lot of cross country/running' (P23)*. In some cases childhood pain had been severe enough to restrict functional activity *'As a young 6 yr old not being able to climb down or up stairs due to leg pains' (P123).*

Pain in adolescence and puberty was a distinct group who reported the onset of aches and pains in adolescence and puberty as opposed to childhood or since birth. Within this theme activity was also associated with pain as was the onset of dislocations. *'In school I suffered pain during PE, my knee dislocated while I was dancing when I was in my teens' (PE49)* It is interesting to note for those who reported pain around the time of adolescence and puberty that for some pain preceded the onset of dislocations *'My knees started to be painful around the age of 12 & started to dislocate around the age of 13' (P144).* One of the threads in this sub theme related to activity and was picked up in the next theme.

5.4.4 Pain associated with activity

Sixteen patients with JHS subscribed to the theme of 'pain associated with activity' explored the experiences of patients with JHS and the reporting of pain in relation to the sub themes dynamic or static activity. The subtheme dynamic activity was defined as involving activity associated with locomotion. While the subtheme static activity was defined as activities where the body was static but primarily involved upper limb activity.

Dynamic activity Only female patients with JHS reported the onset of aches and pains to be associated with dynamic activity. The women experienced the onset of their pain while engaged in a variety of activities (e.g. practicing yoga, walking, dancing, swimming and other sports). It was interesting to note that an activity that set off pain need not be very intense for example that experienced by one 30 year old female occurred with *'Any type of exercise e.g. walking down the street' (P85).* Although for this patient with JHS the site of pain was not recorded another patient with JHS reported the global nature of the problem *'Just generally walking sets off the majority of my leg pain. Whole body has gone into full muscle spasm including the chest' (PE112).*

In addition to the types of activity that might cause the onset of pain in some patients with JHS reported different parts of the body being affected by different types of activity. *'Injured right wrist*

tendon 2003 while doing craft work; injured elbows 2007 while learning to swim; injured knee 2008 exercising' (P93). The multiple sites of pain reported in this theme were consistent with the reporting of multiple sites of pain recorded on the pain chart of the questionnaire. A few patients with JHS reported the onset of their aches and pains being caused by both dynamic and static activities (e.g. dancing and driving or walking and sitting for too long).

Static activity Only female patients with JHS reported pain associated with static activity for example *'Standing up, sitting for long periods' (P8).* It would appear that activities engaged in which did not include locomotion were also associated with the onset of pain in some patients with JHS. These included standing or sitting, wearing high heels or using a smart phone.

5.4.5 Pain associated with life events

Thirty five patients subscribed to the theme of 'Pain associated with life events' this theme explored patients with JHS' experiences of both intrinsic and extrinsic factors associated with triggering the onset of pain under the sub themes of physically traumatic, physically non traumatic and pregnancy.

Physically traumatic under this sub theme was the report that falls, traumatic sporting injuries or road traffic accidents had triggered pain. These comments were not gender specific. One male patient with JHS described *'Yes, on 18/3/03 I was involved in a car accident where my car was hit as I got out, this brought on back pain & sciatica which I still have trouble with' (P29).* While one female patient with JHS described her traumatic experience *'A fall down stairs at home caused a torn ligament in my shoulder and displaced my lower back and neck' (P75).*

Physically non traumatic under this sub theme there were a variety of intrinsic and extrinsic factors that patients with JHS associated with the onset of their symptoms and again were not gender specific. These included weather, stomach complaints, infections, anaesthetics, emotions and menopause. '*Cold weather brings on terrible aches/pains in shoulders and upper thighs' (P54). 'Following septic shock after stent removal 6 weeks after renal auto-transplant 2006' (P6).*

Pregnancy In this study several patients with JHS reported their symptoms started in pregnancy. For some they reported either pain starting in pregnancy or as a result of having a baby. One patient with JHS reported multi site pain during pregnancy. *'1st pregnancy = SPD (symphysis pubis dysfunction), sciatica, neck & shoulder pain' (P43).* While another reported pain continuing after pregnancy. *'Worse when pregnant and continued to get worse even though my daughter is now nearly 4' (P131).*

By analysing the qualitative data above, there has been an attempt to enhance the understanding of what triggers the onset of aches and pains in patients with JHS. This method is referred to as purposeful sampling (Patton 1990). If the qualitative data is then quantitised, it can be further analysed under the term probability sampling, thus permitting statistical inferences to be made. Sandelowski (2000) suggests that generalisation from individual cases may then be orientated toward the development of scientific based knowledge and generalisation to populations.

5.4.6 Long term pain and functional difficulties

It might be suggested that individuals who report long term pain are those with biomechanical dysfunctions that occur as a result of impaired motor coordination. Earlier in this chapter it was reported that patients with JHS were significantly more likely to record FDS ≥22 than healthy volunteers. In chapter 4 it was reported that on average those who recorded FDS ≥22 reported functional difficulties in childhood and adulthood while on average those who recorded FDS<22 reported no functional difficulties. In this study it was established that under the theme 'long term pain' 32/73 (44%) of patients with JHS reported pain for as long as they could remember, or starting in early childhood, adolescence or puberty. An analysis was undertaken to study what proportion of patients within this group also reported functional difficulties in childhood and adulthood. The proportion of Patients with JHS who recorded FDS ≥22 who reported long term pain were significantly more than those who recorded FDS < 22 (72% versus 28%) $p = 0.016$ (Fisher's Exact two sided). This would suggest an association between long term pain and the reporting of functional difficulties as a child and an adult.

5.4.7 Summary of pain in patients with JHS

Chronic widespread pain was common for patients with JHS in this study. The commonest pain sites were the knee and low back. Patients with JHS reported long term pain, pain associated with activity and pain associated with life events. Many patients with JHS reported the onset of pain in infancy, childhood and adolescence. They also reported the onset of pain being associated with being active or static. Patients with JHS who reported their pain starting as a result of a life event reported pain continuing long after the initial event. Although the thematic framework revealed three main themes and several sub themes, in the analysis it was evident that there was cross over between the themes suggestive of links between the themes. A significant proportion of patients with JHS who reported long term pain also reported functional difficulties in childhood and adulthood.

5.5 Physical activity participation

The aim of this part of the study was to explore how much time was spent engaged in weekly physical activity. Data relating to physical activity was collected using two questions. The first was a closed question asking responders about the amount of time they spent engaged in weekly physical activity (See appendix 9 Questions 6-7). The categories were; half an hour, one hour, two hours, three hours and more than three hours. The second was asking for information on types, duration and frequency of activity.

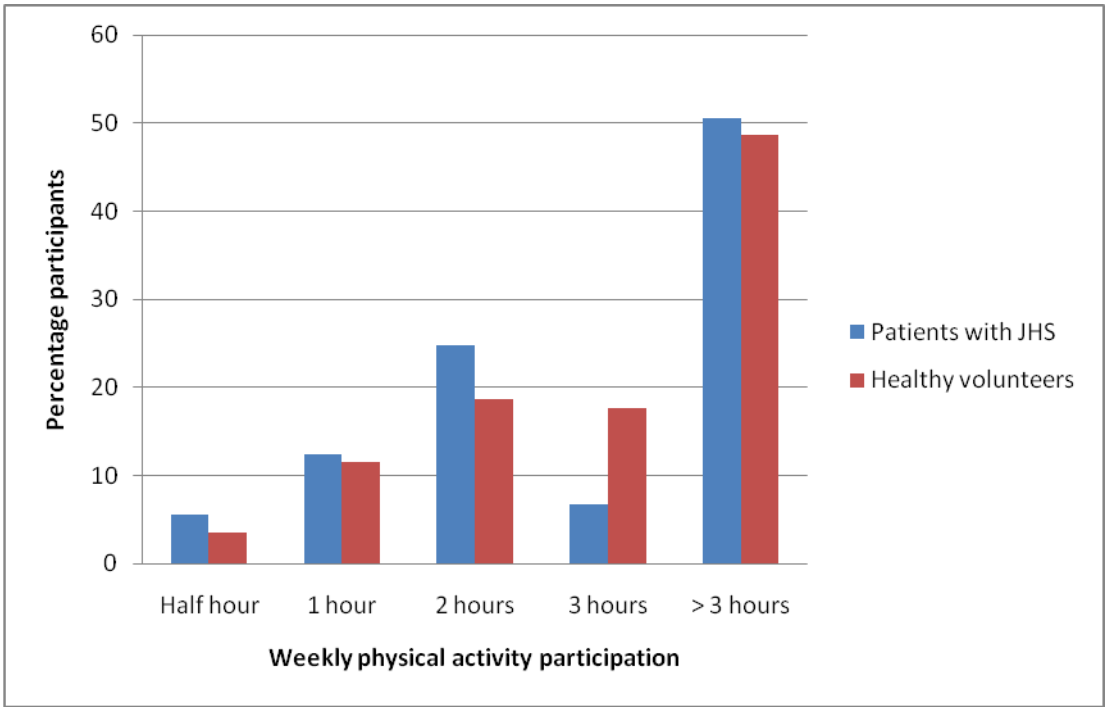
Walking was the commonest activity reported and was reported similarly by healthy volunteers (62%) and patients with JHS (63%). Only patients with JHS reported barriers to physical activity participation. This information was cross referenced with the numerical data and can be viewed (See appendix 20).

5.5.1 Differences in weekly physical activity participation

Null hypothesis 5: There is no difference in the time spent engaged in weekly physical activity between patients with JHS and healthy volunteers.

To address this hypothesis a graph was initially constructed with the aim of presenting data related to the time spent engaged in weekly physical activity for patients with JHS and healthy volunteers (See figure 5-9). Data were missing from one patient with JHS.

Figure 5-9 Percentage of patients with JHS (n=89)* and healthy volunteers (n=113) and time spent engaged in weekly physical activity



*Data missing from one patient with JHS.

A comparison was made between the number of patients with JHS and healthy volunteers who were engaged in weekly physical activity. This analysis was carried out for the five time categories; half an hour, one hour, two hours, three hours and more than three hours. There was no significant difference between the groups.

A pragmatic approach was used to analyse the data based on the United Kingdom government's recommendations for physical activity (HSE 2008a). The recommendations are for adults to be engaged in moderate intensity physical activity for at least half an hour on five days equating to two and a half hours a week. The data for this study was divided into two categories the first capturing those engaged in physical activity for two hours or less a week and the second those engaged in three hours or more a week. The categorical data for the two groups were analysed using Pearson's chi square test (See table 5-11)

Table 5-11 Comparison of weekly physical activity for patients with JHS (n=89)* and healthy volunteers (n=113)

Participants	Weekly physical activity ≥ 3 hours	Weekly physical activity ≤ 2	Chi square	*p* (2-sided)	95% CI
Patients with JHS n=89 (%)	51/89 (57%)	38/89 (43%)	1.745	0.187	1.035 – 3.146
Healthy volunteers n=113 (%)	75/113 (66%)	38/113 (34%)			

*Data for one patient with JHS missing

The percentage of healthy volunteers who reported being engaged in weekly physical activity for three or more hours a week was slightly more than the percentage of patients with JHS chi square = 1.745 *p* = 0.187 (two sided) this was not significant. There was evidence to accept the null hypothesis, as there was no statistically significant difference in the time spent engaged in weekly physical activity between patients with JHS and healthy volunteers.

5.5.2 Physical activity participation for patients with JHS with functional difficulties

The aim of this next section was to explore whether there was an association with the reporting of functional difficulties and physical activity participation. This analysis was considered relevant as reduced physical activity participation and sport participation had previously been reported in children and young adolescence with functional difficulties associated with dyspraxia/DCD (Chen and Cohn 2003; Poulsen et al 2007).

Null hypothesis 6: There is no association between the reporting of functional difficulties and the time spent engaged in physical activity for patients with JHS and healthy volunteers.

To answer this hypothesis a multivariate logistic regression was performed to investigate the relationship between times spent engaged in physical activity. The dependent variable employed the categorical variable weekly physical activity ≤ 2 hours. The explanatory variables for this model were; healthy volunteers = 0 patients with JHS = 1; no *chronic fatigue syndrome (CFS) =0, CFS =1; no *cardiovascular symptoms (CVS) = 0, CVS symptoms=1; no* autonomic nervous system (ANS) symptoms = 0, ANS symptoms 1, sex female = 0 male = 1; age (years); number of pain sites (numerical) functional difficulties (FDS numerical) see table 5-12.

*Data relating to chronic fatigue syndrome, cardiovascular and autonomic nervous system symptoms are reported in section 5.7

Table 5-12 A comparison of the relationship of physical exercise (≤ 2 hours week – reference) with the explanatory variables, age (years), gender, group membership, CFS, CVR symptoms, ANS symptoms, number of pain sites and FDS (n=202)

Predictor variable Reference category ()	***SE***	**Estimated odds ratio**	***p***	**95% CI lower -upper**
Age (years)	0.013	0.992	0.567	0.967 – 1.018
Gender (female)	0.425	1.066	0.880	0.464 – 2.453
Group membership (HV)	0.664	1.321	0.675	0.359 – 4.856
CFS (No CFS)	0.538	2.614	0.074	0.911 – 7.495
CVR symptoms (No CVR symptoms)	0.470	1.735	0.241	0.691 – 4.353
FDS	0.037	1.090	0.018*	1.015 – 1.171
ANS symptoms (no ANS symptoms)	0.426	0.892	0.789	0.347 – 2.056
Pain sites (number of)	0.062	1.080	0.217	0.956 – 1.220
Overall model evaluation				
Test		Chi square	*df*	*p*
Wald test		12.116	1	0.001**
Goodness-of- fit test Hosner and Lemeshow		7.292	8	0.505

Cox and Snell R^2 = .072 Nagelkerke. Model R^2 = 0.098, -2 log likelihood = 252.417
Reference categories: Age (years), sex (female); Group membership (healthy volunteers HV); Chronic Fatigue Syndrome (CFS) (no CFS); cardiovascular (CVR) (no CVR symptoms); Functional Difficulties Scores (FDS) (number), Autonomic Nervous System (ANS) (no ANS symptoms), pain sites (number)
*p < 0.05, **p <0.001

The Hosner and Lemeshow statistic was employed to evaluate the goodness of fit. This was not significant indicating a good prediction by the model. The Wald test was significant indicating the logistic model was more effective than the null model. These statistics indicated a good regression model.

Although there were differences in the percentages of males and females and differences in the reporting of CFS, ANS and CVR symptoms (See section 5.7) which might have a confounding effect the only explanatory variable which had a significant effect on the dependent variable was FDS.

Increased FDS were a significant predictor of the dependent variable physical activity ≤ 2 hours a week, p = 0.018. This indicated that the odds of those with higher FDS reporting physical activity participation of ≤ 2 hours weekly was 1.09 [95%CI 1.02 – 1.17] greater than those reporting physical activity participation of ≥ 3 hour weekly. Odds ratios close to 1 indicate a weak relationship between the explanatory and dependent variables. It was therefore decided to explore if there was an association between times spent engaged in physical activity and whether or not participants reported functional difficulties in both childhood and adulthood. A Pearson's chi square test was employed to explore this association, employing the categorical variables weekly physical activity ≥ 3 hours and ≤ 2 hours versus FDS ≥22 (on average participants report functional difficulties in

childhood and adulthood) and FDS <22 (on average participants report no functional difficulties). Data were analysed separately for patients with JHS and healthy volunteers and may be viewed (See table 5-13)

Table 5-13 Comparison of weekly physical activity between #patients with JHS (n=89) and healthy volunteers (n-113) with FDS ≥22 or with FDS< 22

Participants	Weekly physical activity ≥ 3 hours	Weekly physical activity ≤ 2 hours	Chi square	*p* (2-sided)	Odds ratio [95% CI]
Patients with JHS with FDS < 22 (n=40)	28 (70%)	12 (30%)	4.787	0.029*	2.638 [1.096 – 6.351]
Patients with JHS with FDS ≥ 22 (n=49)*	23 (47%)	26 (53%)			
Healthy volunteers with FDS < 22 (n=92)	66 (72%)	26 (28%)	6.930	0.011*	3.385 [1.275 – 8.784]
Healthy volunteers with with FDS ≥ 22 (n= 21)	9 (43%)	12 (57%)			

#Data for one patient with JHS missing.

*$p < 0.05$

Relative risk was calculated as it is understood that odds ratios tend to exaggerate a relationship when percentages over 10% are reported (Grimes and Schulz 2008). There was a 1.7[95%CI 1.02 - 2.95] greater probability for patients with JHS to be exercising for ≥ 3 hours a week if they had FDS <22 (on average reported no functional difficulties). This indicated a moderate risk. There was a 1.3 [95% CI 1.02 – 1.62] greater probability for healthy volunteers to be exercising for ≥ 3 hours a week if they had FDS <22 (on average reported no functional difficulties). This indicated a moderate risk.

5.5.3 Summary of physical activity participation

The null hypotheses are summarised (See table 5-14). Patients with JHS and healthy volunteers reported walking as the commonest form of physical activity. Over half of each group reported being engaged in weekly physical activity for ≥ 3 hours. Participants engaged in physical activity for ≥ 3 hours a week were significantly more likely to report no functional difficulties. This finding was similar for patients with JHS and healthy volunteers.

Table 5-14 Summary of the null hypotheses used to investigate physical activity participation in patients with JHS and healthy volunteers

Null hypothesis	Description	Accept/reject
Hypothesis 5	No difference in the time spent engaged in weekly physical activity between patients with JHS and healthy volunteers	Accept
Hypothesis 6	No difference between the reporting of functional difficulties and the time spent engaged in weekly physical activity for patients with JHS and healthy volunteers	Reject

5.6 Dislocations and subluxations

The aim of this next section was to explore the reporting of dislocations/subluxations in patients with JHS. Data relating to dislocations/subluxations was collected as part of the Brighton diagnostic criteria for the diagnosis of JHS (Grahame et al 2000). Dislocations/subluxations were reported frequently in the qualitative data which might suggest that this was considered a troublesome feature for some (See 5.8.2).

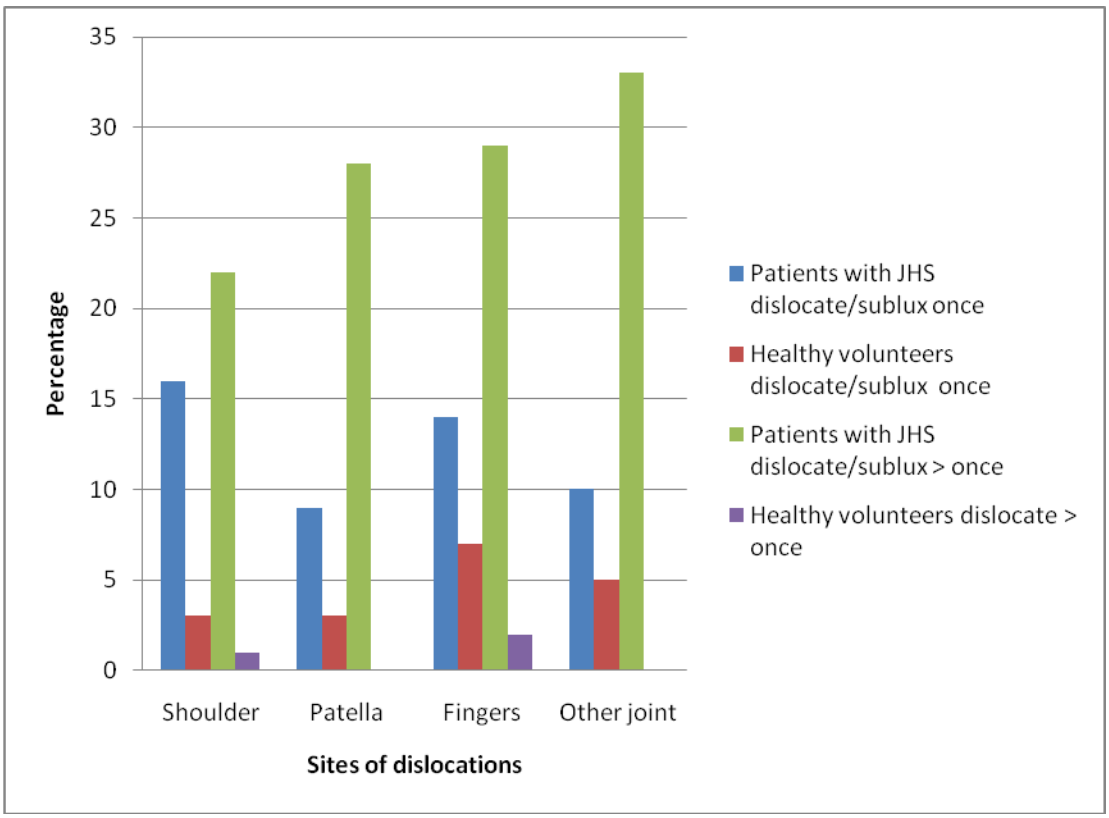
5.6.1 A comparison in the reporting of dislocations/subluxations

Participants were asked to report on dislocations/subluxations of the shoulder, patella and fingers which are all common sites of dislocation. This included reporting dislocations/subluxations of a joint using the following categories; once, more than once or never. Participants were also asked to report on any other joints that dislocated/subluxed. The other joints reported on in this study included the following; jaw, elbow, wrist, thumb, sacro-iliac, hip, ankle and toes. In this next section the data analysis focuses in addressing the following hypotheses;

Hypothesis 7: There is no difference in the reporting of dislocations/subluxations between patients with JHS and healthy volunteers at any site.

There were missing data for both patients with JHS and healthy volunteers; this is taken into account in the analyses. The percentages of reported dislocations/subluxations and frequency in patients with JHS and healthy volunteers can be viewed (See figure 5-10).

Figure 5-10 Percentage of patients with JHS (n)* and healthy volunteers (n)who reported dislocations/subluxations**



Other joints: Jaw, elbow, wrist, thumb, sacro iliac, hip, ankle and toes.
Data were incomplete and the total number of responses collected for each site is listed below.
*Patients with JHS: shoulder (n =82); patella (n = 82); fingers (n = 80); other joints (n =77)
** Healthy volunteers: shoulder (n = 110); patella (n = 112); fingers (n = 112); other (n = 110)

Data relating to dislocations/subluxations at each recorded site were reported and compared between patients with JHS and healthy volunteers (See table 5-15).

Table 5-15 Comparison by site of one or more dislocation/subluxations as reported between patients and healthy volunteers

Joint	Patients with JHS **[n] (%)	HV **[n] (%)	Chi square	*p* (2 sided)	Odds ratios [95% CI]
Shoulder	31 (38%) [82]	2 (2%) [110]	42.75	0.001*	32.824 [7.561 – 142.501]
Patella	30 (37%) [82]	3 (3%) [112]	38.55	0.001*	20.962 [6.115 – 71.854]
Fingers	34 (43%) [80]	10 (9%) [113]	30.14	0.001*	7.613 [3.469 – 16.709]
#Other joints	38 (49%) [77]	6 (6%) [110]	48.51	0.001*	16.889 [6.621 – 43.079]

**Data were incomplete therefore [n] refers to the responses relating to each site
Included jaw, elbow, wrist, thumb, sacro iliac, hip, ankle and toes.
*p < 0.001

Odds ratios and relative risk tend to be similar when the percentage outcome is low (less than 10%), but for higher percentages the odds ratio may exaggerate the occurrence (Grimes and Schulz 2008). As higher percentages were involved for patients with JHS the data were re-analysed to report relative risk.

There was a 2.9 [2.3 – 3.7] greater probability for shoulder dislocations/subluxations in patients with JHS than healthy volunteers. There was a 2.8 [2.2 – 3.6] greater probability for patella dislocations/subluxations in patients with JHS than healthy volunteers. There was a 2.5 [1.9 – 3.3] greater probability for finger dislocations/subluxations in patients with JHS than healthy volunteers. There was a 3.3 [2.5 – 4.4] greater probability for other joint dislocations/subluxations in patients with JHS than healthy volunteers. These statistics indicated that patients with JHS were significantly more likely to report dislocations/subluxations at all sites compared with healthy volunteers and so the null hypothesis was rejected.

5.6.2 Summary of dislocations and subluxations

A summary of the hypotheses relating to dislocations/subluxations is presented (See table 5-16). In this study dislocations/subluxations were reported by at least a third of patients with JHS. Although a small proportion of healthy volunteers reported dislocations/subluxations at the shoulder or in the fingers occurring more than once. Dislocations/subluxations occurring more than once was a common finding for patients with JHS at all sites.

Table 5-16 Summary of the null hypotheses used to investigate dislocations/subluxations in patients with JHS and healthy volunteers

Null Hypothesis	Description	Accept/reject
Hypothesis 7	No difference in the reporting of dislocations/subluxations between patients with JHS and healthy volunteers at any site	Shoulder – reject Patella – reject Fingers – reject Other joints - reject

5.7 Associated conditions

The aim of this next section was to explore data related to conditions and symptoms which had previously been acknowledged to be associated with JHS. Initially descriptive data were presented on the self report of fibromyalgia which was only reported by patients with JHS. A comparison is presented on the following condition and symptoms; Chronic Fatigue Syndrome (CFS); Gastrointestinal symptoms (GI), Cardio respiratory symptoms (CR) and Autonomic Nervous System symptoms (ANS).

5.7.1 Associated musculoskeletal conditions

Fibromyalgia is a clinical syndrome distinguished by widespread chronic musculoskeletal pain diagnosed by the reporting of tender points at specific sites (Wolfe et al 1990). Fibromyalgia has been reported to be associated with joint hypermobility in both adults and children (Acasuso-Diaz and Collantes-Estevez 1998; Gedalia et al 1993). In this study data was collected relating to the self report of Fibromyalgia. Only patients with JHS self reported fibromyalgia. The number of patients with JHS who self reported fibromyalgia were 17/90 (18.9 %).

5.7.2 Associated non musculoskeletal conditions

JHS is a multisystem disorder and although clinicians may be more familiar with the presentation of musculoskeletal signs and symptoms, there are a range of symptoms that are non musculoskeletal, these include symptoms of the ANS, CR and GI and the condition CFS. This led to the following hypothesis:

Hypothesis 8: There is no difference in the reporting of Gastrointestinal (GI), cardiorespiratory (CR) and Autonomic Nervous System (ANS) symptoms and the condition Chronic Fatigue Syndrome (CFS) between patients with JHS and healthy volunteers.

