THE UNIVERSITY
of EDINBURGH

Hypermobility Syndromes in Paediatrics:

Progressions in Assessment and Management

by

Alice M. Mooney

THE UNIVERSITY *of* EDINBURGH

A Thesis Presented for the Degree of Master of Philosophy

Institute for Sport, Physical education and Health Sciences

Moray House School of Education

University of Edinburgh

June 2016

Declaration

I confirm that content the work contained within this thesis is the author's own, that the thesis has been composed solely by the author, and that no aspect of the work has been submitted for any other degree or professional qualification.

06/06/16

_____ _____

Alice M. Mooney Date:

Abstract

Joint Hypermobility Syndrome (JHS) and Ehlers Danlos Syndrome-Hypermobility Type (EDS-HM) referred to collectively as Hypermobility Syndromes (HMS), are heritable disorders of connective tissue comprising symptomatic joint hypermobility predisposing to arthralgia, soft-tissue injury and joint instability which if not managed effectively result in ongoing cycles of disability. How HMS affects paediatric patients and how physiotherapists approach the condition in this population is unclear. The aim of this thesis was to address gaps in knowledge and practice and advance strategies in assessment and management of symptoms. Study 1 involved an original online survey of paediatric physiotherapists, gauging understanding of HMS in children, and investigating current trends in clinical practice regarding diagnosis, treatment and management, in a UK context. Findings highlighted the prevalence of musculoskeletal pain and injury in children, the unsuitability of current diagnostic tools for assessing children, the lack of a standardised approach to diagnosis in addition to preferences for exercise interventions. This needs analysis informed Study 2 which involved the design and implementation of a novel Physical Assessment Battery for Paediatric Hypermobility merging 4 existing tests: the Nine-Point Beighton Score, Revised Brighton Criteria, Paediatric Balance Scale and Paediatric Pain Questionnaire, to capture a more complete profile of symptoms in the functional and clinical assessment of children. Children with diagnoses of HMS were assigned to a clinical group (n=29), and age and gender matched children recruited as a control group (n=25) were tested. Distinct differences were revealed between groups in terms of functional balance, pain intensity and location and trends in physical activity, exercise and sport, in addition to significant correlations observed between hypermobility and both balance and pain intensity scores. Findings from Study 1 and Study 2 twinned with supplementary qualitative data, collectively confirm the need to validate a paediatric specific assessment tool, and design

blended treatment and management strategies for children experiencing symptoms to increase quality of life and reduce disability.

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Context of the Research

An increasing body of evidence shows the symptomatology associated with a clinical impression of symptomatic joint hypermobility that extends beyond the musculoskeletal system, and affects quality of life in physical and psychosocial aspects in both adult (Simpson and Michael, 2006, Ross and Grahame, 2011a, Bird, 2011, Grahame and Kazkaz, 2014) and paediatric and adolescent populations (Murray and Woo, 2001, Adib et al., 2005, Murray, 2006, Fatoye et al., 2012, Scheper, 2014). To date, research has focused and reported more on adult populations with joint hypermobility, with less information available on how children are affected. There remains considerable uncertainty regarding how symptomatic joint hypermobility is presently diagnosed, and due to variability in screening and assessment, accurate prevalence rates have also been difficult to define. Diagnosis and recognition of symptoms by medical professionals is problematic (Grahame and Bird, 2001, Ross and Grahame, 2011a, Russek et al., 2014) which negatively impacts on the ability to align specific treatment and management programs to individuals who experience disabling symptoms such as pain, fatigue and musculoskeletal injury.

My personal focus in this research stems from my education [B.Sc. (Hons), M.Sc. (Med-Sci)] and career experience in applied sport and exercise science, including 11 years practicing as an Accredited Remedial and Sports Massage Practitioner (ITEC, MSMA L4). This has involved working as part of multidisciplinary teams in private clinical practice, with sports teams notably golf, basketball and triathlon, with aging populations and at the Commonwealth Games Glasgow 2014 polyclinic managing the physical preparation, maintenance and recovery of athletes and clients in particular the management and prevention of musculoskeletal symptoms. Influences from 11 years of R.A.D classical ballet

training and examinations, distance running, triathlon, diving and continued scholarship in Rehabilitation Science also link to my interest in this research theme.

1.2 Purpose and Significance of the Research

The overall purpose of this thesis is to provide a focused and in-depth inquiry into symptomatic joint hypermobility specifically in paediatrics. The aim is to build on a previous publication of consultant rheumatologists' perspectives of symptomatic joint hypermobility (Grahame and Bird, 2001) by investigating physiotherapists' experiences and current clinical practice. It aims to inform medical professionals as well as the wider community who come into contact with this population, who require special considerations. Through the use of data from clinical practitioners and patients, this thesis is intended to develop specific knowledge and awareness of symptomatic joint hypermobility in children, and to advance methods of diagnosis, assessment and rehabilitation. It is apparent that updated strategies to accurately diagnose (Remvig et al., 2007b) treat and manage symptoms (Pacey et al., 2013) in individuals with symptomatic joint hypermobility are urgently needed to prevent and reduce cycles of disability and improve function and quality of life.

1.3 Summary of Individual Thesis Chapters

This chapter has briefly explained the context of the research area and has identified the purpose and significance of the research.

In chapter 2, current literature is reviewed as a base to create study designs from. The literature review commences with recent definitions of both asymptomatic and symptomatic hypermobility, including medical classifications of the condition. An overview of the stages of human growth and development in typically developing individuals is presented, followed by the probable aetiologies of joint hypermobility. Symptoms which suggest symptomatic joint hypermobility in adults, adolescents and paediatrics are detailed, and available

prevalence rates for hypermobility are discussed. The chapter then moves on to review and critique the various available diagnostic tools currently used in clinical practice and research. The limitations of these tools in assessing adults and especially paediatric patients are examined. The importance of accurate and timely diagnosis of joint hypermobility is emphasised, in addition to factors that hinder this and the likely risks and consequences for children who are undiagnosed or misdiagnosed. The current lack of a paediatric specific diagnostic tool is highlighted. Available evidence on awareness of hypermobility among medical professionals is also reviewed, including findings from a survey of consultant rheumatologists, which brings to light the fact that there is no such similar data published on understanding hypermobility and trends in practice within the physiotherapy profession, who are the main practitioners involved in the care of patients.

The importance of awareness of hypermobility among the wider community who come into contact with children with hypermobility is also documented. Following this is a discussion on pain experience in school-aged children and pre-adolescents, musculoskeletal pain associated with hypermobility in paediatrics, and chronic pain and pain management relevant to paediatrics. Musculoskeletal injury in paediatrics, injury associated with hypermobility (in adults and paediatrics) and injury prevention and management strategies are reviewed. Subsequently, newly emerging clinical trials and studies involving physiotherapy and proprioceptive training interventions are reviewed, while recommendations on treatment and management are outlined.

Chapter 3 presents study 1, a predominantly quantitative study, which through an original online survey explored chartered paediatric physiotherapists' understanding of hypermobility in children as well as current trends in diagnosis, treatment and management. The chapter integrates supplementary qualitative data procured from responses to open-ended survey questions. Combined quantitative and qualitative findings from study 1 provide a foundation

and a needs analysis for areas that have received limited attention in research. These are methods of assessment and diagnosis in children, and interventions including clinical trials and blended multidisciplinary treatment and management programs. The scarcity of these to date inevitably contribute to musculoskeletal injury, pain and fatigue experience in children which impacts on reduced school attendance and academic performance, decreased physical fitness and condition, reduced social integration and declines in mental health and psycho-social development. It is clear there is an urgent need to address this in order to reduce the number of children who remain in a cycle of disability.

Chapter 4 presents study 2, which is guided by the existing narrative literature and findings from study 1. It involves the development of a novel screening tool for use in the clinical assessment of children with symptomatic joint hypermobility, and the implementation of this tool working with 2 groups of children: a sample with clinical diagnoses of joint hypermobility and a sample of healthy, typically developing children. Quantitative results data on prevalence, functional static and dynamic balance, musculoskeletal pain intensity and location, and trends in children's participation in physical activity, sport, exercise and dance are discussed with accompanying qualitative data. The data give unique insight to this population from a UK perspective.

Chapter 5 discusses how the data and individual studies discussed contribute to the research aims of this thesis. Implications of the research findings on clinical practice and future research directions are discussed.

Chapter 2: Literature Review

A detailed literature search was conducted for full-text articles, book chapters and editorials using databases including, EBSCOhost, CINAHL (Cumulative Index to Nursing and Allied Health Literature), PubMed, MEDLINE, ScienceDirect, SPORTDiscus, PEDro (Physiotherapy Evidence Database) and publisher sites including BMJ group, SAGE publishing group and Elsevier, without date or language restrictions. In addition, the reference lists of retrieved journal articles and relevant reviews were hand searched. A non-systematic review of literature was performed selecting manuscripts in particular themes using search terms such as "hypermobility", "joint hypermobility", "joint hypermobility syndrome", "joint hypermobility and children", "joint hypermobility and diagnosis", "hypermobility and injury", "hypermobility and pain", "hypermobility and fatigue", "hypermobility and dance", "hypermobility and sport", hypermobility and exercise", "hypermobility and physiotherapy".

2.1 Generalised Joint Hypermobility, Joint Hypermobility Syndrome and Hypermobility Syndromes: Definitions

Hypermobility or Generalised Joint Hypermobility (GJH) is a condition in which most of an individual's synovial joints move beyond their 'normal' limits, with the age, gender and ethnic background of the individual taken into account (Hakim and Grahame, 2003a). Individuals with asymptomatic generalised hypermobility are classified as having GJH. In everyday language, the non-medical term 'double-jointed' is often used. Attributes of ligamentous laxity are flexibility, extensibility and increased range of movement of joints, which are valued assets in professional performing artists such as dancers, gymnasts, acrobats, cirque performers, contortionists and musicians (Grahame, 1993, McCormack et al., 2004). This unique ability and aesthetic quality is often a positive factor in the selection of junior performers including dancers (Scheper et al., 2014). Individuals who experience

symptoms attributable to their GJH are classified as having Joint Hypermobility Syndrome (JHS) (Grahame and Hakim, 2008, Ross and Grahame, 2011a). JHS is a heritable disorder of connective tissue (HDCT) that comprises symptomatic hypermobility predisposing to arthralgia, soft tissue injury and joint instability (Hakim and Grahame, 2003a). JHS has previously been known as Benign Joint Hypermobility Syndrome (BJHS) and is referred to as this in some literature (Simpson and Michael, 2006). Similarly, terms such as tissue laxity, joint laxity (Grahame, 2009), generalised joint laxity (Boyle et al., 2003), ligamentous laxity of joints (Murray, 2006) and Hypermobility Syndrome (Grahame and Bird, 2001) are also used. The Revised Nosology for HDCTs defined JHS as an entity discrete from more rare and serious inherited abnormalities of connective tissue such as Ehlers-Danlos Syndrome (EDS) (Beighton et al., 1998), including Classical EDS and Vascular EDS (Type IV), Marfan Syndrome (MFS), Osteogenesis Imperfecta (OI) and Stickler Syndrome which all have symptomatic hypermobility as a feature (Grahame, 1999, Simpson and Michael, 2006, Grahame and Kazkaz, 2014). Established classification criteria exist for each aforementioned HDCT defined by clinical patterns of disease, identifiable inheritance patterns, genetic abnormalities of collagen, collagen modifying proteins and fibrillin and histologic abnormalities of the dermis (Hakim and Sahota, 2006). Most authorities currently acknowledge that JHS and EDS-Hypermobility Type III (EDS-HM), which is the most common of 7 EDS classifications, share the same characteristics (Tinkle et al., 2009, Beighton et al., 2012b). In this thesis, symptomatic GJH, JHS and EDS-HM are referred to collectively under an umbrella term of 'Hypermobility Syndromes'. The research is focused on HMS in paediatrics however literature in adolescents and adults is also reviewed.

2.2 Growth and Development

In a physiological context, infancy is defined as the first year of life. The most rapid period of growth occurs between infancy and early childhood (between birth and 6 years of age). In chronological years, childhood spans the time between the end of infancy (the first birthday)

and the beginning of adolescence. Middle childhood spans the time from 8 years of age to adolescence (Malina et al., 2004). The period of adolescence is more difficult to define in chronological years, as it varies among individuals in both its onset and its conclusion. Adulthood is considered as the time from the end of adolescence, when full physical growth and maturation have been achieved. Growth and maturation are dynamic processes of movement toward the adult state of maturity. Growth refers to an increase in the size of the body and development refers to functional changes that occur with growth. Maturation refers to the point when the body has taken on adult form and becomes fully functional. For example, skeletal maturity refers to having a fully developed skeletal system within which all bones have completed normal growth and ossification (Malina et al., 2004).

Infancy and childhood are dynamic periods of growth and change. Development of voluntary control of movement begins in infancy and progresses into childhood as a child gradually attains postural and loco motor control and competence. Basic patterns such as walking, running and jumping are the foundation on which other more specialised movements are subsequently developed and refined with the development of cognitive function, motor skill acquisition and neuromuscular control of movement (Ford et al., 2012). Physical growth and neurodevelopment (in all domains of gross motor, fine motor, problem-solving, receptive language and the social-emotional) proceed in a sequential and predictable pattern that is intrinsically determined (Gerber et al., 2010). Skills progress from generalized responses to stimulus-based reflexes to specific, goal-oriented and purposeful actions that become more precise. In a healthy, typically developing infant, gross motor milestones include lying prone, rolling over, achieving hands and knees and sitting postures, pulling to stand, and walking. They progress to more complex bipedal movements such as moving backwards, running, jumping and gait reaching an adult pattern. By the time a child starts primary school, they should be able to perform multiple complex gross motor tasks simultaneously such as pedalling, maintaining balance and steering while on a bicycle

(Foster and Cabral, 2006, Gerber et al., 2010)

Fine motor milestones do not proceed in isolation but depend on other areas of development including gross motor, cognitive and visual perception skills. Fine motor milestones in a healthy, typically developing infant include visually tracking faces and objects, joining hands together, transferring objects from hand to hand, mastery of reach, grasp and release, advancing to stacking blocks, feeding themselves with a spoon and fork, drawing horizontal and vertical lines and circles and putting on shoes. At 4 years old, finer control of pencil movements should be achieved and by 5 years old, so should brushing teeth, spreading with a knife and cutting a circle using scissors (Gerber et al., 2010).

Intrinsic and extrinsic factors influence development. Intrinsic influences include genetically determined attributes such as physical characteristics and health status, while extrinsic influences include parent and sibling personalities, nurturing from family, caregivers and the cultural environment. Red flags that may suggest motor developmental delays are a lack of steady head control while sitting at 4 months old, an inability to sit at 9 months old, or an inability to walk independently at 18 months old (Gerber et al., 2010). The development of 6 particular gross motor milestones are reported to be largely independent of variations in physical growth: sitting without support, hands and knees crawling, standing with assistance, walking with assistance, standing alone and walking alone (WHO and Multicentre Growth Reference Study, 2006). Due to gross motor milestones within certain age ranges being predictable, it's easy to reliably measure motor development in children by using such milestones and age ranges. The extent of a young person's participation in physical activity during critical periods of growth is considered an important variable in the development of motor skills. Skills are also affected by the type and amount of physical activity undertaken during this time (Visser et al., 1998). This highlights the importance of exposure to physical activity in terms of motor development in young people, and suggests that individuals who

do not participate in physical activity, for example due to ill health or medical conditions, may risk delays in aspects of motor skill development.

The period of adolescence involves 2 major events: the adolescent growth spurt (somatic maturation) and sexual maturation (Malina et al., 2004). Young people enter this phase of growth at different ages (differential timing) and proceed through it at variable rates (differential tempo). Puberty happens in response to a change in the hormones circulating in the body, with girls maturing physiologically about two years earlier than boys. Under the influence of oestrogen and progesterone from the ovaries (in girls) and testosterone from the testes (in boys), the reproductive organs grow and mature. An increase in height velocity marks the initiation of the adolescent growth spurt and this eventually reaches a maximum peak height velocity (PHV), before gradually declining (Malina et al., 2004). Increases in muscle mass and lean body mass in males occur during biological maturation (Ford et al., 2012). Similarly, increases in flexibility in girls during and following the onset of biological maturation (Quatman et al., 2008) are influenced by elastin, a female hormone that regulates elasticity of collagen and other components of connective tissue. This contributes to the greater flexibility seen in females, and potentially to the more natural suitability of pubertal and post-pubertal adolescent girls to activities that require greater ranges of movement, such as gymnastics and ballet (McCormack and Briggs, 2002). Flexibility is documented to reduce with advancing age (Jansson et al., 2004, Foster and Cabral, 2006).

Characteristics of muscular strength, motor performance and aerobic power show well-defined development in adolescence, but the timing of these respective growth spurts varies in relation to PHV in both boys and girls, as well as in relation to menarche in girls (Malina et al., 2004). Strength, speed and flexibility are also reported to increase rapidly during the adolescent growth spurt in typically developing males (Buenen and Malina, 1988). This may allow enhanced physical capacity, and a better response to more focused and specialised training regimes in sport may be experienced at this time. Temporary disruption of motor

coordination is however believed to occur during adolescent growth spurts, due to biomechanical changes produced by rapid physical growth spurts that disturb the 'fine tuning' of sensorimotor systems (Visser et al., 1998). For example, a rapid change in height can alter the centre of gravity and challenge balance and stability. Similarly, increases in the width of the pelvis can alter balance and proprioception, and changes in the distribution of body fat and increases in percentage body fat in females. During the growth spurt, limbs often grow disproportionately quicker in relation to the rest of the body and movement may be less controlled if core strength and stability is not yet strong enough to stabilise the trunk in dynamic movement patterns. The adolescent growth spurt can also be a sensitive time in terms of musculoskeletal injury risk, which is discussed in more detail in section 2.9.

2.3 GJH and HMS: Aetiology

HMS represents the mild end of the spectrum of HDCTs in terms of being non-life threatening (Hakim and Sahota, 2006), with the pathogenic root suggested to be a genetic abnormality of connective tissue matrix proteins (Grahame, 2008). Connective tissues are the materials that bind musculoskeletal structures together i.e. ligaments, tendons, fascia, capsules, cartilage, fat pads, disc tissue, bone and skin. Ligaments function to provide stability. For example in the knee joint, anteroposterior stability is provided by anterior and posterior cruciate ligaments (ACL and PCL), lateral stability and resistance to varus and valgus stresses are assisted by medial and lateral collateral ligaments (MCL and LCL), and prevention of hyperextension of the knee is also aided by ACL, PCL, MCL, LCL, oblique popliteal and posterior oblique ligaments (Harris et al., 2014).

Type I collagen is the most common collagen in the human body and is found in ligaments, tendons, joint capsules, skin, demineralised bone and nerve receptors. It is characterised by high tensile strength. Type II collagen is found in cartilage and is designed to withstand

compressive stress. Type III collagen is much more extensible and unorganised and is present in skin, blood vessels and organs such as the stomach. Normally, fibroblast cells produce dense, parallel arranged groups of collagen and elastin (protein) fibres in ligaments and tendons, which when aligned along the lines of stress, give connective tissues their resistance to tension forces while allowing some stretch (McCormack, 2010). In inherited joint laxity there is a problem with how collagen is made due to the genetic disorder affecting the genes that encode the aforementioned proteins. It has been proposed that individuals with HMS have an abnormal ratio of type III collagen to type I collagen Clinical scientists, epidemiologists and geneticists have attempted to define clinical patterns of the disease in the pursuit of reliable systems of classification and diagnosis. Reports of genetic studies in patients and families with HMS and EDS-HM are scarce and the genetic abnormalities and inheritance patterns of HMS and EDS-HM are reported to be poorly understood (Malfait et al., 2006). Genes encoding collagens and collagen-modifying enzymes have been considered as candidate genes for these conditions, however research investigating this in individuals with HMS has been inconclusive and not revealed any candidate genes (Bird, 2011). Mutations in genes encoding type 1 collagen (COL1A1 and COL1A2) play an important role in the pathogenesis of joint hypermobility (Malfait et al., 2006). Similarly, mutations in a non-collagenous molecule called tenascin-X have been identified in a subset of patients with EDS-HM and HMS in research by Zweers *et al.* (2003), which is an important model in research of the genetic basis of EDS and HMS.

Hypermobility as a consequence of collagen type and structure is likely to be widespread throughout most joints in the body where the extent of laxity present in each of these joints is similar (Bird, 2011). Effects of hormones on symptoms, for example the effects of elastin and oestrogen in females approaching puberty, are indicators of this aetiology, as is the presence of widespread clinical features in other organs that can be attributed to widespread laxity in collagen, such as easy bruising in blood capillaries. In males the predominant

androgen hormones have little effect on collagen, though these hormones may increase lean muscle mass around the joints providing stability and strength. In female's oestrogen tends to stabilise collagen, while progesterone loosens it. Increased pain in joints, clumsiness and a greater tendency to dislocate joints were reported in female hypermobility patients in the 5 days before menstruation and the few days following menstruation. This is the time in the menstrual cycle when progesterone far exceeds the stabilising oestrogen compounds. Hormonal aspects of HMS are reported to warrant more research (Bird, 2011).

Joint hypermobility may arise from shallow or unusually shaped, bony and cartilaginous articulating surfaces of joints. This tends to be severe at a small number of joints and absent at others. Ball and socket joints, for example the hip joint and saddle joints, seem to be susceptible to this variant of hypermobility. This type is much less likely to be hormonally influenced, not being linked to features of lax collagen, and may be accompanied by a family history of orthopaedic problems such as developmental dysplasia of the hip joint. These are the most common causes of hypermobility and they can co-exist in the same individual (Bird, 2011). This signifies how important a full medical, family and injury history is in the assessment and diagnosis of a patient with HMS. Hypermobility due to specific training and frequent stretching is an acquired type and is more likely to be localised rather than generalised (Vaughn and Nitsch, 2008). This type of hypermobility may present in a single joint or pair of joints that are exercised in a sport's specific movement patterns, for example in the hip joints of track hurdlers, or the shoulder joints of butterfly swimmers, throwing and racquet sport athletes (Johnson and Robinson, 2010, Kaux et al., 2013). An indicator of this aetiology is the need for a pre-exercise warm-up for laxity to be achieved hence, a test for this would be useful in a diagnostic tool.

2.4 Symptoms of HMS

The range of symptoms associated with a clinical expression of HMS is broad and multi-systemic, and extends beyond the musculoskeletal system. The signs and symptoms of the spectrum may present in varying degrees and combinations. Based on the evidence available and case series reviewed by Ross and Grahame (2011a) and continued by the author, symptoms that give a clinical impression of HMS in adults are presented in Table 2.1. Common symptoms indicative of HMS in paediatrics and adolescents are presented in Table 2.2.

2.4.1 Symptoms in Adults

Table 2.1 Symptoms of HMS in Adults

Articular Features of HMS
Arthralgia (Ross and Grahame, 2011a)
Myalgia (Ross and Grahame, 2011a)
Spinal pain (Beighton et al., 2012b)
Musculoskeletal injuries (recurrent and multiple) including joint subluxations and dislocations (Simpson and Michael, 2006)
Weakness in abdominal and pelvic wall with herniation and prolapse (Ross and Grahame, 2011b)
Laxity in supporting tissues such as pelvic floor and varicose veins (Ross and Grahame, 2011a)
Entrapment neuropathies (Granata et al., 2013)
Degenerative changes of joints and premature osteoarthritis (Kirk et al., 1967, Jonsson et al., 1996)
Increases in pain unresponsive to analgesics (Grahame, 2009)
Progressive loss of mobility due to pain avoidance (Grahame, 2009)
Extra-articular Features of HMS
Chronic fatigue (Rombaut et al., 2010)
Chronic widespread pain (Clark et al., 2014)
Chronic recurrent pain (Sacheti et al., 1997)

Ocular anomalies (Gharbiya et al., 2012)
Gastrointestinal dysfunction (Zarate et al., 2010, Clark et al., 2014, Kovacic et al., 2014)
Autonomic nervous system dysfunction such as orthostatic intolerance (dizziness, faintness, syncope) and postural tachycardia syndrome (POTS) (Gazit et al., 2003, Clark et al., 2014, Grahame and Kazkaz, 2014)
Hernia (Grahame et al., 2000)
Mitral valve prolapse (Beighton et al., 2012c)
Rupture of lung tissue (Beighton et al., 2012c)
Dermal hyper elasticity (Hakim and Sahota, 2006)
Reduced posture (Booshanam et al., 2011)
Migraine (Bendik et al., 2011)
Daily persistent headache (Rozen et al., 2006)
Abdominal/pelvic pain (Castori et al., 2012)
Anxiety (Garcia-Campayo et al., 2011, Baeza-Velasco et al., 2015)
Depression (Grahame, 2000, Baeza-Velasco et al., 2015)

An early study (Kirk et al., 1967) reported premature osteoarthritis as a feature in female adults with GJH, with the condition arising between ages 33 and 56. More recent research has used biomechanical gait analysis (Simonsen et al., 2012, Celletti et al., 2012b) and electromyographic (EMG) activity analysis (Greenwood et al., 2011) to further investigate the impact of GJH on musculoskeletal structures. However, in terms of these studies' relevance to clinical practice, caution should be taken when rationalising results and conclusions. Greenwood et al. (2011) measured EMG activity of pelvic and lower limb muscles during postural tasks in adults with HMS and non-hypermobile adult controls, whose ages ranged from 22 to 45 years old. Findings revealed that in individuals with HMS, poor motor control patterning of pelvic muscles was evident during more challenging tasks such as one-leg standing where the base of support was removed. Lower gluteus medius and erector spinae muscle activity during balancing tasks contribute to pelvic instability and lower back pain. Increased co-contraction of the rectus femoris and semitendinosis to

stabilise the hypermobile joint may increase compression at the knee joint. Repeated stress, trauma and injury to the joints are likely to contribute to degeneration, which can progress to arthritic changes and an increased risk of premature osteoarthritis. This may affect individuals who have typically overworked these joints over an extended timeframe, for example through a career in performing arts (Knight and Bird, 2010), however further in-depth investigations and studies that include paediatric patients are needed to advance knowledge.

Clinical gait analysis using force platforms (Simonsen et al., 2012) showed higher joint moments during walking and increased knee joint loadings in adult GJH patients when compared with healthy controls. Peak knee and hip abductor moments in the frontal plane were 13% higher in GJH patients. In the sagittal plane, the peak knee extensor moment was 10% higher for GJH patients and the mid-stance knee flexor moment was 27% lower, with increased flexion of the knee joint also observed. These findings add to the understanding of potential origins of knee pain symptoms and knee joint injuries in individuals with hypermobility. As these forces were measured during walking, it is anticipated that they will be even higher in activities of running and jumping, however specific data is currently unavailable. The relationship between muscle fatigue and gait abnormality in adult patients with HMS/EDS-HM was tested (Celletti et al., 2012b) using 3D gait analysis and the Fatigue Severity Scale (FSS), a standardised questionnaire. Data showed the FFS value correlated negatively with the peak of the vertical component of the ground reaction force, which indicated that higher fatigue is associated with reduced force during gait. In turn, muscle fatigue is likely to be linked to a loss of proprioceptive acuity in lower limb muscles, which may predispose them to inefficient movement patterns and repetitive strain. As adults were tested in these studies, effects in paediatrics remain unknown and need to be investigated.

2.4.2 Symptoms in Paediatrics

Early identification of symptoms in children and modification of risk factors for pain and injury may have significant implications on the subsequent development of clinical symptoms in young adulthood (listed previously in Table 2.1) such as lower back pain, chronic pain syndromes, fatigue cycles and premature osteoarthritis (Murray, 2006).

Table 2.2 Symptoms of HMS in Paediatrics and Adolescents

Motor delay (Falkerslev et al., 2013)
Late walking (Adib et al., 2005)
Fatigue and tiring easily (Murray, 2006)
Poor ball catching skills (Murray and Woo, 2001)
Poor handwriting skills (Adib et al., 2005)
Developmental dislocation of the hip (Adib et al., 2005)
'Clicky' hips at birth (Adib et al., 2005)
Congenital hypotonia (Murray and Woo, 2001)
'Growing pains' (Viswanathan and Khubchandani, 2008)
Multiple joint pain (Murray, 2006)
Nocturnal leg pains (Murray and Woo, 2001)
Recurrent back pain n.b. lumbar spine (Gedalia and Brewer, 1993)
Hip pain (Murray and Woo, 2001)
Pes Planus (flat feet/pronated feet) (Murray and Woo, 2001)
Recurrent ankle sprains (Murray, 2006)
Soft tissue injury e.g. joint subluxation and dislocation (Murray, 2006)
Exercise-related and post-exercise joint pain (Adib et al., 2005)
Developmental Coordination Disorder (Kirby and Davies, 2007)
Clumsiness and dyspraxia (Murray and Woo, 2001)
Easy bruising (Adib et al., 2005)
Impaired proprioception and spatial awareness (Fatoye et al., 2009)

Delays in motor development were observed in one third of a paediatric sample with GJH (Engelbert et al., 2005), and children with HMS and pain exhibited reduced physical activity and participation in childhood tasks such as riding a bicycle (Schubert-Hjalmarsson et al.,

2012). Comparably, delays in the development of fine motor coordination have been reported in a case study of two siblings aged 5 and 10 years old with HMS who both had difficulty holding a spoon (Toker et al., 2010). Limitations of case studies such as reduced generalizability of findings to the wider population with HMS are acknowledged, yet it is accepted that poor control and inefficiency of joints are risk factors for musculoskeletal pain and injury, which are discussed further in sections 2.8 and 2.9.

2.5 GJH and HMS: Prevalence

GJH is influenced by age (van der Giessen et al., 2001, Hasija et al., 2008), gender (Al-Rawi et al., 1985, Larsson et al., 1993, Decoster et al., 1997, Qvindesland and Jónsson, 1999, Klemp et al., 2002, Jansson et al., 2004, Seçkin et al., 2005, Quatman et al., 2008, Menendez Alejo et al., 2009) and ethnicity (Remvig and Jensen, 2005), factors that have been extensively reported in the literature. The presence of GJH is more common in children than adults (Kirk et al., 1967), and more common in females than males in paediatric (Rikken-Bultman et al., 1997), adolescent (Clinch et al., 2011), young adult (Al-Rawi et al., 1985, Du Toit et al., 2011) and middle-aged adult populations (Larsson et al., 1993). It is more prevalent in Asian and African races than in Caucasians (Hakim and Grahame, 2003a). Recent prevalence rates of GJH among schoolchildren in the UK with a mean age of 14 are reported to be 27.5% in girls and 10.5% in boys (Clinch et al., 2011). The prevalence of HMS in a late teenage Caucasian population is suggested to be around 5% (H. Bird, 2012, personal communication). Among a performing arts-specific population of Royal Ballet School dancers (McCormack et al., 2004) GJH was present in 74% of girls and 82% of boys in the lower school (aged 11 to 16 years), with the prevalence of HMS in this group being 47% in girls and 45% in boys. The prevalence of GJH in the 16 to 18 year-old dancers was similar, with 94% of females and 83% of males affected, while the prevalence of HMS was 46% in females and 35% percent in males. Summary tables of prevalence data from studies researching hypermobility in adults, adolescents and paediatrics are presented in tables 2.3,

2.4 and 2.5. The wide variation in prevalence rates in published research is understood to exist due to differing definitions and case identifications (Murray, 2006) and different populations chosen for studies, including different ethnic origins and different ages at which joint examinations were undertaken. This means results can only be generalised to these specific cohorts. In addition, methodological variations including different screening tools used to assess GJH and HMS, modifications made to existing screening tools and varying cut-off points in the use of the Nine-Point Beighton Score (Beighton et al., 1973) also considerably affect prevalence rates and are discussed further in section 2.6.

Beighton et al. (2012a) suggested that the majority of musculoskeletal complaints attributable to hypermobility present in the most supple 5 to 10% of the population, however a specific population was not detailed. The disparity among methods of diagnosis, research methodologies and arbitrary allocation of cut-off points in hypermobility research is clear in the 3 population groups, which signifies the need for a standardised and more uniformed approach. Some limitations of the published literature focusing on paediatric hypermobility (detailed in table 2.5) are that only GJH was measured and possible symptoms and consequences of hypermobility were not taken into account (Rikken-Bultman et al., 1997, van der Giessen et al., 2001, Hasija et al., 2008, Yazgan et al., 2008). Many of the study designs are cross-sectional, presenting a snapshot view of the population investigated, so findings need to be considered in that particular culture and context. An increased prevalence of GJH in girls aged 15 years compared with girls aged 9 years (Jansson et al., 2004) could be due to the influence of hormones discussed previously in section 2.3 on aetiology. Similarly, in the same study the decrease in GJH in males with advancing age from 9 to 12 to 15 is potentially due to gains in lean body mass and strength, which balance lax joints. This is influenced by hormones, specifically testosterone (Quatman et al., 2008).

Table 2.3 Summary Table of Hypermobility Prevalence Data: Adult Studies. GJH= generalised joint hypermobility. HMS= joint hypermobility syndrome. n= number of study/group participants. yrs= years. M= male. F= female

Authors and Country	**Construct Measured**	**Diagnostic Tool**	**Cut-off Point**	**Sample (size, age & gender)**	**Prevalence**
(Sanches et al., 2015) Brazil	GJH and HMS	Nine-Point Beighton Score + Brighton Criteria	≥4/9	N=77, age 18-40 yrs.	58% GJH. 16% HMS (ballet students) 36% HMS (ballet teachers)
(Russek and Errico, 2015) USA	GJH and HMS	Nine-Point Beighton Score + Brighton Criteria	≥5/9	N=267 college & graduate students, age 17-26 years	26.2% GJH (36.7% F & 13.7% M) 19.5% HMS (24.5% F & 13.7% M)
(Mulvey et al., 2013) UK	GJH and Pain	Five-Item Questionnaire for Hypermobility Pain Questionnaire	Answering 'Yes' to ≥2/5 questions.	N=12,853 ≥25 yrs	18.3% GJH
(Clark and Simmonds, 2011) Oman	GJH and HMS	Nine-Point Beighton Score + Brighton Criteria	≥4/9	N=184 F only, age 18-50 yrs. G1 patient n=94 G2 control n=90	G1 GJH in 51% & HMS in 55% G2 GJH in 30% & HMS feature without pain in 21%
(Du Toit et al., 2011) South Africa	GJH	Nine-Point Beighton Score	≥4/9	N=480, 55% M & 45% F, mean age 20 yrs, range 18 to 25 yrs	36.4% F 13.9% M

(Grahame, 2007a) UK	HMS	Brighton Criteria	2 major or 1 major + 2 minor	N=214 M & F, 80 dancers & 134 musicians	70% HMS in dancers 40% HMS in musicians (pianists 45% & string players 40%)
(Hudson et al., 1995) Canada	GJH and HMS	Nine-Point Beighton Score Hospital del Mar (Barcelona) Criteria	≥4/9 ≥4/9 M & ≥5/9 F	N=378	13.2% GJH
(Larsson et al., 1993) Sweden	GJH	Nine-Point Beighton Score modification (substituted palms on floor with dorsiflexion and eversion of foot)	≥4/9	N=642. 320 M mean age 37.2 yrs. 286 F N=286 mean age 40.0 yrs.	69% F & 59% M
(Al-Rawi et al., 1985) Iraq	GJH	Nine-Point Beighton Score	≥4/9	N=1774 20-24 yrs. 1187 M & 587 F	25.4% M & 38.5% F

Table 2.4 Summary Table of Hypermobility Prevalence Data: Adolescent Studies. GJH= generalised joint hypermobility. HMS= joint hypermobility syndrome. n= number of study/group participants. Yrs= years. M= male. F= female.

Authors and Country	**Construct Measured**	**Diagnostic Tool**	**Cut-off Point**	**Sample (size, age & gender)**	**Prevalence**
(Clinch et al., 2011) UK	GJH	Nine-Point Beighton Score	≥4/9	N=6022, mean age 13.8 yrs	27.5% F & 45% GJH in fingers 10.6% M & 29% GJH in fingers
(Menendez Alejo et al., 2009) Cuba	HMS	Brighton Criteria + survey data on pain and MSK symptoms.	≥5/9	N=280 mean age 15.7 yrs, 89 M & 191 F	11.4%
(Gyldenkerne et al., 2007) Denmark	GJH	Nine-Point Beighton Score	≥4/9	N=364, age range 12 to 13 yrs	9.4% i.e. 16.6% F& 3.3% M
(Seçkin et al., 2005) Turkey	GJH	Nine-Point Beighton Score	≥4/9	N=861, mean age 15.4 yrs, 428 M + 433 F	11.7%. 7.2% M & 16.2% F.
(Decoster et al., 1997) USA	GJH	Carter-Wilkinson Method (1964)	≥5/9	N=264 athletes, 150 M & 114 F. mean age 15.5 yrs.	12.9% (9 M & 25 F)

Table 2.5 Summary Table of Hypermobility Prevalence Data: Paediatric Studies. GJH=generalised joint hypermobility. HMS=joint hypermobility syndrome. n=number of study/group participants. Yrs=years. MSK=musculoskeletal. M=male. F=female. G1=group1. G2=group2.