All participants were asked to self-report their symptoms and conditions. GI symptoms were nausea, constipation, diarrhea and stomach aches. CR symptoms were heart palpitations, shortness of breath and chest pain. ANS symptoms were dizziness, fainting and lightheadedness. (The justification for these questions is reported in section 3.3.2.7). Participants were asked to

report CFS and Myalgic Encephalopathy (ME) as participants all responded positively to both the results have been reported under the term CFS. The following data analysis relates to the self-reporting of one or more symptoms for; GI, CR or ANS and to the self-report of CFS.

To answer this hypothesis data which related to the self report of GI, CR, ANS symptoms and CFS were described and compared using Pearson's chi square test between patients with JHS and healthy volunteers (See table 5-17). Data is presented in a graph (See figure 5-11).

Figure 5-11 Graph showing the percentage of self report associated symptoms and chronic fatigue syndrome in patients with JHS (n=90) and healthy volunteers (n=113)

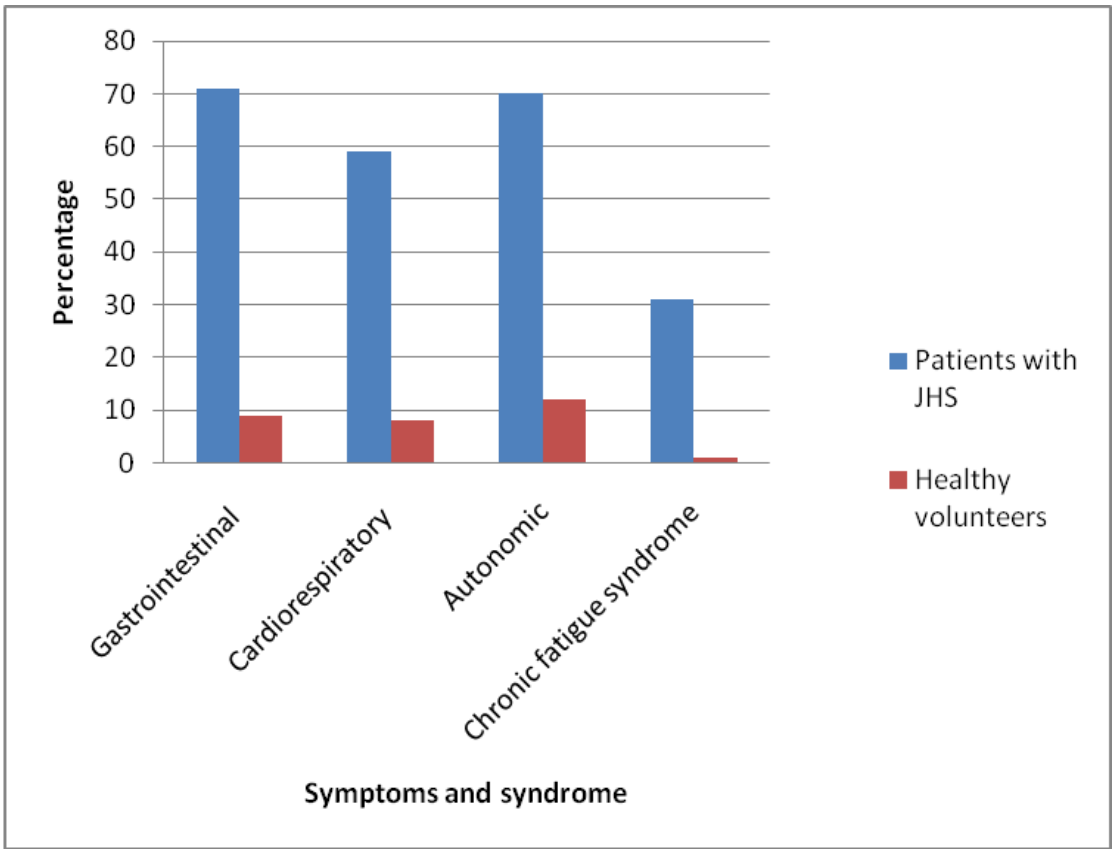


Table 5-17 The self report of one or more gastro-intestinal, cardiorespiratory, autonomic nervous system symptoms and chronic fatigue syndrome are described and compared between patients with JHS (n = 90) and healthy volunteers (n = 113)

Participant group	Yes Symptoms	No Symptoms	Chi square	P (2-sided)	Odds ratio and [95% CI]
	#Gastro intestinal symptoms (GI)				
Patients with JHS (n=90)	64 (71%)	26 (29%)	83.84	0.001*	25.354 [11.469 – 56.046]
Healthy volunteers (n=113)	10 (9%)	103 (91%)			
	##Cardio-respiratory symptoms (CR)				
Patients with JHS (n=90)	53 (59%)	37 (41%)	58.61	0.001*	16.553 [7.437 – 36.841]
Healthy volunteers (n=113)	9 (8%)	104 (92%)			
	###Autonomic nervous system symptoms (ANS)				
Patients with JHS (n=90)	63 (70%)	27 (30%)	70.625	0.001*	16.500 [8.042 – 33.853]
Healthy volunteers (n=113)	14 (12%)	99 (88%)			
	Chronic fatigue syndrome (CFS)				
Patients with JHS (n =90)	28 (31%)	62 (69%)	Fisher's Exact	0.001*	
Healthy volunteers (n=113)	1 (1%)	112 (99%)			

#GI; nausea, constipation, diarrhea, stomach ache
##CR; heart palpitations, shortness of breath, chest pain
###ANS; dizziness, fainting lightheadedness.
*$p < 0.001$

Odds ratios tend to exaggerate the probability of a condition if the condition being investigated is greater than about 10%, where as relative risk relates to a ratio of probabilities and will vary depending on the reference group (Grimes and Schulz 2008). Therefore the estimated risk and the 95% confidence interval for the true risk for each associated condition were calculated.

The GI symptoms that were recorded in this study were; nausea, diarrhea, constipation and stomach ache. There was a 3.3 [95% CI 2.4 – 4.4] greater probability of one or more GI symptoms being self reported by patients with JHS than healthy volunteers. This indicated a high risk. The number of patients with JHS who also reported fibromyalgia and who reported one or more GI symptoms was 15/17 (88%).

CR symptoms that were recorded in this study were; heart palpitations, shortness of breath and chest pain. There was a 4.3 [3.0 – 6.1] greater probability of CR symptoms being self-reported by patients with JHS than HV this indicated a high risk.

ANS symptoms recorded in this study were; dizziness, fainting and lightheadedness. There was a 5.6 [95%CI 3.40 – 9.40] greater probability of ANS symptoms being self-reported by patients with JHS than healthy volunteers which indicated a high risk.

ANS symptoms are reported in those with a diagnosis of postural orthostatic tachycardia syndrome (POTS). In this study patients with JHS added their own comments to the questionnaire. Seven patients with JHS reported a diagnosis of POTS of whom 5/7 reported all three symptoms and 2/7 reported two symptoms. The percentage of patients with JHS who self-reported two or more or all three autonomic nervous system symptoms were 52% and 34% respectively.

Patients with JHS were significantly more likely to report chronic fatigue syndrome than healthy volunteers 28/90 (31%) and 1/113 (1%) respectively, $p < 0.001$ (two sided) Fisher's Exact).
The results of this analysis identified significant differences between self-reported GI, CR, and ANS symptoms and CFS between patients with JHS and healthy volunteers. There was evidence to reject the null hypothesis.

5.7.3 Summary of associated conditions

A summary of the hypotheses relating to the associated conditions is presented (See table 5-18).

Table 5-18 Summary of the null hypotheses used to investigate gastrointestinal (GI), cardio-respiratory (CR), autonomic nervous system (ANS) symptoms and chronic fatigue syndrome (CFS) in patients with JHS and healthy volunteers

Null hypothesis	Description	Accept/reject
Hypothesis 8	No difference in the reporting of Gastrointestinal, Cardiorespiratory and Autonomic Nervous System symptoms and Chronic Fatigue Syndrome between patients with JHS and healthy volunteers	Reject

The nature and experiences of patients with JHS

The aim of this next section was to explore the text response of patients with JHS through qualitative data analysis in order to answer the research question;

- How do patients with JHS report the nature of their condition and their experiences with the condition?

5.7.4 Exploring the nature of the condition and experiences of patients with JHS

Pragmatism as a paradigm in research supports the use of both qualitative and quantitative research in the same study, presenting the researcher with a practical approach to answering research questions and hypotheses (Teddlie and Tashakkorie 2003). The qualitative data for this part of the study came from the open ended question at the end of the questionnaire (See appendix 9). The question was 'Is there any other information you wish to add?' The qualitative data analysis in this section was based on the three step process described by Miles and Huberman (1994 p55) which involved data reduction, data display and initial interpretation which is presented (See appendix 18). The linking and integration of the qualitative and quantitative data occurs in the discussion chapter as the data are drawn together in order to portray the impact of this condition (See 6.6).

A total of 45/90 (50%) patients with JHS contributed to this qualitative data of whom 44/83 (53%) were female and 1/7 (14%) was male. The themes are presented in a table alongside the demographic details of the responders (See table 5-19).

Table 5-19 Demographic details of the responders for each theme reported by patients with JHS (n=45) 44 female and one male

*Themes	n = 45 (%)	Female/Male	Age Mean (range) years	Employment status– number in category
Nature of the condition	37 (82%)	37 F 0 M	35.7 years (21 – 59 years)	Fully employed around the home - 5 Full time employment - 11 Part-time employment - 10 Unemployed - 6 Student - 5 Unable to work - 0 Voluntary work - 0
Experiences with JHS	24 (53%)	23 F 1 M	37.5 years (23 – 59 years)	Fully employed around the home - 3 Full time employment - 7 Part-time employment - 7 Unemployed - 5 Student - 2 Unable to work - 0 Voluntary work - 0

*Some patients with JHS contributed to more than one theme

Information on the two themes; nature of the condition and experiences with JHS are presented, these themes are further divided into sub themes (See table 5-20).

Table 5-20 Themes and sub themes for patients with JHS with pain

Themes	Sub themes
The nature of the condition	• Multisystemic nature of the condition • Family history of the condition
Experiences of JHS	• Helpful experiences, • Un helpful experiences • Pain experiences

5.7.5 Nature of the condition

This theme describes the nature of the condition and consists of two sub themes the multisystemic nature of the condition and the family history of the condition. Within the 'nature of the condition' patients with JHS described a variety of signs and symptoms which they attributed to JHS. The variety of symptoms described highlight the complexity of the condition, this in turn may link with the experiences of JHS described by respondents and will be discussed in more depth in the next chapter. Patients with JHS also described family members with the condition some of whom demonstrated symptoms while others did not. The sub themes are sometimes interlinked as

patients with JHS record the nature of their condition and this is linked to the story of the family history of the condition.

Multisystemic nature of the condition. The complex heterogeneous nature of JHS is captured by patients with JHS in this study who reported symptoms associated with connective tissues. Dislocations/subluxations were frequently reported as noted in a previous section of this chapter (5.6). In some instances dislocations/subluxations were reported to be associated with pain and one 23 year old described the differences in pain associated with subluxations and dislocations as she wrote: *'Knee subluxation not full dislocation Toes dislocate regularly but not as painful as a normal dislocation'. PE49K*. In several instances the dislocations/subluxations were discussed in relation to functional restrictions as a 28 year old woman wrote: *'Difficulty lifting heavy things, because of wrist and shoulder subluxations.' P132K.*

The symptoms patients with JHS reported were not always joint or pain related as one 27 yr old woman wrote '*I have had 5 hernias to date and have been told to expect more.' P78K. S*everal patients recorded symptoms of irritable bowel syndrome (IBS) as reported by one 31 year old woman who wrote '*My hypermobility has been identified as a result of investigations into my chronic IBS'. P75K* and then went on to report *'... I have also been diagnosed with osteoporosis, which is relatively severe in a person of my age.'*

Symptoms of autonomic dysfunction and in particular postural orthostatic tachycardia syndrome (POTS) were reported commonly and in some cases these were noted to have a important impact on function as reported by a 35 year old woman who wrote *'POTS, this takes up lots of time takes 5 hours to get up in the morning because of dizziness and blood pooling...' P49K.* It would appear that the severity of some of the symptoms reported were such that they affected not only the sufferer but others close to them as one 35 year old woman acknowledged *' I have a lot of problems with my soft tissues .... That alongside the POTS have the biggest impacts upon mine and my partner's lives'. P17K.*

Clumsiness and poor balance were referred to by some patients with JHS with important consequences in the case of a 50 year old woman who wrote *'I walk with a stick as I am a 'trip' hazard. I have had 3 nasty falls this year alone.' P115K*

The nature of JHS and its effect on daily living was summarised by one 28 year old woman who wrote *'.. it [JHS] truly does have an impact on my day to day tasks and physical and emotional health' P131*

Family history of the condition. Many patients with JHS reported a family member or several family members with JHS or hypermobility. It was interesting to note that in some cases a prior diagnosis of a family member with JHS had been the prompt for a patient with JHS in this study to seek out a diagnosis for themselves. As reported by one 31 year old woman '*I only discovered I was hypermobile after my sister was diagnosed following treatment from a private healthcare consultant.' P21K.*

In addition patients with JHS recognised that not all their family members had pain or symptoms associated with their hypermobility. As one 49 year old female wrote *'My mother has very flexible joints but no pain.' P93K*. Some parents recognised the condition in their own children but had difficulty explaining the condition either to health professionals or educators. One 42 year old mother wrote; *'[My] Children all have JHS, ….They [local doctors] did not understand my children's symptoms of pain.' P65K.*

5.7.6 Experiences with JHS

This theme of 'experiences with JHS' relates to the circumstances or factors associated with the condition. This theme consists of three sub themes; helpful experiences, unhelpful experiences and pain experiences. There is some overlap with the symptoms described in the first theme 'nature of the condition', but in this theme there is a focus on the context of these experiences.

Helpful experiences. Patients with JHS reported aspects which had helped them in the management of their own condition. Exercise appeared to be important for prevention of stiffness and or pain, but as one 27 year old woman explained '*The more active I am the better for joints & pain but then you are left with physical exhaustion (catch 22)'. P78K.* While one 27 year old male described in more detail how he coped with his condition. *'Manage own condition with diet and exercise, carefully paced, start with swimming and gradually build up to running etc'. P37K.* There was an interesting insight by a 37 year old woman who described her experiences of a pain management course. *'I went to a pain management course - very interesting - at the time found it quite difficult to cope with. I needed time to accept that the pain would not be relieved. Coping techniques were useful but afterwards rather than at the time of the course.' P144K*

Unhelpful experiences. It appeared that the unhelpful experiences tended to be those associated with meeting health professionals who lacked an understanding or awareness of the global nature of JHS.

> *'My 'journey' has highlighted how dis-jointed the approach to pelvis/back & joint problems is.... There is a desperate need for a more holistic approach where practitioners are willing*

(open to the idea) of secondary problems - looking at the body as a whole rather than in isolation! I live in hope!' P39K

In some cases this lack of understanding and awareness had brought about frustration and anger. A number of patients with JHS in this study acknowledged the importance of working with health professionals and were happy to be involved in the process of improving understanding of the condition. As one 42 year old woman explained:

'Feel very frustrated and angry about lack of awareness about JHS and systemic problems it brings…... I have no physical or mental energy left because of constant stress because of what people have put me through because they know nothing about JHS or its effects. Have been through so much with local doctors who tried to say was all in my head and gave me drugs which lowered my BP and left me paralysed as I already had POTS. ..... - all very wrong would be pleased to help in any way to get doctors to help us'. P65K

In addition to describing how they perceived their condition as either not being understood or not recognised by health professionals, was the lack of appreciation of the pain they had. As one 26 year old woman reported *'....they don't see many people with hypermobility and the time standard response is 'aren't you flexible?' followed by a general tendency to not understand/appreciate or treat the terrible pain issues I have'. P53K*

Patients with JHS explained the need to be listened to and for the condition to be viewed more holistically. In addition one 43 year old female accountant highlighted the significant effort required by patients to gain access to treatment.

'So many doctors and specialists STILL have no understanding of the symptoms and presentation of Ehlers Danlos syndrome [JHS}. They are often dismissive of symptoms complained of, rather than to listen to the sufferer who is essentially the best witness of the problems.
The NHS do not have the scope to deal with such conditions as the patient is not viewed holistically, which is VITAL to such conditions. Expertise is also often scarce and required a great deal of determination to gain the right treatment at the time it is needed'. P97K

Pain experiences. Patients with JHS described their pain experiences in particular the fact that medication was not always helpful. One 37 year old woman reported '*I have been on tablets for so long and they never give any pain relief'. P144K. A*nother 29 year old woman highlighted the dilemma of coping with pain when medication was ineffective. '*Medication does not work for me and*

when I cannot handle my pain alone I don't know where to go to get help. I feel totally distraught over all this'. P92K.

The long term nature of pain was again discussed by some patients with JHS who reported 'growing pains' and 'pain for many years'. This is mentioned here as part of the pain experience but has previously been discussed in more depth earlier (See 5.4). For some women the progressive nature of the pain was recorded as an important feature as one 35 year old woman wrote *'Daily pain gets worse' P49K.* Others explained pain experiences contributing to mood changes as reported by this 33 year old woman who wrote *'My constant pain makes me irritable and low' PP1K.*

5.7.7 Summary and reflection of the nature of JHS

Data collected for this analysis was generated by an open ended question at the end of the questionnaire. Half the patients with JHS contributed to this question. Analysis of the qualitative data for this section of the study illustrated the heterogeneous nature of JHS as patients with JHS reported many different signs and symptoms. They also provided information on family members with the condition and how their own condition might affect other family members. Patients with JHS reported helpful and unhelpful experiences. The helpful experiences related to their ability to manage their own needs and condition. Unhelpful experiences recounted in this study tended to be those associated with meeting health professionals and the difficulties experienced in communicating their problems or being heard. Experiences with pain were described in relation to the effects of pain and difficulties with pain relief. Data in this section revealed the richest qualitative descriptions in this study revealing information that was both personal and pertinent to understanding the global nature of JHS.

5.8 Reporting on the health burden of patients with JHS

The aim of this next section was to explore the health burden of patients with JHS. In this study the health burden was measured by employing the generic SF-12 questionnaire in which there are two summary scores related to physical and mental health (Ware et al 1996). The SF-12 questionnaire was embedded in the Health and Activities questionnaire and answered by both patients with JHS and healthy volunteers. The questions may be viewed as questions 29 – 40 (appendix 9). The SF-12 involved all participants self-reporting retrospectively over the previous four weeks. In this study the raw scores were converted into a standardised score using a computerised algorithm scoring system supplied by Quality Metric ®. The standardised scores reported by Quality Metric ® range from 0-100 points. Higher scores indicate better health and the mean population scores are approximately 50 points.

The two summary scores relate to the:

- Physical component summary (PCS) score
- Mental component summary (MCS) score

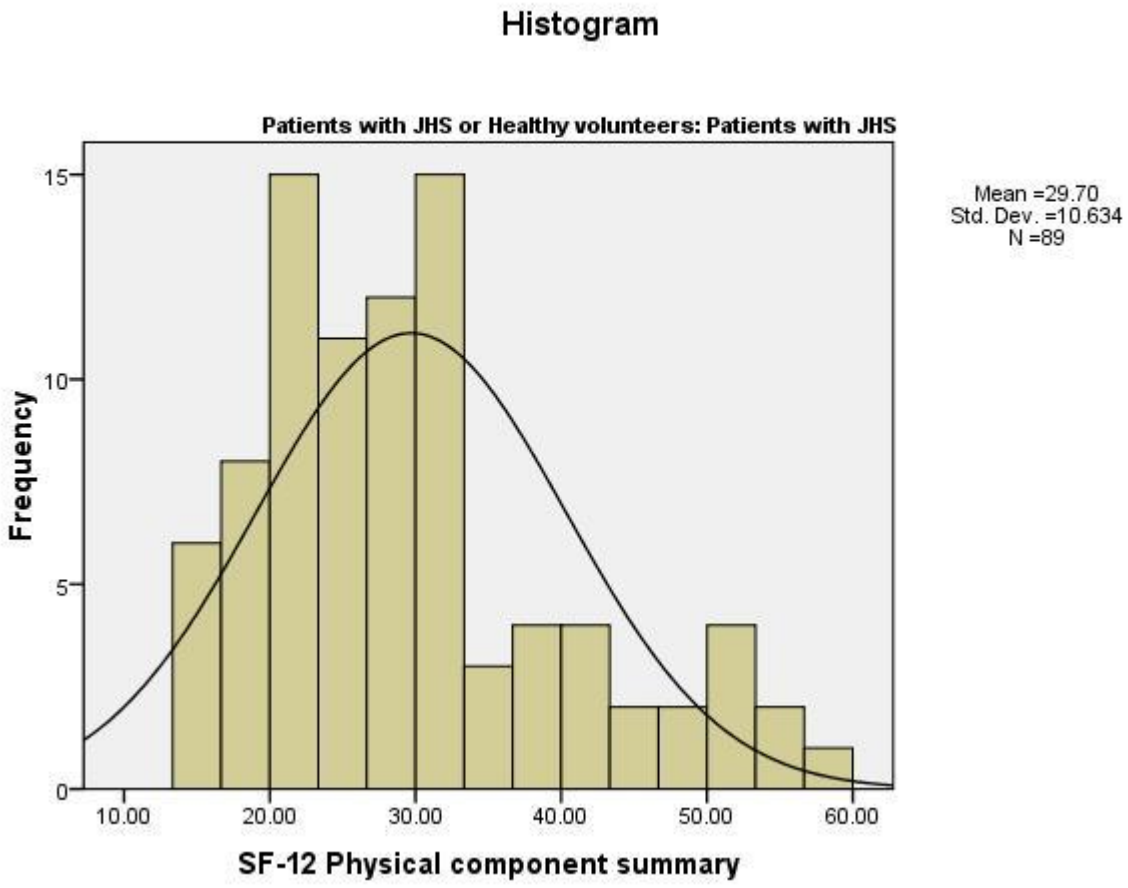
5.8.1 Analysis of the PCS score for patients with JHS and healthy volunteers

In the following section data were analysed in relation to the following hypothesis.

Null hypothesis 9: There is no difference in the mean physical component summary (PCS) scores of the SF-12 between patients with JHS and healthy volunteers.

Data relating to the physical component summary (PCS) score of the SF-12 for patients with JHS and health volunteers were described and compared (See table 5-21). Data were incomplete for one patient with JHS. It was noted that the data for patients with JHS and for healthy volunteers were not normally distributed. The PCS scores of patients with JHS were positively skewed (See figure 5-12) indicating lower mean scores which equate to lower quality of life scores. The PCS scores for healthy volunteers were negatively skewed (See figure 5-13) indicating higher mean scores which equates to higher quality of life scores. In this instance Levene's test was (p <0.05 therefore equal variances were not assumed. The unequal variance t-test was used to analyse the mean differences of the PCS score for both groups.

Figure 5-12 Histogram of the SF-12 physical component summary score of patients with JHS *(n=89)



*Data for one patient with JHS incomplete

Figure 5-13 Histogram of the SF-12 physical component summary score of healthy volunteers (n=113).

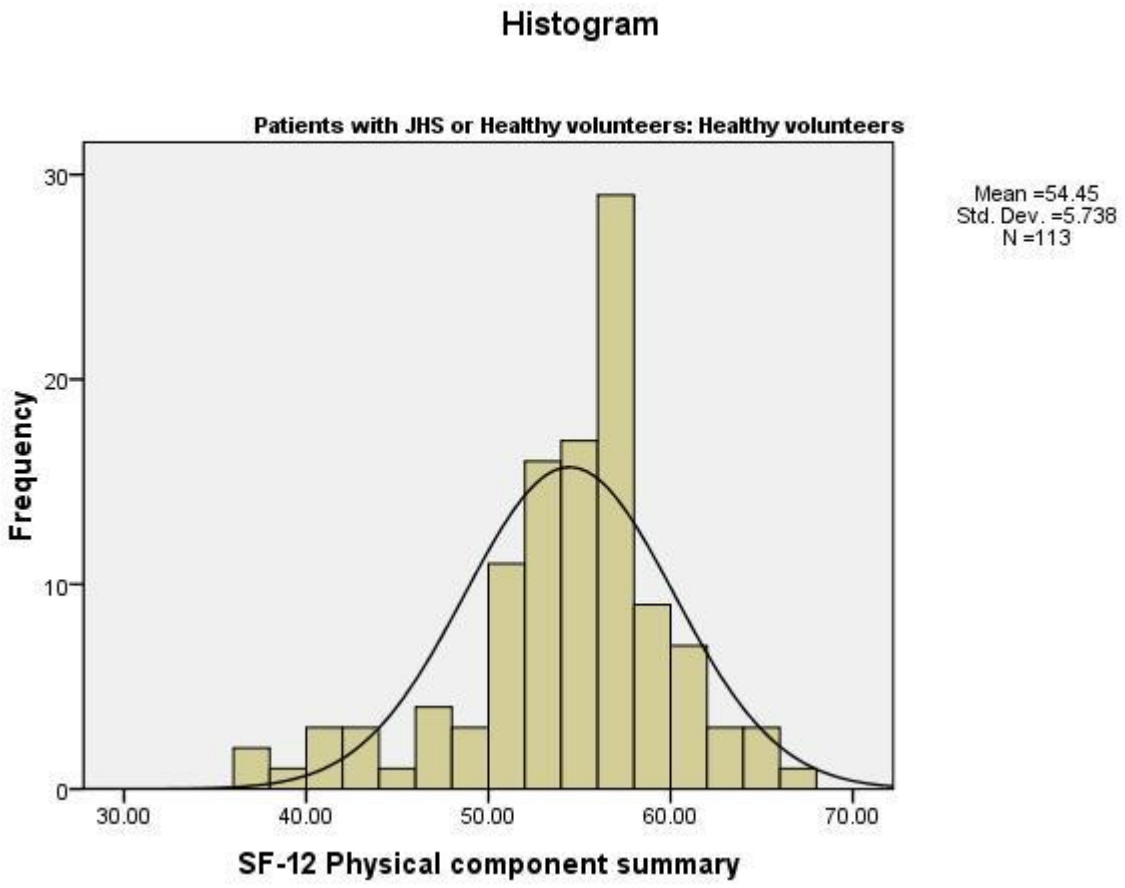


Table 5-21 Comparison of the mean, SD, SE and 95% CI for the physical component score (PCS) summary of the SF-12, between patients with JHS (n=89*) and healthy volunteers (n = 113)

Participants (n)	Mean PCS (SD)	SE	95% CI of the mean	Difference in the means	SE	95% CI of the difference of the means	*p* (two tailed)
#Patients with JHS (n=89)	29.70 (10.63)	1.13	27.46 – 31.94	24.75	1.17	22.44 – 27.06	0.001*
Healthy volunteers (n=113)	54.45 (5.74)	0.54	53.38 – 55.52				

#Data for one in the patient group were incomplete.