Authors and Country	**Construct Measured**	**Diagnostic Tool**	**Cut-off Point**	**Sample (size, age & gender)**	**Prevalence**
(Nicholson et al., 2014) Australia	HMS EDS-HM	Brighton Criteria Villefranche Criteria	≥4/9	N=100, 47 M & 53 F. mean age 11.5±3.1 yrs N.B clinical sample of HMS patients.	94% HMS 90% EDS-HM
(Smits-Engelsman et al., 2011) Netherlands	GJH	Nine-Point Beighton Score	≥0-4/9, ≥5/9 and ≥7/9	N=551, 258 M & 293 F age range 6 to 12 yrs.	≥0-4/9 64.4% ≥5/9 26.5% ≥7/9 9.1%
(Qureshi et al., 2010) Pakistan	GJH & HMS	Nine-Point Beighton Score + Brighton Criteria + questionnaire	≥4/9	N=872, 474 M & 398 F. mean age 12.85±3.9 yrs.	GJH 37%, 39.5% M & 34.2% F. HMS 4.8% (n=49). 3.6% M & 6.3% F
(Juul-Kristensen et al., 2009) Denmark	GJH & HMS	Nine-Point Beighton Score + Brighton Criteria + questionnaire	≥4/9, ≥5/9 and ≥6/9	N=524. 8 yrs.	≥4/9 29% ≥5/9 19% ≥6/9 10%
(Leone et al., 2009) Italy	GJH + MSK pain	Nine-Point Beighton Score + pain questionnaire	≥5/9	N=1064, mean age 10.8 yrs	22.2% GJH 18% MSK pain

(Yazgan et al., 2008) Turkey	GJH	Nine-Point Beighton Score	≥4/9, ≥5/9 and ≥6/9	N=922, 509 M & 413 F mean age 8.2 ± 1.07 yrs	≥4/9 39.3% ≥5/9 22.7% ≥6/9 13.3%
(Viswanathan and Khubchandani, 2008) India	GJH and growing pains.	Nine-Point Beighton Score and Petersons Criteria (to assess growing pains)	≥5/9	N=433, 219 M & 214 F age 3-9 yrs	40.8% GJH 42.3% growing pains
(Hasija et al., 2008) India	GJH	Nine-Point Beighton Score	≥4/9	N=829 3-19 yrs / 3 categories by age i.e. 3-7 yrs, 7-13 yrs and 13-19 yrs	58.7%. 3-7 yrs 79.7%. 7-13 yrs 61.2%. 13-19 yrs 29.5%
(Gyldenkerne et al., 2007) Denmark	GJH and pain	Nine-Point Beighton Score	≥4/9	N=364 M + F 12-13 yrs (6^{th} grade)	34/364, 9.4%
(Adib et al., 2005) UK	HMS	Nine-Point Beighton Score + medical history records.	≥8/9	n=125, 64 F & 61 M <18 yrs	94% N.B clinical sample of HMS patients.
(Lamari et al., 2005) Brazil	GJH	Nine-Point Beighton Score	≥4/9	N=1120, 586 F & 534 M, age range 4 to 7 yrs	64.4%
(Jansson et al., 2004) Sweden	GJH	Nine-Point Beighton Score	G1: ≥8/9 G2: ≥6/9 M & ≥7/9 F G3: ≥6/9 M & ≥8/9 F	N=1845. G1 mean age 9 yrs n=573, 317 M & 256 F G2 mean age 12 yrs n=703, 349 M & 354 F G3 mean age 15 yrs n=569, 284 M & 285 F	GJH: G1 37.6% M & 47.9% F G2 21% M & 37% F G3 15.5% M & 53% F

(Klemp et al., 2002) New Zealand	GJH and HMS	Nine-Point Beighton Score + personal interview + MSK examination + medical including rheumatologic history + radiographs in some cases.	≥4/9	N=792, 438 Maori and 354 European New Zealanders.	Maori: 9% F & 2.2% M. European NZ: 5.6% F & 1.9% M
(van der Giessen et al., 2001) Netherlands	GJH	Nine-Point Beighton Score	≥4/9	N=773 4-12 yrs.	26.5% 4-9 years 5.3% 10-12 yrs.
(Rikken-Bultman et al., 1997) Netherlands	GJH	Nine-Point Beighton Score + Biro Score	≥4/9	N=252 4-13 yrs (primary school) & n=658 12-17 yrs (secondary school)	15.5% 13.4%

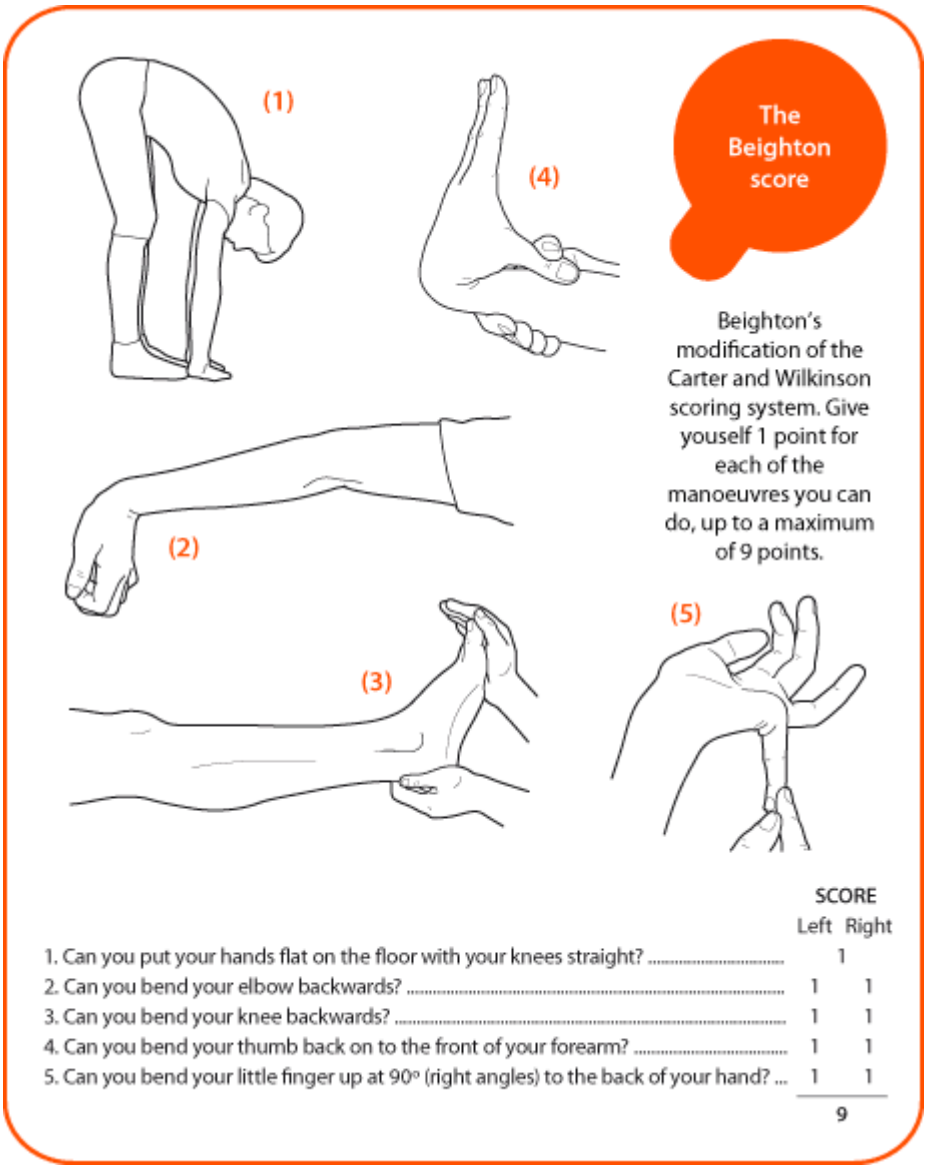
2.6 GJH and HMS: Diagnosis

2.6.1 Diagnosis in Adults

The original scoring system, first devised by Carter and Wilkinson (1964) and modified by Beighton et al. (1973), is the Nine-Point Beighton Score (Figure 2.1). This is a simple diagnostic tool originally used to measure joint hypermobility in large population epidemiological studies. Five joints are tested (4 of them bilaterally), where the scoring system involves gaining 1 point for each joint in the body that moves beyond its 'normal' limits (counting left and right joints individually). There is a maximum score of 9 points if all tests are positive. The British Society of Rheumatology recommends a standardised criterion of ≥ 4 positive tests out of 9 in the Nine-Point Beighton Score (Beighton et al., 1973) to indicate GJH (Remvig et al., 2007). The movements illustrated in Figure 2.1 include:

- passive dorsiflexion of the fifth metacarpophalangeal joint to ≥ 90 degrees (1 point for left and 1 point for right)
- passive opposition of the thumb to the flexor aspect of the forearm (1 point for left and 1 point for right)
- hyperextension of the elbow to ≥ 10 degrees (1 point for left and 1 point for right)
- hyperextension of the knee to ≥ 10 degrees (1 point for left and 1 point for right)
- placing hands flat on the floor without bending knees (1 point)

Figure 2.1 Nine-Point Beighton Score



The Nine-Point Beighton Score (Beighton et al., 1973) is a measure of GJH and has been used internationally. A standardised protocol for the Nine-Point Beighton Score with passive range of motion was defined for clinical studies of reproducibility in adults (Juul-Kristensen et al., 2007). Other investigators consider the Nine-Point Beighton Score calculated with the standardised Beighton protocol and used with goniometry to be a valid method to measure GJH in children aged 6 to 12 years old (Smits-Engelsman et al., 2011). While goniometry provides a more precise measure of the degree of joint range of

movement, it adds to the timeframe needed for individual assessment. This may preclude its use as a quick test in research and clinical settings, which was what it was originally designed for (Scheper et al., 2013b).

The 1998 Revised Brighton Criteria by Grahame et al. (2000) is an instrument used in the classification of HMS in adults. It takes clinical musculoskeletal symptoms into account.

Table 2.6 1998 Revised Brighton Criteria

Major Criteria

1. A Beighton score ≥ 4/9 (currently or historically).
2. Arthralgia for > 3 months in ≥ 4 joints.

Minor Criteria

1. A Beighton score of 1–3/9 (0–3/9 if aged over 50 years).
2. Arthralgia (for ≥ 3 months) in 1–3 joints or back pain (for ≥ 3 months), spondylosis, spondylolysis/spondylolisthesis.
3. Dislocation/subluxation in more than 1 joint, or in 1 joint on more than 1 occasion.
4. Soft tissue rheumatism with ≥ 3 lesions (e.g. epicondylitis, tenosynovitis, bursitis).
5. Marfanoid habitus (tall, slim, span/height ratio > 1.03, upper: lower segment ratio < 0.89, arachnodactily [positive Steinberg/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 hernia or uterine/rectal prolapse.

Using this set of criteria for diagnosis of HMS, an individual needs to score 2 major criteria, or 1 major plus 2 minor criteria, or 4 minor criteria. Two minor criteria are accepted where there is an unequivocally affected first-degree relative. HMS is excluded by presence of Marfan Syndrome or EDS (apart from the EDS-HM) which are defined by the Ghent Criteria (De Paepe et al., 1996) and Villefranche Criteria (Beighton et al., 1998) respectively. Major

criteria 1 and minor criteria 1 are mutually exclusive, as are major criteria 2 and minor criteria 2. These proposed criteria have been accepted as a way of diagnosing HMS in adults (Remvig et al., 2007b) and have been used in research studies in adults (Clark and Simmonds, 2011) , adolescents (Menendez Alejo et al., 2009) and paediatrics (Pacey et al., 2014, Juul-Kristensen et al., 2014).

An alternative scale that includes the shoulder, hip, patella, ankle, foot and toes is the 10-Point Hospital Del Mar (Barcelona) Criteria for clinical assessment of joint hypermobility, also known as Bulbena Criteria (Bulbena et al., 1992). While its use is noted briefly in the literature (Hudson et al., 1995) it does not appear to be widely used. A simple, statistically validated Five-Point Questionnaire for identifying hypermobility has been more recently created (Hakim and Grahame, 2003b).

Table 2.7 Five-Point Self-Report Questionnaire for 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 kneecap or shoulder dislocate on more than one occasion?
5. Do you consider yourself double-jointed?

This tool does not require physical screening and can be answered in retrospect. Answering yes to two or more questions suggests the presence of joint hypermobility in the respondent. The language and self-report style points towards its use in adults, and while its use is not

widely reported in the literature, it has recently been utilised as a component of screening for GJH in a large UK-based cross-sectional population survey (Mulvey et al., 2013) and in an elite female netball population (Soper et al., 2015) (see Table 2.3).

2.6.2 Limitations of Current Diagnostic Tools

The Nine-Point Beighton Score (Beighton et al., 1973) tests four joints in the body bilaterally plus one other joint (as described in section 2.6.1). This may miss identifying localised hypermobility in joints not tested, for example the temporomandibular joint (TMJ), shoulders, hips, ankles and cervical spine (Hakim and Grahame, 2003a). Due to potential clinical consequences of pain, instability and injury associated with hypermobile joints, it is important to still consider symptoms even if an individual does not reach a score above 4 in the Nine-Point Beighton Score. Another limitation to note is that the Nine-Point Beighton Score does not measure the degree or extent of joint laxity (Grahame and Bird, 2001), for example whether a joint is ≥ 12 degrees or ≥ 16 degrees beyond 'normal' range of movement hence it remains undefined where a patient is on the spectrum or continuum of hypermobility. This has implications for the treatment and management of HMS, which are recommended to be directed to insufficiency and functional limitations (Sahin et al., 2008). If the extent of laxity and consequences are unknown, designing specific treatment and management strategies will also be limited and potentially problematic. While more recent research (Maillard et al., 2014) suggests the degree of GJH did not impact on pain intensity, it could be useful as a baseline value to measure change in response to interventions and/or growth and maturation over time.

A Beighton score of ≥ 4/9 as an indicator of GJH is understood to be used by the majority of clinicians (Beighton et al., 2012a) yet inconsistencies of this cut-off point are evident in the literature. For example it is specified as ≥ 5/9 in children (Falkerslev et al., 2013), ≥ 7/9 in children (Yazgan et al., 2008), ≥ 7/9 in white children aged 6–12 (Smits-Engelsman et al.,

2011); and ≥ 6/9 in pre-adolescents (Mikkelsson et al., 1998). A study on the normal distribution of GJH in paediatrics suggested different cut-off points for males and females across three different age groups, including ≥ 8/9 in boys and girls aged 9, ≥ 7/9 in girls and ≥ 6/9 in boys aged 12, and ≥ 8/9 in girls and ≥ 6/9 in boys aged 15 (Jansson et al., 2004). This issue is further acknowledged within the literature by Remvig et al., (2007a), including one systematic review with meta-analysis by Pacey et al., (2010), which reported variation in the definition and assessment of GJH. Seven different measures of GJH were used by 18 selected studies and different cut-off points were used to indicate the presence of hypermobility. Of the 8 studies within the review that reported using the Nine-Point Beighton Score, 4 studies described different criteria for positive identification of GJH. The issue of variation in cut-off points and test administration performed by different researchers is recognised as a shortcoming in published reports (Remvig et al., 2011, Scheper et al., 2014), while prevalence rates are potentially underestimated.

In some adult injury studies detailed in table 2.9, hypermobile individuals have been classified on the basis of the extent of hypermobility, rather than simply as hypermobile or not hypermobile (Stewart and Burden, 2004, Krivickas and Feinberg, 1996). There are three categories: not hypermobile (0–3/9), hypermobile (4–6/9) and extremely hypermobile (7–9/9). The use of this approach seems to be at the discretion of individual research teams and studies. The varied criteria upon which GJH and HMS are defined are likely to be attributable, in part, to the broad spectrum of currently available prevalence data and somewhat lack of specificity. This disparity has implications for undiagnosed cases where the consequence of having no formal diagnosis is that these individuals miss engaging in supervised treatment and management programs and are more likely to experience ongoing cycles of disability involving pain, injury and fatigue. This confirms the crucial importance of timely and precise diagnoses and the need for a more consistent and cohesive approach to diagnosis. It also highlights the need for screening to consider more than measurements of

joint range of motion alone. The assessment of symptoms is also needed in a holistic approach in order to inform the design of specific treatment and management programs, which are implemented to address any weaknesses, limitations and restrictions present in a patient with HMS. Following diagnosis, adults with HMS are reported to still show marked disability mainly linked to pain and fatigue (Voermans and Knoop, 2011). While deterioration of quality of life is primarily associated with pain and fatigue, currently no standardised guidelines exist for the assessment and treatment of these symptoms in HMS/EDS-HM patients (Castori et al., 2012). This suggests that guidelines have not yet been developed for paediatrics either, and highlights the timely need for this to happen.

The 1998 Revised Brighton Criteria (Grahame et al., 2000) (table 2.6) specify a Beighton Score of $\geq 4/9$ either currently or historically as a Major Criteria, which indicates that the (medical) history of a patient is taken into account. The Revised Brighton Criteria were examined by Remvig et al., (2007b) who advised further revision of the criteria, the establishment of differentiated cut-off levels to accurately represent differences in population groups, and the implementation of longitudinal cohort-based diagnostic and treatment studies to identify minor criteria. This is comparable to later work by Remvig et al., (2011), which recommended that national societies within clinically relevant specialities form an International Committee to standardize the clinical assessment of hypermobility in specific age, gender and ethnic groups. In addition, recent data on the prevalence of neurophysiological symptoms in adults showed the need for a review of the diagnostic criteria to encompass these symptoms (Clark et al., 2014, Grahame and Kazkaz, 2014).

Current diagnostic tools are considered by some researchers as not sensitive enough to be used in athletic populations (Collinge and Simmonds, 2009). Recently, the Nine-Point Beighton Score (Beighton et al., 1973) and Revised Brighton Criteria (Grahame et al., 2000) have been recognised as not designed for use in professional dancers (Bird and Knight,

2012) due to acquired type of hypermobility and greater ranges of joint movement as a consequence of specific training sequences in a full-time career and connective tissues being structurally weaker due to abnormal collagen type ZWEERS 2005 and possible overuse/repetitive strain. The pressing need for the development and validation of new scoring scales for hypermobility in dancers that are more specific and transferable to dancers' physiology and movement patterns has recently been acknowledged (Bird and Foley, 2013). This is also very true for paediatric, adolescent and athletic populations who require more specific consideration. While reliable and accurate criteria are recognised by Grahame (2007b) as vital for precise diagnosis of joint hypermobility, there remains considerable uncertainty in assessment and diagnosis, particularly when considering paediatric populations. A revision in the way GJH is determined is reported (Scheper et al., 2013b, Scheper et al., 2014).

2.6.3 Diagnosis in Paediatrics

Measurement of hypermobility in children is recognised by Bird (2005) as being especially complex due to the greater natural laxity in children compared with adults, and current literature advises not to rely on the Nine-Point Beighton Score alone to diagnose HMS (Grahame et al., 2000). HMS is documented to be poorly recognised in children (Adib et al., 2005). In view of the discussion in section 2.2 on growth and development, due to children's growth patterns and development of motor skills, responses to movement vary at different stages. A current clinical challenge is reported to be distinguishing young children with significant hypermobility who are unlikely to improve from those who are in the normal spectrum of GJH and will improve with time (Tofts et al., 2009). This requires clinical follow-up and monitoring over several years, which seems logical but can only happen if a child has had initial screening and if medical history notes are available and kept up-to-date. In a retrospective study by Adib et al. (2005), the average age of onset of hypermobility related symptoms in paediatrics was reported to be six years old, and the average age at

diagnosis was nine years old. Referral patterns and the two to three-year time delay between symptom onset and paediatric rheumatology assessment suggested that in most cases, a timely connection between children's symptoms and hypermobility as a cause was not established. Similarly, it is documented in the literature that poor paediatric musculoskeletal clinical skills among doctors are likely to contribute to reported delay in referral of children with other pathologies such as suspected juvenile idiopathic arthritis (JIA) (Foster et al., 2007).

The current criteria discussed in section 2.6.1 were created for use in diagnosing adults, yet they have been applied frequently to paediatrics in clinical and research settings (Kerr et al., 2000, Adib et al., 2005, Juul-Kristensen et al., 2009, Toker et al., 2010, Kemp et al., 2010, Pacey et al., 2013). While the limitations of their use in adult populations are noted, even less is known regarding their suitability for children, and they have been considered by some to be inadequate in diagnosing paediatric populations (Murray, 2006, Clinch et al., 2011). A recent study suggested merit in the Nine-Point Beighton Score (Beighton et al., 1973) when it is used in combination with other tests as part of a clinical assessment tool for foot and ankle pathology in paediatrics (Evans et al., 2012). The other tests included the Foot Posture Index (FPI-6) (Morrison and Ferrari, 2009) as a measure of foot posture, the ankle lunge test (O'Shea and Grafton, 2013) as a measure of ankle dorsiflexion range of movement, the lower limb assessment scale (LLAS) (Ferrari et al., 2005) and the Oxford Ankle Foot Questionnaire (OxAFQ-C) (Morris et al., 2008). A recent study (Nicholson et al., 2014) implied that the LLAS may provide a more valid quantification of how lower limb GJH affects physical activity and function than the Nine-Point Beighton Score. Remvig et al., (2007b) proposed the need for further longitudinal diagnostic and treatment studies to identify minor diagnostic criteria for hypermobility, which implied that this is still work in progress in adults. To the author's knowledge, specific major and minor criteria for paediatrics have yet to be established. The Five-Point Self-Report Questionnaire for

Hypermobility seems unsuitable for children, as it asks respondents to comment on childhood in retrospect.

2.7 Awareness of HMS among Medical Practitioners

Clinical overlap occurs frequently and can cause diagnostic confusion for clinicians, for example skin hyper-elasticity occurs in both HMS and Marfan Syndrome, and bone fragility occurs in EDS and EDS-HM (Grahame and Hakim, 2010). Severity of clinical symptoms varies among the HDCTs so it is key for clinicians making diagnoses to be aware of subtle differences that differentiate them (Hakim and Sahota, 2006). HMS is reported by rheumatology and physiotherapy consultants and medical geneticists to be commonly overlooked (Grahame, 2007b), under-recognised (Simmonds and Keer, 2007, Castori et al., 2012, Russek et al., 2014), undiagnosed and presumably untreated (Grahame, 2008), and easily missed (Ross and Grahame, 2011a). In an online survey of Physical Therapists in the United States of America (Russek et al., 2014), knowledge about HMS compared with fibromyalgia and both juvenile and adult rheumatoid arthritis was investigated. From a sample of 496 physical therapists who were members of the American Physical Therapy Association, only 36% were aware of the Nine-Point Beighton Score, and just 26.8% were aware of the Revised Brighton Criteria as assessment tools for HMS. This data indicates that physical therapists working in clinical settings in the United States who are most likely to encounter patients presenting with HMS, are not familiar with assessment criteria or clinical symptomatology. In a survey of British consultant rheumatologists, a striking variability was found in perceptions of recommended treatment modalities for HMS and the perceived effectiveness of these (Grahame and Bird, 2001).

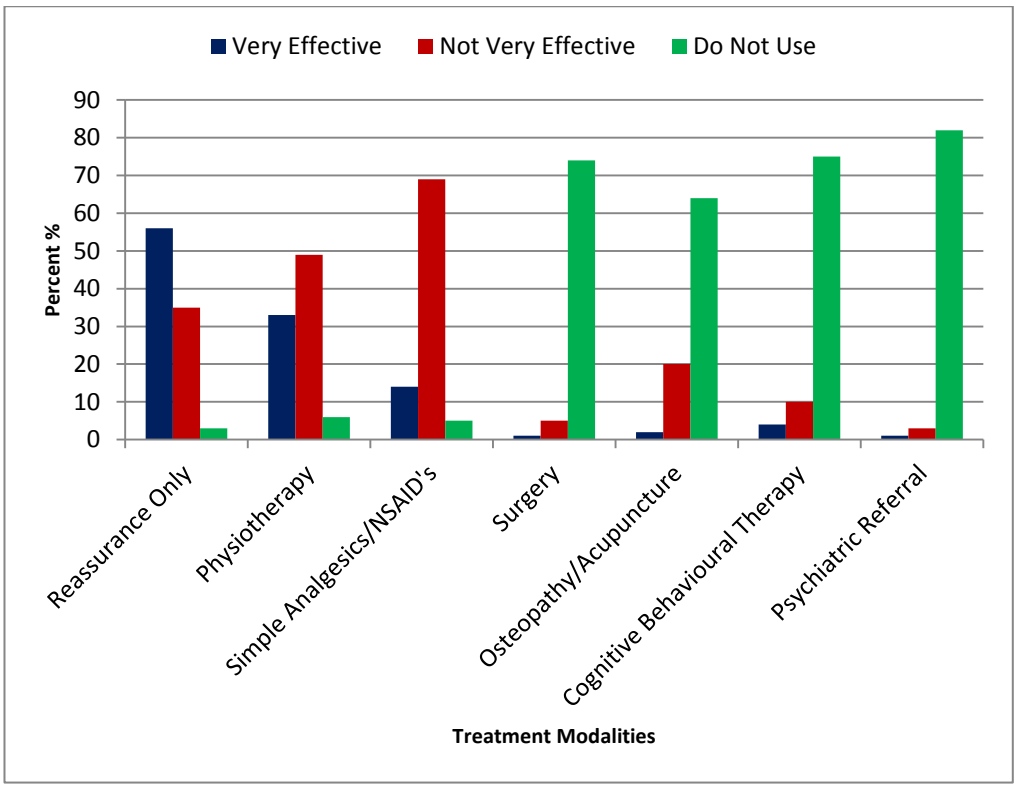


Figure 2.2 British rheumatologists' perceptions of the effectiveness of current treatment modalities for HMS (Grahame and Bird, 2001)

The highest scoring treatment strategy was reassurance alone. While 80% of rheumatologists regarded musculoskeletal symptoms as necessary in the diagnosis of HMS, only 33% rated physiotherapy as a 'very effective' treatment modality, and 49% reported it to be 'not very effective'. Simple analgesics/non-steroidal anti-inflammatory drugs (NSAIDs) are not reported to be popular treatment strategies. Similarly, surgery, osteopathy/acupuncture, cognitive behavioural therapy (CBT) and psychiatric referral were reported as not used by the majority of respondents. These findings indicate that options for effective treatment and management strategies are minimal, which supports the consensus that it can be difficult to alleviate symptoms associated with HMS.

In terms of diagnosis, 58% of rheumatologists believed a Beighton score of $\geq$ 5/9 is needed to diagnose an individual with GJH, while 29% believed $\geq$ 3/9 is required, confirming that

the issues previously discussed regarding cut-off points also exist in rheumatology practice. Similar proportions rated the impact of HMS on patients' lives in most cases as 'significant', although 45% considered the impact to be 'minimal', possibly implying that effects are not well understood. Although in the absence of any qualitative data, the reasons behind these responses remain unknown. While this survey adds very useful insight, perspectives among other medical professionals in the UK are not widely published. As physiotherapists are the practitioners who are most likely to be involved in the treatment and management of patients with musculoskeletal symptoms (Keer and Grahame, 2003), including paediatric HMS patients, investigating understanding and current trends in practice within the physiotherapy profession is a key aim of this thesis.

Paediatric referrals can come from a variety of medical sources including paediatric, rheumatology, physiotherapy, orthopaedic, accident and emergency departments and general practice. Low self-rated confidence in paediatric musculoskeletal clinical skills is reported among doctors who treat paediatric patients (Glazier et al., 1996, Jandial et al., 2009a). Musculoskeletal examination and assessment in inpatients was found to be poorly documented among specialist registrars when compared with examination of cardiovascular and gastrointestinal systems (Myers et al., 2004). It is acknowledged in the literature that paediatric musculoskeletal evaluation is not a core element of education and training in most medical schools in the UK (Jandial et al., 2009b) and to address this gap, specific clinical training should be integrated un undergraduate and postgraduate curricula (Foster and Cabral, 2006). A lack of awareness of HMS among medical professionals has previously led to misdiagnoses of HMS as inflammatory joint disease, which has led to counterproductive orthopaedic investigation or the use of potent anti-rheumatic drugs (Lewkonia and Ansell, 1983).

Evidence-based practice has become fundamentally important in the field of musculoskeletal physiotherapy. There are clinical practice guidelines developed by the National Institute for Health and Care Excellence (NICE) in the UK that cover conditions such as lower back pain (Parr and May, 2013), however they do not yet exist for HMS, which may contribute to the lack of awareness and consistency in the diagnosis and management of the condition among medical professionals. The importance of the need for primary care physicians to be aware of the clinical presentations of HMS in order to enhance their diagnostic acumen is expressed in the literature (Simpson and Michael, 2006). A survey of paediatric occupational therapists' understanding of DCD, HMS and ADHD in children (Baudinette et al., 2010) highlighted a need for training to ensure a more detailed understanding of these conditions, the overlapping nature of conditions in children, and the appropriate management strategies. These concerns regarding awareness of HMS among medical professionals indicate that potentially even less is understood among the wider community who come in contact with children with HMS, such as school teachers, physical education teachers, sports coaches and games and dance instructors.

Data on a cohort of children with HMS (Adib et al., 2005), disclosed 40% experienced problems with handwriting tasks, 48% experienced major limitations in school-based physical education activities, 67% experienced difficulties with other physical activities, and 41% missed significant periods of school as a result of symptoms. Awareness among school teachers is important to allow recognition of the signs of HMS. This may become apparent in the classroom, for example observed in unstable handwriting postures (Murray and Woo, 2001). Handwriting is a fundamental requirement throughout primary school, but as a task that demands fine motor control and coordination (Gerber et al., 2010), children with HMS can struggle. Children commonly develop upper limb problems such as frequent pain, fatigue and repetitive strain in the soft tissues of the hands and wrists, which are involved in writing (Pantoja Zarza et al., 2014) or using paintbrushes, craft needles and musical

instruments. If teachers are unaware of these signs, then the reasons behind a child's poor handwriting skills and lack of accuracy in other tasks will remain unknown. This can result in reduced motivation and confidence in the child (Fatoye et al., 2012) and feelings of dissatisfaction in both the child and teacher if the child is falling behind.

It is important for physical education teachers, sports coaches and games instructors to be aware of children with positive diagnoses of HMS participating in physical education, after school and sports activities. Modifications to activities may be required (Murray and Woo, 2001), for example longer warm-ups and cool-downs, and more frequent short recovery breaks between drills and games for children with HMS. Briggs et al. (2009) suggest dance companies, instructors, physical therapists and coaches to be aware of ballet dancers with HMS, and to incorporate injury prevention interventions into pre-season prehabilitation training. Parallels may be drawn between these ideas and the paediatric and adolescent chronic pain management literature (McGrath and Holahan, 2003), which promotes behavioural interventions with cognitive therapy involving parents, teachers and coaches. The aim is to identify patterns and severity of pain, and to modify activities that trigger pain or increase pain episodes, working towards improved pain control and less disability.

Physical pacing is different for children with HMS than it is for their peers, classmates and team mates who do not have HMS. Pacing is needed to avoid the symptoms of HMS 'peaking and troughing' (Keer and Grahame, 2003, Murray, 2006). If coaches and instructors are unaware, the potential impact on children includes struggling to keep pace in set activities and difficulty keeping up with peers. If children continue with their condition unnoticed, a likely consequence is sustaining soft tissue injury and recurrent injury (Soprano, 2005). This in turn causes pain and distress to a child, and worry and anxiety to parents (Palermo and Eccleston, 2009), possibly causing them to become (over)protective. If children drop out of and discontinue activities, deconditioning negatively affects physical

attributes of strength, endurance, balance, proprioception, postural control and coordination, which are needed for daily life (Simmonds and Keer, 2007). Subsequent musculoskeletal weaknesses and instabilities resulting from deconditioning can contribute to ongoing pain, fatigue and reduced stamina which, if not recognised and managed effectively, continue into adolescence and adult life. Knowledge of HMS among the wider community is essential to create a positive and balanced environment for children to safely participate in activities and sport, yet there has been little evidence to base advice on. A source of accessible and updated information is the Hypermobility Syndromes Association (HMSA) website, which has recently been accredited by the Information Standard for NHS England (HMSA, 2013).

2.8 Pain

2.8.1 Pain in Paediatrics

Almost all children will complain of pains in their limbs or joints at some time during childhood, and in most cases the clinical evaluation is normal and the child and family can be reassured (Davies and Copeman, 2006). Musculoskeletal pain of non-inflammatory origin is common in childhood and is a frequent cause of referral to paediatric rheumatologists, orthopaedic surgeons, and sports medicine and primary care physicians. Non-inflammatory causes of pain in paediatrics are reported to be more common than inflammatory causes and include GJH, common overuse injuries such as muscle strains and tendinopathy, osteochondroses such as Osgood-Schlatter's, and developmental conditions such as nocturnal leg pains. Each of these may be secondary to muscle tendon imbalances, neuromuscular or proprioceptive deficits, rapid growth and/or change in activity level (LeBlanc and Houghton, 2011). Age and gender are predictive factors for persistent pain (Mikkelsson et al., 1998), as pain prevalence rates are documented to be higher in girls and to increase with age (Perquin et al., 2000, Zapata et al., 2006, King et al., 2011).

In the most widely accepted definition of pain by the 'International Association for the Study of Pain' (1979), pain is viewed as a simultaneously physiological and psychological experience: "an unpleasant sensory and emotional experience associated with actual or potential tissue damage" (Merskey, 1986). Researchers have since developed a more advanced pain model, the 'Bio-Behavioural Model of Pain', which encompasses the unique and interactive components of nociceptive activity, emotions, cognitions and behaviour (Rapoff and Lindsley, 2000). This multidimensional approach acknowledges the complexity of pain, which is needed for effective pain management.

Ståhl et al. (2008) investigated non-specific neck pain in typically developing schoolchildren aged 9–12 years old, looking at the prognosis, risk factors, and the persistence of pain in a 4 year follow-up study. In this population, fluctuating neck pain was experienced by 71% of children, and persistent weekly pain was experienced by 5%, with no pain reported by 24%. Risk indictors for a more persistent pain course within subsequent years were documented to be the frequent co-occurrence of other musculoskeletal symptoms (in girls) and/or markers of psychological stress (in girls and boys) with existing neck pain. Psychological distress as a contributing factor for persistent musculoskeletal pain in pre-adolescents is also reported by Mikkelsson et al. (1998), and the neck and cervical spine is acknowledged in the literature as the most common location for recurrent pain in pre-adolescents (El-Metwally et al., 2004, El-Metwally et al., 2007). These risk factors are clearly relevant to typically developing young people, and furthermore they are symptoms associated with HMS (Adib et al., 2005) yet the neck and cervical spine are currently not assessed in the Nine-Point Beighton Score. For example, reduced postural strength and stability in the cervical spine in an individual with GJH may contribute to a greater vulnerability and sensitivity to neck pain. Children are likely to be at a greater risk of being affected by persistent and recurrent pain as they mature into adolescence and young adulthood with increased demands of study at school and university.

2.8.2 Pain and HMS

The relationship between hypermobility and chronic pain is well known and has been frequently reported in paediatric and adolescent literature (Murray and Woo, 2001, Adib et al., 2005) (see Table 2.8). Despite a significant body of literature on pain, study findings are conflicting. El-Metwally et al. (2004) reported GJH to be a strong predictive risk factor for musculoskeletal pain recurrence in pre-adolescent females. This is comparable to Tobias et al. (2013) who revealed that GJH $\geq 6/9$ in childhood is associated with an increased risk of subsequent moderate-intensity musculoskeletal pain in the lower back, shoulders, upper back, knees, neck and ankle/foot (listed in descending order), and also comparable to Juul-Kristensen et al. (2014) who confirmed GJH in 8 to 10 year olds poses a threefold risk factor for musculoskeletal pain in adolescence. Increased pain intensity and reduced overall quality of life perception in physical, emotional, social and school functioning domains are documented in paediatric HMS patients when compared with healthy control group participants (Fatoye et al., 2012). In the study, physical function is more severely affected than the other domains. Conversely, other studies have questioned the clinical implications of GJH and its relationship to musculoskeletal pain in paediatrics (Mikkelsson et al., 1996, Qvindesland and Jónsson, 1999, Leone et al., 2009). The occurrence of musculoskeletal pain was very similar in healthy pre-adolescents (29.9%) as it was in young people with GJH (32.3%), however pain intensity was not examined in this study (Mikkelsson et al., 1996).

Limitations in studies exist. For example, the study by Leone *et al.* (2009) asked school-aged children to comment on pain retrospectively in a previous 3-month timeframe, potentially introducing recall bias. Authors concluded that this area remains complex. Some studies have examined the occurrence and/or non-occurrence of pain but have not examined the duration, frequency or intensity of pain, indicating scope for more thorough investigations regarding pain and HMS in paediatrics (Mikkelsson et al., 1996, Pacey et al., 2013). McCluskey *et al.* (2012) conducted a recent systematic review of hypermobility and

musculoskeletal pain in children, which involved 15 studies. Findings reported an association between joint pain and GJH in African and Asian children, yet no association in European and American children. Due to high heterogeneity, the reasons for differences between groups are unclear. The review concluded with the need for further research involving high quality studies using validated tools and consistent data collection. This emphasised how the inconsistencies regarding diagnosis discussed in section 2.5 and section 2.6 need to be addressed to create stronger research methodologies.

In terms of the assessment of pain, self-report measures of pain are considered the 'gold standard' for assessing pain intensity, duration and location in children of 3 years old and above (Stinson et al., 2006). Variation in the use of pain visual analogue scales (VAS) has been illustrated in a recent systematic review of 4 studies on therapeutic exercise for HMS, including both paediatric and adult studies (Palmer et al., 2014) Kemp *et al.* (2010) used a faces pain scale for children aged 7 to 11 years old and a VAS with anchors of 'no pain' to 'worst pain possible' for children aged 11 to16 years old. Studies on adults used anchors of 'no pain' and 'severe pain' for knee pain only (Sahin et al., 2008), while another study did not detail the anchors on the pain VAS used (Ferrell et al., 2004). This indicates that the assessment of pain in individuals with HMS is currently not standardised resulting in varied patient experience. Progression towards a uniformed approach to pain assessment in paediatric HMS patients is needed to enable accurate comparisons to be made in clinical and research settings, to measure changes in symptoms over time and to measure effectiveness (or not) of interventions and management strategies. Studies are discussed in more detail in section 2.10.

2.8.3 Chronic Pain and Pain Management

Chronic pain defined as recurrent or continuous pain for more than 3 months (Perquin et al., 2000) was found to be a common experience in childhood and adolescence among 5,424

young people in the Netherlands. Fifty-four percent reported pain in the previous 3 months and 25% recounted chronic pain. The most common types of childhood pain were reported to be limb pain, headache and abdominal pain (Perquin et al., 2000, Huguet and Miró, 2008), and a marked increase was observed in the reporting of chronic pain (severe pain and multiple pains) among girls aged 12 to14 years (Perquin et al., 2000). Similar classifications of pain in adults with HMS/EDS-HM are reported in the literature, and fatigue is regarded a consequence of multiple factors including muscle weakness, respiratory insufficiency, non-restorative sleep, reactive depression/anxiety and long-term use of analgesics (Castori et al., 2012). The relevance of this paper to paediatric patients is the likelihood of symptoms persisting beyond childhood and adolescence if they are not effectively managed.

Clinical features of chronic musculoskeletal pain in children include the onset being insidious and pain starting in a localised area of the body and intensifying or radiating to other areas (Clinch and Eccelston, 2009). The distribution of chronic pain is diffuse and complex without conforming to anatomical patterns. In most cases, chronic pain cannot be traced to a specific injury, and is often impervious to analgesics (Grahame, 2009). As discomfort and pain intensity increase and become constant, a young person may avoid using areas of the body affected (Clinch and Eccelston, 2009). Development of a fear of pain and avoidance of movement as a strategy to avoid pain is known as kinesiophobia (Vlaeyen and Linton, 2000). This pattern of inactivity is likely to result in deconditioning, reduced fitness levels (Grahame, 2009), reduced posture and abnormal gait, which in turn are risk factors for musculoskeletal pain and fatigue. Also characteristic of individuals experiencing chronic pain are a heightened awareness of pain, amplification of and hypersensitivity to pain, and hypervigilance (Clinch and Eccelston, 2009). Declining function and deconditioning in children results in limited independence in physical, social and school-related tasks, low self-esteem and low self-efficacy (Grahame, 2009), which are detrimental at any age but especially during developmental years. Chronic musculoskeletal pain management in

children involves symptom management and psychosocial rehabilitation to reduce reliance on medical support. This can be achieved through self-management the use of techniques such as goal setting, education, pharmacotherapy, psychological therapies such as Cognitive Behavioural Therapy (CBT) and relaxation strategies, physical therapy and fitness training (Davis and McDonagh, 2006, Clinch and Eccelston, 2009).