*$p < 0.001$

From the scoring manual, the norms of the SF-12 PCS scores are given for a 'well' population as (*M* = 54.7 SD 5.4) (Ware et al 2007). In this study the mean PCS scores of patients with JHS (*M* = 29.70 SD 10.63) were significantly lower than the mean PCS scores of healthy volunteers (*M* = 54.45 SD 5.74), *t* (127.701) = 19.81, *p* <0.001 (two tailed). The mean difference in the PCS scores between patients with JHS and healthy volunteers was 24.75 points [95% CI 22.44 – 27.06]. This represented a statistically significant difference.

A 5−point difference in either the PCS or MCS scores of the SF-12 have been associated with important differences in clinical and population studies (Bjorner et al 2007). This is based on the concept that this is the smallest difference in which patients would perceive a difference (Jaeschke et al 1989). The mean difference reported by patients with JHS and healthy volunteers was greater than 5 points, suggesting that any effect would be large enough to be perceived and therefore is likely to be clinically important.

5.8.2 Analysis of the MCS score for patients with JHS and healthy volunteers

Data relating to the mental component summary (MCS) score of the SF-12 for patients with JHS and healthy volunteers were described and compared in order to address the following hypothesis:

Null hypothesis 10: There is no difference in the mean mental component summary (MCS) scores of the SF-12 between patients with JHS and healthy volunteers.

The difference in the mean MCS scores was analysed using an equal variance t-test. It was noted that the data for patients with JHS and for healthy volunteers was normally distributed. In this instance Levene's test was not significant (*p* > 0.05 two tailed) indicating equal variances. A comparison of the mean MCS scores for patients with JHS and healthy volunteers is presented (See table 5-22).

Table 5-22 Comparison of the mean, SD, SE and 95% CI for the mental component summary (MCS) scores of the SF-12, between #patients with JHS (n=89) and healthy volunteers (n=113)

Participants (n)	Mean MCS (SD)	SE	95% CI of the means	Difference in the means	SE	95% CI of the difference of the means	*p* (two tailed)
#Patients with JHS (89)	41.13 (11.60)	1.23	38.99 – 43.87	4.21	1.60	1.05 – 7.37	0.006*
Healthy volunteers (113)	45.64 (10.91)	1.03	43.61 – 46.22				

#Data for one in the patient group were incomplete

*$p < 0.01$

From the scoring manual, the norms of the SF-12 MCS scores were given for a 'well' population as 53.3 (SD 6.8) (Ware et al 2007). The healthy volunteers in this study scored below with (M 45.64 SD 10.91). The mean for healthy volunteers were significantly higher than the mean MCS scores of patients with JHS (M = 41.13 SD 11.60), t (200) = 2.65, $p < 0$ .01 indicating a statistically significant result.

The mean difference was only 4.21 points [95% CI 1.05 – 7.37] which indicated the difference might not be clinically important. As a difference in the means was below 5 points which is suggested to be the minimum clinically defined score in which a difference is thought to be perceived (Bjorner et al 2007).

5.8.3 Exploring the association of symptoms and the PCS score of the SF-12

After reviewing the qualitative data which were presented earlier in this chapter (See 5.8) it was apparent that patients with JHS reported a number of factors that they perceived to contribute to their condition, this led to the next hypothesis:

Null hypothesis 11: There is no association between the reporting of pain, dislocations/subluxations, functional difficulties, Autonomic Nervous System (ANS) and Gastrointestinal (GI) symptoms in patients with JHS and their PCS scores.

These factors were used as explanatory variables to identify which variables were associated with a reduction in the PCS score of patients with JHS (5.9.1). Pain was recorded in relation to the number of pain sites using data recorded from a pain site chart with a range of 1-17 sites. Dislocations were divided to represent the dichotomous variable of either one or no dislocations (0) or two or more dislocations (1). This split in the variable reflects the Brighton criteria (Grahame et al 2000). ANS and GI symptoms were divided to represent the dichotomous variables of either no

symptoms (0) or one or more symptoms (1). Functional difficulties were reported using the functional difficulties score (FDS) with a range of 9-36. In addition demographic variables of age, sex and education were included. The results of the multiple linear regression analysis are presented (See table 5-23).

Table 5-23 A summary of the multiple linear regression analysis used to investigate the relationship between the physical component summary (PCS) score of the SF-12 and a number of explanatory variables in patients with JHS (n= 89)*

	Unstandardised coefficients				**95% CI**	
	B	**SE**	***t***	***p***	**lower**	**upper**
Constant (PCS)	46.263	6.566	7.041	0.000	33.169	59.303
Age	-0.025	0.177	-0.212	0.833	-0.257	0.208
Sex	0.445	4.430	0.100	0.920	-8.372	9.262
Education	1.749	2.324	0.752	0.454	-2.876	6.374
Functional difficulty score	-0.288	0.221	-1.303	0.196	-0.729	0.152
Gastro intestinal symptoms	-1.115	2.632	-0.452	0.673	-6.353	4.122
Autonomic nervous system symptoms	0.772	2.613	0.295	0.768	-4.428	5.972
Dislocations	-0.582	2.204	-3.192	0.792	-4.968	3.803
Pain sites	-0.968	0.303	-0.264	0.002**	-1.572	-0.364

*Data for one patient with JHS missing
The explanatory variables were:[Age in years; Gender:- 0 = female, 1= male; Education:- 0 = secondary education 1 = tertiary education; Functional Difficulty Score (FDS) (range from 0-36); GI symptoms:- 0 = no symptoms 1 = Gastrointestinal symptoms (GI); Autonomic Nervous System (ANS) symptoms:- 0 = no symptoms, 1 = ANS symptoms; Dislocations/subluxations:- 0 = one or no dislocation, 1 = more than one dislocation, Pain sites recorded as a number, (range from 0-17).
**p <0.01

For this model, the variance inflation factor (VIF) values were close to 1 and the VIF averages were not substantially greater than 1. Tolerance was well above 0.2, these co linearity statistics confirmed that co linearity was not a problem in this model and there was no biasing of the regression model. The value of the R^2 indicated that 23% of the variance in the outcome for which the predictors account was explained by this model.

A high percentage of patients with JHS reported subluxations/dislocations, GI and ANS symptoms and functional difficulties compared with healthy volunteers. In addition patients with JHS expressed their concerns in relation to these symptoms which might mean they have a confounding effect on the dependent variable However, the only variable to have a significant effect on the dependent variable were the number of pain sites (p < 0.01). This indicated that for each recorded pain site there was a decrease in the PCS score of 0.968 [95% CI -1.572 to -0.364] (higher scores indicate better health). The average number of pain sites reported by patients with JHS was 10 and 93% reported pain in four or more sites. This indicates that patients with JHS in this study reported multi

site pain which contributed to a reduction of the PCS score of the SF-12 and therefore to their health burden.

5.8.4 Summary of the analysis of the SF-12 for patients with JHS and healthy volunteers

A summary of the hypotheses relating to the SF-12 for patients with JHS with and without DCD is presented (See table 5-24).

Table 5-24 Summary of the null hypotheses used to investigate the association between patients with JHS and healthy volunteers in relation to the SF-12

Null hypothesis	Description	Accept/reject
Hypothesis 9	No difference in the PCS of the SF-12 between patients with JHS and HV	Reject
Hypothesis 10	No difference in the MCS of the SF-12 between patients with JHS and HV	Reject (but may not be clinically significant)
Hypothesis 11	No association between the reporting of pain, dislocations/subluxations, functional difficulties, ANS and GI symptoms in patients with JHS and the PCS scores of the SF-12	Pain – reject Dislocations/subluxations – accept Functional difficulties – accept ANS symptoms – accept GI symptoms - accept

5.9 Summary of the results and key findings

On average patients with JHS reported higher FDS than healthy volunteers this result was statistically significant and is likely to be clinically important. Patients with JHS were 3 times [95% CI 2.0 – 4.6] more likely to report functional difficulties both in childhood and adulthood than healthy volunteers indicating the long term nature of the functional difficulties reported. On average patients with JHS reported being ‘poor’ in 3/5 items related to gross motor functional difficulties while on average healthy volunteers reported being ‘good’ at 5/5 items, this result was statistically significant and is likely to be clinically important. Patients with JHS reported they were significantly more likely to report being ‘poor’ or ‘very poor’ at obstacle avoidance, balance and ball skills in adulthood. On average patients with JHS reported being ‘poor’ in 1/4 items related to fine motor functional difficulties and healthy volunteers reported being ‘good’ in 4/4 items, this was statistically significant but is unlikely to be clinically important (See 5.3).

Chronic widespread pain was reported by 86% of patients with JHS. Long term pain starting in early childhood or adolescence was a feature for patients with JHS and a finding that was significantly more likely to be found in patients with JHS who reported functional difficulties in childhood and adulthood. Patients with JHS reported pain continuing for many years, long after the initial event

that triggered the onset of the symptoms. The events that triggered the onset of symptoms broadly reflected three themes; traumatic, non-traumatic and pregnancy (See 5.4).

Patients with JHS and healthy volunteers reported spending similar amounts of time engaged in weekly physical activity and walking was the commonest activity reported by both groups. Responders in both groups who reported no functional difficulties were significantly more likely to spend more time engaged in weekly physical activity (See 5.5).

Patients with JHS were significantly more likely to report dislocation/subluxations at any site, than healthy volunteers. Patients with JHS were significantly more likely to report CFS, ANS, GI and CR symptoms than healthy volunteers. Fibromyalgia was reported by a small number of patients with JHS (See 5.5 and 5.6).

Patients with JHS reported significantly lower PCS scores than healthy volunteers. The difference in the scores was large enough to indicate a clinically perceived difference. Patients with JHS reported significantly lower MCS scores than healthy volunteers, but the difference in scores was small and this indicated they may not be enough to be perceived and therefore would not be clinically relevant. The numbers of pain sites were the only significant predictor contributing to a lowering of the PCS score in patients with JHS in a model which explained 23% of the variance (See 5.9).

Half the patients with JHS in this study contributed information which related to two themes the nature of the condition and experiences with JHS. The multisystemic nature of the condition was established in the quantitative data and confirmed in the qualitative data. Patients with JHS revealed their experiences with the condition. The helpful experiences related to exercise, pacing and pain management. Unhelpful experiences tended to be associated with meeting health professionals who had not recognised or accepted that the symptoms reported were related to a multisystemic condition – JHS (See 5.8).

Chapter 6

6 DISCUSSION

6.1 Introduction

This study was divided into two parts, the first involved the development of the Functional Difficulties Questionnaire (FDQ-9) aimed at assessing functional difficulties experienced by those with dyspraxia/DCD (See chapter 4). The second part involved employing that tool and other questions within in the Health and Activities questionnaire in order to explore the multifactorial manifestations of JHS (see chapter 5). The discussion relating to the development of the FDQ-9 is in chapter 4 section 4-8. This chapter focuses on the discussion related to the results presented in chapter 5. The aim has been to integrate the qualitative and quantitative data and the direction of the discussion has in part been driven by what appeared to be the patients' concerns.

The discussion relates to patients with JHS who were attending a hypermobility clinic in a London teaching hospital and healthy volunteers who were staff and students of a university in the south of England who reported no musculoskeletal pain or JHS.

In this study qualitative and quantitative data were collected and in this discussion this data is integrated in order to gain a broader understanding of the multifactorial manifestations of JHS and their impact. The research findings discussed were those related to; the reporting of functional difficulties; physical activity participation; musculoskeletal pain; the health burden of patients with JHS and the nature of the condition and experiences reported by patients with JHS. The chapter concludes with a summary. The limitations, generalisability and transferability of the research were considered initially.

The limitations of the second part of the study

In any study there are limitations whether in terms of resources, logistics, sample groups or time and for this study these limitations were no exception. It is acknowledged that the sample populations came from convenience sample groups and were not matched for age, sex or education. Females were over represented in both sample groups, this has been discussed (Section 4.8). There were differences in the educational achievements of the two samples. To address these limitations a regression analysis was undertaken and presented (table 5-2). In addition data relating to assumptions of the regression were discussed to enable the reader to draw conclusions about a population based on the analysis performed on these samples. Nevertheless

future studies require matching of the groups and randomized sampling. It is acknowledged that this study relied on self-report and therefore there was no verification of the signs, symptoms and abilities. In future studies self-report maybe correlated with observation or clinical test results. Considerations relating to self-report have been discussed (See section 4.3.5). It is acknowledged that the qualitative element of this study was concise and future studies employing a mixed methods approach would benefit from expanding on the qualitative element in order to gain a broader perspective of the impact of JHS. The limitations reported need to be considered when reflecting on the generalisability and transferability of the research.

Generalisability and transferability

Generalisability and transferability are important concepts in health research. Generalisation in essence involves drawing broad conclusions from the results and then making reasoned decisions about an unobserved population from an observed population. This aspect is carried out by the researcher (Polit and Beck 2010). Transferability is the work done by readers as they interpret the researchers' findings and draw their own conclusions as to how the research fits their setting (Polit and Beck 2010). Reader's inferences will be influenced by the manner in which the research is communicated and therefore transparency and clarity are paramount. In this next section the discussion revolves around the sample groups; patients with JHS and healthy volunteers.

Generalisability is defined as the extent to which the research findings in one situation will be pertinent to another (Polit and Beck 2010). To draw broad conclusions from the results about an observed population involves knowing and understanding the observed population. In this study there were two populations one from a hypermobility clinic and the other from a university. By integrating the qualitative data collected only from patients with JHS it has been possible to gain a broader understanding of the persons and settings within this sample. This is a unique feature of this mixed methods study.

The patients with JHS were a sample that came from the hypermobility clinic based in a London teaching hospital. There are only four hypermobility clinics in the United Kingdom and therefore patients attending the one in London travelled long distances to seek either a diagnosis, or for follow on treatment and/or advice. It might be assumed then that only patients with a more 'severe' form of the condition were attending the clinic. Alternatively it might be assumed they were those who were very determined to find a diagnosis or solution to their problems. In some instances it might have been a combination as summed up by one patient with JHS.

> *I have been suffering this problem for 9 yrs and have spent in excess of £10000 trying to find a solution! (visiting a huge variety of practitioners) P39*

It is also important to note that at the time of this data collection (May – July 2009) there had been a recent development in which a link between functional gastrointestinal disorders and JHS had been acknowledged (Zarate et al 2010). This may have led to more patients being referred from a tertiary referral neuro-gastroenterology clinic to the hypermobility clinic during the time this study took place. This is reflected in the comments by one patient with JHS who reported.

> *'My hypermobility has been identified as a result of investigations into my chronic IBS* and a belief that IBS* may be linked to my excessively 'stretchy' connective tissue.' P75*

*IBS Irritable bowel syndrome

This might account for patients with JHS in this study reporting a higher prevalence of gastrointestinal symptoms than those recorded in a previous study (Grahame and Hakim 2004). In addition Farmer and Aziz (2010) report that approximately a third of patients with JHS and gastrointestinal symptoms have dysautonomia, which may relate to a sub type of JHS in which both gastrointestinal and autonomic nervous system symptoms are recorded. A combination of these symptoms is described by one female patient who reported

> *'As I have got older I feel I have suffered more with other problems other than joint problems, particularly internal: stomach problems, palpitations, low blood pressure....' P23*

In this study the participants for the comparison study group were a convenience sample recruited from a university in the South of England. The sample of participants from this group consisted of approximately half from the student population which included a mixture of graduates and undergraduates. The other half of the participants were from academic and non academic staff who worked within an academic school. Limitations in relation to sample populations and sample bias have been discussed (See section 4.8).

The term trustworthiness replaces generalisability in qualitative research (Krefting 1991). Trustworthiness relates to the credibility and validity of the research and includes the aspects of credibility, transferability, dependability and confirmability (Krefting 1991; Rolfe 2006).

Credibility corresponds to the concept of internal validity of research and requires the researcher to demonstrate that a true picture of the subject for enquiry is being given (Taylor 2007; Rolfe 2006). This means relaying information that helps the reader to understand the context of the study and the participants. This is best done by reporting on the demographic details of the participants and a description of the research setting.

In this study there was a description of the setting – a busy outpatient clinic in a London teaching hospital- where many patients with JHS were travelling great distances (from many parts of England and Wales) which involved making considerable efforts to attend. This is evidenced in an extract from the researcher's field diary.

'Clinics 1 & 2 operating, tube strike. Chaos in London with bus queues and lots of people walking or cycling to work etc. Although the outpatient clinic as a whole was quieter the hypermobility clinic had a full compliment.' [Field diary CC 11th June 2009]

Transferability is defined as a form of external validity and relates to how the reader interprets the research findings to match their own setting (Rolfe 2006; Taylor 2007). Ideally for the reader to make an informed judgment about how well the research they are reading fits with their requirements they need richer/thicker descriptions relating to the participants in a study. A minimum requirement would be for these to include age, sex, highest educational achievement and employment status; these have been discussed in the results. Within these descriptions it would be informative to record ethnicity as JHS is more prevalent in non Caucasians than Caucasians. Ethnicity was not recorded and this is a limitation in this study.

Dependability is defined as reliability and relates to the consistency of the data and findings (Rolfe 2006; Taylor 2007). To ensure dependability requires the researcher to be transparent and clear in the description of the research process and to involve colleagues and field experts to review the process. A detailed description of the research methods and analysis is provided in the methodology chapter. This study has used both qualitative and quantitative data when exploring; participation in physical activity, pain, and the multisystemic nature of the condition. The results of the qualitative data have been linked to the quantitative data to enhance dependability.

Confirmability is defined in a broader context in relation to the presentation of the data and refers to the objectivity of a researcher and relies on the researcher putting strategies in place in order to limit bias (Rolfe 2006; Taylor 2007). Audits may be implemented in bigger studies, but in smaller studies a researcher needs to provide a reflexive account of their involvement or stance within the research. It is also important to document and continue dialogue with colleagues, supervisors and field experts throughout the research process and to provide information on the research activity. The researcher's observations and philosophical world view are provided (See 1.4 and 3.2). The research process and activity is referred to in the methodology chapter. There has been continued dialogue with supervisors throughout the process (See appendix 4) and presentation of the findings to colleagues, research and clinical groups documented as research outputs (See appendix 5). Discussions of the results presented in chapter 5 are now considered.

6.2 Functional difficulties

There were differences in the Functional Difficulties Scores (FDS) and types of functional difficulties most commonly reported by patients with JHS and healthy volunteers (See 5.3). Patients with JHS were more likely to report average scores indicative of functional difficulties both in childhood and adulthood than healthy volunteers. These findings were new and have implications for management and clinical intervention. In the results of this study it was reported that patients with JHS recorded significantly higher FDS than healthy volunteers including in the domains of gross and fine motor difficulties.

In this study the probability of patients with JHS reporting they were 'poor' or 'very poor' at balance and obstacle avoidance was significantly greater than healthy volunteers. These results are similar to those presented in an observational study in Belgium (Rombaut et al 2011) in which patients with Ehlers-Danlos Syndrome-Hypermobility Type (EDS-HT)* appeared to have a greater reliance on their visual system. Poor balance is well acknowledged in children with functional difficulties associated with dyspraxia/DCD (Hoare 1994; Macnab et al 2001) and it was observed that children with functional difficulties associated with dyspraxia/DCD were more reliant on their visual system than their peers without functional difficulties (Deconinck et al 2006). There is evidence that adult patients' with JHS report impaired proprioception of the knee (Ferrell et al 2004). Impaired proprioception of the knee will affect standing balance as joint proprioception is one sensory component which contributes to balance perception. There is anecdotal evidence that patients with JHS report poor balance and 'walking into door frames and furniture and tripping over' (Grahame 2010 p 23). In this current study 98% and 76% of patients with JHS who reported functional difficulties both as a child and as an adult reported difficulties with obstacle avoidance and balance respectively. In a group of female patients (mean age 39 years) with EDS-HT and balance difficulties 95% reported tripping or falling over in the past year (Rombaut et al 2011).

**EDS-HT, also known as EDS III is considered synonymous with JHS*

Implications of poor balance

Poor balance is just one of the risk factors that contribute to falls in the elderly according to the review by Rubenstein (2006). The others are a history of falls, gait deficits, muscle weakness, visual deficits, arthritis (joint pain), impaired activities of daily living, depression, the use of an assistive device, cognitive impairment and age (more than 80 years). Age and sex may be risk factors for falls as older women are found to fall more frequently than men (Campbell et al 1981; Nevitt et al 1989). In this study there is an illustration of some of these risk factors being present. One 50 year old female patient with JHS who reported functional difficulties both as a child and as an adult wrote: *'I walk with a stick as I am a 'trip' hazard. I have had 3 nasty falls this year alone.' P115.*

It is possible that some of these risk factors are apparent much earlier in life. The following characteristics are reported in children with functional difficulties associated with dyspraxia/DCD; impaired balance reactions, awkward gait patterns, frequent falls, difficulties associated with activities of daily living and poor visual function (Barnhart et al 2003; APA 2000; Cheatum and Hammond 2000; Coetzee and Pienaar 2010; Miyahara 1994; Mandich et al 2003). If joint pain and deconditioning as noted in those with JHS are added to this list, it appears that patients with JHS who report functional difficulties as a child and as an adult are at a significant risk of falling. There is evidence to suggest that patients with JHS in this study who reported falling had poor balance. The following four patients with JHS reported being 'poor' or 'very poor' at balance activities . *'...fell onto my knee, and needed 3 stitches.' PE49 '.....falling over!!' P70,' A fall down stairs at home caused a torn ligament in my shoulder and displaced my lower back and neck.' P75. 'Fall on knee.' P102.*

Falling may be considered as part of normal development in childhood. It is suggested that by adolescence and adulthood coping strategies have been put in place to avoid falling. This appears to be the case in older adults (Shumway-Cook and Woollacott 2007) some of whom report coping strategies to avoid falling. However, there are individuals who report fear and anxiety in relation to falling and their impaired balance (Maki et al 1991; Tinnetti et al 1990). Older adults may move in ways to minimise their risk of falling. This involves engagement in movement and activities that minimise challenging balance perception. It is suggested that if activities do not challenge balance perception it is unlikely that balance will improve and risks involved with falling are likely to continue. Falls associated with impaired balance need to be recognised and suitable interventions put in place early in life to reduce the risk of falls throughout the life span.

Exercise is one factor that can improve balance and therefore reduce the risk of falling (Shumway-Cook and Woollacott 2007). There is clear evidence that exercise not only improves strength and endurance and but also improves function. Several studies have linked this to a reduction in falls in older people (Rubenstein et al 2000). Although exercise is important for improving balance and reducing the risk of falling there may be barriers involved in engaging individuals in exercise and physical activity. The discussion in the next section involves exploring weekly physical activity participation in patients with JHS and healthy volunteers.

6.3 Weekly physical activity participation

This section discusses physical activity participation reported by patients with JHS and healthy volunteers. The importance of reporting on physical activity participation is because reduced

physical activity participation is thought to contribute to deconditioning and persistence of symptoms in those with JHS.

It was not the intention of this study to develop and validate a tool aimed at assessing physical activity. A pragmatic approach was taken for this aspect of the data collection and the two questions relating to physical activity in this study were adapted from the General Physical Activity Questionnaire (GPAQ) (Armstrong and Bull 2006) (See 3.3.2.5). The discussion begins with the key findings in relation to comparing physical participation; between patients with JHS and healthy volunteers.

Physical activity participation for patients with JHS and healthy volunteers

The first key finding was there was no significant difference in the time spent engaged in weekly physical activity between patients with JHS and healthy volunteers (See 5.5.1). This would suggest that reduced physical activity in patients with JHS was not a feature experienced by all.

The analysis of this data was based on the UK government's recommendations for physical activity participation (HSE 2008a). The dichotomous variables were those exercising for two hours or less a week and those exercising for three hours or more a week.

The recommendations are for adults to be engaged in moderate intensity physical activity for at least half an hour on five days a week, this equates to two and a half hours a week. Moderate intensity activity varies for individuals, but using the information reported by HSE (2008a) it is possible to put the term moderate intensity into context. Cardiac fitness was measured in a subgroup of participants aged 16-74 for the health survey for England (under half the population screened fulfilled the stringent inclusion criteria of being fit enough to carry out the tests). Of the group that remained it was found that to walk three miles per hour on the flat required moderate exertion for 84% of men and 97% of women.

In this current study walking was the commonest reported physical activity for both patients with JHS and healthy volunteers. A greater proportion of healthy volunteers (66%) were engaged in physical activity for three or more hours a week than patients with JHS (57%) but this was not a statistically significant difference. The percentage of adults aged 16 – 64 years who met the government's recommendations and were engaged in moderate physical activity for at least half an hour on five days a week was between 30% - 45% (HSE 2008b). Therefore a greater percentage of patients with JHS and healthy volunteers in this current study reported being engaged in physical activity for three or more hours a week than the population sample reported in the HSE (2008a).

This may be explained as follows. It is possible that patients with JHS in this study were highly motivated individuals (See 6.1) and therefore had sought information about their condition. There is a growing body of evidence to support the benefits of exercise in the management of individuals with JHS (Barton and Bird 1996; Kerr et al 2000; Ferrell et al 2004; Simmonds 2003; Simmonds and Keer 2008; Simmonds 2010). Alternatively it may have been that patients with JHS in this study had observed that exercise was important for their condition. There was evidence of this in the text data provided. One patient with JHS was able to report on the types of exercise found to be helpful. *'Very active do yoga and Pilates If I don't exercise stiffen up and loose fitness quickly' P56.* While another patient with JHS had recognised that strength was a helpful factor, *' All exercise helps, the stronger the better.' P49.* There appeared to be a variety of physical activities that were perceived as helping. *Jogging makes me feel looser in a 'good way'. P21.* Also of note from the descriptions above was that patients with JHS reported they needed to exercise to prevent 'stiffening up' or to contribute to 'feeling looser'. Stiffness has previously been reported as a common complaint by hypermobile individuals who have reported that exercise involving stretching can be helpful (Keer and Butler 2010; Harding 2003).

Conversely it might have been assumed that patients with JHS who had a more 'severe' form of the condition as suggested (See 6.1) were exercising less because there were restrictions to their physical activity participation. One patient with JHS reported on how physical activity participation was restricted. *'Walking but need to rest every few minutes because knee gives way.' PE21* Barriers to physical activity participation were not reported by any healthy volunteers, but just under a quarter of patients with JHS reported their participation in weekly physical activity as being restricted. The commonest reason cited was pain for example. *'Minimal amounts of walking during the course of the week restricted by pain' P92.*

Physical activity participation and functional difficulties

Higher Functional Difficulties Scores (FDS) indicating more functional difficulties were the only significant factor associated with physical participation of ≤ 2 hours a week in a model which controlled for age, sex, self report of chronic fatigue syndrome (CFS), cardiorespiratory and autonomic nervous system symptoms (See 5.5.2). It should be acknowledged there may be limitations in drawing conclusions about a population within a sample employed using a regression model and therefore data relating to assumptions were provided. Further exploration of these findings showed that both patients with JHS and healthy volunteers who on average reported 'no' functional difficulties were significantly more likely to be in the group that reported physical activity participation for ≥ 3 hours a week. Both healthy volunteers and patients with JHS who reported functional difficulties 'both as an adult and a child' were less likely to be engaged in physical activity for ≥ 3 hours a week.

It has previously been reported that young children with functional difficulties associated with dyspraxia/DCD were less likely to participate in vigorous, active play (Cantell et al 1994; Hands and Larkin 2002). In addition children and adolescents with dyspraxia/DCD were noted to be less physically active than their peers. It was reported that this was related to a reduction in generalised self-efficacy (Cairney et al 2005) as a result of perceived poorer motor competency. It has been suggested that by late adolescence it is possible to predict sport participation by asking adolescents what they feel about their ability in sport (Fox and Corbin 1989). Feelings of low sporting competency and autonomous motivation are related to low engagement in physical activity (Fox and Corbin 1989; Fox and Wilson 2007; Standage et al 2012). Poulsen et al (2007) reported that boys aged 10 – 13 years with functional difficulties associated with dyspraxia/DCD were less likely to participate in all forms of physical activity, whether structured (team sports) or unstructured (informal play). It is suggested that the combination of perceptions relating to motor competency and poor motor competency together might influence reduced physical activity participation.

The results of this current study indicate that the trends in reduced time spent engaged in physical activity participation for those with functional difficulties may continue into adulthood. It is understood that this is a preliminary result based on self-report and that further studies are required to investigate physical activity participation and possible barriers to participation. The implications of these findings are considered.

Implications of physical activity participation findings

The implications of reduced physical activity are well acknowledged, these relate to; an increased risk of chronic heart disease (Shaper et al 1991; Lee et al 2001), some cancers (Giovannucci et al 1995), obesity (Waller et al 2008) and type II diabetes (Sigal et al 2006). Diet and poor activity patterns are thought to increase the health burden of those with type II diabetes. It has been found that counseling to affect behavioral change leads to significant changes in diet and time spent engaged in moderate intensity physical activity in older persons. (Goode et al 2011) This suggests that affecting change in behaviour may alter motivation and perceptions relating to physical activity. If reduced physical activity seen in adulthood is as a result of poor motor competency and motivation persisting from childhood then it is suggested that behavioral change needs to be targeted early in life.

For some patients with JHS who reported functional difficulties both as a child and as an adult there was evidence to suggest that their average weekly physical activity participation was less than 20 minutes a day. It is suggested that in these individuals deconditioning is likely. Deconditioning of the neuromusculoskeletal system occurs as a result of inactivity (Simmonds 2010) and neuromusculoskeletal adaptive changes that occur will also affect cardio-respiratory fitness. This

has particular clinical significance when prescribing suitable exercise programs. Health professionals and patients need to work together to understand individual current physical activity participation prior to planning future exercise programs that are realistic, achievable and relevant.

The long term effects of reduced physical activity are well recognised. The main efforts for increasing physical activity promotion in England have been through Sport England and the government department related to Culture, Media and Sport (Department of Culture, Media and Sport (DCMS) 2001). Efforts to promote physical activity participation have primarily involved improving activity associated with sport in a more 'formal' context which might not be applicable to those with perceived lower physical competency.

For those reporting they avoided physical activity in childhood, and continued this trend into adolescence because of low physical competency, it might be suggested that addressing changes in physical activity participation requires a two tiered approach. The first aimed at facilitating children in early life to be actively involved in play. The second requiring a broader profile aimed at behavioral change in relation to physical activity that continues through life. For some children the facilitation of physical activity will require therapeutic intervention, their requirements need to be recognised early. For the majority this requires a broader perspective and an appropriate environment that facilitates engagement in physical activity that is not necessarily formal or informal sport. The broader perspective is that suggested by Fox and Hillsdon (2007) which involves sustainable environments where people are motivated to be physical activity is a part of daily life. These would include walking/cycling to school, work and/or shopping.

Only patients with JHS reported physical activity being restricted. They reported a variety of factors that contributed to reduced participation in weekly physical activity. It is important in the clinical setting that health professionals are aware of these limitations and that treatment programs address these issues. Pain was commonly reported as limiting physical activity participation in this current study. Functional difficulties appear to be associated with reduced physical activity and impaired balance identified in patients with JHS may be a 'hidden' barrier to physical activity participation. Barriers to physical activity participation require further investigation if they are to be addressed appropriately.

6.4 JHS and conditions associated with chronic widespread pain

This section reports on chronic widespread pain in patients with JHS and discusses these results alongside associated conditions or symptoms (See 5.4 and 5.7). The associated conditions or symptoms are fibromyalgia and autonomic nervous system (ANS) and/or gastrointestinal (GI)

symptoms. In this next section the quantitative and qualitative data have been integrated. This has enabled a unique insight in relation to pain in this study. Quantitative data reported on the number of joints in which pain was perceived for more than three months and the widespread nature of the pain. Qualitative data highlighted the long term nature of chronic pain, events that triggered the onset and the persistence of pain long after the initial nociceptive incident. Nociceptive pain relates to pain that is triggered peripherally by a noxious stimuli, this may be as a result of inflammation or nerve damage following a traumatic or non traumatic incident. Patients with JHS who reported long term pain were significantly more likely to report functional difficulties both as a child and as an adult than those who reported no functional difficulties (See 5.4.8). This is a finding that has not previously been reported and is likely to be important when considering the integration and modulation of pain perception.

Chronic widespread pain was a salient feature for patients with JHS with 93% reporting pain in ≥ 4 or more sites for ≥ 3 months (See 5.4). The data was collected using a pain chart and it is acknowledged that one of the limitations in the collection of this data was that the pain chart did not allow for the recording of regional muscle pain. The number of patients with JHS who self reported fibromyalgia was 17 all of whom reported pain in ≥ 4 sites for ≥ 3 months. Patients with JHS were significantly more likely to report one or more gastrointestinal and/or autonomic symptoms than healthy volunteers (See 5.7.2).

Chronic widespread pain

Pain associated with JHS may be regional, localised or widespread (Hakim et al 2010). The majority of patients with JHS in this study reported chronic widespread pain as opposed to localised or chronic regional pain. Chronic widespread pain is a phenomenon that has previously been described in patients with fibromyalgia (Wolfe et al 1990) The diagnostic criteria for fibromyalgia established by the American College of Rheumatology relies on the reporting of chronic widespread pain and tenderness (on palpation) of at least 11 out of 18 pre-designated sites (Wolfe et al 1990). Fibromyalgia has not previously been reported in patients with JHS using the Brighton criteria (Grahame et al 2000). Although studies have shown that joint hypermobility, recorded employing the Beighton score (Beighton et al 1973) were recorded more frequently in patients with fibromyalgia (Gedalia et al 1993; Acasuso-Dias and Collantes-Estevez 1998; Karaaaslan et al 2000; Sendur et al 2007).

Fibromyalgia, gastrointestinal symptoms and pain

Epidemiological studies of patients with fibromyalgia have shown that between 50-70% of patients with fibromyalgia may complain of gastrointestinal symptoms such as dyspepsia and irritable bowel syndrome (Triadafilopoulos et al 1991). In this study 71% of patients with JHS and 88% of patients

with JHS who also self-reported fibromyalgia recorded gastrointestinal symptoms. Patients with JHS were 3 times more likely to report gastrointestinal symptoms than healthy volunteers. Gastrointestinal symptoms have previously been reported in patients with JHS (Hakim and Grahame 2004). Unexplained gastrointestinal symptoms are common and generally referred to as functional gastrointestinal disorders (FGID). These relate to a group of disorders for which structural and biomechanical abnormalities have yet to be identified. The FGID share similar epidemiological and clinical features with JHS and fibromyalgia (Farmer and Aziz 2010). It has been hypothesised that connective tissue laxity may be a contributory factor to alterations in gut biomechanics (Zarate et al 2010). However, an alternative suggestion would be that there is a centrally driven neurophysiological element that contributes to alterations in gut biomechanics.

The common feature amongst patients reporting FGID, fibromyalgia and JHS is chronic widespread pain. It has been suggested that where there are 'disease clusters' that have similar patho-aetiological factors like widespread pain the common factor may be central sensitisation (Wessely et al 1999; Whitehead et al 2002). Central sensitisation relates to an increased excitability of neurons within the CNS. This leads to normal sensory inputs being perceived as abnormal with consequent abnormal responses. Central sensitisation may follow an adverse peripheral nociceptive incident (Woolf 2011). The observation that pain may continue to be perceived either in the absence of noxious stimuli or after the inflammatory or neural event has 'healed' (Cook et al 1987) led to the understanding that noxious stimuli are not always required in order for pain to be perceived. It has been acknowledged that central sensitisation of pain may be as a result of neurobiological alterations within the CNS (Woolf 2004; Woolf 2011).

Aberrant sensory processing within the CNS is understood to be the underlying mechanism for pain in those with functional gastrointestinal disorders and fibromyalgia (Chang et al 2003). Sensory processing relates to the registration and modulation of sensory stimuli (Humphry 2002). It has been found that impairments in sensory modulation resulted in higher pain catastrophisation (Engel-Yeger and Dunn 2011). It is possible that pain reported in patients with JHS is centrally sensitised.

Experimental studies have shown that central sensitisation may be induced in healthy individuals following a nociceptive stimulus (Shenker et al 2008) and in a variety of tissues (Brock et al 2010). In the clinical setting a nociceptive incident might be as a result of trauma for example a fall, road traffic accident or as a result of surgery (Woolf 2011).

In this study when patients with JHS reported life events which had triggered the onset of their aches and pains, (5.4.5). These themes included traumatic, non traumatic events and pregnancy.

Patients with JHS who reported pain related to pregnancy revealed pregnancy as influencing their aches and pains but that the pains continued long after the birth of the child. For example pain was described as *'Worse when pregnant and continued to get worse even though my daughter is now nearly 4.' P131.* Patients with JHS who reported trauma revealed the onset of pain associated with an accident and again there was indication of pain continuing; *'With back + neck pain caused by car accident, other problems just started aching and got worse for no particular reasons.' P92.* For one patient with JHS in this study the incident was following an infection *'Following septic shock after stent removal 6 weeks after renal auto-transplant..' P6.* The qualitative data from the patients with JHS in this study indicated that a peripheral nociceptive event may have been the trigger for long term and often unexplained aches and pains. It was also evident that aches and pains were not necessarily only those associated with the musculoskeletal system as one patient with JHS reported *'Always had some pain in legs and stomach.' P137*. Central sensitisation can be induced in a variety of tissues, for example the gastrointestinal tract; this highlights the global nature of central sensitisation (Kato et al 2006). The global nature of the pain reported and details of 'continuing' pain would seem to indicate there are impairments in perception and/or in the integration of perception within the CNS.

Chronic widespread pain and dysautonomia

As previously described chronic widespread pain is a feature of fibromyalgia, JHS and FGID. There is evidence to suggest that patients with JHS and patients with fibromyalgia report signs and symptoms consistent with dysautonomia (Gazit et al 2003; Hakim and Grahame 2004; Martinez - Lavin 2007). In this study the percentage of patients with JHS who reported one or more autonomic nervous system symptoms was 70% (See 5.7.2). Over 50% of patients with JHS in this study reported two or three autonomic nervous system symptoms of whom seven volunteered a diagnosis of postural orthostatic tachycardia syndrome (POTS). Symptoms of dysautonomia have previously been reported in patients with hypermobility and JHS (Gazit et al 2003; Hakim and Grahame 2004).

In this study patients with JHS were significantly more likely to report one or more ANS symptoms than healthy volunteers. There is anecdotal evidence that approximately a third of patients with JHS and FGID have dysautonomia (Farmer and Aziz 2010). At present the mechanism of dysautonomia in patients with JHS is not clear although there appears to be no peripheral nerve pathology in patients with JHS who have POTS (Iodice 2011). In those with fibromyalgia it is suggested that sympathetic over activity alters central modulation which enhances maladaptive behaviour not only to pain but to bowel and cardio-vascular pathology (Sato and Perl 1991; Barron et al 1999; Bravo et al 2010). It might be suggested that the conditions associated with JHS for example, fibromyalgia, chronic widespread pain, FGID and dysautonomia are as a result of impairment within the CNS and not just as a result of connective tissue changes. This does not preclude the concept that inherently

lax connective tissues may contribute to the 'setting' of the CNS and that aberrant connective tissues might contribute to the initial nociceptive incident.

Long term pain and functional difficulties

Patients with JHS reported the onset of their pain under the theme 'long term pain' (See 5.4.7). The theme 'long term pain' included the sub themes; 'always had pain', 'pain started in childhood' and 'pain started in adolescence or puberty'. Under the sub theme 'always had pain' patients with JHS reported their aches and pains being a feature that started in infancy. Under the sub theme 'pain started in childhood' patients reported on their childhood memories relating to the onset of their pain. Under the sub theme 'pain in adolescence and puberty' patients with JHS included a description of pain which was sometimes accompanied by the onset of dislocation. Under the sub themes 'always had pain' patients with JHS provided the following insights; *'Always had [aches and pains] since birth P65; '.... aches and pains for as long as can remember... P 49.* This suggests that pain perception is a feature very early in life and links with the theory that pain sensitivity may have a hereditary component (Aggarwal et al 2006) and maybe a linked to the integration of sensory information within the higher centers of the CNS.

The proportion of patients with JHS who reported functional difficulties both as an adult and as a child were significantly more likely to report 'long term pain' than patients with JHS who reported no functional difficulties. The long term nature of pain in children with JHS has previously been observed (Sachetti et al 1997; Adib et al 2005). The commonest symptoms reported by school children with JHS were clumsiness and pain. Very often they reported the onset of pain after exercise and reported missing physical education sessions (Adib et al 2005). The relationship between centrally sensitised pain and movement dysfunctions requires further examination.

Clinical implications of chronic widespread pain

Chronic widespread pain was a major feature for patients with JHS in this study. In addition patients with JHS reported fibromyalgia and were significantly more likely to report, gastrointestinal and autonomic symptoms than healthy volunteers. It is possible that these associated conditions and symptoms share a similar aetiology within the CNS. The combination of these symptoms has an important part to play in the daily lives of those with a diagnosis of JHS. At present there are no validated biomarkers to help clinicians diagnose these conditions (JHS, fibromyalgia, functional gastrointestinal disorders and dysautonomia) and they may not be recognised in patients presenting with musculoskeletal pain.

In an era where disorders are often managed in super-specialised clinics and where sub-specialisation in health care is the norm this may lead to disorders being managed in isolation

rather than holistically. Health professionals may not be aware of this although patients with JHS are:

> *My 'journey' has highlighted how dis-jointed the approach to pelvis/back & joint problems is.... There is a desperate need for a more holistic approach where practitioners are willing (open to the idea) of secondary problems - looking at the body as a whole rather than in isolation! I live in hope! P39K*

Prior to the plethora of diagnostic tools which are now available to the clinician the statement of the problem delivered by the patient would have been the primary basis on which to clinically reason a diagnosis. It is possible that health professionals currently rely too heavily on diagnostic tools to define a biological or mechanical problem. Instead of listening to the patient's testament and then employing a clinically reasoned hypothesis for the symptoms described. It would appear in some instances that if the tests return 'negative' to any biological or mechanical marker clinicians may not take the condition 'seriously'.

> *'So many doctors and specialists STILL have no understanding of the symptoms and presentation of Ehlers Danlos syndrome [Joint hypermobility syndrome]. They are often dismissive of symptoms complained of, rather than to listen to the sufferer who is essentially the best witness of the problems.' P97K*

The narrow focus of specialties may prevent health professionals from understanding the complex overlapping nature of multiple symptoms. The concept derived from this study was that a combination of symptoms including long term pain may be as a result of the 'setting' or 'sensitisation' of the CNS. It is anticipated that conceptualisation of the CNS as a factor contributing to the symptoms reported by those with JHS will enable a better understanding of this complex multifactorial condition. It is anticipated this will in the future assist health professionals in understanding their patients' requirements and enable suitable therapeutic interventions. It is apparent that the concept of chronic widespread pain is not always acknowledged and the complexities of multisystemic conditions such as JHS are challenging to manage. It is suggested that patients who live with their condition have already put strategies in place to manage their condition and health professionals need to work together and be guided by patients. In this case the most important requirement for health professionals is the art of 'listening'. This is summed up by Maitland (1986 p8) who wrote;

> *'It is extraordinary how often doctors and physiotherapists (in fact all people who deal with people) do not listen, nor listen carefully enough, or listen sensitively enough, nor listen at*

sufficient depth, to their patients.....There is so much to learn about a patient's problem if only we will listen'.

While the biological mechanisms may still be a puzzle in our understanding of the nature and associations between JHS, fibromyalgia, functional gastrointestinal disorders, autonomic nervous system dysfunction, chronic pain and functional difficulties. It is apparent that these symptoms and in particular pain impact on the lives of patients with JHS and are a health burden which deserve serious consideration.

6.5 The health burden of JHS

In this section the key findings which relate to the health burden, nature of the condition and experiences of the condition for those with JHS are discussed. The first key finding was that patients with JHS reported significantly lower mean quality of life scores than healthy volunteers (See Section 5.9.1).

As previously acknowledged patients with JHS reported in the text data that a number of features were troublesome, this enabled triangulation of the data and an insight on how these features impacted on the overall health burden. The second key finding was that pain was the only commonly reported symptom which was a significant predictor to a lower PCS score of the SF-12 (See 5.9.5). Patients with JHS also reported their experiences these were; family experiences and the lack of awareness of the condition (See 5.8).

SF-12 physical component summary scores

The SF-12 questionnaire measures the physical and mental health quality of life. The two scores are referred to as the physical component summary (PCS) score and the mental component summary (MCS) score.

The PCS scores for patients with JHS and healthy volunteers were previously reported (See 5.9.1). Distributions of the mean PCS scores for these groups were not normal. A histogram of the mean PCS scores for patients with JHS showed a positive skew which indicated the majority of patients with JHS reported results at the lower end of the scale indicating an increased health burden. The mean PCS scores for healthy volunteers viewed on the histogram showed the results were negatively skewed with the majority of healthy volunteers recording scores above 50 points and a decreased health burden. The SF-12 medical outcomes scoring manual recorded similar mean scores for a 'well population' as the healthy volunteers in this study. Patients with JHS in this study recorded PCS scores that were more than 2 SD below the healthy volunteer mean scores.

This study is the first to report the PCS scores of the SF-12 for patients with JHS and therefore there are no studies with which to compare. In the following discussion the scores from this study are compared with the SF-12 scores from a chronic low back pain study (which was used for the sample size calculation for this study) (See 3.5.3.9) and studies for individuals with fibromyalgia.

Chronic low back pain is commonly reported in patients with JHS and was reported by over two thirds of the patients with JHS in this study. The results of this study were compared with that of a prospective cohort study in the USA for workers with chronic low back pain who had not been able to return to work a year after their initial back pain incident (Baldwin et al 2007). The mean PCS scores of the SF-12 for workers who had not been able to return to work for a year were slightly higher than the mean scores for patients with JHS in this study.

Earlier in this thesis (See 5.7.1) it was reported that 17 patients with JHS self reported fibromyalgia. And there is evidence to suggest that fibromyalgia and JHS share similar pathophysiological mechanisms related to chronic widespread pain, and may share an association.

There have been several studies that have reported on the health status of patients with fibromyalgia using the SF-12 and SF-36 (the original longer version of the SF-12) and found that individuals with fibromyalgia around the world show a similar health burden pattern (Hoffman and Dukes 2008). For example the mean PCS scores of the SF-12 for 287 women with fibromyalgia in the US was 29.2 [SD 8.5] (Reisine et al 2004) and in a Spanish study in which 93% of the 35 patients with fibromyalgia were female and the mean PCS scores were 27.7 [SD 7.7].

It has been previously suggested that those with fibromyalgia report a 'health status burden' that is similar or greater than many conditions in which health status impairments are widely accepted for example rheumatoid arthritis and systemic lupus erythematosus (Hoffman and Dukes 2008; Walker et al 1997; Costa et al 2000). It is suggested that patients with JHS share similar health status impairments. This is an important finding as it highlights the debilitating nature of the physical component of this condition.

SF-12 mental component summary scores

Data relating to the MCS score for patients with JHS and HV were reported in the results (See 5.9.2). From the scoring manual the mean scores of the SF-12 MCS for a 'well' population were 53.3 [SD 6.8] (Ware et al 2007). In this study the healthy volunteers recorded a lower mean MCS and a larger SD than those of a previously recorded 'well' population. Patients with JHS recorded significantly lower mean MCS scores and similar SD to healthy volunteers. The difference in the

mean scores of the patients with JHS was less than one SD lower than the mean MCS score of the HV.

The mean MCS scores for patients with JHS in this study were similar to those recorded by workers in the USA who experienced long term back pain and women in Spain who reported fibromyalgia (Reisine et al 2004; Baldwin et al 2007). The mean scores for patients with JHS in this study were slightly lower than the mean scores reported by patients with rheumatoid arthritis (Walker et al 1997). It is again suggested that patients with JHS share similar health impairments as other conditions in which the health burden is widely acknowledged.

Integration of data relating to the clinical features of JHS

The second key finding was related to the clinical features which patients reported on qualitatively this is discussed alongside the quantitative data. This part of the discussion starts with the reporting of dislocations/subluxations which were referred to by patients with JHS in the quantitative (See 5.6) and qualitative data (See 5.8). Patients with JHS and healthy volunteers were asked to report if they had had dislocations/subluxations at the following joints; shoulder, patella and fingers. An option to include 'other joints' was also included and dislocations/subluxations were reported at the following joints; jaw, elbow, wrist, thumb, sacro-iliac, hip, ankle and toes. Only patients with JHS had the opportunity to report qualitatively about their dislocations and subluxations.

In the quantitative data patients with JHS were significantly more likely to report dislocations/subluxations than healthy volunteers at all sites. In addition patients with JHS were more likely to report recurrent dislocations than a single episode at each site. Patients with JHS also referred to the regularity and the impact of their dislocations/subluxations in the text data which enable some insight into the troublesome nature of frequent dislocations.

'Toes dislocate regularly' PE49.

'Difficulty lifting heavy things, because of wrist and shoulder subluxations' P132.

'For 20 yrs back & forth to hospital knees dislocating everything put down to growing pains. When I had dislocations didn't want to see anyone because they said this would happen and I was given injections under the knee cap.' P144

As previously discussed pain was an important feature for patients with JHS in this study. In this section the discussion relates to the 'nature of pain' and the 'pain experiences' reported by patients with JHS. The 'nature of pain' relates to the identity or character of the pain. The identity of the pain; some patients related this to an area of the body for example the face and gave the type of pain a

name *'neuropathic facial pain, dental pain' P6* While another patient with JHS reported the tissues affected *'..muscle, soft tissue and ligament pain (rather than joints) P16.* Some patients with JHS reported the joints that were worst affected for example *'Hip and back worst affected joints P31* or *'Painful hands'P49.*

The character of the pain related to the traits or types of pain that patients with JHS reported were often aspects not captured anywhere else in the study questionnaire. '*I also get severe migraines/back to back headaches* P115 *'Various difficulties not covered in this survey, shooting pains etc'.* P27. Late onset of pains *My joint pains did not commence until I entered my 40s....,P93.*

*'Pain experiences' c*aptured the experiences of Patients with JHS in relation to their pain. Several patients with JHS report that pain medication was not always helpful. '*I have been on tablets for so long and they never give any pain relief. P 144K'* and '*Medication does not work for me and when I cannot handle my pain alone I don't know where to go to get help....' P92K .* It is acknowledged that pain management for patients with JHS who report chronic widespread pain is complex and that non-steroidal, opiate based and tricyclic analgesics may not be effective (Hakim et al 2010). In these cases it has been suggested that physical interventions, pain management and cognitive behavioural therapy may be more appropriate for patients with JHS (Hakim et al 2010; Simmonds and Keer 2007; Keer and Butler 2010; Daniel 2010).

It would appear that patients with JHS in this study recognised that activity was important for reducing pain '*The more active I am the better for joints & pain but then you are left with physical exhaustion (catch 22) P78K.* In this instance this patient with JHS had recognised the importance of activity but not the need for the activity to be 'paced'. Pacing of activities in this context involves being engaged in restrained activity which reduces the chance of exacerbating symptoms. Although there is little evidence relating to the beneficial effects of 'pacing' (Gill and Brown 2009) it is widely used in clinical practice and there is anecdotal evidence to support its use in both adults and children with JHS (Harding 2003; Maillard and Payne 2010).

Patients with JHS reported a variety of problems. In some cases there was no explanation as to whether they felt these were associated with their JHS but it is assumed that because they were included in this questionnaire some association was anticipated.

> *'Ruptured ovarian artery, recurrent miscarriages (4), born with talipes and odontogeneisis imperfecta, mitral valve prolapse'. P22*

In the case of another patient with JHS there was an explanation of how the features of JHS appeared to have changed with time.