Characteristics of chronic non-specific musculoskeletal pain in children and adolescents attending a rheumatology outpatients clinic were examined in a cross-sectional study (O'Sullivan et al., 2011). Predictive factors for pain included psychosocial factors such as anxiety, depression and somatic pain complaints, a lifestyle of low physical activity levels, and physical factors such as poor spinal posture, reduced back muscle endurance, increased GJH and poor gross motor skills. This data illustrated pain experience in typically developing young people, and it signifies how pain experience is likely to be greater and more persistent in children who have a medical condition with musculoskeletal symptoms, such as HMS, although these predictive factors are modifiable if recognised and addressed. A key reason for the accurate diagnosis of HMS and assessment of associated symptoms, as previously discussed in section 2.6 on diagnosis, is to identify and manage symptoms such as pain, and prevent progression of pain into adult life becoming chronic pain.

The Bio-Behavioural Model of Pain suggests a blend of treatment strategies rather than one alone (Rapoff and Lindsley, 2000). It aims to manage symptoms as part of an overall holistic approach to pain management. CBT with pharmacological treatments is consistent with the Bio-Behavioural Model of Pain and is empirically supported as a treatment for chronic paediatric pain (Eccelston et al., 2002). Psychological interventions that reduce negative emotional states, such as relaxation and problem-solving techniques, are likely to reduce pain intensity and pain interference by promoting autonomy and self-management of pain experiences, and reducing negative emotions. Social support of family, teachers and

friends can foster greater participation in social and recreational activities, thereby reducing emotional distress and preoccupation with pain during episodes, hence reducing tension and symptoms.

CBT treatments for pain management (Jensen, 2011), CBT for chronic pain in paediatrics and adolescents (McGrath and Holahan, 2003) and specifically for symptoms of HMS (Baeza-Velasco et al., 2011) are advocated in current literature. CBT strategies typically involve a core component of cognitive therapy to promote engagement in more effective coping. It involves teaching skills to help the patient replace maladaptive thinking such as catastrophizing with adaptive thinking such as focusing on what can be done to control pain. This can be achieved through the use of interventions to alter behaviour such as deep breathing, guided imagery, desensitisation, stress management, pacing/activity-rest cycling, exercise and activity management, pleasant activity scheduling and relaxation strategies (Jensen, 2011). CBT interventions specific to children include play therapies, art therapies and attention and distraction techniques (McGrath and Holahan, 2003). Parents are advised to encourage children to stay as active as possible, to engage in positive coping strategies and to avoid reinforcing pain behaviours such as allowing children to miss days of school or other responsibilities. Emotional symptoms are documented to accompany chronic pain experience, and relationships between HMS and psychological distress (Smith et al., 2013b), anxiety (Garcia-Campayo et al., 2011) and depression (Grahame, 2000) are reported in adults in addition to psychiatric conditions (Baeza-Velasco et al., 2015). Considering this, children experiencing recurrent pain and injury without diagnosis, and without specific pain management and injury rehabilitation programs, are at risk of ongoing and persistent pain and fatigue cycles through stages of growth and maturation.

Table 2.8 Summary Table of Pain Studies: Paediatrics and Adolescents. GJH=generalised joint hypermobility. HMS= joint hypermobility syndrome. n=number of study/group participants. Yrs= years. MSK= musculoskeletal. M= male. F= female.

Authors	**Country**	**Study Design**	**Construct Measured**	**Sample** **(size, age & gender)**	**Prevalence of Pain**	**Predictive Factors**
(Juul-Kristensen et al., 2014)	Denmark	Cohort study	GJH and physical function in adolescents. Association between GJH and development of pain (arthralgia).	N=301 at 14 yrs of age.	Significantly ↑ pain during sitting and ↓ physical function in adolescents with GJH >4 and >5.	GJH in childhood (8-10 yrs) was a threefold risk factor for developing pain in adolescence.
(Maillard et al., 2014)	UK	Pilot study	Relationship between degree of MSK pain, pain associated with disability & QoL affected by hypermobility.	N=30 (18 F, 12 M). mean age 11.08 yrs, range 8-14.	Mean pain VAS score 49/100 (lower limb).	GJH Reduced muscle strength
(Pacey et al., 2013)	Australia	Prospective, parallel group, randomised control trial (RCT)	Knee pain	N=26 HMS age 7-16 yrs.	Knee pain for ≥3 months + back and hand pain in all participants.	Psychosocial health Thigh muscle strength
(Tobias et al., 2013)	UK	Prospective cohort study	MSK pain and GJH	N=4130. mean age 17.8 yrs		GJH specifically in shoulder, knee, ankle/foot.
(McCluskey et al., 2012)	UK	Systematic review	MSK pain and GJH	15 studies included		
(King et al., 2011)	Canada	Systematic review	Chronic and recurrent pain in children and adolescents	41 studies included		Lower socioeconomic status Headache

(O'Sullivan et al., 2011)	Australia	Cross sectional	Characteristics of chronic non-specific MSK pain (CNSMSP)	N=30 (18 F & 12 M) mean age: 12.7 yrs, range 7-18 yrs and matched pain free control group.		*Psychosocial:* Anxiety, depression and somatic pain complaints *Lifestyle:* Low physical activity levels *Physical:* Poor spinal posture, reduced back muscle endurance, increased GJH, poor gross motor skills.
(Fatoye et al., 2012)	UK	Cross sectional	Pain intensity and QoL i.e. physical, emotional, social, school functioning	N=29 HMS and N=37 controls mean age 11.9 yrs, range 8-15 yrs.	Average knee joint pain in previous 1 week	
(Leone et al., 2009)			Pain and QoL			
(Huguet and Miró, 2008)	Spain	Cross sectional	Chronic pain, intensity and location	N=561, 290 M & 271 F. mean age 11.89±2.0, range 8 to 16 years	37.3% chronic pain 5.1% moderate or severe pain intensity. 47% lower limb pain 43% headache 34.3% abdominal	Male gender for lower limb pain Female gender for headache and abdominal pain. Increasing age for back pain

(Mikkelsson et al., 2008)	Finland	Cross sectional survey. Prospective 4 year follow up	Widespread Pain (WSP) - new onset and prognosis	N=1282 children (of original 2004 n=1756 cohort) Age range: 10-12 yrs	*WSP at baseline...* 31% recurrent WSP at 1 yr follow up (f/up) 30% recurrent WSP at 4 yr f/up 10% at 1 & 4 yr f/up. *No Pain at baseline:* 18% new onset WSP at 1 yr f/up 3% new onset WSP at 4 yr f/up	Older age Gender i.e. female Depressiveness Regional back pain symptoms i.e. neck, upper back, lower back pain
(Ståhl et al., 2008)	Finland	Cross sectional survey. 4 year follow up	Non-specific neck pain from pre/early adolescence to mid adolescence.	N=1268 children (of original 2004 n=1756 cohort) Age range: 9-12 yrs	*At baseline:* 61% no neck pain 24% NP once/month 15% NP once/week *4 year follow up:* 24% pain free 71% fluctuating pain 5% persistent pain	Co-occurrence of other MSK symptoms i.e. headache, abdominal pain Markers of psychological stress i.e. depressive mood, sleep difficulties
(El-Metwally et al., 2007)	Finland	Cross sectional survey. Prospective 1 year follow up	New onset MSK pain symptoms and risk factors for non-specific pain	N=1192 children without pain symptoms (of original 2004 n=1756 cohort) Mean age 10.8 yrs	21.5% new pain episodes 19.4% non-traumatic pain n.b. neck 4% traumatic pain n.b. lower limb	Vigorous exercise (predictor - traumatic pain) Headache (predictor - non traumatic pain) Day time tiredness (predictor - both types of pain)

(El-Metwally et al., 2004)	Finland	Cross sectional survey. Prospective 4 year follow up	Non-specific MSK pain	N=1756 Mean age 10.8 yrs.	32.1% non-specific MSK pain (baseline survey) 53.8% persistent preadolescent MSK pain (1 yr follow up) 63.5% persistent/recurrent MSK pain (4 yr follow up)	Older age i.e. 11+ yrs Gender i.e. female Hypermobility (females only) Co-existing psychosomatic symptoms High disability index Preadolescent pain x 3 higher risk of pain recurrence.
(Zapata et al., 2006)	Brazil	Cross sectional	MSK pain i.e. back pain, localised pain in upper/lower limbs, diffuse pain MSK pain syndromes i.e. fibromyalgia (FM), myofascial pain syndrome (MFS) Soft tissue stress injuries (STSI) i.e. tendonitis, bursitis, epicondylitis.	N=791. mean age: 14.17 yrs (age range 10-18 yrs)	40% MSK pain 23% back pain 9% upper limb 4% diffuse pain 5% MFS, 1% FM 15% STSI	Age i.e. increasing Gender i.e. female
(Perquin et al., 2000)						
(Mikkelsson et al., 1998)	Finland		Persistent MSK pain symptoms	N=452	59.2%	

2.9 Musculoskeletal Injury

2.9.1 Injury in Paediatrics

Young people prone to overuse injuries present physical profiles with a combination of muscle weakness, excessive connective tissue laxity and muscle tightness that predisposes to stress injuries in the body (Lysens et al., 1989). Inadequate conditioning and preparation pre-season in sport is also recognised as a contributing factor to injury (DiFiori, 2010). Causative factors for overuse injuries in paediatrics include training errors, improper technique, excessive training in sport, inadequate rest, muscle weaknesses and imbalances, and early specialisation (McLeod et al. 2011). Common musculoskeletal overuse injuries in paediatrics and adolescents are similar to those sustained by adults such as tendinosis, apophysitis, chronic anterior knee pain and stress fractures. In addition, there are paediatric-specific injuries such as damage to growth plates, apophyses and joint surfaces (Soprano and Fuchs, 2007). Repetitive micro trauma or repeated application of force on soft-tissues through a range of movement can put undue strain on tissues causing more generalised diffuse pain in the tendon or other muscles associated with the physical activity that the joint is engaged in. This pain is localised and the injury will invariably recur with repeated overuse especially in pathologic soft-tissues. For example, a spondylolysis (stress fracture of the spine) can occur in a young gymnast performing repetitive hyperextension activities (Brenner et al., 2007). Tendinopathy is an overuse/repetitive strain injury caused by chronic irritation from excessive or repetitive movement patterns and is characterised by tendonitis (i.e. inflammation) and tendinosis (i.e. micro tears in the tendon). Common locations of tendinopathy in young athletes include the iliopsoas in dancers, and the ankles in dancers, gymnasts and figure skaters. It can cause injuries to the Achilles tendon, the tibialis anterior and posterior muscles, and the peroneal tendons. In swimmers and overhead throwing athletes, tendinopathy may affect the rotator cuff, for example tendons of the supraspinatus, subscapularis, infraspinatus and teres minor muscles (Brenner et al., 2007).

Recalling the stages of human development discussed in section 2.2, injury risk has been researched in typically developing girls aged 10 to 13 years old where longitudinal changes in oestrogen and anterior knee laxity, lower limb strength and flexibility were examined throughout the adolescent growth spurt (Wild et al., 2013). Results revealed a significant effect of time on anterior knee laxity: from the time of PHV, isokinetic quadriceps strength was significantly increased over time, while there was no apparent increase in isokinetic hamstring strength. This imbalance of knee strength in terms of hamstrings to quadriceps ratio, combined with increased knee laxity during the adolescent growth spurt in girls, is thought to contribute to knee joint instability and increased risk of injury and pain, such as Patellofemoral Pain Syndrome and Anterior Knee Pain (Sandow and Goodfellow, 1985, Waryasz et al., 2008), which are documented to commonly present in adolescent girls. In addition, Acute Patellar Dislocation and Recurrent Patellofemoral Instability are reported in the literature as prevalent in female adolescents aged 10 to 17 (Fithian et al., 2004, Shubin Stein and Ahmad, 2007, Hennrikus and Pylawka, 2013). Due to young people with GJH/HMS having greater laxity, an even higher risk of injury applies if reduced control, strength and stability is present through outer ranges of movement. This coincides with the opinions of Juul-Kristensen et al. (2012), who also considered an imbalance in knee strength to be a risk factor for ligament injury including ACL injury. Knee joint dislocation is understood to occur during high-force or high-velocity sports such as rugby. The most frequent forms of dislocations in adults are reported to be anterior dislocations caused by extreme hyperextension of the joint and posterior dislocations. These account for approximately 40% and 33% of dislocations respectively (Robertson et al., 2006).

2.9.2 Intrinsic Risk Factors for Injury and HMS

Connective tissues that rely on tensile strength within their collagen component for physical integrity are more likely to fail mechanically in hypermobile individuals compared with

others (Grahame, 2009). This is especially sensitive in typically developing children, whose musculoskeletal structures are still developing. Connective tissues become stronger in response to work load, however excessive loading is likely to cause overuse, premature degeneration or mechanical failure. Four factors involved in joint stability are ligaments, any factors that reinforce the joint capsule, muscle control around the joint and bone congruity (Harris et al., 2014). Ligaments play a major role by limiting the range and direction of movement to protect and prevent excessive movement such as hyperextension and by holding respective condyles together closely. Instability is associated with ligament injuries, for example ACL in the knee joint. Other factors that supplement the action of ligaments in the knee joint include the iliotibial band, the retinacula and complex insertions of muscles, in particular the semimembranosus muscle of the hamstrings group. Muscle control is another major factor, with coactivation of hamstrings, quadriceps and gastrocnemius being particularly important. The shapes of the femoral and tibial articular surfaces on the condyles, together with the menisci, are adapted for movement but only have a minimal role in congruity while menisci alone contribute to congruency to a small extent. Considering the inherent abnormality of connective tissues (Hakim and Grahame, 2003a) and associated functional limitations in individuals with HMS, this instability is a risk factor for injury.

Ligaments can be classified into three groups according to their relation to the joint capsule: intracapsular, capsular and extracapsular (Harris et al., 2014). Intracapsular ligaments of the knee joint are the ACL and PCL, and the meniscofemoral and transverse intermeniscal ligaments. PCL has a prime role in knee stability, resisting forward displacement of the femur on the tibia, for example when walking downstairs, and resisting posterior displacement of the tibia. In flexion and extension, the PCL remains taut by virtue of having two components, a larger anterolateral part that is tight during flexion and a smaller

posteromedial part that is tight during extension. The ACL resists posterior displacement of the femur and anterolateral tibial rotation and hyperextension. Stretching and tearing ligaments in dynamic movements involving twisting, falling, jumping, sudden deceleration or direct trauma cause instability of the knee joint. Complete rupture of the ACL results in anterolateral rotatory instability and potential recurrent injury. Extracapsular ligaments of the knee include the medial and lateral collateral, posterior oblique, oblique popliteal and popliteofibular ligaments (Harris et al., 2014). Medial and collateral ligaments of the knee together become taught on full extension of the knee, preventing hyperextension. In knee extension, ligaments give lateral stability and the oblique popliteal ligament is part of the ligamentous mechanism that prevents overextension. Any instability, weakness or failure in biomechanics such as proprioceptive acuity and neuromuscular control through dynamic movement will increase injury risk (Fatoye et al., 2009).

Research has been conducted on GJH as a risk factor for symptoms and injury. The Childhood Health Activity and Motor Performance School Study (CHAMPS-study) Denmark (Wedderkopp et al., 2012) evaluated the general health of 1300, 10-15 year olds, including children with GJH. Within this study, a sub case-control study investigating knee joint neuromuscular control during landing from a jump was conducted, to test knee joint stability and the influence of GJH and specifically knee joint hypermobility on mechanisms of knee injuries in young people (Junge et al., 2015b). Knee joint neuromuscular control was defined in children as muscle activity, time of onset and co-contraction before and after landing from the Single-Leg-Hop-for-Distance test (SLHD test). Findings revealed no difference in jump length between children with GJH and controls, but before landing children with GJH had 33% lower semitendinosus activity, 32% higher gastrocnemius medialis activity and 39% higher co-contraction of lateral knee muscles when compared with controls without GJH. After landing GJH demonstrated 36% lower semitendinosus activity than controls but with no compensatory gastrocnemius medialis activity, resulting in

decreased stability and control through dynamic movement patterns of jumping, hopping, skipping etc. Reduced pre and post activation of semitendinosus may be a risk factor for traumatic knee injuries such as ACL ruptures in young people with knee joint hypermobility. From the CHAMPS-study children aged 9-14 years (N=999) were tested for GJH ≥5/9 (Junge et al., 2015a) on two occasions between 2012 and 2013, with an aim to evaluate the extent and risk of knee injuries in this population. Thirty-six children presented with GJH and knee joint hypermobility and musculoskeletal injuries were registered by WHO ICD-10 diagnosis. Associations between GJH and knee injuries were examined using logistic and Poisson regression analyses. Results showed 86% of knee injuries to be overuse injuries, hence more common than traumatic (acute) injuries. Specifically, apophysitis and patella-femoral pain were prevalent, and in terms of traumatic injuries knee joint sprains and contusions were most frequently sustained though the total number of children sustaining injuries was low.

Knee joint proprioception, joint kinaesthesia, knee joint position sense, and muscle torque in knee extensor (hamstrings) and knee flexor (quadriceps) muscles were measured in children with HMS (Fatoye et al., 2009). Significant deficits in knee joint proprioception and muscle strength were evident when compared with a control group, which confirmed functional limitations that affect joint stability in young people with HMS. Proprioception was measured with a purpose-built motorised device and muscle torque was measured using a digital myometer. While the study offers detailed methodology and quantitative results data, the laboratory-based testing protocol and specialised equipment means the transferability to clinical practice, in terms of using these methods as assessment tools on patients in physiotherapy and rheumatology clinics, is impractical. The HMS group (n= 29) was predominantly female (n=21), however in the control group (n= 37), more males were tested (n=20) than females (n=17), meaning clinical and control groups were not exactly gender matched. A further limitation to the study was that the age range of 8 to 15 years

encompassed puberty and adolescent growth spurts, where the effects of hormones (Behringer et al., 2010) were not controlled. This could potentially have influenced results, for example the anabolic activity of testosterone in males promotes lean body mass and strength improving stability, while oestrogen in females influences greater laxity which could have contributed to instability. Recent literature (Junge et al., 2015a) confirmed that growth should be considered in future studies on paediatrics with GJH due to fluctuation in individual child's status of GJH in a one year timeframe. Juul-Kristensen *et al.*, (2012) also tested knee function in terms of proprioception and knee strength balance (hamstrings to quadriceps ratio) in both paediatrics and adults with HMS. Findings revealed that children (mean age 10 years) exhibited normal knee function while adults (mean age 40 years) experienced impaired knee function. As impaired proprioceptive acuity and lower knee strength balance are considered intrinsic risk factors for knee ligament injuries such as ACL, children ideally need to be monitored over time to prevent the development of injury.

In a case-control study of 18-25 year old males (Bin Abd Razak et al., 2014) those presenting with musculoskeletal injury, particularly lower limb injuries to knees and ankles, were 3.35 times more likely to have GJH $\geq$ 4/9 vs. control participants without injury, indicating GJH may be a risk factor for injury. Increased medial foot loading was observed in female soccer players with a mean age of 16.2(2.8) years (Barber Foss et al., 2009). Out of 112 girls, 27 scored $\geq$ 4/9 (which was classified in this study as 'high GJH') and 85 girls scored < 4/9 (which was classified as 'low GJH'). Dynamic peak plantar pressure and maximum force in the medial midfoot were greater in girls with 'high GJH' when compared with the 'low GJH' group. Increased medial pressure and relative loading of the midfoot can be a risk factor for medial collapse of the foot, pronation and subsequent acute or chronic lower limb injury. As male soccer players were not tested, it remains unknown if this affects males in the same way or not. Findings from the studies reviewed in 2.9.2 provided valuable

insight into how the knee joint in particular is affected, yet proprioception and strength at other symptomatic joints including upper limb joints such as the shoulder, elbow and wrist remain unknown and also require investigation.