> *'As I have got older I feel I have suffered more with other problems other than joint problems, particularly internal: stomach problems, palpitations, low blood pressure, dizziness, chest pains, eye problems, sickness, tiredness many kidney infections.' P23.*

Dizziness and low blood pressure have been reported in patients with JHS and dysautonomia, more recently this has been reported in relation to postural orthostatic tachycardia and orthostatic hypotension. Orthostatic hypotension is defined as a rapid drop in blood pressure when standing. Postural orthostatic tachycardia syndrome (POTS)* is defined as a rapid drop in blood pressure that is accompanied by an increase in pulse rate (Bravo et al 2010). ANS symptoms were reported in the results chapter (See 5.7.2) and were discussed earlier in this chapter in relation to pain (See 6.4). Patients with JHS in this study were significantly more likely to report ANS symptoms than healthy volunteers. It would appear for some that POTS significantly affected their lives as reported by one patient with JHS

> *'POTS*, this takes up lots of time takes 5 hours to get up in the morning because of dizziness and blood pooling. Exercise intolerant do 10 reps and sit out for 5 minutes otherwise would faint. I started fainting aged 13 and fainted daily from 20 years...' P49*

It has previously been reported that for those with POTS, tachycardia may be worse during exercise and it is suggested that it is difficult to differentiate whether POTS in these cases is as a result of a primary dysautonomia or from deconditioning (Joyner and Masuki 2008). Deconditioning caused by a lack of physical activity may continue to be a feature for some with POTS who report becoming tachycardic when exercising. The results of this study (See 5.5.2) indicated that for patients with JHS and healthy volunteers the reporting of ANS symptoms were not associated with reduced physical activity participation. This may be because reduced physical activity associated with ANS symptoms occurs in only a few. Alternatively it might be that those with ANS symptoms are proactive and spend more time engaged in physical activity because they recognise the importance of physical activity. To further our understanding of how ANS symptoms may contribute to deconditioning and exploring features that mitigate these symptoms is an area for further research.

Gastrointestinal symptoms were frequently reported by patients with JHS (See 5.7.2) and are discussed in relation to pain (See 6.7.2). A few patients with JHS in this study reported gastrointestinal symptoms in the text data *'..stomach problems..' P23* or '... *IBS [irritable bowel syndrome]' P75* but there was no information on how these symptoms affected their lives.

Clinical features which predict the PCS scores of the SF-12

The third key finding was that pain was the only commonly reported clinical feature which was a significant predictor to a lower PCS score of the SF-12. To explore this analysis qualitative data relating to the more common troublesome features reported by patients with JHS in this study informed the multiple regression analysis. In this section qualitative and quantitative data were integrated and interpreted. It was established that patients with JHS commonly reported the following features of their condition; pain, dislocations, functional difficulties, autonomic nervous system and gastrointestinal symptoms. The number of pain sites was the only significant predictor in a model which explained 23% of the variance.

Patients with JHS reported that pain was a reason that prompted other family members to seek advice form a healthcare professional and for some this had resulted in a diagnosis for themselves.

> *'It wasn't until my daughter complained of hip pain (put down to growing pains) that I sought a diagnosis for her and through her found a diagnosis for me.' P144*

> *'I only discovered I was hypermobile after my sister was diagnosed following treatment from a private healthcare consultant.' P21.* This patient with JHS then wrote *'...There seems to be a lack of awareness about this condition'. P21.*

The lack of awareness of the condition recorded by a patient with JHS in this study was similarly noted in a survey undertaken nearly 10 years earlier which indicated the lack of awareness of the multisystemic nature of the condition and in particular the chronic widespread pain reported by patients with JHS. In this survey of over 300 British consultant rheumatologists 72% reported that JHS made only a 'minimal' contribution to the morbidity of rheumatic disease (Grahame and Bird 2001).

The lack of awareness of the condition and the nature of the condition continue to be problematic for patients in this study. '*Feel very frustrated and angry about lack of awareness about JHS and systemic problems it brings...' P65K.* One patient with JHS summed up the difficulty for health professionals

'....they don't see many people with hypermobility and the time standard response is 'aren't you flexible?' followed by a general tendency to not understand/appreciate or treat the terrible pain issues I have'. P53K.

This patient with JHS suggested that health professionals might not recognise hypermobility and in particular JHS because it is relatively uncommon. However, as previously reported there are studies to suggest that symptomatic JHS may be identifiable in 30-60% of patients attending hospital clinics in the UK, Chile and Oman (Grahame and Hakim 2004; Bravo and Wolff 2006; Clark and Simmonds 2011).

The answer might be in the following statement '*Hypermobility is easy to spot if you look for it. It is equally easy to miss if you do not.*' (Grahame 2003a p 2).

The diverse nature of the problems that patients with JHS complain of have been discussed and it is perhaps not surprising that health professionals have difficulty recognising and understanding this complex multifactorial condition which shows overlapping associations with other conditions. It might also be acknowledged that it is equally difficult for patients with JHS to communicate their diverse seemingly unconnected problems to health professionals. This indicates a need for health professionals to encourage patients to tell their 'story', to listen and be open to the diverse nature of the stories reported.

6.6 Summary of the discussion

This study identified that patients with JHS reported significantly higher FDS and were more likely to report functional difficulties both as a child and as an adult than healthy volunteers. This finding is new and adds a neurophysiological dimension to JHS which is largely unexplored. Impaired balance and ability to avoid obstacles were important features for patients with JHS and concur with a recent observational study. The mechanisms of these impairments need understanding if interventions are to be successful.

Only patients with JHS reported barriers to physical activity participation of which pain was an important factor. The only significant predictor for a group reporting reduced physical activity participation were higher FDS, this was similar for both patients with JHS and healthy volunteers. This finding has not previously been reported in adults. The implications of reduced physical activity and co-morbid conditions were discussed. There is a requirement for physical activity participation to be explored further to investigate whether decreased physical participation and fitness recorded in children with functional difficulties associated with dyspraxia/DCD continue into adulthood. There is also a requirement to understand barriers that affect physical activity participation. These include intrinsic factors (for example motor control and motivation) and extrinsic factors (for example environment, culture and daily occupation). It is anticipated this understanding would enable appropriate interventions and strategies to be put in place to increase activity participation.

The majority of patients with JHS in this study reported chronic widespread pain and some self-reported fibromyalgia. There was evidence to suggest an association between patients with JHS and CFS, GI and ANS symptoms. These findings were not new and confirm the results of previous research. The discussion focused on conceptualising pain reported by patients with JHS. In which it was reported that pain for many had started in their early years and that pain associated with a nociceptive incident continued long after the initial nociceptive event. If pain is a barrier to physical activity participation this might explain the downward spiral of immobility and deconditioning leading to social and occupational detachment sometimes seen in those with JHS.

Patients with JHS were noted to have a significantly lower PCS score of the SF-12 (indicating a greater physical health burden) than healthy volunteers. Pain was the only significant predictor of a lower PCS score for patients with JHS. It has been acknowledged in this chapter that the health burden reported by those with JHS was significantly greater than that reported by healthy volunteers but similar to other that previously recorded in other rheumatological conditions in which the health burden is widely acknowledged.

Patients with JHS in this study emphasized the multi-factorial nature of their symptoms and their experiences. Their experiences highlighted the lack of recognition, awareness and understanding of the condition amongst health professionals.

Effective management of patients with JHS requires knowledge of its multi-factorial nature and health burden ultimately requiring an interprofessional approach. As such complex conditions like JHS could be introduced in interprofessional units of undergraduate programs to enable health professionals to identify their roles and the roles of their colleagues in the management of complex conditions. Further research is required to identify the specific clinical and social needs of individuals with JHS. It is suggested, to achieve this, health professionals collaborate with individuals with JHS and the HMSA (hypermobility association patient support group).

Chapter 7

7 CONCLUSION

The purpose of this study was to explore the multifactorial manifestations of JHS. The first part of the study focused on the development and validation of the Functional Difficulties Questionnaire (FDQ-9) (See 4.1, 4.3 and figure 4-1). The intention was to develop a questionnaire to assess for dyspraxia/DCD in adults. It was developed in line with the WHO definition, the APA criteria and existing questionnaires and was piloted on individuals from four convenience sample groups. Exploratory factor analysis was employed to explore the underlying structure and aspects of validity and reliability were reported. However, in the absence of a benchmark tool, concurrent validity was not achieved (See 4.6.2). Therefore the FDQ-9 was employed in the second part of the study to assess for functional difficulties rather than dyspraxia/DCD in patients with JHS and healthy volunteers (See 4.10).

For the first time this study reports that adult patients with JHS were three times more likely to report functional difficulties both as a child and as an adult than healthy volunteers (See 5.3). In particular patients with JHS were significantly more likely to report difficulties associated with balance and obstacle avoidance than healthy volunteers. These findings have important implications for the management of JHS. At the beginning of this thesis the mechanisms essential for movement (action, perception and cognition) were discussed within the context of the performing artiste (See 1.2). To achieve the balance requirements of the performing artiste require perceptual input from proprioceptors in the connective tissues of muscles, skin, ligaments, joint capsules, vestibular and visual apparatus. This perceptual information requires integration with cognition within the central nervous system (CNS) to achieve coordinated movement. It is suggested that the composition and structure of the connective tissues in those with JHS contribute to impairments in movement because of the relationship of the receptors and the connective tissues. Receptors throughout the body are situated in or close to connective tissues. It is likely that the composition of the connective tissues in those with JHS contribute to the ‘setting’ of the CNS and the intrinsic mechanisms of motor control. This might explain the differences in functional difficulties between healthy volunteers and patients with JHS. Further research is required to explore this neurophysiological aspect of JHS.

In this study chronic widespread pain was a salient feature for patients with JHS (See 5.4). In addition patients with JHS reported the onset of their aches and pains in relation to three themes; long term pain, pain associated with activity and pain associated with life events. Patients with JHS

who reported functional difficulties both as a child and as an adult were significantly more likely to report long term pain (pain in early life) than patients with JHS who reported no functional difficulties. Pain has been previously been discussed as a feature in children who had functional difficulties associated with dyspraxia/ DCD. This has important clinical implications because pain may contribute to functional difficulties in children. Alternatively functional difficulties may be contributing to biomechanical dysfunction, impaired perception and therefore pain. Longitudinal studies are required to explore the long term nature of pain in this subgroup of patients with JHS.

The multisystemic nature of the symptoms reported in this study included musculoskeletal, gastrointestinal, autonomic symptoms as well as chronic fatigue syndrome and for some fibromyalgia (See 5.6, 5.7). It has previously been acknowledged that where conditions share similar symptoms or common features this may indicate a common patho-aetiology. Chronic pain can be a feature of the functional gastrointestinal disorders, autonomic symptoms, musculoskeletal symptoms and fibromyalgia. The underlying pain mechanisms in those with functional gastrointestinal disorders and fibromyalgia are as a result of aberrant sensory processing in the CNS. This study offers further evidence that pain reported by patients with JHS may share similar pain mechanisms as those in other overlapping conditions.

Those who reported functional difficulties both as a child and as an adult reported spending less time engaged in physical activity than those who reported no functional difficulties (See 5.5). This is an important clinical finding as reduced physical activity participation maybe contributing to deconditioning in patients with JHS. It was also interesting to note that only patients with JHS reported barriers to physical activity participation. Previous studies have reported that children and adolescents with functional difficulties associated with dyspraxia/DCD were less likely to be physically active and had decreased levels of cardiorespiratory fitness than their peers. Children's functional difficulties may influence their participation in physical activity but reduced self-efficacy is also important. It is possible that low self-efficacy associated with reduced levels of physical activity exhibited in children with movement dysfunctions continues into adulthood. Self-efficacy was not recorded in this study and it is suggested this requires further enquiry in association with functional difficulties reported both as a child and as an adult.

Patients with JHS scored significantly lower physical component summary (PCS) scores of the SF-12 than healthy volunteers (See 5.9). The low scores recorded for patients with JHS in this study were similar to those reported in several other countries in other rheumatological conditions in which the health burden is well recognised. Pain was the only significant predictor of the reduced PCS scores in a model which explained 23% of the variance.

This study has provided evidence of the multifactorial manifestations of JHS. Management of the associated conditions and symptoms requires early recognition and understanding of their complex multisystemic nature. In practice patients with JHS report a need for clinicians to understand the condition and to engage in a holistic treatment approach (See 6.7.9). Pain was an important feature in this study reported starting early in life or continuing long after the initial nociceptive incident. This indicates that the pain reported in these patients was not just as a result of biomechanical dysfunction and aberrant connective tissues.

This study has employed a mixed methodological approach in which the patient's perspective has also been explored. This has enabled a unique insight into the understanding of JHS. It is anticipated that the results of this study will subscribe towards an acceptance of the multidimensional nature of JHS.

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APPENDICES

Appendix 1

Diagnostic criteria for hypermobility and Benign Joint Hypermobility Syndrome (BJHS)/Joint Hypermobility Syndrome (JHS)

Figure 1. **The 9-Point Beighton Hypermobility Score (Beighton et al 1973)**		
Ability to:	Right	Left
1. Passively dorsiflex the fifth metacarpo-phalangeal joint to ≥ 90°	1	1
2. Oppose the thumb to the volar aspect of the ipsi-lateral forearm	1	1
3 Hyperextend the elbow to ≥ 10°	1	1
4 Hyperextend the knees to ≥ 10°	1	1
5 Place the hands flat on the floor without bending the knees	1	
Maximum total	9	

Figure 2 **The Revised Brighton 1998 Criteria for BJHS (Grahame et al 2000)**

BJHS is diagnosed in the presence of either two major criteria, or one major and two minor criteria, or four minor criteria. Two minor criteria will suffice where there is an unequivocally affected first-degree relative. BJHS is excluded by the presence of MFS or EDS (other than the EDS hypermobility type formerly known as EDS Type III) as defined by the Ghent 1996 and Villefranche 1998 criteria, respectively. Criteria Major 1 and Minor 1 are mutually exclusive as are Major 2 and Minor 2.

Major criteria

1. Beighton score of 4/9 or greater currently or historically
2. Arthralgia for longer than 3 months in four or more joints

Minor criteria

1. Beighton score of 1,2 or 3/9 (o,1,2 or 3 if aged 50+)
2. Arthralgia ($\geq$ 3 months) in one to three joints or back pain ($\geq$ 3 months), spondylosis, spondylolysis/spondylolithesis
3. Dislocation/subluxation in more than one joint, or in one joint more than one occasion
4. Soft tissue rheumatism. Three or more lesions (e.g. epicondylitis, tenosynovitis, bursitis)
5. Marfanoid Habitus (tall slim, span/height ratio >1.03, upper segment ratio less than 0.89, arachnodactyly (positive Steinburg/wrist signs)
6. Abnormal skin: striae, hyperextensibility, thin skin, papyraceous scarring
7. Eye signs: drooping eyelids or myopia or antimongoloid slant
8. Varicose veins or uterine/rectal prolapse

Figure 3.The five-part questionnaire for identifying hypermobility (Hakim and Grahame 2003a) Answering yes to two or more questions indicates hypermobility	
1.	Can you now (or could you ever) place your hands flat on the floor without bending your knees?
2.	Can you now (or could you ever) bend your thumb to touch your forearm?
3.	As a child did you amuse your friends by contorting your body into strange shapes or could you do the splits?
4.	As a child or teenager did your shoulder or knee cap dislocate on more than one occasion?
5.	Do you consider yourself double-jointed?

Appendix 2

The diagnostic criteria and definitions for developmental coordination disorder (DCD)

Table 1. Diagnostic criteria for Developmental Coordination Disorder DSM-IV-TR (APA, 2000) Including summarised recommendations from the Leeds consensus statement (LCS) (Sugden 2006)
A. Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (e.g. walking, crawling and sitting), dropping things, "clumsiness", poor performance in sports or poor handwriting. *[Standard tests of motor performance should identify children falling below the 5th percentile, and those between the 5th and 15th percentile should be considered 'at risk' of having DCD].(Sugden 2006)*
B. The activities in Criterion A significantly interfere with academic achievement or activities of daily living. *[Assessment should consider relevant developmental norms relating to activities of daily living, that these should be culturally sensitive and include the views of parents, teachers and children] (Sugden 2006).*
C. The disturbance is not due to a medical condition (e.g. cerebral palsy, hemiplegia or muscular dystrophy) and does not meet criteria for a Pervasive Developmental Disorder. *[That a neurological examination be carried out to exclude major neurological conditions, although it was understood there maybe dual diagnoses such as those already identified with DCD (dyslexia, ADHD, autistic spectrum disorder] (Sugden 2006)*
D. If mental retardation (learning difficulties) is present, the motor difficulties are in excess of those usually associated with it *[Assessment should include a measure of IQ, but where this was not possible to establish intellectual ability through national tests] (Sugden 2006).*

Table 0-1 The definition of specific developmental disorder of motor function SDDMF (WHO 1992; WHO 2007)

Under the definition SDDMF (WHO 1992) "The child's motor coordination, on fine or gross motor tasks, should be significantly below the level expected on the basis of his or her age and general intelligence. Difficulties should have been present since early in development and they should not be a direct result of any defects of vision or hearing or any diagnosable neurological disorder. Developmental milestones may be delayed and there may be some associated speech difficulties. The young child may be awkward in general gait, being slow to learn to run, hop, go up and down stairs. Likely to be difficulties in learning to tie shoe laces, to fasten and unfasten buttons and to throw and catch balls. Child may also be clumsy in fine and/or gross motor movements, tending to drop things, to stumble, to bump into obstacles and to have poor hand writing. Drawing skills are usually poor and children are often poor at jigsaw puzzles, using constructional toys, building models, ball games and drawing and understanding maps. May show 'soft' neurological signs and immaturities such as mirror movements.
Under the heading 'Disorders of psychological development (F80-F89) (WHO 2007) it is acknowledged; 'The disorders included in this block have in common: (a) onset invariably during infancy or childhood; b) impairment or delay in development of functions that are strongly related to biological maturation of the central nervous system; and c) a steady course without remissions and relapses. In most cases, the functions include language, visuo-spatial skills and motor coordination. Usually, the delay or impairment has been present from as early as it could be detected reliably and will diminish progressively as the child grows older, although milder deficits remain in adult life.'
Under the definition SDDMF (F82) (WHO 2007) 'A disorder in which the main feature is a serious impairment in the development of motor coordination that is not solely explicable in terms of general intellectual retardation or of any specific congenital or acquired neurological disorder. Nevertheless, in most cases a careful clinical examination shows marked neurodevelopmental immaturities such as choreiform movements of unsupported limbs or mirror movements and other associated motor features, as well as signs of impaired fine and gross motor coordination.'

Appendix 3

Summary and concept table relating to the literature review

Author	Design	Country	Population	Measurement tools	Aims of study
Jaffe et al 1988	Longitudinal case comparison study	Israel	715 infants aged 8-14 months and again 6 months later.	Carter Wilkinson (Carter and Wilkinson 1964) for hypermobility Denver Development screening test (Frankenberg and Dobbs 1967) questionnaire for motor development	Investigating the association of joint hypermobility and motor development
Tirosh et al 1991	Longitudinal case comparison study	Israel	59 infants assessed at 18 months and again at aged 5 years.	Carter Wilkinson (Carter and Wilkinson 1964) for hypermobility Hoskin Squires (Hoskins and Squire 1973) test for gross motor function. BOT-MP* (Bruininks 1978) Fine motor development. Peg board Beery-Buktencia for VMI** (Beery and Buktencia 1967) Parental questionnaire	Assess prospectively motor proficiency of children with hypermobility. Re-assess association between joint hypermobility and motor function at age 5 years.
Murray and Woo 2001	Editorial	UK			JHS a common cause of musculoskeletal complaints in

Author	Design	Country	Population	Measurement tools	Aims of study
					children with a variety of disorders from congenital dislocated hips, hypotonia , delayed motor development, growing pains back pain and spondylolysis
Ferrell et al 2004	Experimental case control intervention study	UK	18 patients with JHS	JHS – Brighton criteria (Grahame et al 2000) MOSQOL*** – SF-36 (Ware et al 2000) Proprioceptive threshold detection level. Balance Muscle strength Pain perception	Investigation of whether a home exercise program could lead to symptomatic improvement and proprioceptive improvement
Adib et al 2005	Systematic retrospective and prospective research study	UK	125 children under the age of 18	Beighton score (Beighton et al 1973), history, clinical examination	Study aimed at defining clinical characteristics of those under 18 presenting with JHS signs and symptoms
Englebert et al 2005	Retrospective observational study	Netherlands	72 children either younger than 2.5 years or between 4-12 years	Bulbena Criteria (Bulbena et al 1992) Bayley Scale (Bayley1996) MABC**** (Henderson and	Investigating the relationship between presence and locality of hypermobility

Author	Design	Country	Population	Measurement tools	Aims of study
				Sugden 1992)	and motor development delay.
Kirby et al 2005	Survey case comparison	UK	68 children with JHS 58 children with DCD	Questionnaire	Study aimed at comparing and contrasting functional difficulties reported in those with DCD and those with JHS
Murray 2006	Review				Exploration of the relationship of hypermobility and clinical musculoskeletal disorders in children and adolescents
Kirby and Davies 2007	Case comparison study	UK	27 children with DCD aged 9-17 years. 27 typically developing children aged 5-18 yrs without JHS	Questionnaire	Exploration of the overlap in symptoms between those JHS and those with DCD
*BOT-MP Bruininks-Osteretsky test of motor proficiency **VMI visual motor integration ***MOSQOL Medical outcomes study quality of life ****MABC Movement assessment battery for children					

Appendix 4

Table of Research Meetings October 2007 – July 2011

Date	Topic	Supervisors present
10/10/2007	Introduction to the research project by the researcher to the supervisors. An investigation of the association between JHS and DCD and how these conditions might impact on activities of daily living	LF-H, EC
28/11/2007	Investigating the use of questionnaires to collect qualitative data	EC
23/01/2008	Requirement to increase depth of understanding of qualitative methodology and mixed methods research. Review of screening tools for the diagnosis of DCD	EC, AB
20/03/2008	Critique of screening tools for DCD in accordance with the diagnostic criteria for DCD (APA) and ICD-10 and ICF	EC, AB
09/05/2008	Start to write up literature review relating JHS and DCD Further reading and critiquing around mixed methods research Submission RD6.	EC,AB
10/07/2008	Current populations identified not feasible Project needs re-thinking	EC, AB,
09/09/2008	Write research protocol Ethics training and ethics application start on line process Discussions relating to clinical population – hypermobility clinic	EC, AB
11/11/2008	Progress made on developing questionnaire aimed at identifying DCD Progress made on research protocol and ethics application	EC, AB
15/01/2009	Ethics submission on line Start to write literature review on the association of JHS and DCD – article for submission	EC, AB
15/04/2009	Discussion related to details of the start of the clinical data collection Pilot of the assessment tool Health and Activities (non clinical group) Questionnaire	AB

Date	Topic	Supervisors present
29/05/2009	Discussion in relation to pilot of the clinical group Data from the initial pilot of (non clinical group) Begin to write up transfer document	AB
10/07/2009	Discussion relating to continuing data collection in hypermobility clinic. Write up of transfer document	EC, AB
20/10/2009	Data collection in hypermobility clinic complete Discussion relating to validation of questionnaire for identifying DCD, test-retest reliability and construct validity Transfer document write up discussed	EC, AB
30/11/2009	Transfer document ready for submission Validation of DCD questionnaire test-retest increase sample size	EC, AB
23/02/2010	Transfer viva completed Statistical analysis of data relating to reliability and validity of DCD questionnaire continuing. Awaiting comparison group. Start write up of methodology section of thesis	EC, AB
24/05/2010	Writing of research needs to be more succinct Qualitative data analysis, mixed methods analysis integration and transformation Timeline for completion of PhD Data collection from comparison group – healthy volunteers	EC, AB
12/07/2010	Comparison group data collection complete – controlling for matched data Analysis of Functional difficulties questionnaire for DCD continued – Cut-off scores 2 SD ROC curve Mixed methods analysis within a pragmatic paradigm and MMD	EC, AB
13/10/2010	Case comparison data analysis – this now needs ordering and re-writing. Write an abstract for the thesis Submission of abstracts to World Confederation of Physical Therapists and Manipulative Association of Chartered Physiotherapists	EC, AB
16/12/2010	Continuation of qualitative and quantitative data analysis and integration and then discussion.	EC

Date	Topic	Supervisors present
	Qualitative data reduction peer reviewed, frameworks for qualitative data analysis discussed Submitted abstract to European Sensory Integration and Bournemouth University postgraduate conferences	
10/03/2011	Submission of part of the discussion end of February. Development of new concepts, uniqueness of the study. Write up of thesis and submission to supervisors end June/beginning July. Details of examiners to be forwarded to supervisors	EC, AB, AK
19/07/2011	Discussion relating to feedback from the submission of the thesis with the aim of making the thesis easier to read with clearer sign posts Continue to aim for submission 01/10/2011	AK, AB
07/12/2011	Viva – re-submission	
13/12/2011	Discussion relating to the viva outcome, re-submission and examiner's comments	AK
21/12/2011	Discussion in relation to examiner's comments and plans to address the re-submission	AK
09/01/2012	Discussion relating to the resignation of the external examiner and how to move forward with the re-submission process	AK
12/01/2012	Discussion relating to focusing on addressing the external examiners comments and the re-write of chapter 4	AK
07/02/2012	Following a submission of a document relating to the examiners comments. There were areas that required re-writing, more detail required and further clarity of data.	AK
16/04/2012	Met to discuss the thesis changes and the comments document in the light of feedback from AK, EC and AB External examiner agreed. Re-write and comments documents to AK, EC and AB by mid June.	AK
26/06/2012	Discussion around all the comments in relation to the revised thesis. Some minor corrections to be addressed. thesis ready for re-submission	AK

Appendix 5

Research Outputs 2007 – 2012

Papers

Clark, C.J., Carr, E.C.J. and Breen, A. 2009. Joint Hypermobility Syndrome and Developmental Coordination Disorder in Adults: Comorbid or Overlapping Conditions? *Dyspraxia Foundation Professional Journal* , 8, 2-26

Clark C. 2010. Joint Hypermobility Syndrome and Symphysis Pubis Dysfunction. *British Journal of Midwifery,* 18 (2) 92-97

Clark C.J. and Simmonds, J.V, 2010. An Exploration of the Prevalence of Hypermobility and Joint Hypermbility Syndrome in Omani Women Attending a Hospital Physiotherapy Service. *Musculoskeletal Care,* 9 (1) 1-10

Clark, C.J. and Khattab, A.K., 2012 Association Between Joint Hypermobility Syndrome and Developmental Coordination Disorder – A Review. Journal of Sports and Doping Studies (In Press doi: 10.4172/2161-0673.S4-001

Clark, C.J., Thomas, S., Carr, E.C.J., Khattab, A.D. and Breen, A. The development and initial validation of the Functional Difficulties Questionnaire (FDQ-9) aimed at identifying developmental coordination disorder (DCD) in adults. Re-Submission

Conference proceedings

Clark C. 2007. Joint Hypermobility Syndrome and Back Pain. *1st Physical Therapy Conference Muscat, Oman. 18th November, 2007*

Clark, C.J., Carr, E.C.J. and Breen, A. 2009. Exploring Coordination Difficulties Linked to Joint Hypermobility Syndrome. *2nd Postgraduate Symposium 2009 Bournemouth University 2nd October 2009.*

Clark, C.J. and Simmonds, J.V., 2009. Joint Hypermobility Syndrome: A Common Musculoskeletal Disorder? *Chartered Society of Physiotherapy Congress 2009 Liverpool 16-17 October 2009* http://www.cspcongress.co.uk/joint-hypermobility-syndrome-common-neuromusculoskeletal-disorder

Clark, C.J., Carr, E.C.J. and Breen, A. C. 2010 Hypermobility, Coordination and Spinal Pain: An Inherent Association *Annual Manipulative Association of the Chartered Society of Physiotherapy Study Day School of Oriental and African Studies London 25th September 2010*

Clark, C.J., Carr, E.C.J. and Breen, A. C. 2011. Exploring Joint Hypermobility Syndrome, Developmental Coordination Disorder and Pain*. 2nd European Sensory Integration Congress, Algarve Portugal. 27-29 May 2011*

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Clark, C.J., Carr, E.C.J. and Breen, A. C. 2011 Hypermobility, Coordination and Spinal Pain: An Inherent Association. *16th World Confederation of Physical Therapy Amsterdam, The Netherlands 20-23 June 2011*

Clark, C., Worswick, L and Langworthy, J. 2011 Learning to Improve the Management of Back Pain in General Practice: Collaboration Between Service Users and Service Providers. *16th World Confederation of Physical Therapy Amsterdam, The Netherlands 20-23 June 2011*

Clark, C., Khattab, A, Carr, E., Breen, A and Grahame, R., 2012 Functional Impairments in Patients with Joint Hypermobility Syndrome and Developmental Coordination Disorder**.** IFOMPT 2012, the World Congress of Manual/Musculoskeletal Physiotherapy, September 30 to October 5, 2012 Centre des congrès/Convention Centre in Québec City, Canada (accepted)

Clark C.,Thomas, S., Carr, E. and Breen A., 2012. Development and Validation of the Functional Difficulties Questionnaire for Assessing Developmental Coordination Disorder in Adults. IFOMPT 2012, the World Congress of Manual/Musculoskeletal Physiotherapy, September 30 to October 5, 2012 Centre des congrès/Convention Centre in Québec City, Canada (accepted)

Clark C., Khattab, A, Carr, E. Breen A. and Grahame, R., 2012. An Exploration of Neurophysiological Symptoms in Patients with Joint Hypermobility Syndrome and their Impact on Quality of Life. Physiotherapy UK 2012 Liverpool Convention Centre, Liverpool, UK. October 2012 (accepted)

Presentations

Clark, C. 2008. Prevalence of hypermobility and Joint Hypermobility Syndrome in female Omanis. Master Class, University of Hertfordshire 8th December 2008.

Clark, C. 2009. Hypermobility and Joint Hypermobility Syndrome. Master Class Bournemouth University 2nd July, 2009

Clark , C., 2009 Hypermobility and Joint Hypermobility Syndrome: Prevalence and multisystemic features. National Inter-professional Hypermobility Syndrome Study Day 25th November, 2009 Bournemouth University, Bournemouth UK 25th November, 2009

Clark C., 2011 Joint Hypermobility Syndrome and Developmental Coordination Disorder an association. Poole Hospital, OT and PT teams 18th January, 2011, Poole. UK.

Clark C., 2011. Exercise prescription considerations for patients with Joint Hypermobility Syndrome (JHS) and Developmental Coordination Disorder (DCD) National Study Day for the Association of Chartered Physiotherapists in Exercise Therapy (ACPET) , Poole Hospital 11th March 2011

Clark C., 2011. Multisystemic features of Joint Hypermobility Syndrome, London and the South East Hypermobility Club, University College London, London. UK 23rd November 2011

Clark C., 2012. Physiotherapy management of Joint Hypermobility Syndrome. Interprofessional Ehlers-Danlos Master Class, Royal Devon and Exeter Foundation Trust Hospital, Exeter. UK 10th February, 2012

Clark, C., 2012. Hypermobility and Joint Hypermobility Syndrome in children. Interprofessional national Hypermobility Study Day, Bournemouth University and Poole Hospital NHS Foundation Trust, Bournemouth.UK 28th March, 2012

Clark, C., 2012. Conceptualising pain in Joint Hypermobility Syndrome. Interprofessional national Hypermobility Study Day, Bournemouth University and Poole Hospital NHS Foundation Trust, Bournemouth. UK 28th March, 2012

Clark C., 2012. The Multifactorial manifestations of Joint Hypermobility Syndrome. Bournemouth University Seminar Series, Bournemouth University, UK 23rd May 2012

Clark C., 2012. Recognising, understanding and managing Joint Hypermobility Syndrome. Somerset PCT Interprofessional Rheumatology Study Day, Wellington Hospital, Wellington, UK 13th June, 2012

Newsletters

Clark C. 2010 Joint hypermobility syndrome and developmental coordination disorder in adults. *Hypermobility syndrome association (HMSA)* Summer newsletter p 3

Clark C. and Simmonds J. 2011. Investigating the prevalence of hypermobility and joint hypermobility syndrome (JHS) in women attending a hospital physiotherapy service in Oman. *Hypermobility syndrome association (HMSA)* Autumn newsletter (submitted August 2011)

Appendix 6

Ethics approval 09/H0716/5

The National Hospital for Neurology and Neurosurgery
& Institute of Neurology Joint REC

Carol Clark
R601, Royal London House
Landsdowne Road
Bournemouth
BH1 3LT

Research & Development
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WC1N 1EH
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Fax: 020 7905 2701
Email: S.Vandayar@ich.ucl.ac.uk
Website: www.uclh.nhs.uk

Our Ref: 09L 080

05 March 2009

Dear Clark

Full title of study:	**A two-phase, sequential mixed methods research project aimed at explaining how the lives of those with joint hypermobility syndrome (JHS) are affected by this condition. The initial phase will involve the collection of mainly quantitative data using a questionnaire. The second phase will involve the collection of mainly qualitative data via case studies aimed at clarifying data in phase one and adding to the depth of enquiry. It is anticipated this knowledge will enhance recognition of this condition and increase understanding of this complex multisystem disorder. This information together with current published research will assist clinicians in their prescription of future treatment.**
REC reference number:	**09/H0716/5**

Thank you for your letter of 02 March 2009, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information was considered at the meeting of the Sub-Committee of the REC held on 05 March 2009. A list of the members who were present at the meeting is attached.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to the research sites listed on the attached form.

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission at NHS sites ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Response to Request for Further Information	1	02 March 2009
Covering Letter	1	02 March 2009
Protocol	3.1	02 March 2009
Narrative for email invitation to Comparative group	2.1	05 January 2009
Participant Consent Form	2.1	11 January 2009
Participant Information Sheet: Case study	2.1	11 January 2009

Participant Information Sheet	2.1	11 January 2009
GP/Consultant Information Sheets	2.1	11 January 2009
Letter of invitation to participant	2.1	11 January 2009
Questionnaire	2.1	11 January 2009
Interview Schedules/Topic Guides	2.1	11 January 2009
Compensation Arrangements	1	01 August 2008
Summary/Synopsis	2.1	11 January 2009
Covering Letter	1	15 January 2009
Protocol	1	14 January 2009
Investigator CV	1	11 January 2009
Application	2.0	15 January 2009
Participant Information Sheet: PIS for email	2.1	11 January 2009
Sample Diary/Patient Card	2.1	11 January 2009

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document “After ethical review –guidance for researchers” gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

09/H0716/5	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project

Yours sincerely

Ms Katy Judd
Chair

Email: S.Vandayar@ich.ucl.ac.uk

Enclosures: *List of names and professions of members who were present at the meeting.*

Copy to: *Dr B. Gail Thomas*

The National Hospital for Neurology and Neurosurgery & Institute of Neurology Joint REC

Attendance at Sub-Committee of the REC meeting on 05 March 2009

Mrs Katy Judd Chair

Dr Yogi Amin Vice-Chair

The National Hospital for Neurology and Neurosurgery & Institute of Neurology Joint REC

LIST OF SITES WITH A FAVOURABLE ETHICAL OPINION

For all studies requiring site-specific assessment, this form is issued by the main REC to the Chief Investigator and sponsor with the favourable opinion letter and following subsequent notifications from site assessors. For issue 2 onwards, all sites with a favourable opinion are listed, adding the new sites approved.

REC reference number:	09/H0716/5	**Issue number:**	1	**Date of issue:**	05 March 2009
Chief Investigator:	Clark				
Full title of study:	A two-phase, sequential mixed methods research project aimed at explaining how the lives of those with joint hypermobility syndrome (JHS) are affected by this condition. The initial phase will involve the collection of mainly quantitative data using a questionnaire. The second phase will involve the collection of mainly qualitative data via case studies aimed at clarifying data in phase one and adding to the depth of enquiry. It is anticipated this knowledge will enhance recognition of this condition and increase understanding of this complex multisystem disorder. This information together with current published research will assist				

	clinicians in their prescription of future treatment.

This study was given a favourable ethical opinion by The National Hospital for Neurology and Neurosurgery & Institute of Neurology Joint REC on 05 March 2009. The favourable opinion is extended to each of the sites listed below. The research may commence at each NHS site when management approval from the relevant NHS care organisation has been confirmed.

Principal Investigator	*Post*	*Research site*	*Site assessor*	*Date of favourable opinion for this site*	*Notes* [1]
Professor Rodney Grahame	Consultant Rheumatologist	University College London Hospital.	The National Hospital for Neurology and Neurosurgery & Institute of Neurology Joint REC	05/03/2009	

Approved by the Chair on behalf of the REC:

…… (Signature of Chair/Co-ordinator)
(delete as applicable)

…… (Name)

(1) *The notes column may be used by the main REC to record the early closure or withdrawal of a site (where notified by the Chief Investigator or sponsor), the suspension of termination of the favourable opinion for an individual site, or any other relevant development. The date should be recorded.*

Appendix 7

Permission Damascus Shell Centre

From: Damascus Shell Center Manager [DSC-Manager@shell.net.sy]
Sent: 31 March 2009 08:44
To: Carol Clark
Subject: RE: Questionnaire

Dear Carol,

I sent your information and the questionnaire after going through them. It's
quite interesting and I'm sure you'll get a lot of feed back.
About your future talks we'll time table you in from September, which seems
like a brilliant idea. The topics sound fitting especially 'coping with back
pain' and 'children and exercise'.
Please feel free to let us know if we can be of any help.

Thank you for your effort!

Kind regards,

Victor.

DSC Duty Manager
Office: 011 6133923
Bar: 011 6120995
West Mezzeh
Damascus

Appendix 8

Research Governance School of Health and Social Care Bournemouth University approval

Bournemouth University

School of Health & Social Care

Research Administrator
Sara Glithro
sglithro@bournemouth.ac.uk
Direct line +44 (0) 1202 962196

Ref: CC/*RG2/SG*

5th May 2009

Ms Carol Clark
Monks Mean
Tarrant Monkton
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Dorset
DT11 8RU

Dear Carol

RE: Study entitled: **A two-phase, sequential mixed methods research project aimed at explaining how the lives of those with joint hypermobility syndrome (JHS) are affected by this condition.**

Thank you for forwarding the evidence of this studies, already established, ethical approval from the National Hospital for Neurology and Neurosurgery & Institute of Neurology Joint Research Ethics Committee in relation to your intention to seek additional participants for this study from this university site.

This evidence has been studied by Martin Hind who currently co-ordinates the School of Health and Social Cares Research Governance Review Group (RG2) and Martin has confirmed that your original approval is sufficient for our schools research governance requirements.

You are therefore fully approved to proceed with this extra element of data collection.

Dr Lee-Ann Fenge
School Postgraduate Committee Chair

Appendix 9

	Original Date:
	Code:

Health and Activity QUESTIONNAIRE (Hypermobility clinic)

The answers you give to these questions will be kept strictly confidential

PERSONAL INFORMATION					
1. How old are you? ☐ years	☐ Male	☐ Female			
2. What age were you when you left school	☐ 16 years and below	☐ +16 years			
3. What was the highest educational level you achieved?	NVQ s ☐	CSEs ☐			
GCSEs/ 'O' Levels ☐	Highers/AS levels ☐	'A' Levels ☐			
Degree ☐	Masters ☐	Doctorate ☐			
1. What is your occupation? ☐					
5. Are you? ☐ Fully employed around the home ☐ Full time employed ☐ Part time employed ☐ unemployed ☐ Student					
6. How much time do you spend **each week** doing physical activity? (Please include gardening, any physical exercise such as walking, gym, exercise class or sport.)	Half hour ☐	One hour ☐	Two hours ☐	Three hours ☐	More than three hours ☐
7. Please give details below about the type, duration and frequency of physical activity.					

Present Health		
8. Have you ever had treatment for any muscle, bone, tendon or joint pain condition before?	☐ **Yes**	☐ **No**

9. Can you recall an event that triggered the onset of your aches and pains? If YES please explain.

10.How often in the last **TWO** years have you visited the following professionals for any muscle, bone, tendon, cartilage or joint pain condition?

	HOW MANY VISITS		
Profession	**1-3**	**4-10**	**+10**
Doctor	☐	☐	☐
Nurse	☐	☐	☐
Physiotherapist	☐	☐	☐
Chiropractor	☐	☐	☐
Osteopath	☐	☐	☐
Other practitioners Details:	☐	☐	☐
11. How long did you have your aches and pains before being diagnosed with Joint hypermobility syndrome (JHS)?		☐	**Months/years**

12. Please tick the box against any condition that is relevant to you.	
	comments
Fibromyalgia ☐	
Dyslexia ☐	
Dyspraxia ☐	

Attention deficit hyperactivity disorder (ADHD) ☐	
Heart palpitations ☐ shortness of breath ☐ chest pain ☐	
Nausea ☐ constipation☐ diarrhea ☐ stomach ache ☐	
Chronic fatigue syndrome (CFS) ☐	
Myalgic Encephalopathy (ME) ☐	
Dizziness ☐ fainting ☐ lightheadedness ☐	

	YES	NO
13. Can you now (or could you ever) place your hands flat on the floor with out bending your knees?	☐	☐
14. Can you now (or could you ever) bend your thumb to touch your forearm?	☐	☐
15**. AS A CHILD** did you amuse your friends by contorting your body into strange shapes or could you do the splits?	☐	☐
16. **AS A CHILD OR TEENAGER** did your shoulder or kneecap dislocate on more than one occasion?	☐	☐
17. Do you consider yourself double jointed?	☐	☐

18. **Please put a cross in the area of the body where you have had pain lasting more than 3 months?**		
	Left	**Right**
Shoulder	☐	☐
Elbow	☐	☐
Wrist or hand	☐	☐
Hip	☐	☐
Knee	☐	☐
Ankle	☐	☐
Foot	☐	☐
Neck	☐	
Upper back	☐	
Lower back	☐	

ACTIVITIES AND GENERAL HEALTH

Activities	**Very good**	**Good**	**Poor**	**Very poor**
19. **AS A CHILD,** how good was your hand writing?	☐	☐	☐	☐
20. **AS A CHILD,** were you good at team games that involved balls? i.e. football, netball, basketball,	☐	☐	☐	☐
21**. AS A CHILD,** how did others rate your coordination	☐	☐	☐	☐
22. **AS AN ADULT,** how good are you at avoiding obstacles, like bumping into doors?	☐	☐	☐	☐
23. **AS AN ADULT,** how good are you at organizing yourself? i.e. getting ready for work or for a meeting	☐	☐	☐	☐
24. AS AN ADULT, how good were you at catching a ball one handed?	☐	☐	☐	☐
25. **AS AN ADULT,** how good are you at balancing on a bike, in a bus or train, or on skis?	☐	☐	☐	☐
26. **AS AN ADULT,** how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?	☐	☐	☐	☐
27. **AS AN ADULT,** how good is your hand writing now?	☐	☐	☐	☐

28. **Were you born early? If yes how early.**							
Yes	☐	No	☐	Don't know	☐	How early	

29. In general would you say your health is:	☐ Excellent	☐ Very Good	☐ Good	☐ Fair	☐ Poor

The following two questions are about activities you might do during a typical day.

Does **YOUR HEALTH NOW LIMIT YOU** in these activities? If so how much?	**Yes. Limited a lot**	**Yes. Limited a little**	**No. Not limited at all**
30. Moderate Activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf	☐	☐	☐
31. Climbing several flights of stairs	☐	☐	☐

During the **past 4 weeks** have you had any of the following problems with your work or other regular activities **AS A RESULT OF YOUR PHYSICAL HEALTH?**

32. **ACCOMPLISHED LESS** than you would like?	☐ **YES**	☐ **NO**
33. Were limited in the **KIND** of work or other activities?	☐ **YES**	☐ **NO**

During the **past 4 weeks,** were you limited in the kind of work you do or other regular activities **AS A RESULT OF ANY EMOTIONAL PROBLEMS** (such as feeling depressed or anxious)?

34. **ACCOMPLISHED LESS** than you would like?	☐ **YES**	☐ **NO**
35. Didn't do work or activities as **CAREFULLY** as usual?	☐ **YES**	☐ **NO**

36. **During the past 4 weeks ,How much did pain interfere with your normal work including both work outside the home and housework?**

☐ **Extremely**	☐ **Quite a bit**	☐ **Moderately**	☐ **A little bit**	☐ **Not at all**

The next three questions are about how you feel and how things have been during the **past 4 weeks**. For each question, please give the one answer that comes closest to the way you have been feeling.
How much of the time during the **PAST 4 WEEKS-**

	All of the time	**Most of the time**	**A good bit of the time**	**Some of the time**	**A Little of the time**	**None of the time**
37. Have you felt calm and peaceful?	☐	☐	☐	☐	☐	☐
38. Did you have a lot of energy	☐	☐	☐	☐	☐	☐
39. Have you felt down hearted and blue	☐	☐	☐	☐	☐	☐

40. During the **past 4 weeks** How much of the time has your **PHYSICAL HEALTH OR EMOTIONAL PROBLEMS** interfered with your social activities (like visiting friends, relatives etc)?

All of the time	**Most of the time**	**Some of the time**	**A little of the time**	**None of the time**
☐	☐	☐	☐	☐

41	Have you ever dislocated any of the following joints		
Joint	**Yes**	**No**	**More than once**
Shoulder	☐	☐	☐
Knee cap	☐	☐	☐
Fingers	☐	☐	☐
Other Joints Details: ☐	☐	☐	☐
42	**Have you ever suffered from any of the following?**		
Joint	**Yes**	**No**	**More than once**
Tennis elbow	☐	☐	☐
Golfers elbow	☐	☐	☐
Frozen shoulder	☐	☐	☐
Carpal tunnel syndrome	☐	☐	☐
Achilles tendinitis or rupture	☐	☐	☐
Hernias	☐	☐	☐
Varicose veins	☐	☐	☐
Uterine prolapse	☐	☐	☐
Rectal prolapse	☐	☐	☐
43	**Yes**	**No**	**Not sure**
Do you think you have much longer arms or legs than your friends or colleagues?	☐	☐	☐
Can you wrap your little finger and thumb around your wrist with an overlap?	☐	☐	☐
Do you scar easily?	☐	☐	☐
Do you have stretch marks	☐	☐	☐
Do you have drooping eye lids?	☐	☐	☐

Have you ever required glasses to correct your vision for seeing into the distance?	☐	☐	☐

GENERAL STUDY QUESTIONS				
Would you be happy to be contacted for the **case study** part of the research as mentioned in the information sheet?	☐ **Yes**		☐ **No**	
How would you like to be contacted?	Home phone ☐	Mobile phone ☐	Email ☐	Mail ☐
Would you like to receive a summary of the findings of this study?	☐ **Yes**		☐ **No**	
How would you like this sent	Email ☐		Mail ☐	

Email address; ____

Address:
Phone number

Is there any other information you wish to add.

Thank you for filling in the questionnaire. If you have any questions you wish to ask related to the study please contact Carol Clark either in the clinic or using the following addresses.
Carol Clark, R 601, School of Health and Social Care, Bournemouth University, Royal London House, Bournemouth, Dorset. BH1 3LT
Tel:01202 962196 (The phone will be answered by Eva Popadopoulou the research administrator who will forward on your queries).
Email: cclark@bournemouth.ac.uk

Appendix 10

Measuring and reporting on physical activity

Measuring and reporting on physical activity using questionnaires remains complex although is the method of choice when studying physical activity participation in populations (Health Survey for England (HSE 2008). There are no standardised methods for assessing physical activity in a general population (Kutze et al 2008), let alone in a population with musculoskeletal pain or functional difficulties. At the beginning of this study it was not the intention to develop such a tool. However, it was deemed important to collect information on physical activity participation which could be compared. Measuring intensity, duration, and frequency of physical activity need to be taken into account in order to record activity expenditure. It remains unclear whether intensity, duration and frequency reported in physical activity questionnaires correlate with activity energy expenditure (Neilson et al 2008). What was required for this study was a global view of physical activity participation.

It was therefore decided to investigate employing elements of the Global Physical Activities Questionnaire (GPAQ) which was being developed by a working group of experts at the WHO (Armstrong and Bull 2006). The aim of the GPAQ was to develop a questionnaire that would be able to provide reliable and valid information about physical activity (Armstrong and Bull 2006).The GPAQ (Armstrong and Bull 2006). is part of a 16 page document which collects information on demographics, behaviour related to tobacco and alcohol use, diet, physical activity, BP, Diabetes, Physical and Biochemical measurements. In this form the GPAQ (Armstrong and Bull 2006) was too big for use in this current study, in which the focus was to investigate physical activity participation. The researcher therefore focused on the physical activity section.

The physical activity section is divided into four smaller sections relating to the report of physical activity at; work, transport to work, recreational activity and sedentary behaviour.
Participants are asked in a typical week, ‘on how many days do you do vigorous-intensity activities as part of your work?’ OR ‘on how many days moderate intensity activities?’ However, the GPAQ (Armstrong and Bull 2006) did not enquire about low intensity activity which anecdotally may be closer to the exercise intensity reported in some individuals with JHS. In this section the GPAQ (Armstrong and Bull 2006) also asked participants to record the time spent doing the various activities, at work, getting to and from work, and during recreational activities. Again low intensity activities are not recorded, I think these maybe important for those with JHS where yoga, Pilates and some other forms of exercise may be considered low intensity because the person does not ‘break into a sweat’, but are important elements of physical activity for those with hypermobile joints.

After discussions with field experts, and participants with JHS, it was decided that participants would be asked about how much activity they did each week. In addition participants with JHS requested the use of a lower category of half an hour per week. It was decided to use a use a 5 point Likert score where half an hour would be recorded as 1 and > 3 hours would be recorded as 5. A pragmatic approach was used for the data analysis based on the UK government's recommendations for physical exercise participation (HSE 2008). The data would be analysed employing the dichotomous variables of more than two and a half hours of physical activity a week (Likert scores 4 and 5) and less than two and a half hours a week (Likert scores 1,2,3) (See appendix 10).

The questions were as follows.

How much time do you spend each week doing physical activity?
Please include gardening, any physical exercise such as walking, gym, exercise class or sport
half hour one hour two hours three hours > three hours
Please give details about the type, duration and frequency
.....
.....

Discussion and reflection relating to possible amendments to the physical activity questions following the transfer viva

During the transfer viva I was asked to consider the possibility of distinguishing between the different types of daily activity and whether this could be incorporated into the questionnaire. I reviewed the GPAQ (Armstrong and Bull 2006) and decided that three questions could be added, again using a text box for confirmation of these activities. The questions were to be written in the same format as the original question to prevent any confusion when answering the questions.

The first question included the length of time doing physical activity either at work or around the house, with space to report on types and duration of activity.

The second question included the length of time spent being physically active getting to or from work, with space to report on types and duration of activity.

The third question included the length of time spent being physically active during recreational activities, with space to report on types and duration of activity.

Following the above amendments of the questionnaire, I piloted the questionnaire, and all participants reported that when they got to the activity questions, they were 'repetitive', 'boring', 'disrupted the flow of the questionnaire'. I then experimented by reducing the questions to two, but the feedback was similar. With this feedback I decided to abandon the addition of the three additional physical activity questions.

Appendix 11

University College London Hospitals NHS
NHS Foundation Trust

Participant information sheet – Health and Activity Questionnaire (Hypermobility Clinic)

Explaining the life effects of joint hypermobility syndrome

If you need an audio, large print or translated version of this document please mention this on the clinic registration form and we will do our best to accommodate your needs.

You are being invited to take part in a research study. Before you agree to take part it is important for you to understand the purpose of the research and what it will involve. Please take time to read the following information carefully. You may find it helpful to talk to others about the study.

Please ask us if there is anything you are not clear about or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

Hypermobility is commonly seen in gymnasts, ballerinas and acrobats who exhibit stretchy skin and lax ligaments which allow extra movement. Joint hypermobility syndrome is said to exist when symptoms are reported, this occurs in a minority of people who are hypermobile.

Joint hypermobility syndrome is part of a family of genetically based conditions, thought to be similar to Ehlers-Danlos Syndrome (formerly type III) hypermobility type. Although problems associated with joint hypermobility syndrome are not life threatening, for some they are persistent and troublesome symptoms that affect their lives.

This study is aimed at explaining how joint hypermobility syndrome affects people's lives and will serve to increase the recognition and understanding of this condition amongst health care professionals.

Why have I been chosen?

This study is being carried out in the hypermobility clinics at University College London Hospital. Your rheumatologist has volunteered to take part in this study and will invite patients with joint hypermobility syndrome to take part.

Do I have to take part?

Not at all. It is entirely up to you whether you decide to take part or not. If you do, you will be given this information sheet to keep and a questionnaire. If you agree to fill in the questionnaire, you will be asked to sign a consent form (with a copy for you to keep).