2.9.3 Injury in Sport and HMS

Ankle sprains are a major injury in sport, with a high incidence in court games and team sports with a high rate of recurrence (Fong et al., 2007, Holmes and Delahunt, 2009). Chronic Ankle Instability is associated with deficits in proprioception, neuromuscular control, strength, postural control and frontal plane ankle joint position sense indicating children with hypermobile ankles are at risk. Fifty percent of children with HMS experienced chronic ankle pain associated with recurrent episodes of ankle instability from neuromuscular origin. Thirteen percent had foot pain for more than 3 months, 36% experienced recurrent "rolling" of one or both ankles and 8% experienced foot instability (Nicholson et al., 2014). Acute Patellofemoral Dislocation is reported as the most common acute knee injury in children and adolescents, with adolescent females from 10 to 17 years being most at risk for patellar dislocation (Fithian et al., 2004). These risk factors for injury are modifiable with specific interventions which are discussed in sections 2.9.4 and 2.10.

Research into GJH and injury in athletic populations has been published, covering the team sports of male football (Collinge and Simmonds, 2009), male rugby (Stewart and Burden, 2004), hockey (Kelly and Hudson, 2010)**,** lacrosse (Decoster et al., 1999), junior netball (Smith et al., 2005) elite netball (Soper et al., 2015) and evidently ballet (Klemp and Learmonth, 1984, Klemp et al., 1984, Byhring and Bo, 2002, McCormack et al., 2002, McCormack and Briggs, 2002, Hincapie et al., 2008, Scheper et al., 2013a) (Table 2.9). Much of this research has been conducted with young adult rather than paediatric populations, meaning gaps still exist in understanding how sport affects children with GJH.

This is influenced by the severity of symptoms and where on the spectrum of hypermobility individuals are i.e. some may be asymptomatic and high-functioning but at risk of injury through participation in sport, while others may be symptomatic, low-functioning and unable to participate in sport due to pain, instability and lack of motor coordination. For the low-functioning children, there is in turn a risk of deconditioning (Keer and Grahame, 2003), which contributes to clinical sequelae of pain, fatigue and recurrent injury.

The prevalence of GJH and HMS among junior dancers of the Royal Ballet School London (McCormack et al., 2004) was previously noted in section 2.5 Prevalence. Among the professional dancers, HMS was identified in smaller proportions (26% of females and 36% of males). In the principal dancers, there was no evidence of HMS, which is in contrast to dancers of the lower school. This data suggests that while a specific physical body type is selected for ballet, dancers with HMS who have experienced injuries and symptoms on the severe end of the spectrum are unlikely to progress into a full-time professional dancing career (McCormack, 2010). A study on ballet dance students and ballet teachers in Brazil (Sanches et al., 2015) found a significant difference in the prevalence of HMS between students and teachers (aged 18-40 years) of 16% and 36% respectively. This data suggests that ballet dancers with HMS may advance into alternative careers teaching ballet as opposed to professional performing careers. Like athletic populations, dancers with HMS require some unique consideration due to tissues being structurally weaker with a slower response to training effects and a greater risk of injury (Briggs et al., 2009, Scheper et al., 2014).

Research on professional adult ballet dancers at the Royal Ballet School and Company UK suggested that similar to athletic populations with HMS dancers is associated with a greater injury risk and prolonged post-injury recovery periods, which may have an adverse effect on career development (McCormack et al., 2004). Specific symptoms of HMS in the same cohort of ballet dancers were reported in a 5 year follow-up study (Briggs et al., 2009) and

included multiple joint pain, joint dislocation, neck pain, lower back pain, ankle sprain, ligament injury, dorsal pain, shoulder capsulitis and fractures. Findings highlighted a significantly higher frequency of multiple joint pains in male HMS dancers than non-HMS dancers. In the same way, significantly more tendon injuries and instances of absence from performance for > 6 weeks due to injury were reported by male and female HMS dancers.

Table 2.9 Summary Table of (Sport) Injury and Hypermobility: Adult Studies. GJH= generalised joint hypermobility. HMS= joint hypermobility syndrome. n= number of study participants. Yrs= years. M= male. F= female

Authors and Country	**Sport**	**Sample (size, age & gender)**	**Diagnostic Tool for Hypermobility, Cut-off Point & Prevalence**	**Injury Prevalence**	**Injury Type / Location/Risk Factors**
(Soper et al., 2015) UK	Netball	N=27 elite netball players. mean age 19.3 yrs (range 14-26).	Nine–Point Beighton Score ≥4/9 + Brighton Criteria. 63% GJH and 15% HMS	Not included	Risk factors for injury in netball: Increased postural instability in functional movement control tests (posturography and balance).
(Bin Abd Razak et al., 2014)					
(Scheper et al., 2013a) Netherlands	Ballet	N=36 F ballet dancers + N=30 F controls. mean age 20.1 yrs (range 17 to 27 yrs).	Nine–Point Beighton Score ≥4/9 66% GJH in dancers 29% GJH in controls	Not included	Risk factors for injury in dancers when compared to non-dancers: Lower muscle strength Higher fatigue Higher psychological distress
(Konopinski et al., 2012) UK	Professional football	N=54 M. mean age 22.5±4.17 yrs	Nine–Point Beighton Score ≥4/9 GJH 18/54, 33%	11.52±11.39 injuries/1000 hrs 172 injuries in GJH group 61	Severe Injury: Knee: 6 cartilage and 3 tendon injuries. Thigh: 25.6% Ankle: 18.7% Muscle tears, strains, ruptures, cramp: 39.1%
(Pacey et al., 2010)					

(Collinge and Simmonds, 2009) England	Professional football	N=33 M. mean age 24.4±4.8 yrs (range 18 to 35 yrs).	Nine–Point Beighton Score ≥4/9 Categories in this study: 0-3/9 non-hypermobile 4-6/9 hypermobile 7-9/9 excessively hypermobile GJH 14/33, 42% GJH 7-9/9 4/33, 12% mean score: 3.3±2.8	GJH 6.2 injuries/1000 hrs Non-GJH 6.3 injuries/1000 hrs	Lower limb injuries: 83% 71 days training missed + 12 games missed in GJH 31 days training + 5 games missed in non-GJH.
(Stewart and Burden, 2004) New Zealand	Rugby (first division club)	N=51 M. mean age 23.6±3.3 yrs	Nine–Point Beighton-Horan Score ≥4/9 GJH 12/51, 24% GJH 7-9/9 4/51, 8% Mean score 2±2.4.	New injuries in this season only included. 116.7 injuries/1000 hrs training in GJH players 43.6 injuries/1000 hrs training in Non-GJH players	19/23 sustained 1 new injury, 4/23 sustained 2+ injuries. Ankle: 17.6% Knee: 15.7% Shoulder: 13.7% Wrist and Hand: 11.8%
(Byhring and Bo, 2002) Norway	Ballet	N=41		Foot and Ankle	75% sustained 1+ injury 22% acute injuries & 75% soft-tissue injuries
(Decoster et al., 1999) USA	NCAA Lacrosse	N=310, 147 M and 163 F. mean age 20	Nine–Point Beighton Score ≥5/9 GJH: 23.8%, 13.6% M & 33.1% F.		

Table 2.10 Summary Table of (Sport) Injury and Hypermobility: Paediatric Studies. GJH= generalised joint hypermobility. HMS= joint hypermobility syndrome. n= number of study/group participants. Yrs= years. M= male. F= female

Authors	**Country**	**Sport**	**Sample** **(size, age & gender)**	**Diagnostic Tool for Hypermobility & Cut-off Point & Prevalence**	**Injury Prevalence**	**Injury Type / Location**
(Leanderson et al., 2011) (injury study only, not hypermobility)	Sweden	Ballet	N=476, 297 F and 179 M. age range 10 to 21 years.			Overuse Ankle sprain Metatarsal fractures FHL and peroneal tendons.
(Barber Foss et al., 2009)	USA	Soccer	N=112 F. age range 11 to 21 yrs.	Beighton and Horan Joint Mobility Index (BHJMI) ≥ 4/9 (high) and < 4/9 (low)		
(Smith et al., 2005)	Australia	Netball	N=200 F. mean age 11±2.5.	Nine–Point Beighton Score Categories in this study: 0-2/9 = non-hypermobile 3-4/9 = moderately hypermobile 5-9/9 = distinctly hypermobile Mean score 3.99.	69/200, 35% sustained injuries playing netball 0-2/9 15/70, 21% 3-4/9 19/51, 37% 5-9/9 34/79 43% 44/200 sustained injuries in other sports.	Distribution of netball injuries: Ankle: 42% Knee: 27% Fingers: 15%

2.9.4 Injury Prevention and Management

Recommendations of the National Athletic Trainers Association (NATA) Position Statement on the prevention of paediatric overuse injuries (McLeod et al. 2011) include injury surveillance; pre-participation physical examination to screen each child for potential risk factors including injury history, stature, maturity, joint stability, strength and flexibility (this may be important for preventing recurrent injuries); identification of risk factors such as certain anatomic factors that may predispose to overuse injury including GJH; coach education (and parents and officials) about signs and symptoms of overuse injuries and medical supervision; education on sport alterations; training and conditioning programs and delayed specialisation (Carter and Micheli, 2011). It is noteworthy that the type of activities that hypermobile children are often involved in, such as gymnastics and ballet, are focused on early specialisation and carry the risk of burnout and overuse injury, as acknowledged in the literature (Malina, 2010).

Pre-season medical screening and prehabilitation with the aim of minimising injury risk are recommended in the literature (Pearce, 2006, Aaltonen et al., 2007, MacAuley, 2007, Waryasz et al., 2008, Collinge and Simmonds, 2009, Paterno et al., 2013). Prehabilitation is a system of evaluating physical condition and involves functional assessments of strength, flexibility and biomechanics, with education in training techniques and injury prevention (Pearce, 2006). Individuals subsequently undertake preventative exercise programs set by physiotherapists and strength and conditioning coaches to address any weaknesses and restrictions identified during screening, in order to be fully prepared for the approaching season of training and competition. Extended return-to-play timeframes are recommended to prevent re-injury in athletes with HMS (Collinge and Simmonds, 2009), which is an optimal strategy considering the longer injury healing times (McCormack et al., 2004). This strategy is transferable to others sports and settings although there are often time pressures in terms of team selections. In professional sport, these decisions are mostly based on assessments of

readiness to return to play after injury (Beardmore et al., 2005). The need for musculoskeletal injury prevention programs for young dancers of the Royal Swedish Ballet Research was reported (Leanderson et al., 2011), with a view to reduce overuse injury rates relating specifically to the lower limb including ankle sprain, metatarsal fractures, flexor hallucis longus and peroneal tendon injuries. The prehabilitation strategy also poses potential for the Norwegian National Ballet, where musculoskeletal injury incidence was investigated (Byhring and Bo, 2002). In this dance troupe, 59% of injuries reported occurred in August and September, which implied that deconditioning between seasons is a risk factor for injury on return to training. Considering this in the time between in-season maintenance conditioning is recommended as a protective strategy reinforcing the need for effective pacing.

2.10 Treatment and Management of Symptoms in HMS in Paediatrics

Principles of physiotherapy adapted to the needs of HMS patients with fragile connective tissues are considered efficacious (Keer and Grahame, 2003, Simmonds and Keer, 2007, Simmonds and Keer, 2008, Engelbert and Scheper, 2011, Bale et al., 2014). Principles include:

- reassurance, education and advice
- core and joint stabilising exercises
- proprioception enhancing exercises
- avoiding resting in end-of-range postures
- mobilising techniques and restoration of normal (hyper) mobility in soft-tissues that have become restricted
- pacing, coping and behavioural strategies for managing chronic pain
- addressing deconditioning
- promotion of general physical fitness and stamina with aerobic exercise

- encouraging self-management and self-efficacy
- podiatry and occupational therapy

This supports literature that suggests exercise training as an appropriate treatment modality to stabilise joints and build protective muscle tone (Beighton et al., 1989, Koutedakis et al., 2005, Simpson and Michael, 2006), although the evidence base to date has been minimal. Specific intervention studies on paediatrics are very newly emerging (Kemp et al., 2010, Pacey et al., 2013, Scheper et al., 2013b, Bale et al., 2014) and are beginning to show higher quality study designs with higher levels of evidence than earlier publications.

An RCT called 'The Bendy Study' was conducted in the UK, to determine the efficacy and cost-effectiveness of an 8 week individualised multidisciplinary intervention program vs. standard management of advice and physiotherapy for paediatric HMS patients aged 5 to 16 years old (Bale et al., 2014). Child and parent reported pain measured using a VAS, coordination measured by Movement-ABC and strength measured by grip strength dynamometry all showed significant improvements. This included a positive outcome of 56.9% of children in the targeted intervention group who were pain free after 12 months, and 45.5% children in the standard management group. While both programs of physiotherapy were beneficial to educate and empower children with skills in self-management and being accountable to physiotherapists, no additional benefit was achieved in the targeted intervention. This shows the difficulties related to demonstrating subtle benefits from specific interventions without better tools for case definition and assessment of outcomes. A lack of detail of exercises within interventions, and information on the time required for each session means assessing how repeatable the interventions are in clinic appointments or as home based interventions is unknown.

Another RCT was carried out comparing generalised with targeted physiotherapy in paediatrics with HMS (Kemp et al., 2010). The generalised program involved graded

exercises focused on developing general strength and cardiovascular fitness, with moderate/low impact strengthening activities to increase resilience and endurance such as shuttle runs, bunny hops, squat thrusts, sitting to standing, step ups and star jumps. Ten repetitions or 30 seconds of each exercise were prescribed initially with a recommended graded increase, plus daily home exercises and continuation of sport and normal activities. The targeted program involved re-training neutral joint position and optimal joint alignment, dynamic control and motion control of joints, and lengthening of specific muscles such as hamstrings to correct tightness and restrictions. Statistically significant improvements were seen in the children's and parents pain scores in both groups between baseline and follow up assessments. The targeted physiotherapy program demonstrated significant benefits over time. In addition, reduced global assessment of the impact of hypermobility, and reduced pain scores among parents were evident which is a positive finding in terms of management of symptoms in families.

A 3 week home based intervention for paediatrics (Kerr et al., 2000) involved daily isometric muscle co-contraction exercises performed in the unstable range. This is the end of the normal range of motion and the beginning of the hypermobile range, typically around 15 degrees. Week 2 involved daily eccentric and concentric isotonic contractions performed around the unstable range. Bodyweight was used to provide sub-maximal resistance because it reflects normal functional loading. Repetitions were increased daily by increments of five in the absence of pain. Week 3 involved the progression of repetition, resistance and speed of exercises to improve endurance and muscle strength. Findings from a 6-week review suggested positive outcomes in terms of patient-reported symptomatic relief however long term outcomes have not been monitored.

Exercise into hypermobile range versus exercise into neutral knee extension in paediatrics with HMS and knee pain for $\geq$ 3 months was tested in a recent RCT (Pacey et al., 2013).

The impact of a strengthening and conditioning exercise intervention on knee pain, quality of life, thigh muscle strength and function was assessed. An 8-week physiotherapist prescribed program comprising 6 sessions of 30 to 60 minutes in duration was undertaken by participants. Strengths of this study include the hospital setting, and the use of medical tests including echocardiography, bone density scans and ophthalmological reviews, for more complete and accurate diagnoses of participants and to exclude other HDCTs. This design developed on other studies that used the Nine-Point Beighton Score (Beighton et al., 1973) and/or the Revised Brighton Criteria (Grahame et al., 2000) alone. A significant improvement in child-reported maximal knee pain (measured by a pain VAS) was reported by both groups irrespective of group allocation. This finding suggests merit in strengthening and conditioning however pain frequency and duration were not measured. It also remains unknown how long the positive effects of the intervention last for and if these effects 'wash out' over time. Findings revealed parents' perceptions of the impact of the intervention on children. In terms of overall physical health parents favoured exercising into the neutral range only, while parents perceived improved overall psychosocial health specifically self-esteem, mental health and behaviour when children exercise into the hypermobile range. This indicates a positive shift away from a fearful, hyper vigilant frame of mind which is linked to children with HMS discontinuing physical activities. Clinicians are advised to focus knee joint proprioceptive training interventions throughout the knee range of motion from early flexion into hyperextension in 8 to 16 year olds with HMS and hypermobile knees (Pacey et al., 2014).

In rehabilitation in adults, maintaining full range of movement of hypermobile joints is advocated (Keer and Simmonds, 2011, Celletti et al., 2012a) with development of protective muscle tone and proprioception. Further studies on adults (Ferrell et al., 2004, Sahin et al., 2008) provide justification for proprioceptive and strengthening exercise prescription in HMS patients. An 8 week home-based program of progressive closed kinetic chain

exercises including squats, plies, bridging, side lunges and front lunges was undertaken by a group of predominantly female adult patients (Ferrell et al., 2004). Muscle strength (specifically peak and average eccentric muscle contractions of hamstrings and quadriceps) was assessed using an isokinetic dynamometer, balance was measured using a specially designed balance board with linked software, knee joint pain perception was evaluated using a pain VAS, and quality of life in terms of physical functioning and mental health was determined using the Short Form 36 questionnaire. Results indicated that from baseline to 8 weeks, the closed kinetic chain exercise program elicited significant improvements in proprioceptive acuity in participants. In the same way, significant increases were found in quadriceps and hamstrings muscle strength and symptomatic improvement of pain and increased quality of life. A limitation of the study was that due to the specific inclusion criteria, a limited number of patients were available to participate. As a consequence, there was also the lack of a parallel control group to compare with the intervention group.

Another study (Sahin et al., 2008) revealed predominantly female adults with HMS exhibited impaired knee joint proprioception, specifically knee hyperextension, when compared with non-HMS controls (tested using isokinetic dynamometry). This study design advanced from previous studies in its inclusion of two groups, a clinical HMS group who completed an intervention of proprioceptive exercises and a clinical HMS control group who did not. Knee pain intensity was measured at rest and during movement using a VAS, while the Arthritis Impact Measurement Scale-2 (AIMS-2) questionnaire was employed to evaluate the functional status of participants' health condition and quality of life at baseline and eight weeks. Post-intervention results data revealed that the exercise group experienced significantly improved proprioception, reduced knee pain and significantly improved occupational activity. The paper shared details of the exercise program and a reproducible protocol yet limitations of the study include the fact that only the knee joint was assessed, and the transferability from a laboratory to a clinical setting.

While physiotherapy is urged to prove its worth via rigorous scientific research such as in RCT's, systematic reviews and meta-analyses (Ritchie, 1999), concerns exist that limited methodologies are used to explore complex therapeutic issues (Culpepper and Gilbert, 1999). Some researchers believe that the physiotherapy profession relies too heavily on quantitative research studies to provide its evidence base (Johnson and Waterfield, 2004). Considering this, higher levels of evidence are required in mixed methods study designs which include a qualitative element. Recent systematic reviews (Smith et al., 2014, Palmer et al., 2014) are based on a limited number of studies highlighting that the evidence base is still sparse. One systematic review focused on therapeutic exercise for JHS (Palmer et al., 2014) comprised 1 controlled trial, 1 comparative trial and 2 cohort studies indicating levels 2 and 3 of evidence of studies within. Only one study was a true controlled trial which failed to report between-group statistical analyses post-treatment limiting the quality and level of evidence. Similarly, a systematic review of clinical trials for physiotherapy and occupational therapy interventions for individuals with JHS (Smith et al., 2014) reviewed only 3 trials where there was insufficient research to determine specific exercise interventions from the available evidence.