You are free to withdraw from the study at any time and without giving a reason. It is important that you realise that if you withdraw from the study at any time this will not affect the care you receive in any way.

What will happen to me if I take part?

You will be asked to sign a consent form and fill in a questionnaire. The questions are designed to find out about how joint hypermobility syndrome affects your life with questions such as 'Do you consider yourself double-jointed?' And 'During the past 4 weeks how much did pain interfere with your normal work?' The questionnaire should take between 10-15 minutes to complete. Everything you tell us is confidential. None of the information can be identified to your name as we will allocate you a unique number.

You may hand in your completed questionnaire at the clinic reception desk when you come for your appointment.

At the end of the questionnaire you will be asked if you wish to take part in an interview as part of a case study for this research (details at the end of this sheet.). If you are happy to do this you will be asked for a telephone number and when it would be convenient for the researcher to contact you.

What do I have to do?

By agreeing to take part in the study we expect you to:-

- Sign the consent form
- Fill in all the questions on the questionnaire at a time convenient to yourself.
- Hand the questionnaire in at the clinic reception desk when you come for your appointment.
-

What are the possible disadvantages and risks of taking part?

We do not anticipate any disadvantages or risks with taking part in this study.

Expenses and payments:

Unfortunately we do not have any financial resources to pay you for taking part in the study. If you agree to be telephoned we will of course telephone you to ensure you do not incur any telephone costs.

What are the possible benefits of taking part?

This project is aimed at increasing our understanding of the nature of joint hypermobility syndrome and how it affects the lives of those with the syndrome. It is anticipated that as more health professionals recognise the condition, they will be able to tailor appropriate treatment programmes. So that when you visit your doctor, physiotherapist or other health professional in the future they will be in a better position to help you.

What happens when the research study stops?

The initial part of the study will stop when 110 patients have returned their questionnaires. The second part of the study will be completed in 2010. At the end of this study the research will be written up to enable other health professionals to access the study information. You may wish to receive some information on the study findings, we are more than happy to send a summary of the findings. Details of the study will be published on the Hypermobility syndrome association (HMSA) web site

What if there is a problem?

If for any reason you are not happy with the way in which you have been treated in this study you may contact any of the following:

Carol Clark – research investigator at Bournemouth University. Please use the following telephone number 01202 962196 (The phone will be answered by Eva Popadopoulou the research administrator who will forward on your queries).

University College Hospital (UCH) patient advice and liaison service (PALS) will be able to provide you with confidential advice and support about the research.
They also have a translation and signing service, this can be booked in advance either by yourself or via the clinic if they are notified in advance of your needs.

Tel: 0207380 9975
PALS email : PALS@uclh.nhs.uk
PALS desk is open from Monday to Friday from 9-4 in the main reception of the hospital found at 235, Euston Road.

If you remain unhappy and wish to complain formally, you can do this through the Independent Complaints Advocacy service (ICAS) on 0845 120 3784.

Will my taking part in the study be kept confidential?

Yes. All the information about your participation in this study will be kept confidential. If you consent to participate in the study you will be assigned a unique number. This means that for the data collection records there will be no record of personal information like name and address , but instead a code for example ‘participant 05’. The overall data sheet with your name and telephone number will be kept in a locked filing cabinet accessible only by the researcher. The data will be stored on a password protected computer. After the study all the data will be stored for 5 years and then destroyed.

Involvement of the General Practitioner or family Doctor

It is your decision as to whether you wish to be involved in the study, and it is not normal for the researcher to seek the consent of your GP. However, it is normal as a courtesy to inform your GP that you are taking part in the study. It is usual to send a short note informing the GP of the study and that you are taking part, but no other details or information will be sent.

The case study.

To get a better understanding of how the lives of those who have joint hypermobility syndrome are affected we have decided to interview patients as part of a case study and ask them to fill in an activity diary.

The activity diary is a book that will be given to each patient who consents to do this part of the study. It will be structured to find out about your daily activities. It is anticipated that it will take no longer than 10 minutes daily to fill in, over a period of 1 week.

The researcher will telephone you to find out if you wish to take part in this aspect of the study. You will be sent a consent form and diary. If you return the consent form the researcher will contact you about a suitable day and date for the interview. All aspects of this part of the research will be kept confidential and both the interview and diary will be assigned a code.

Who is organising and funding the research?

This research is being undertaken by Carol Clark as part of a PhD at Bournemouth University (School of health and Social Care). The research is being supervised by Dr. Eloise Carr and Professor Alan Breen of Bournemouth University with assistance from Professor Rodney Grahame, Consultant Rheumatologist University College Hospital and Honorary Professor Department of Medicine, University College London.

There is no funding at present.

Who has reviewed the study?

The study has been reviewed by the Research committee at the School of health and Social Care, Bournemouth University. It has also been reviewed by The National Hospital for Neurosurgery & Neurology and the Joint Institute of Neurology REC.

Can I find out any more about this research?

Yes. If you would like to find out more about this research you may contact Carol Clark when you attend your clinic appointment as she will be available to answer any queries or concerns related to the research. Alternatively you may contact her at the following addresses.

Contact Details:

Carol Clark, R 601, School of Health and Social Care, Bournemouth University, Royal London House, Bournemouth, Dorset. BH1 3LT Tel:01202 962196 (The phone will be answered by Eva Popadopoulou the research administrator who will forward on your queries).

Email: cclark@bournemouth.ac.uk

Appendix 12

Letter of invitation for patients

University College London Hospitals NHS
NHS Foundation Trust

Rheumatology Department,
3rd Floor Central,
250 Euston Road,
London NW1 2PQ
11th May, 2009

Dear Patient,

Joint Hypermobility Syndrome Research Study

You are invited to participate in a research study because you are a patient of Professor Grahame and are visiting the Hypermobility Clinic at University College London Hospital.

This study involves completing a questionnaire.

Enclosed with this letter you will find an:

- **An information sheet** giving details of the study.
- **A consent form** which we ask you to sign when you attend the clinic after you have read the information sheet confirming you understand your participation is voluntary.
- **A questionnaire** for you to complete and hand into the clinic reception.

Please make sure you have read the information sheet and sign the consent form before you fill in the questionnaire. Your participation is entirely voluntary and will in no way affect your treatment.

When you attend your appointment you will also have the opportunity to talk to the researcher at the clinic about any queries or concerns regarding the study and these will be answered for you.

Kind regards

Carol Clark
Researcher,
Tel: 01202 962196
Email: cclark@bournemouth.ac.uk

Appendix 13

University College London Hospitals NHS
NHS Foundation Trust

Consent form

Life effects of joint hypermobility syndrome (questionnaire)

Centre No.
Study No.
Patient identification:

Researcher: Carol Clark

Please initial the box

1. I confirm I have read and understand the information sheet dated 02/03/2009 version 3.1 for the above named study. I have had the opportunity to consider the information and ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and I am free to withdraw at any time without giving a reason and without my medical care or legal rights being affected. ☐

3. I understand that my address and telephone number maybe required if I wish to take part in the case study part of the research or if I wish to be informed about the results of the study. I give permission for the researcher to access these. ☐

4. I understand that relevant sections of my medical notes and data collected during the study, may be looked at by individuals from Bournemouth university, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐

5. I agree to my general practitioner (G.P.) being informed about my participation in the study. ☐

6. I agree to take part in the above mentioned study. ☐

Name of patient	Date	Signature
……..	……..	……..

Name of person taking consent	Date	Signature
……..	……	……..

Appendix 14

Letter to general practitioner (GP)

University College London Hospitals NHS
NHS Foundation Trust

Rheumatology Department,
3rd Floor Central,
250 Euston Road,
London NW1 2PQ
11th January, 2009

Dear GP,

Joint Hypermobility Syndrome Research Study

Today your patient …… …….visited the Hypermobility Clinic at University College Hospital, and consented to participating in a research study aimed at explaining the life effects of joint hypermobility syndrome.

This is a mixed methods sequential research study which initially involves the patient completing a questionnaire. A few patients will have the opportunity to attend an interview if they wish. If you would like to know more about the study, please contact the researcher.

Kind regards,

Carol Clark
Researcher.
Tel 01202 962196
Email: cclark@bournemouth.ac.uk

Appendix 15

Email information about the research study

Explaining the life effects of Joint Hypermobility Syndrome

You are being invited to take part in a research study. Before you agree to take part it is important for you to understand the purpose of the research and what it will involve. Please take time to read the following information carefully.

If there is anything you are not clear about or if you would like more information please contact the researcher Carol Clark.

What is the purpose of the study?

The purpose of the questionnaire you are being asked to complete is to record the details of 110 healthy people in order to compare this information with that recorded from 110 participants with a condition called joint hypermobility syndrome.

Hypermobility is commonly seen in gymnasts, ballerinas and acrobats who exhibit stretchy skin and lax ligaments which allow extra movement. Joint hypermobility syndrome is said to exist when symptoms are reported, this occurs in a minority of people who are hypermobile.
Joint hypermobility syndrome is part of a family of genetically based conditions. Although problems associated with joint hypermobility syndrome are not life threatening, for some there are persistent and troublesome symptoms that affect their lives.
This study is aimed at explaining how joint hypermobility syndrome affects people's lives and will serve to increase the recognition and understanding of this condition amongst health care professionals

Do I have to take part?

Not at all. It is entirely up to you whether you decide to take part or not. Before you decide to fill in the questionnaire, please read this information sheet. It is anticipated that by filling in the questionnaire you are giving your consent to take part in the study.

What will happen to me if I take part?

All you have to do is fill in the questionnaire and return it. The questions are designed to find out about your general health and activities with questions such as 'Do you consider yourself double jointed?' The questionnaire should take about 10 minutes to complete. Everything you tell us is confidential. None of the information can be identified to your name as we will allocate you a unique number.

What will happen if I don't want to carry on with the study?

You are not obliged to continue participating in the study and should you change your mind, you are free to withdraw at any time without giving a reason and your data will be removed.

Will my taking part in the study be kept confidential?

All information which is collected on the questionnaire will be kept strictly confidential. If you consent to participate in the study you will be assigned a unique number. This means that for the data collection records there will be no record of personal information like name and address , but instead a code for example 'healthy volunteer 05'. The overall data sheet with your name and email address will be kept in a locked filing cabinet accessible only by the researcher. The data will be stored on a password protected computer. After the study all the data will be stored for 5 years and then destroyed.

What will happen to the results of the research study?

When studies such as this are finished it is normal for the study findings to be published in journals or to be presented at conferences. This is done to publicise findings so that health practitioners may use this knowledge in the future to improve care. You will not be identifiable in these findings as all information is coded.

You may wish to receive some information on the study findings, we are more than happy to send a summary of the findings, in this case you will be asked to tick a box on the questionnaire.

Who is organising the research?

This research is being undertaken by Carol Clark as part of a PhD at Bournemouth University (School of Health and Social Care). The research is being supervised by Dr. Elosie Carr and Professor Alan Breen of Bournemouth University with assistance from Professor Rodney Grahame, Consultant Rheumatologist University College Hospital and Honorary Professor Department of Medicine, University College London.

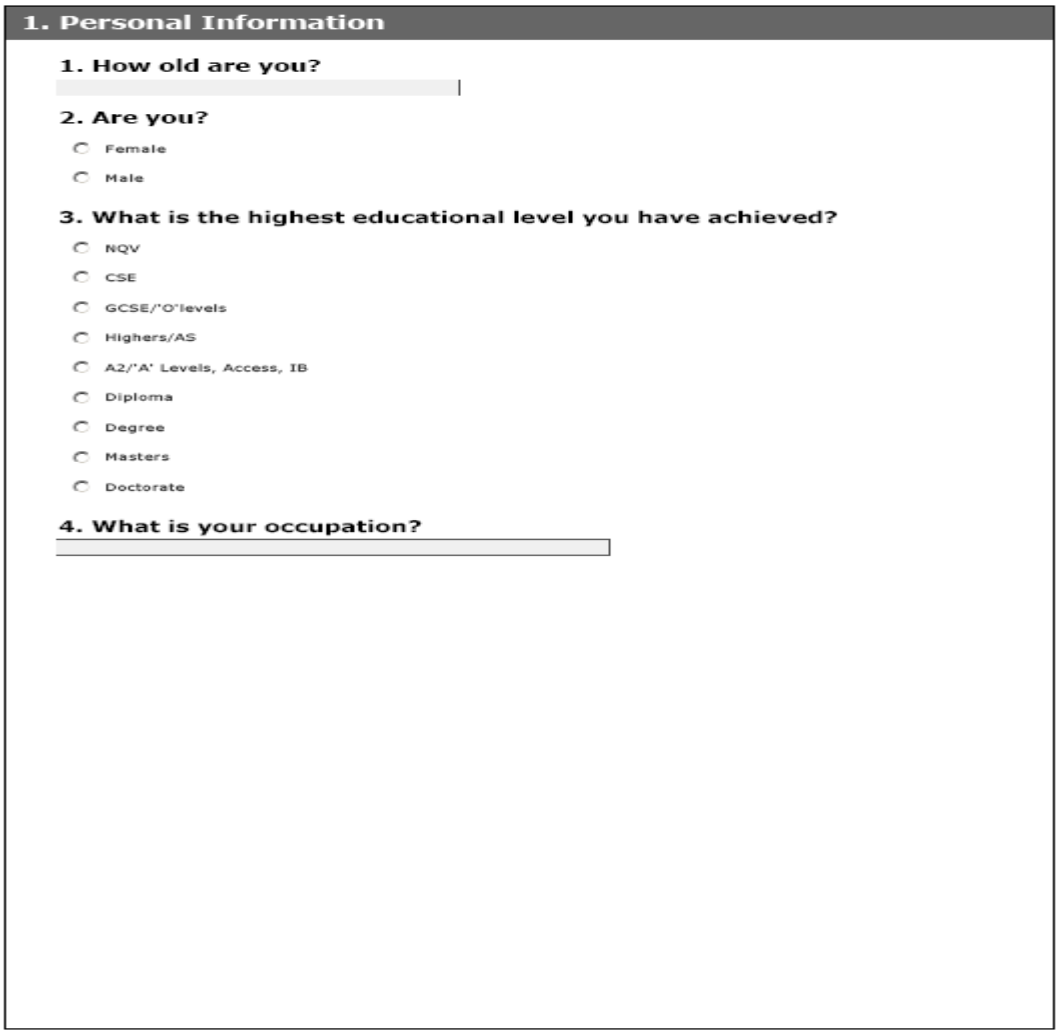
Who has reviewed the study?

The study has been reviewed through internal monitoring procedures for the School of Health and Social Care, Bournemouth University. It has also been reviewed by The National Hospital for Neurosurgery & Neurology and the Joint Institute of Neurology REC. These processes monitor the quality of the research and involve peer review and expert input.

Contact Details: Carol Clark, School of Health and Social Care, Bournemouth University, Royal London House, Bournemouth, Dorset. BH1 3LT, UK. Email: cclark@bournemouth.ac.uk

Appendix 16

Survey Monkey Health and Activities Questionnaire for comparison group



1. Personal Information

1. How old are you?

2. Are you?

- Female
- Male

3. What is the highest educational level you have achieved?

- NQV
- CSE
- GCSE/'O'levels
- Highers/AS
- A2/'A' Levels, Access, IB
- Diploma
- Degree
- Masters
- Doctorate

4. What is your occupation?

2. General health questions

1. Please answer below

	Yes	No
Have you had treatment from a health professional for any aches and pains in the last 6 months?	○	○
Have you ever experienced pain in more than three joints which lasted for more than three months?	○	○
Have you suffered from a previous condition which has affected the brain or nervous system i.e. a stroke, head injury or multiple sclerosis?	○	○

3. Health and Activity

1. How much time do you spend each week doing physical exercise? (please include gardening, and any physical exercise such as walking, gym, exercise class or sport)

- ○ Half an hour
- ○ One hour
- ○ Two hours
- ○ Three hours
- ○ More than three hours

2. Please give details about the type, duration and frequency of exercise:

4. Present Health

1. Please tick the box against any condition that is relevant to you.

- ☐ Fibromyalgia
- ☐ Dyslexia
- ☐ Dyspraxia
- ☐ Attention deficit hyperactivity disorder (ADHD)
- ☐ Chronic fatigue syndrome (CFS)
- ☐ Myalgic Encephalopathy (ME)
- ☐ Heart palpitations
- ☐ Shortness of breath
- ☐ Chest pain
- ☐ Nausea
- ☐ Constipation
- ☐ Diarrhea
- ☐ Stomach ache
- ☐ Dizziness
- ☐ Fainting
- ☐ Lightheadedness
- ☐ None of the above

2. If you have ticked any of the boxes above and wish to comment please do so:

5. Activities - How flexible are you?

1. Can you now (or could you ever) place your hands flat on the floor without bending your knees?

☐ Yes ☐ No

2. Can you now (or could you ever) bend your thumb to touch your forearm?

☐ Yes ☐ No

3. AS A CHILD did you amuse your friends by contorting your body into strange shapes or could you do the splits?

☐ Yes ☐ No

4. AS A CHILD OR TEENAGER did your shoulder or kneecap dislocate on more than one occasion?

☐ Yes ☐ No

5. Do you consider yourself double jointed?

☐ Yes ☐ No

6. Activities - How do you rate your coordination?

1. AS A CHILD, how good was your hand writing?

- ○ Very good
- ○ Good
- ○ Poor
- ○ Very poor

2. AS A CHILD, were you good at team games that involved balls? i.e.football, netball, basketball.

- ○ Very good
- ○ Good
- ○ Poor
- ○ Very poor

3. AS A CHILD, how did others rate your coordination?

- ○ Very good
- ○ Good
- ○ Poor
- ○ Very poor

4. AS AN ADULT, how good are you at avoiding obstacles, like bumping into doors?

- ○ Very good
- ○ Good
- ○ Poor
- ○ Very poor

5. AS AN ADULT, how good are you at organising yourself? i.e. getting ready for work or for a meeting

- ○ Very good
- ○ Good
- ○ Poor
- ○ Very poor

6. AS AN ADULT, how good are you at catching a ball one handed?

- Very good
- Good
- Poor
- Very Poor

7. AS AN ADULT, how good are you at balancing on a bike, in a train, or on skis?

- Very good
- Good
- Poor
- Very poor

8. AS AN ADULT, how good are you at using your hands i.e. to do jobs around the home, DIY, sewing or using scissors?

- Very good
- Good
- Poor
- Very poor

9. AS AN ADULT, how good is your handwriting now?

- Very good
- Good
- Poor
- Very poor

7. General questions

1. Were you born early(before your due date)? If yes how early.

☐ Yes ☐ Yes more than three weeks ☐ No ☐ Don't know

2. Have you ever considered yourself to be 'clumsy' or uncoordinated in your everyday activities?

○ Yes, but only as a child

○ Yes, but only as an adult

○ Yes, both as a child and as an adult

○ No

8. General Health

1. In general would you say your health is:

- ○ Excellent
- ○ Very good
- ○ Good
- ○ Fair
- ○ Poor

2. Does YOUR HEALTH NOW LIMIT YOU in these activities? If so how much? Please answer a) and b).

	Yes. limited a lot	Yes. Limited a little	No. Not limited at all
a) Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf	○	○	○
b) Climbing several flights of stairs	○	○	○

3. During the PAST 4 WEEKS have you had any of the following problems with your work or other regular activities AS A RESULT OF YOUR PHYSICAL HEALTH? Please answer a) and b)

	Yes	No
a) ACCOMPLISHED LESS than you would like?	○	○
b) Didn't do work or activities as CAREFULLY as usual?	○	○

4. During the PAST 4 WEEKS were you limited in the kind of work you do or other regular activities AS A RESULT OF ANY EMOTIONAL PROBLEMS (such as feeling depressed or anxious)? Please answer a) and b).

	Yes	No
a) ACCOMPLISHED LESS than you would like?	○	○
b) Didn't do work or activities as CAREFULLY as usual?	○	○

8. General Health

1. In general would you say your health is:

- ○ Excellent
- ○ Very good
- ○ Good
- ○ Fair
- ○ Poor

2. Does YOUR HEALTH NOW LIMIT YOU in these activities? If so how much? Please answer a) and b).

	Yes. limited a lot	Yes. Limited a little	No. Not limited at all
a) Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf	○	○	○
b) Climbing several flights of stairs	○	○	○

3. During the PAST 4 WEEKS have you had any of the following problems with your work or other regular activities AS A RESULT OF YOUR PHYSICAL HEALTH? Please answer a) and b)

	Yes	No
a) ACCOMPLISHED LESS than you would like?	○	○
b) Didn't do work or activities as CAREFULLY as usual?	○	○

4. During the PAST 4 WEEKS were you limited in the kind of work you do or other regular activities AS A RESULT OF ANY EMOTIONAL PROBLEMS (such as feeling depressed or anxious)? Please answer a) and b).

	Yes	No
a) ACCOMPLISHED LESS than you would like?	○	○
b) Didn't do work or activities as CAREFULLY as usual?	○	○

5. During the past 4 weeks, how much did pain interfere with your normal work including both work outside the home and housework?

- ○ Extremely
- ○ Quite a bit
- ○ Moderately
- ○ A little bit
- ○ Not at all

6. The next three questions are about how you feel and how things have been during the PAST 4 WEEKS. For each question, please give the one answer that comes closest to the way you have been feeling. Please answer a), b) and c).

How much of the time during the PAST 4 WEEKS-

	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
a) Have you felt calm and peaceful?	○	○	○	○	○	○
b) Did you have a lot of energy?	○	○	○	○	○	○
c) Have you felt downhearted and blue?	○	○	○	○	○	○

7. During the PAST 4 WEEKS how much of the time has YOUR PHYSICAL HEALTH OR EMOTIONAL PROBLEMS interfered with your social activities (like visiting friends, relatives etc.)?

- ○ All the time
- ○ Most of the time
- ○ Some of the time
- ○ A little of the time
- ○ None of the time

9. General Health (continued)

1. Have you ever dislocated any of the following joints?

	Yes	No	More than once
Shoulder	☐	☐	☐
Knee cap	☐	☐	☐
Fingers	☐	☐	☐
Other joints	☐	☐	☐

Other joint (please specify)

2. Have you ever suffered from any of the following?

	Yes	No	More than once
Tennis elbow	☐	☐	☐
Golfers elbow	☐	☐	☐
Frozen shoulder	☐	☐	☐
Carpal tunnel syndrome	☐	☐	☐
Achilles tendinitis or rupture	☐	☐	☐
Hernias	☐	☐	☐
Varicose veins	☐	☐	☐
Uterine prolapse	☐	☐	☐
Rectal prolapse	☐	☐	☐

3. Questions about yourself

	Yes	No	Not sure
Do you think you have much longer arms or legs than your friends or colleagues?	○	○	○
Can you wrap your little finger and thumb around your wrist with an overlap?	○	○	○
Do you scar easily?	○	○	○
Do you have stretch marks?	○	○	○
Do you have drooping eyelids?	○	○	○
Have you ever required glasses to correct your vision for seeing into the distance?	○	○	○

5. During the past 4 weeks, how much did pain interfere with your normal work including both work outside the home and housework?

- ○ Extremely
- ○ Quite a bit
- ○ Moderately
- ○ A little bit
- ○ Not at all

6. The next three questions are about how you feel and how things have been during the PAST 4 WEEKS. For each question, please give the one answer that comes closest to the way you have been feeling. Please answer a), b) and c).

How much of the time during the PAST 4 WEEKS-

	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
a) Have you felt calm and peaceful?	○	○	○	○	○	○
b) Did you have a lot of energy?	○	○	○	○	○	○
c) Have you felt downhearted and blue?	○	○	○	○	○	○

7. During the PAST 4 WEEKS how much of the time has YOUR PHYSICAL HEALTH OR EMOTIONAL PROBLEMS interfered with your social activities (like visiting friends, relatives etc.)?

- ○ All the time
- ○ Most of the time
- ○ Some of the time
- ○ A little of the time
- ○ None of the time

9. General Health (continued)

1. Have you ever dislocated any of the following joints?

	Yes	No	More than once
Shoulder	☐	☐	☐
Knee cap	☐	☐	☐
Fingers	☐	☐	☐
Other joints	☐	☐	☐

Other joint (please specify)

2. Have you ever suffered from any of the following?

	Yes	No	More than once
Tennis elbow	☐	☐	☐
Golfers elbow	☐	☐	☐
Frozen shoulder	☐	☐	☐
Carpal tunnel syndrome	☐	☐	☐
Achilles tendinitis or rupture	☐	☐	☐
Hernias	☐	☐	☐
Varicose veins	☐	☐	☐
Uterine prolapse	☐	☐	☐
Rectal prolapse	☐	☐	☐

3. Questions about yourself

	Yes	No	Not sure
Do you think you have much longer arms or legs than your friends or colleagues?	○	○	○
Can you wrap your little finger and thumb around your wrist with an overlap?	○	○	○
Do you scar easily?	○	○	○
Do you have stretch marks?	○	○	○
Do you have drooping eyelids?	○	○	○
Have you ever required glasses to correct your vision for seeing into the distance?	○	○	○

10. THANK YOU

1. If you wish to receive a summary of the findings of this study please add your email address below. It is anticipated that the results will be published within the next two years.

Appendix 17

Qualitative data relating to the onset of aches and pains

The aim of this section was to explore how patients reported the onset of their aches and pains and the data was generated in response to the question 'Can you recall an event that triggered the onset of your aches and pains? If YES please explain'.

There were 86/90 (96%) responses to the open ended question of these 13/86 (15%) reported 'no' trigger to their aches and pains. Text data for the remaining respondents 73/90 (81%) was analysed. To begin with the text was read several times as open-mindedly as possible to enable the researcher to gain an understanding of how patients with JHS reported the onset of their aches and pains. Inductive analysis was employed initially to codes, categories and themes (See appendix 20 table 1) within the text data as previously suggested (Patton 2000 p454).