Table 2.11 Summary Table of Physiotherapy Interventions for Hypermobility: Paediatric Studies. GJH= generalised joint hypermobility. HMS= joint hypermobility syndrome. S&C= strength and conditioning exercises. N= number of study/group participants. Yrs= years. M= male. F= female

Authors & Country	**Study Design**	**Sample (size, age & gender)**	**Outcome Measure(s)**	**Intervention**	**Results**
(Bale et al., 2014) UK	RCT (prospective, single centre parallel group trial) →The Bendy Study	N=119, age range 5-16 years.	Pain, Function, Coordination and Strength	8 week individualised multidisciplinary program (I) (n=59) vs. current standard management i.e. advice and physiotherapy appointment (S) (n=60).	Significant pain reduction (>40%) in 50% of (I) group and 41% (S) group. Significant improvement in both groups, no added benefit from targeted program.
(Smith et al., 2014)	Systematic Review of Clinical Trials	3 clinical trials			
(Pacey et al., 2013) Australia	RCT (Prospective, parallel group)	N=26, aged 7-16 years with HMS / 2 groups i.e. N=12 hypermobile group N=14 neutral group	Knee Pain QoL Thigh muscle strength Function	8-week exercise program 3 stages i.e. initial assessment, post baseline period and post treatment	
(Palmer et al., 2014) UK	Systematic Review	3 studies			

(Kemp et al., 2010) UK	RCT (Physiotherapy)	N=57, aged 7-16 years with HMS	Pain/Global Impact Function Muscle strength Fitness	6 weeks Generalised program (n=27) Targeted program (n=30)	
(Sahin et al., 2008) Turkey	Proprioceptive Exercise Intervention				
(Ferrell et al., 2004) UK	Proprioceptive Exercise Intervention	N=40 with HMS /	Brighton Criteria Proprioception Pain Functional Status AIMS-2		
(Kerr et al., 2000) UK	Physiotherapy Intervention	N=39, 17 M & 22 F. age range 2 to 14 yrs GJH with joint pain.		6-week S&C home based program / week 1 - isometric muscle co-contractions in end (hypermobile) ROM 15º 5 reps for 5 seconds each, week 2 small amplitude 20º eccentric & concentric isotonic muscle contractions in hypermobile ROM 5 times + increase daily, week 3 continue with increases in reps, speed, resistance + 3 weeks continue with re-intro to physical activity, week 6 follow-up physio review appointment.	69% improved symptoms 15% complete resolution of symptoms

2.11 Summary of the Literature

From the literature reviewed it is apparent that there is a need for research examining how HMS affects paediatric populations. In addition, an investigation of current trends in clinical practice is required as a needs analysis to develop paediatric-specific diagnostic and screening tools, treatment and management programs for young people experiencing symptoms and injury.

Chapter 3: Study 1: Survey of Physiotherapy Practice

3.1 Introduction

In the preceding chapter, current literature regarding GJH and HMS was reviewed. This chapter comprises an exploratory investigation into the present understanding of HMS among physiotherapists, and current trends in clinical physiotherapy practice in terms of diagnosis, treatment and management of HMS in paediatric patients in the UK.

Perspectives of consultant rheumatologists (Grahame and Bird, 2001) reveal varied understanding regarding the cut-off points for the Nine-Point Beighton Score (Beighton et al., 1973) when using the tool to diagnose HMS in patients. Furthermore, few treatment modalities were perceived to be effective in managing HMS-related symptoms, indicating limited available strategies. These issues, which are related to the clinical care of adult patients, are likely to contribute to ongoing symptoms and disability including musculoskeletal injury, pain and fatigue (Ross and Grahame, 2011a) yet have not been fully investigated in paediatric patients.

Initial research has been published, predominantly in the rheumatology literature, with less representation in the physiotherapy literature and by practitioners who are likely to receive patients experiencing HMS-related musculoskeletal symptoms as referrals. Accordingly, the aims of the current study are firstly to explore chartered physiotherapists' understanding of HMS in paediatric patients, and secondly to investigate current trends in physiotherapy practice regarding diagnosis, treatment and management of the condition in a UK context.

Questions this study aimed to answer are presented below.

Research Question 1:

What is the current understanding among physiotherapists in the UK of HMS in paediatric patients, specifically, causes, consequences, characteristics, clinical symptoms, musculoskeletal injury type and location and impact on quality of life?

Research Question 2:

What are the current trends in physiotherapy practice regarding diagnosis, treatment and management of HMS in paediatric patients in the UK?

3.2 Methods

3.2.1 Study Design

An exploratory approach was taken in this study using a survey comprising predominantly quantitative closed questions and supplementary qualitative open-ended questions.

3.2.2 Participants

Recruitment of study participants took place in March 2012, firstly through research and enquiries made to paediatric physiotherapy departments in hospitals and clinics via internet searches, phone call and email communications where a database of 85 practitioners from 45 paediatric physiotherapy clinics was established and an email distribution list was created. Secondly, the Hypermobility Syndrome Association (HMSA) and the Association of Paediatric Chartered Physiotherapists (APCP), a clinical interest group of the Chartered Society of Physiotherapists (CSP), assisted by circulating the survey to paediatric physiotherapists on their member databases of approximately 45 and 234 members respectively. The study background and research aims were explained and practitioners were requested to be involved. Inclusion criteria stipulated participants should be:

a. Members of the Chartered Society of Physiotherapists (MCSP).
b. Paediatric physiotherapists working in NHS Foundation Trust hospitals or private practice clinics in the UK.

3.2.3 Procedures

The survey was distributed to participants online by email with a direct link to the survey on Bristol Online Survey (BOS, 2012) in June 2012. The electronic format was chosen for time and cost effectiveness. Data was collected between June and September 2012. The overall response rate (ORR) comprised a total of 102 returned surveys which was of 28% from a maximum sample pool of 364. As the data protection agreement for one association precluded names and contact details being shared, it is possible some practitioners were counted twice, meaning the sample pool is potentially overestimated and the ORR underestimated. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement checklist (von Elm et al., 2007) was considered in reporting the present study.

3.2.3.1 Instrument

An electronic survey entitled 'Physiotherapists' Perspectives of Paediatric Hypermobility Syndromes' was created using 'Bristol Online Survey' (BOS, 2012) (Appendix 1). The study protocol was approved by the University of Edinburgh Moray House School of Education Ethics Committee (Appendix 2). A 'Participant Informed Consent' statement within BOS explained that consent was implied by participants completing and returning the survey, that participation was voluntary, and participants had the right to withdraw at any time without penalty and that data would be stored securely and confidentially. The survey comprised 5 sections of questions containing a total of 22 items and is presented in Appendix 1.

3.2.3.2 Pilot Study

The survey was piloted on a group of four senior chartered physiotherapists (MCSP) who were not on the final distribution list. In the pilot study participants were asked to complete the survey and give feedback to the principal investigator on language, terminology, content, structure, ease of answering questions using the electronic format. Minor modifications were made to some questions following suggestions from the pilot study participants, such as the addition of paediatric-specific injury types and spaces for optional further comments should respondents wish to share additional detail. It was recognised that the answer options of 'Very Effective', 'Not Very Effective', 'Useless' and 'Don't Use' are negatively biased, however the principal investigator chose to use them in order to allow direct comparisons of responses with those from an existing survey (Grahame and Bird, 2001).

Section 1 of the survey aimed to gather information on participants' career backgrounds as physiotherapists using closed questions. Closed questions (Shank, 2012) involve a forced choice of answer from a given selection of options. This format was included to allow direct comparability of responses.

Section 2 aimed to gauge physiotherapists' understanding of HMS in paediatrics. Items 5, 6, 9, 13 and 14 were taken from a published survey of British consultant rheumatologists (Grahame and Bird, 2001) to enable comparisons to be drawn between the two groups of medical professionals on the subject of HMS. Items 12, 14 and 19 employed a ranked scale of answer choices i.e. 'Very Effective', 'Not Very Effective', 'Useless' and 'Don't Use', which were also selected based on an existing format (Grahame and Bird, 2001). Item 8 was an open-ended question that asked participants to comment on their understanding of HMS in children regarding three particular areas: causes of HMS, consequences of HMS and characteristics of HMS. Open-ended questions (Shank, 2012) were included to capture the reasons behind responses and more detailed experiences and opinions that could not be

obtained in a closed question format. The survey design advanced on previous quantitative-only research designs, which were previously recommended for clinical research in HMS (Bird, 2005, Simmonds and Keer, 2007). Item 10, a newly constructed question, presented 20 clinical features related to HMS in children and adolescents, drawn from a range of sources. Participants were asked for their opinions on which symptoms commonly present in children with HMS attending their clinics. The list of symptoms consisted of arthralgia (Adib et al., 2005), myalgia (Simpson and Michael, 2006), multiple joint pain (Adib et al., 2005), lower back pain (Murray, 2006), musculoskeletal injury (Wolf et al., 2011), exercise-related joint pain (Smith et al., 2005), post-exercise related joint pain (Smith et al., 2005), 'growing pains' (Murray and Woo, 2001), nocturnal leg pains (Murray and Woo, 2001), tiring easily, chronic fatigue syndrome (van de Putte et al., 2005), bruising easily (Adib et al., 2005), poor gross motor coordination (Adib et al., 2005), poor fine motor coordination (Adib et al., 2005), poor hand-eye coordination (Adib et al., 2005), developmental coordination disorder (DCD) (Grahame, 2009), hypotension, dysautonomia of the autonomic nervous system (Clark, 2012), attention deficit hyperactivity disorder (ADHD) (Koldaş Doğan et al., 2011) and gastrointestinal issues (Adib et al., 2005). The option of 'Other(s) – please specify' was also included to capture any outliers.

Section 3 was designed to collect information on current trends in physiotherapy practice including diagnosis, assessment and treatment modalities. Items 11 and 12, both newly created questions. Items 13 and 14 were taken from an existing survey (Grahame and Bird, 2001) to allow comparisons between rheumatologists and physiotherapists responses to be made. Education was added to item 14 as a treatment modality.

Section 4 involved three new items 16, 17 and 18 created to accumulate information on soft tissue injuries in paediatric HMS patients, including injury types and location. Item 16 listed musculoskeletal injury types and asked respondents to note their experience of HMS patients presenting with these injuries at their clinics. The list was created using current paediatric

injury literature and included joint dislocation (Adib et al., 2005), joint subluxation (Adib et al., 2005), ligament sprain (Soprano, 2005), muscle strain grade one, two or three (Soprano, 2005), tendon strain (Soprano and Fuchs, 2007), chronic tendinopathy (tendonitis, tendinosis) (Soprano and Fuchs, 2007), bursitis, spondylolysis (Murray, 2006, Brenner et al., 2007), apophysitis (Soprano and Fuchs, 2007), contusion, haematoma, growth plate injury, stress fracture (Soprano and Fuchs, 2007, Paterno et al., 2013), fracture (Rennie, 2007), Sever's disease (Soprano, 2005), Osgood-Schlatter's disease (Soprano and Fuchs, 2007, Paterno et al., 2013), little leaguer's injury (Soprano, 2005), Sinding-Larsen-Johansson syndrome (Soprano and Fuchs, 2007) and pain syndromes (Grahame, 2009). Again, 'Other(s) – please specify' was also an option. Item 17 focused on musculoskeletal injury location and asked physiotherapists to record their experiences on which sites injuries present in paediatric HMS patients. The list included cervical spine, shoulders (Soprano, 2005), thoracic spine, elbows, lumbar spine, wrists, metacarpals, finger phalanges, hips, pelvis, knees (Soprano, 2005, Paterno et al., 2013), ankles (Soprano, 2005), metatarsals, toe phalanges and 'Other(s) – please specify'.

Section 5 was designed to attain information on physiotherapists' practice, including treatment, management and physical interventions. Item 19, a newly created question presented seven physical training interventions, which were addressed in a report (Faigenbaum and Micheli, 2012) for the American College of Sports Medicine (ACSM). The list included muscular strength training, muscular endurance training, proprioception and balance training, core/trunk strength and stability training, flexibility training, aerobic (cardiovascular) training and manual therapy. 'Other(s) – please specify' was added to capture any further comments. Items 20, 21 and 22, all original questions were newly designed to gather specific information and recommendations on the optimal setting for physical interventions, frequency and challenges encountered by children engaging in exercise programs.

3.2.4 Data Analysis

3.2.4.1 Quantitative

Data were analysed using summary statistics generated by Bristol Online Survey. Data are presented descriptively using frequencies and percentages, following a format used in other published studies on paediatrics in a medical context (Kerr et al., 2000, Adib et al., 2005, Rennie, 2007).

3.2.4.2 Qualitative

Qualitative data were analysed using a six-step inductive content analysis technique involving unitizing, sampling, recording, reducing, inferring and narrating (Krippendorf, 2004). The inductive content analysis procedure in this study was used directly on the text of survey responses, using a set of techniques to make replicable and valid inferences from the texts (Figure 3.1). Data are presented descriptively. The reliability of the established coding scheme was assessed with a second coder (Barry et al., 1999, Barbour, 2001). The principal investigator and second coder worked from hard-copy print outs of data from Bristol Online Survey, by firstly independently creating codes to categorise responses into and secondly, by reconvening to compare codes and number of responses assigned to each category. High reproducibility was confirmed with an inter-rater reliability score of 80 to 100%.

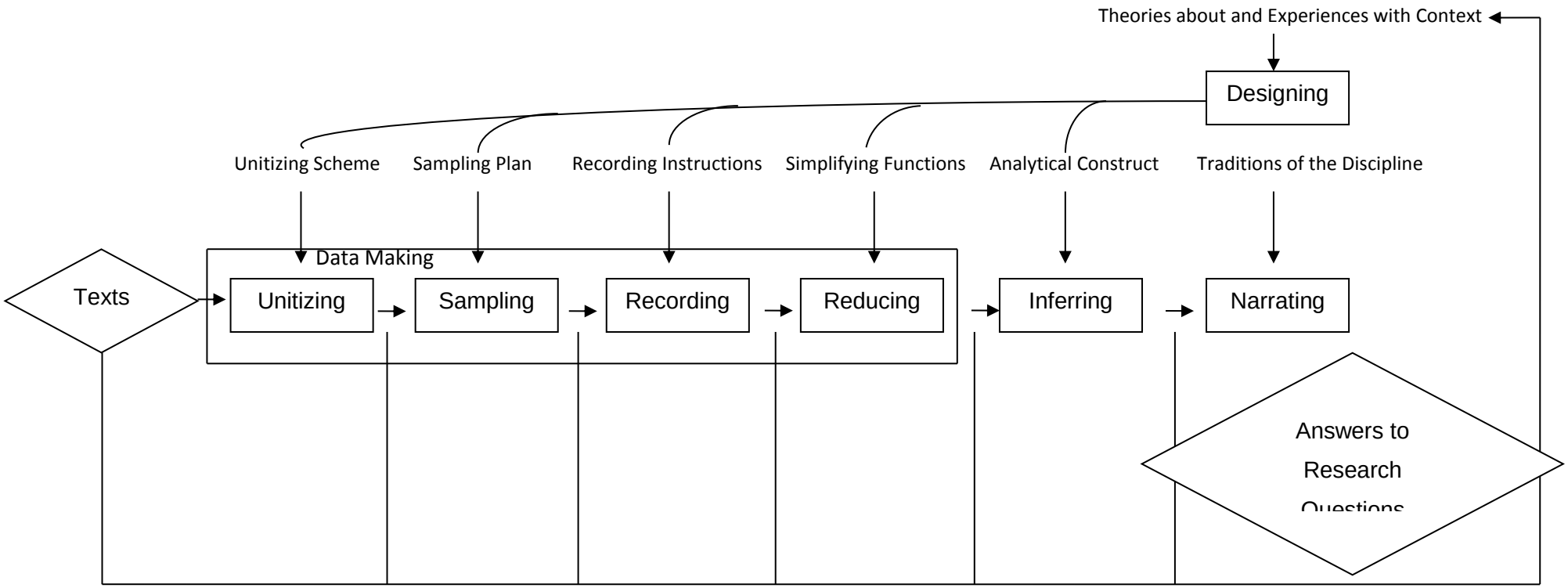


Figure 3.1 Components of Content Analysis (Krippendorf, 2004)

BOS produced report documents which contained data in the format of lists of electronically recorded responses to open-ended survey questions such as “Any further comments” or “Other(s) – please specify”. Each participant’s responses were individually reported (anonymously) and categorised per survey item. Responses ranged from a single word to a brief comment, a sentence or a small group of sentences. In step 1 of the content analysis (see Figure 3.1) recording units were defined. Units in the form of words were considered the smallest units that bear all information needed for analysis. An example of a recording unit in the response to item 8 is ‘genetic’ (see Table 3.4a).

A sampling plan was devised in step 2 (see Figure 3.1), where representative samples were drawn to reduce data to manageable subsets. Recurring themes were identified according to units that were reported with the highest frequency. Definitions for each theme, in the context of the study were created (for example, see Table 3.4c Consequences of HMS in paediatrics). Sample quotes and examples which represented similar cases were selected for later use (in step 4). As an example, the themes for the questions about consequences of HMS were:

- Theme 1 = ‘physical symptoms’, comprised units noting musculoskeletal symptoms or features.
- Theme 2 = ‘psychosocial symptoms’, comprised units of social, psychological, school and family features.
- Theme 3 = ‘multiple symptoms’, comprised a combination of both physical and psychosocial units.
- Theme 4 = ‘other’, comprised responses not part of the primary themes or responses that were un-codable.

A coding scheme (recording process) was designed, tested and implemented in step 3 (see Figure 3.1). Each original individual unit on each item list (survey answer) was coded by number, and totals for each theme were calculated. Using the sampling plan and raw data sheets, the reliability of the established coding scheme was assessed with a second coder on a sample of 10% of each item's responses. High reproducibility is a minimum standard for content analysis, as it measures the consistency of shared meaning held by two or more coders (Weber, 1990). Step 4 of the content analysis procedure involved reducing data to manageable representations. Tables of content analysis results data (for example Table 3.4c) contain specific details:

- Theme (participants' answers are coded and themes are identified).
- Response (n), indicating the number of study participants whose answers are included in each theme.
- Selected sample of real quotes from physiotherapists that reflect the main themes.
- Total (n), denoting the total number of responses for combined theme categories.

Step 5, inferring and interpreting the data in the context of the study, and step 6, narrating the answers to the research questions and linking themes to current literature, are demonstrated within section 3.4.

3.3 Results

3.3.1 Participants' Professional Background Details

Physiotherapists' locations in the UK included Scotland (19.6%), England (75.5%), Northern Ireland (1.0%) and Wales (3.9%). Specialist areas of practice included paediatric musculoskeletal, neuromuscular, rheumatology, rehabilitative and extended scope physiotherapy.

Table 3.1 Professional Levels of Physiotherapists

Professional Level	**Number (%)**
Band 5	3 (2.9)
Band 6	19 (18.6)
Band 6 Specialist	13 (12.7)
Band 7	33 (32.4)
Band 7 Advanced	18 (17.6)
Band 8 Consultant	12 (11.7)
Private practice	3 (2.9)

Professional levels of physiotherapists ranged from band five to band eight plus private practice practitioners.

Table 3.2 Years of Clinical Career Experience Practicing Physiotherapy

Years of Experience	**Number (%)**
0-5	18 (17.6)
6-15	43 (42.2)
15+	34 (33.3)
Other	7 (6.9)

Years of clinical experience ranged from one to thirty years.