Appendix 17 Table1. Frame work showing the inductive codes, categories and themes relating to the onset of aches and pains

Theme	Categories	Inductive Codes
Long term pain	Always had pain	Always had since birth
	Pain started in childhood	8 or 9 when the pains started As a 6 year old not being able to climb
	Pain started in adolescence or puberty	Pain in teens Painful around 12 Remember growing pains age 12
Pain associated with activity	Onset with dynamic activity	Any type of exercise Walking sets off the majority of leg pain
	Onset with static activity	Standing up, sitting for long periods Ironing/washing up these are key triggers
Pain associated with life events	Physically traumatic –vehicle accidents or falls	A fall down stairs Involved in a car accident back pain ever since
	Physically non traumatic – infections or stress	Cold weather brings on aches/pains Following septic shock
	Pregnancy	1st pregnancy SPD, neck and shoulder pain Worse when pregnancy continued

Appendix 18

Qualitative data analysis relating to additional information for patients with JHS

The aim of this next section was to allow patients with JHS an opportunity to add their comments in order to explore if there were features of the condition that had not be addressed in the questionnaire. At the end of the questionnaire there was an open ended question 'Is there any other information you wish to add?' The collection of data from this section was taken from the text data written at the end of the Health and Activity Questionnaire. The qualitative data analysis for this question was based on the three step process described by Miles and Huberman (1994) which involved data reduction, data display and finally drawing conclusions and verification from the data. The final step is described in the discussion chapter of this thesis.

Appendix 19 Table1. Frame work showing the inductive codes, categories and themes reported by patients with JHS

Theme	Categories	Inductive code
Nature of the condition	Multisystemic	Toes dislocate regularly Had 5 hernias to date Hypermobility as a result of IBS I have been diagnosed with osteoporosis Lots of problems with soft tissues POTS....dizzyness and blood pooling Severe migraines/back to back headaches Suffer from TMJ and dental problems,
	Family history	Children all have JHS Only discovered hypermobile after sister diagnosed Mother has flexible joints
Experiences with JHS	Helpful experiences	The more active the better Manage condition with diet and exercise Pain management course – very interesting
	Unhelpful experiences	Lack of awareness of JHS and systemic problems Desperate need for a more holistic approach They don't see many people with hypermobility. Tablets never give any relief When I cannot handle my pain I don't know where to go
	Pain experiences	Daily pain gets worse Constant pain makes me irritable Local anaesthetics don't work

Appendix 19

The international classification of functioning disability and health (ICF) and DCD

This next section serves as an introduction to the ICF and how DCD may be viewed within its framework. The ICF has provided a standardised framework for the description of health and health related states which can be employed to enable the sharing of knowledge (WHO 2007)

The ICF model is divided into two components, functioning and context and these components are further divided into domains with alphanumeric references denoting activity limitations or participation restrictions.

The next section uses a table with the alphanumeric definitions within the ICF (WHO 2007) as a template for classifying aspects of DCD cross referenced with the definitions in the literature. It is not intended that this reference list should be exhaustive but only to serve as examples within the literature. This template can be viewed in the following table.

Appendix 20 table 1. ICF codes, definitions the relationship with DCD and reference to the difficulties in the literature

ICF alphanumeric code	ICF definition	Relationship to DCD	Reference
d1550	Acquiring basic skills – learning to manipulate eating utensils, a pencil, simple tool	Difficulties with pencil grasp, using scissors and utensils. The most common referral of DCD children to school health services is the identification of fine motor problems	Polatajko and Cantin 2006 Macnab et al 2001
d1551	Acquiring complex skills like learning to play a game like football	Children with a diagnosis of DCD may have poor balance skills or poor locomotor skills or both which impact on their ability to perform more complex skills. Difficulty kicking Children with DCD experience considerable difficulties in motor based activities	Miyahara 1994 Polatajko and Cantin 2006 Smyth and Anderson 2000
d160	Focusing attention. Intentionally focusing on specific stimuli, such as filtering out distracting noises	Children with a diagnosis of movement problems can be easily distracted. Short attention span	Gillberg & Gilberg 1989 Portwood 1999; Addy 2003

ICF alphanumeric code	ICF definition	Relationship to DCD	Reference
d170	Writing. Using or producing symbols or language to convey information, such as producing a written record of events or ideas or drafting a letter.	Untidy hand writing and poor presentation of written work is commonly reported in those with DCD. Slow and or messy handwriting. Studies have linked poor hand writing to fine motor disorders in children.	Losse et al 1991 Polatajko and Cantin 2006 Barnett 1994; Smits-Englelsman et al 2003
d220	Undertaking multiple tasks Carrying out simple or complex and coordinated actions as components of multiple, integrated and complex tasks in sequence or simultaneously	DCD children perform poorly when they have to integrate vestibular, proprioceptive and tactile information i.e. when multi tasking. They also have difficulty with visual processing which affects tasks involving length discrimination. Children with DCD have difficulty handling equipment for science and have problems with arts and crafts.	Ayres 1975; Wilson and McKenzie 1998; Hulme et al 1982 Losse et al 1991
d230	Carrying out daily routine Carrying out simple or complex and coordinated actions in order to plan, manage and complete the requirements of day-to-day procedures or duties, such as budgeting time and making plans for separate activities throughout the day.	Adults with motor impairments consistent with DCD reported that their activities of daily living are profoundly affected. Sub types of DCD have been identified in which children show deficits in motor sequencing. Poor integration of body and mind	Cousins and Smyth (2003) Dewey and Kaplan (1994) Peters et al 2001
d240	Handling stress and other psychological demands. Carrying out simple or complex and coordinated actions to manage and control the psychological demands required to carry out a task	Adults with DCD experience considerable problems with sequencing and dual task performance	Cousins & Smyth 2003
d415	Maintaining a body position Staying in the same position as required, such as remaining seated or remaining standing for work or school	Children with DCD fidget and wriggle in sitting occasionally falling off their chairs.	Kirby 1999
d4351	Kicking Using the legs and feet to propel something away, such as kicking a ball.	Children with DCD have difficulty kicking	Polatajko and Cantin 2006
d440	Fine hand use Performing the coordinated	Fine motor problems are the commonest reason for	Macnab et al 2001

ICF alphanumeric code	ICF definition	Relationship to DCD	Reference
	actions of handling objects, picking up, manipulating and releasing them using one's hand, fingers and thumb, such as required to lift coins off a table or turn a dial or knob	referral to school health services	
d4452	Reaching Using the hands and arms to extend outwards and touch or grasp something, such as when reaching across the table or desk for a book	Accident prone students were poorer at blind reach in conjunction with tracking. Clumsiness may be recognised in the class room	Porter and Corlett 1989 Addy 2003
d4454	Throwing Using fingers, hands and arms to lift something and propel it with some force through the air, such as when tossing a ball	Children with DCD are noted to be significantly less precise in their ability to throw accurately. Children with DCD who find ball throwing difficult tend to avoid the activity	Crawford et al 2001 Cantin et al 2007 Henderson & Henderson 2002; Schoemaker et al 1994
D4455	Catching using fingers, hands and arms to grasp a moving object in order to bring it to a stop and hold it, such as when catching a ball	Children with DCD are noted to have difficulty with catching as well as throwing balls	Miyahara and Register 2000 Polatajko and Cantin 2006
d450	Walking Moving along a surface on foot, step by step, so that one foot is always on the ground, such as strolling, sauntering, walking forwards, backwards or sideways	Delayed Walking	Addy 2003
d455	Moving around Moving the whole body from one place to another by means other than walking, such as climbing over a rock, running down a street, skipping, scampering, jumping, somersaulting or running around obstacles. Inclusions crawling, climbing, running, jogging, jumping and swimming	Children with DCD have difficulty mentally simulating movement. Awkward running gait, difficulty with skipping and climbing on play structures. Fail to perform hopping and skipping age appropriately Specific difficulties with balance have been noted which may affect these activities. Some DCD children are impaired with whole body tasks i.e. running and jumping Dislike of playgrounds, difficulty in physical education and swimming	Williams et al 2006 Polatajko and Cantin 2006 Miyahara and Register 2000 Huh 2001; Wann et al 1998 Larkin and Hoare 1992 Addy 2003
d4750	Driving human powered transportation Driving human powered vehicle,	Children with DCD have difficulty riding bikes	Mandich et al 2003; Polatajko and

ICF alphanumeric code	ICF definition	Relationship to DCD	Reference
	such as a bicycle, tricycle or rowboat		Cantin 2006; Miyahara and Register 2000
d4751	Driving motorized vehicles Driving a vehicle with a motor, such as an automobile, motorcycle, motorboat or aircraft	Adults reporting and noted to have coordination difficulties were noted to be unable to or unwilling to drive	Cousins and Smyth 2003
d510	Washing oneself Washing and drying one's whole body or body parts, using water and appropriate cleaning and drying materials or methods, such as bathing, showering, washing hands and feet, face and hair, drying with a towel	Children with DCD noted to have difficulty bathing showering or washing hair.	Polatajko and Cantin 2006
d5202	Caring for hair Looking after the hair on the head and face, such as by combing, styling, shaving or trimming	DCD children have difficulty undertaking activities without seeing their hands e.g. combing hair	Addy 2003
d540	Dressing Carrying out the coordinated actions and tasks of putting on and taking off clothes and footwear in sequence and in keeping with climatic and social conditions	Clumsy children find acquiring the skill of tying shoe laces and fastening buttons difficult. Difficulty with shoe tying People with DCD may appear untidy and inappropriately dressed. for the occasion	Barnett & Henderson 1992 Mandich et al 2003; Miyahara and Register 2000 Kirby 1999
d550	Eating Carrying out the coordinated tasks and actions of eating food that has been served, bringing it to the mouth and consuming it in culturally acceptable ways, cutting or breaking food into pieces, opening bottles and cans, using implements, having meals, feasting or dining.	Clumsy children find acquiring the skill of using a knife and fork difficult	Barnett & Henderson 1992
d710	Basic interpersonal interactions Interacting with people in a contextually and socially appropriate manner.	Children with DCD who have poor ball skills tend to have poor peer relations. The inability to participate in physical activities may lead to social isolation. Poor social skills correlated with emotional symptoms	Miyahara et al 1996 Poulsen et al 2007; Mandich & Polatajko 2003 Green et al 2006
d9201	Sports Engaging in competitive and informal or formally organised games or athletic events, performed alone or in a group, such as gymnastics or soccer	Children with DCD have difficulty playing sports. Boys with DCD unable to fully participate in social-physical activities like team games.	Polatajko and Cantin 2006 Smyth and Anderson 2001; Poulsen et al 2007

ICF alphanumeric code	ICF definition	Relationship to DCD	Reference
		DCD children less physically active	Cairney et al 2005

DCD Developmental Coordination Disorder; ICF International Classification of Functioning, Disability and Health

Appendix 20

Physical activity participation – Codes for patterns and themes.

Qualitative data relating to physical activity for JHS patients and healthy volunteers in response to; **'Please give details about the type, duration and frequency of physical activity'**
There were 83/90 (92%) responses from patients with JHS. Patients with JHS were coded either P, PP or PE and a numerical code for example P18. There were 108/113 (96%) responses from Healthy volunteers. Healthy volunteers were coded either CUSF or CUST and a numerical code for example CUSF 18.

All data relating to type, duration and frequency of physical exercise was transferred to a word document. The texts were initially read through to identify themes relating to types of physical activity. The data was read through several times to identify all types of physical activity reported. Data were analysed by employing content analysis. Data were coded and then consolidated

Appendix 20 table 1 Description of types of physical activity reported by patients with JHS (n=83) and healthy volunteers (n=108). Participants from both groups subscribed to more than one theme

Themes	Healthy volunteer n=108 (%)	Patients with JHS n=83 (%)	Sub themes	Physical activity described
Walking	67 (62%)	52 (63%)	Walking for recreation	*'Dog walking – 1 hour minimum per day' CUSF68*
			Walking for occupation	*'I work 4 days a week in physical job teaching school groups on a large nature reserve. I walk 2-5 miles a day as part of my job' P104*
Sport and recreational physical activity	72 (67%	46 (55%)	Gym based activities	*'Cardiovascular at the gym for 40 minutes X 4 per week.' CUSF80*
			Sports and recreational activities	*'Swimming 20 minutes 1-2 times a week, cycling locally – most day per week'. P19*
Physical activity associated with occupation	23 (21%)	27 (33%)	Activities associated with home, garden and work	*'I will potter around house and garden & do house work every day (2 hours) (P115*

Appendix 20 table 2 Patterns of physical activity relating to duration and frequency of activity. Patients with JHS (n=83) some subscribed to more than one pattern. Healthy volunteers (n=108)

Healthy volunteers n=108 (%)	Patients with JHS n=83 (%)	Pattern code descriptor	Pattern code descriptor inclusion
27 (25)	30 (36)	Not reported	Only themes mentioned, duration, frequency context not mentioned
51 (47)	38 (46)	Regular activity on most days of the week	Per day, daily, most days, reporting of activities 4 x or more per week, every morning, every day
30 (28)	15 (18)	Activity reported but not on most days	Weekly, every week, 3 days a week or less, or 3X a week or less
0 (0)	19 (23)	Amount of activity reported limited by circumstances	Limitations – feeling unwell, pain, at risk to exercise, bad day, need to rest, fatigue

Appendix 21

The Adult Developmental Co-ordination Disorder/Dyspraxia Checklist (ADC) (Kirby et al 2010) Questions and Psychometric properties

Introduction

Standardisation of the Adult Developmental Co-ordination Disorder/Dyspraxia Checklist (ADC) was published in 2010 (Kirby et al). In this appendix the questionnaire is presented (see table 1) and the published psychometric properties are discussed

Table 2. Adult Developmental Co-ordination Disorder/Dyspraxia Checklist (ADC) (Kirby et al 2010). Responses were Never =1, Sometimes = 2, Frequently =3, Always = 4. Scores could range from 40 - 160

Item	Question
A	**As a child did you....**
1	Have difficulty with self care tasks such as tying shoelaces, fastening buttons and zips?
2	Have difficulty with eating without getting dirty?
3	Have difficulty learning to ride a bike compared with your peers?
4	Have difficulty playing team games, such as football, volleyball, catching or throwing balls accurately?
5	Have difficulty writing neatly (so others could read it)?
6	Have difficulty writing as fast as your peers?
7	Bump into objects or people, trip over things more often than others?
8	Have difficulty plying a musical instrument (e.g. violin, recorder)?
9	Have difficulties with orgainising/finding things in your room?
10	Have other commented about your lack of coordination or called you clumsy?
B	**Do you currently have difficulty with the following items....**
1	Self-care tasks, such as shaving or make-up?
2*	Eating with a knife and fork/spoon?
3	Hobbies that require good co-ordination?
4	Have difficulty writing neatly when having to write fast?
5	Writing as fast as your peers?
6*	Reading your own writing?
7	Copying things down without mistakes?
8	Organising/finding things in your room?
9	Finding your way around new buildings or places?
10	Have others called you disorganised?
C	**Currently...**
1	Do you have difficulties with sitting still or appearing fidgety?
2	Do you lose or leave behind possessions?
3	Would you say that you bump into things, spill or break things?
4	Are you slower than others at getting up in the morning and getting to work or college?
5	Did it take you longer than others to learn to drive?
6	Do others find it difficult to read your writing?
7	Do you avoid hobbies that require good co-ordination?
8	Do you choose to spend your leisure time more on your own than with others?
9	Avoid team games/sports?
10	If you do a sport, is it more likely to be on your own, e.g. going to the gym than with others?
11	Did you tend in your teens/twenties or currently avoid going to clubs/dancing?
12	If you are a driver, do you have difficulty parking a car?
13	Do you have difficulty preparing a meal from scratch?
14	Do you have difficulty packing a suitcase to go away?
15	Do you have difficulty folding clothes to put them away neatly?
16	Do you have difficulty managing money?
17	Do you have difficulties with performing two things at the same time (e.g. driving and listening)?
18	Do you have difficulties with distance estimations (e.g. with regard to parking, passing through objects)?

19	Do you have difficulty planning ahead?
20	Do you feel you are losing attention in certain situations?

*Questions found not to be discriminatory between a group with DCD/dyspraxia and a control group

Considerations of the psychometric properties of the ADC (Kirby et al 2010)

Samples

There were two groups of participants recruited. One group from Wales were English speakers aged 16 - 25 years (n=45) and the other from Israel were Hebrew speakers aged 16– 40 years (n=62). Participants formed two mixed groups from these countries; one group were diagnosed in the past with dyspraxia/DCD or self reported symptoms consistent with DCD or dyspraxia (n=49). The control group consisted without a diagnosis or symptoms (n= 58). This indicated a total of 107 participants. There was no significant difference in the mean age between the groups, but sex and education were not reported or controlled for.

Structure of the questionnaire

Factor analysis was not reported and therefore the dimensionality of the questionnaire was not explored which has implications for the scoring. In order to satisfy the criterion of Bryant and Yarnold (1995) the participant-to-item ratio should be no lower than 5:1 therefore for a 40-item questionnaire 200 participants would be required.

Internal consistency

Although Cronbach's alpha was reported for all 40 items and was high, this may be expected in a scale with so many items. To demonstrate internal consistency requires also reporting on both the inter item correlations and the average inter item correlations (Cortina 1993; Field 2005). The average inter item correlations were not reported. Cronbach's alpha was reported for the subscales of the questionnaire subscales A, B and C (See table 1) and again these were high, but there was no indication that these subscales had been identified as part of a factor analysis in addition inter item correlations were not reported for these subscales. The authors of the ADC have presumed that the ADC measures one underlying factor or construct, but there is no data to suggest that to be the case.

Test-retest reliability

Test-retest reliability was not reported. The lack of published data relating to test-retest reliability and internal consistency indicate that the reliability of the ADC has not been established. It is suggested that tests which are not reliable cannot be considered to be valid Kline (1999).

Construct validity

Construct validity was analysed by comparing the total scores between the control group and the group diagnosed in the past with dyspraxia/DCD or self reported symptoms consistent with dyspraxia/DCD. The mean scores of the control group were significantly lower than the mean scores of the group diagnosed in the past with dyspraxia/DCD or self reported symptoms consistent with dyspraxia/DCD.

Discriminant analysis

Discriminant function analysis was assessed between a group without dyspraxia/DCD and a group with either a previous diagnosis of Dyspraxia/DCD or who self reported symptoms of Dyspraxia/DCD. Wilks' Lambda was significant. There was a significant difference between the groups in the reporting of 38/40 items. The lack of discriminant validity on two items would have an effect on the overall score. The data employing 38 questions requires re-examination.

Concurrent validity

Concurrent validity of the ADC was assessed by correlating the total scores of this 40 item adult questionnaire with a ten item child Handwriting Screening Proficiency Questionnaire (HSPQ) (Rosenblum 2006). The HSPQ had been validated for use in children but not validated as a screening tool for DCD. To assess concurrent validity requires correlating one test with another test of the same variable at the same time (Wilkin et al 1992; Kline 1999). In the case of the ADC vs HSPQ it is argued that the ADC and HSPQ are not measuring the same variable. The ADC is assessing for Dyspraxia/DCD in adults and the HSPQ is assessing hand writing in children (See table 1). Although concurrent validity was reported for the ADC, the results need to be interpreted with caution as it is argued they were not measuring the same variable and because the ADC is not likely to be a more practical, economic or less time consuming tool.

Table 1. Comparison of questions between the 40-item ADC to be compared with the ten item child Handwriting Screening Proficiency Questionnaire (HSPQ) (Rosenblum 2006).The HSPQ is scored by employing a 5 part Likert score 0= never, 4 = always, scores range from 0 – 40, higher scores indicating greater difficulties. The ADC has a 4 part Likert score Scores range from 40 - 160

Item	HSPQ	ADC
1	Unreadable hand writing	Have difficulty writing neatly (so others could read it)?
2	Unsuccessful in reading his/her own handwriting	Have difficulty writing as fast as your peers?
3	A lack of time to copy	Have difficulty writing neatly when having to write fast?
4	Often erases	Writing as fast as your peers?
5	Does not want to write	Reading your own writing?
9	Needs to look often when copying	Copying things down without mistakes?
10	Not satisfied with his/her handwriting	
6	Does not do homework	
7	Complains about pain	
8	Tired while writing	
	A total of 7/10 items from the HSPQ	A total of 6/40 items from the ADC

Conclusion

In conclusion the factor structure of the questionnaire was not explored which has implications in relation to the scoring of the questionnaire. The lack of published data relating to test-retest reliability and internal consistency indicate that the reliability of the ADC has not been established. It is suggested that tests which are not reliable cannot be considered to be valid Kline (1999). Construct validity was established, and discriminant function analysis was significant. There was a significant difference between 38/40 items when assessed between the two groups. Concurrent validity was established but not with a tool that was measuring the same variable. It is anticipated that in the future more data will be presented which confirms the reliability and validity of the ADC.

Appendix 22

Statement for Reporting Studies of Diagnostic Accuracy (STARD) checklist and table with the FDQ-9

In studies of diagnostic accuracy results from a test are compared with the results obtained with a reference standard on the same subjects. In this thesis in chapter 4 section 4.6 the diagnostic accuracy of the FDQ-9 was compared with the reference standard self-report of dyspraxia. To critique the quality of these results the Statement for Reporting Studies of Diagnostic Accuracy (STARD) checklist has been employed in the table below. The checklist is provides verification that the essential elements have been included (Bossuyt et al 2003).

STARD items	**Questionnaire [Page (P) in the thesis]**
1.Identify the article as a study of diagnostic accuracy	Functional Difficulties Questionnaire-9 (FDQ-9) To determine the sensitivity and specificity of the FDQ-9 to assess for dyspraxia/DCD in adults using self report dyspraxia as the reference standard. [P 90]
2 Research Question or study aims stated	In the following section the aim was to assess the diagnostic accuracy of the FDQ-9 and to establish a cut-off point at optimal sensitivity and specificity. Determining the optimal cut-off points was explored by employing two methods. [P90]
3. Study population defined	Sample four (S4); was a convenience sample of staff and students from a university and consisted of 152 participants (mean age in years (range in years) [SD] 36.8 (18-63) [12.88]; female 115).[P75]
4. Participant recruitment described	Participants from S4 were sent an invitation, information about the study and questionnaire by email with a link to the questionnaire on survey monkey (http://www.surveymonkey.com). It was explained to participants that participation was voluntary and that by completing the questionnaire they were giving informed consent to participate in the study.[P76]
5. Participant sampling described	Participants were a convenience sample who completed a questionnaire and fulfilled the inclusion criteria.
6. Data collection prospective or retrospective	Prospective
7. Description of reference standard and rationale	The ROC curve was employed to assess the diagnostic accuracy of the FDQ-9 in assessing for dyspraxia/DCD in adults. The reference standard employed was the self report of dyspraxia as this was the condition being assessed. The term dyspraxia was employed instead of DCD as the term DCD has only more recently been recognised (Polatajko et al 1995). [P76 & 84]

STARD item	Questionnaire
8. Methods described inclusion criteria and tests	Participants aged between 18 – 65 years were included Participants were excluded if they reported a known neurological condition and if there was no report of secondary school qualifications, this was in fulfillment of criteria C and D of the diagnostic criteria for DCD, DSM-IV-TR (APA 2000) and in consideration of the LCS (Sugden 2006). [P69]
9. Definition and rationale for cut-offs and results of index and reference standard	Two methods were employed to identify a cut-off score. The first involved finding the point at which sensitivity and specificity were balanced this is the point on the curve closest to the (0,1) point (Perkins and Schisterman 2006). The second method to determine an optimal cut-off score is to employ the Youden index (Fluss et al 2005). Using both methods the cut off score was 21.5. Based on a pragmatic decision as there are no half scores in the FDS a score of 22 was deemed the cut-off. The sensitivity and specificity of which were 86% [95% CI 78% - 94%] and 81% [95% CI 73% - 89%] respectively. [P91 & 92]
10 Description of number, training and expertise of persons executing test	Not applicable as this test was self report
11. Were testers blind to the results of the index and reference test	Not applicable as this was self report.
12. Description of methods for calculating diagnostic accuracy [95% CI]	Only one index test was being compared with a reference standard. The area under the curve was calculated for diagnostic accuracy (See section 21)
13. Methods for calculating test reproducibility	Methods for calculating test reproducibility were not discussed because this was a self report questionnaire.
14. Dates in which study was carried out	Data collection from the sample groups took place between March 2009 and May 2010. [P74]
15. Clinical and demographic characteristics of study population (age, sex)	Sample four (S4); 152 (mean age in years (range in years) [SD] 36.8 (18-63) [12.88]; female 115). S4 convenience sample of staff and students from a university.
16. Participants satisfying the inclusion/exclusion criteria who did not take the reference standard and index tests	All participants who fulfilled the inclusion/exclusion criteria had an opportunity to respond to the index test and reference standard.
17.Time interval reported between index and reference test	Date on which a participant was ‘diagnosed’ with dyspraxia and the type of test employed to diagnose dyspraxia was not reported in this study. The self-report of dyspraxia and the answering of the FDQ-9 were at the same time.

STARD item	Questionnaire
18. Report distribution of the severity of the condition	Functional Difficulty Scores (FDS) range 9 - 36. A score of 9/36 indicates being 'very good' at each item. A score of 36/36 indicates being very poor at each item. Self-report dyspraxia' (n=7) median scores 28, range 20 – 30, LQ 22, UQ 29 and IQR 7. No self-report dyspraxia (n=145) median scores 18, range of 11 - 30, LQ 15, UQ 21 and IQR 6. The mean scores self- report dyspraxia (25.86, SD 4.100) significantly higher than those no self-report dyspraxia (18.06, SD3.777), *U* = 83.000, p < 0.001 (two tailed). The mean differences between the groups were 7.795 [95% CI 3.998 to – 11.593]. [P84 & 85]
19. Cross tabulation of results of index test versus reference standard	Data relating to cross tabulation of the FDS and reference standard is presented (see section 4.5.7 and in figure 4-7, and figure 4-12) [P84 & 96]
20. Adverse events that occurred from performing the tests	Self report questionnaire -none recorded
21. Estimates of diagnostic accuracy with 95% CI	The area under the curve was 0.918 [95% CI 0.837 – 1.000] with a standard error of 0.042 ($p < 0.001$). This represents an excellent diagnostic test (Swetts 1988) [P91]
22. Report how missing data were handled including outliers	There was no missing data for the FDQ-9 (See section 4.5.4.)
23. Report estimates of variability of diagnostic accuracy between subgroups	There were no report estimates of diagnostic accuracy between sub groups. This was because it was anticipated that the numbers of those self reporting dyspraxia would be too small.
24. Report estimates of test reproducibility	Test reproducibility was not reported as this was a self report questionnaire.
25. Discuss clinical applicability of study findings	It is anticipated that in clinical practice the FDQ-9 would have several uses this would include its use as a screening tool for recognising functional difficulties either currently or as a persisting feature and to identify specific functional difficulties which would warrant further investigation and as a guide to intervention. [P116-119]