3.3.2 Physiotherapists' Understanding of HMS in Paediatrics

Table 3.3 Physiotherapists' Opinions on HMS as a Distinct Clinical Entity and a Distinct Pathological Entity

Responses	Clinical entity	Pathological entity
Yes	85 (83.3)	68 (66.7)
No	8 (7.8)	16 (15.7)
Don't know	9 (8.8)	18 (17.6)
Total	102	102

The majority of physiotherapists perceived HMS to be a distinct clinical entity, with some uncertainty expressed regarding HMS as a pathological entity (Table 3.3).

Table 3.4a Content Analysis of Causes of HMS in Paediatrics

Theme	Response (n)	Selected Quotes
Multiple causes (responses)	32	'…change in collagen elastin genetic makeup, increased ligament laxity, acquired through repetitive training'
Genetic/congenital	26	'…genetic predisposition, familial link'
Abnormality of connective tissue	26	'…abnormality of connective tissue (collagen) affecting ligament function and joint stability'
Others/ Don't know	7	…'unknown cause'
Total	**91**	

Physiotherapist's recognised that the aetiology of HMS in paediatrics may be a consequence of coexisting origins, or may stem from a single origin (Table 3.4a).

Table 3.4b Content Analysis of Characteristics of HMS in Paediatrics

Theme	Response (n)	Selected Quotes
Multiple symptoms	67	'…painful joints, poor muscle endurance, abdominal pains, clicking joints, anti-gravity muscle weakness, proprioception problems'
Hypermobile joints	10	'…excessive joint laxity'
Other	8	'…clinically hypermobility is not always generalised, I have seen children where it mainly manifests mid limb (elbows & knees) or peripheral joints (wrists, fingers, thumbs, ankles)'
Diagnostic measure	7	'…Beighton score ≥4/9'
Total	**93**	

Respondents acknowledged that HMS is predominantly characterised by multiple symptoms presenting in varying degrees and combination, hypermobile joints and positive hypermobility test scores (Table 3.4b).

Table 3.4c Content Analysis of Consequences of HMS in Paediatrics

Theme	**Response (n)**	**Selected Quotes**
Physical symptoms	65	'…frequent hyperextension injuries, altered balance & proprioception, prone to sprains/injury due to ligament laxity, postural problems, pain'
Multiple symptoms	21	'…pain, poor coordination, secondary low self-esteem, missed opportunities due to decreased stamina for specific activities, increased tiredness'
Psychosocial symptoms	1	'…can interfere with school attendance and ability to carry out leisure pursuits'
Other	4	'…if not acknowledged and educated/supported can lead to misunderstanding and exclusion'
Total	**92**	

While consequences of HMS in paediatrics encompassed predominantly musculoskeletal indications, psychosocial symptoms often arising from physical disability such as injury, pain and fatigue were also recognised (Table 3.4c).

Table 3.5 Clinical Symptoms Presenting in Paediatric HMS Patients.

Clinical Symptoms	**Number (%) of Yes Responses**
Multiple joint pain	90 (88.2)
Exercise-related joint pain	87 (85.3)
Tiring easily	87 (85.3)
Post-exercise related joint pain	86 (84.3)
Poor gross motor coordination	85 (83.3)
Arthralgia	81 (79.0)
Musculoskeletal injury	81 (79.4)
'Growing pains'	74 (72.5)
Myalgia	67 (65.7)
Poor fine motor coordination	67 (65.7)
Nocturnal leg pains	66 (64.7)
Chronic lower back pain	55 (53.9)
Poor hand-eye coordination	43 (42.2)
Developmental coordination disorder	43 (42.2)
Gastrointestinal issues	38 (37.3)
Bruising easily	36 (35.3)
Chronic Fatigue Syndrome	32 (31.4)
ADHD	23 (22.5)
Dysautonomia of autonomic nervous system	14 (13.7)
Hypotension	10 (9.8)
Other(s)	18 (17.6)

Eight pain phenotypes, injury and impaired coordination patterns featured as the most frequently reported clinical symptoms, with extra-articular symptoms reported less frequently (Table 3.5).

Table 3.6 Musculoskeletal Injury Types Presenting in Paediatric HMS Patients.

Injury Type	**Number (%) of Yes Responses**
Ligament sprain	93 (91.2)
Joint subluxation	81 (79.4)
Pain syndromes	81 (79.4)
Joint dislocation	59 (57.8)
Muscle strain grades 1, 2, 3	50 (49.0)
Osgood-Schlatter's	54 (52.9)
Tendon strain	50 (49.0)
Sever's disease	46 (45.1)
Chronic Tendinopathy	44 (43.1)
Apophysitis	32 (31.4)
Sinding-Larsen-Johansson syndrome	31 (30.4)
Fracture	19 (18.6)
Stress fracture	12 (11.8)
Spondylosis	19 (18.6)
Bursitis	17 (16.7)
Growth plate injury	8 (7.8)
Little leaguer's injury	6 (5.9)
Others(s)	9 (8.8)

Soft tissue injuries this population are susceptible to include acute, overuse and repetitive strain injuries (RSI). Growth related injuries and fractures, which are common injuries in childhood, are also reported to be prevalent, but to occur less (Table 3.6).

Table 3.7 Musculoskeletal Injury Locations in Paediatric HMS Patients.

Injury Location	**Number (%) of Yes Responses**
Knees	94 (94.9)
Ankles	92 (92.9)
Shoulders	59 (60.2)
Lumbar spine	52 (53.1)
Hips	48 (49.5)
Wrists	47 (48.5)
Elbows	21 (21.9)
Finger phalanges	20 (20.8)
Pelvis	15 (15.6)
Cervical spine	14 (14.4)
Metacarpals	13 (13.5)
Metatarsals	11 (11.7)
Toe phalanges	4 (4.2)

Trends showed weight bearing joints in lower limbs to be significantly vulnerable to injury. Similarly, so were the shoulders and lumbar spine, of which the primary function is providing stability in posture and dynamic movement (Table 3.7)

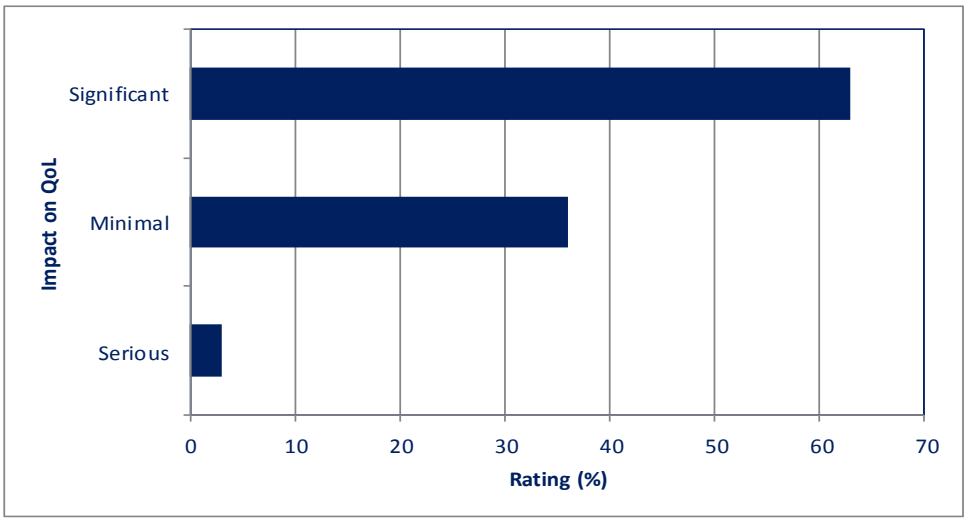


Figure 3.2 Physiotherapists' Ratings of the Impact of HMS on Quality of Life in Paediatric Patients

Differences in opinion exist among physiotherapists in terms of the perceived impact of HMS on patients' quality of life. The scale was taken from a published survey (Grahame and Bird, 2001) to allow comparison of responses. A higher proportion reported a significant impact with only a minority considering the impact to be serious (Figure 3.2).

Table 3.8 Content Analysis of Perceived Impact of HMS on Quality of Life in Paediatrics

Theme	**Response (n)**	**Selected Quotes**
Severity/Variability	33	'**…**dependent on severity and patient'
Other	10	'…with a healthy active lifestyle most cases don't affect QoL but may require adaptations to activities'
Family/parents	7	'…over protective parents can cause problems'
Psycho/social	3	'…QoL appears to be worse if symptoms spiral into a cycle of ongoing fatigue, low confidence etc.'
Combined factors	3	
Total	**57**	

Data showed 'severity' of symptoms and 'variability' to be the most prominent emerging theme influencing QoL, with family and lifestyle also impacting children's lives (Table 3.8).

3.3.3 Current Trends in Physiotherapy Practice Regarding Diagnosis of HMS in Paediatric Patients.

Table 3.9 Number of Cases of HMS Diagnosed in the Previous 12 Months

Number of cases	Physiotherapists Number (%)	Rheumatologists 2001 Number (%)
0	2 (2.0)	9 (3.0)
<10	26 (25.5)	153 (48.0)
11–25	39 (38.2)	111 (35.0)
26–50	21 (20.6)	31 (10.0)
50+	14 (8.8)	6 (2.0)
Total	**102**	**310**

Differences in the numbers of cases of HMS diagnosed by medical professionals are evident. Physiotherapists were more likely to have diagnosed more cases in the last 12 months. On the contrary, rheumatologists (Grahame and Bird, 2001) were more likely to have diagnosed fewer than 10 cases in the last 12 months than they were to have diagnosed more than 10 (Table 3.9).

Table 3.10a Diagnostic Tools and Ratings of Effectiveness

Diagnostic Tool	**Number of Yes Responses (%)**	**Very Effective (%)**	**Not Very Effective (%)**	**Useless (%)**	**Don't Use (%)**
Nine-Point Beighton Score	88 (86.3)	38 (37.3)	51 (50.0)	3 (2.9)	10 (9.8)
Revised Brighton Criteria	46 (45.1)	31 (30.4)	20 (19.6)	1 (1.0)	50 (49.0)
Five-Point Questionnaire	16 (15.7)	10 (9.8)	9 (8.8)	1 (1.0)	82 (80.4)
Others	21 (20.6)	20 (19.6)	4 (3.9)	0 (0.0)	78 (76.5)

Data firstly indicated the proportion of physiotherapists who do use the listed diagnostic tools, and secondly the reported perceived effectiveness of each tool. Disparity exists between the use of available tools and the perceived suitability of these for paediatrics, such as the Nine-Point Beighton Score. Gaps are also evident in the use of some tools, such as the Revised Brighton Criteria and the Five-Point Questionnaire (Table 3.10a).

Table 3.10b Content Analysis of Nine-Point Beighton Score as a Diagnostic Tool

Theme	**Response (n)**	**Selected Quotes**
Excludes joints	7	'… still does not consider the ankle and shoulder'
Not a paediatric measure	5	'…available but have not used as children have been very young' '…not certified for use in children'
Part of assessment	4	'…although I know it is not validated in children I mainly use as a quick test'
Uncodable	1	
Total	**17**	

Emerging themes revealed key reasons for the 'not very effective', 'useless' and 'don't use' scores which are illustrated in the sample quotes (Table 3.10b).

Table 3.10c Content Analysis of Other(s) Diagnostic Tools

Theme	**Response (n)**	**Selected Quotes**
MSK assessment	11	'…clinical observation re posture, coordination and muscle tension'
		'…Movement ABC'
Other	5	'…I will look for TMJ (4 fingers), cervical spine side Fx (ears to shoulders), GHJ external rotation >90 degrees'
All joints	3	'…full joint count measuring ROM at all joints as well as muscle testing of all major muscle groups, balance testing, gait analysis'
Subjective	2	'…subjective history including family history and childhood development'
Total	**23**	

Alternative methods of screening and functional assessment used by some physiotherapists are documented and revealed strategies for a more complete initial musculoskeletal evaluation of a patient (Table 3.10c).

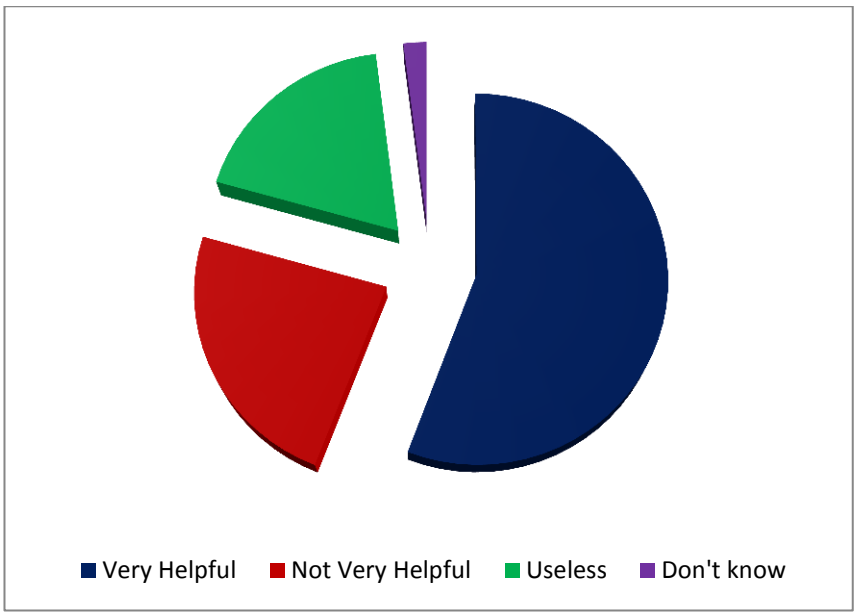


Figure 3.3 Physiotherapists' Ratings of Helpfulness of Patient Diagnoses of HMS

Differences in opinion exist among physiotherapists' regarding how helpful patient diagnoses of HMS are in terms of ongoing treatment plans for paediatrics (Figure 3.3). The scale was taken from an existing publication (Grahame and Bird, 2001)

Table 3.11 Content Analysis of Helpfulness of Patient Diagnoses

Theme	**Response (n)**	**Selected Quotes**
Individual context	9	'…for explanation of why a child may be experiencing pain, muscle inactivity, frequent falls, sprains etc.'
Helpful	5	'…can be helpful, depends on whether chronic pain in associated'
Label	4	'…the label can cause further problems'
Total	**18**	

Data illustrated some reasons why diagnoses are perceived to both positively and negatively influence the prognosis of paediatric patients with HMS. There was a preference for diagnoses to be considered in an individual patient context (Table 3.11).

3.3.4 Current Trends in Physiotherapy Practice Regarding Treatment and Management of HMS in Paediatrics

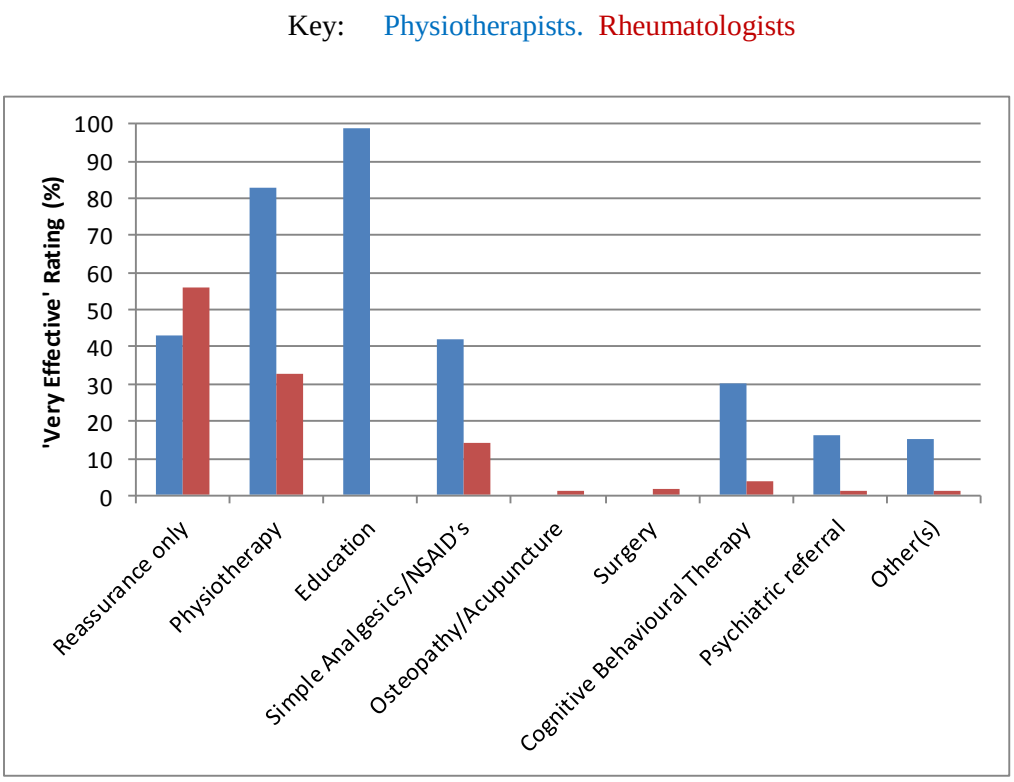


Figure 3.4 Physiotherapists' and Rheumatologists' Ratings of Perceived Effectiveness of Treatment Modalities

Findings indicated differences in preferences for treatment modalities among medical professionals and a lack of strategies perceived to be very effective for HMS patients. The highest scoring modalities of education and physiotherapy reveal a progressive and contemporary trend, yet the evidence base for these has been sparse to date.

Table 3.12 Physical Interventions Types for Paediatric HMS Patients and Physiotherapists' Ratings of Effectiveness

Physical Intervention	**Number (%) 'Very Effective'**
Proprioception and balance	97 (95.1)
Core and trunk strength and stability	94 (92.2)
Muscular strength	92 (90.2)
Muscular endurance	75 (73.5)
Flexibility	48 (47.1)
Aerobic (cardiovascular)	43 (42.2)
Manual therapy techniques	14 (13.7)
Other(s)	16 (15.7)

The listed exercise training types clearly feature some priority interventions for the paediatric hypermobile population (Table 3.12).

Table 3.13 Recommended Setting for Physical Training Interventions

Setting	**Number (%) of Yes Responses**
A combination of clinic, school and home-based	77 (75.5)
Home (supervised)	13 (12.7)
Hospital/clinic	3 (2.9)
School	3 (2.9)
Other	6 (5.9)
Total	**102**

Responses indicated the preferred setting for exercise interventions was a combination of available settings, as opposed to home, hospital, clinic or school settings alone (Table 3.13).

Table 3.14 Recommended Frequency for Physical Training Interventions.

Frequency	**Number (%)**
Daily	45 (44.1)
Three or more times per week	41 (40.2)
Once per week	2 (2.0)
Twice per week	1 (1.0)
Other	13 (12.7)
Total	**102**

Data disclosed physiotherapists' preferences for more frequent exercise training sessions, with once or twice weekly sessions less favoured (Table 3.14).

Table 3.15 Challenges Experienced by Paediatric Patients with Physical Interventions

Challenges	**Number (%) of Yes Responses**
Compliance	93 (91.2)
Replicating correct exercise technique	70 (68.6)

Challenges encountered by children engaging in exercise interventions and programs are recognised by physiotherapists (Table 3.15).

3.4 Discussion

The study set out to investigate physiotherapists' understanding of HMS in paediatrics, and to establish current trends in physiotherapy practice in terms of diagnosis, treatment and management. An accurate understanding of the aetiologies of HMS and the spectrum of symptoms and injuries was evidenced among physiotherapists, however a lack of consensus with regards to diagnosis was shown, as well as variation in preferred treatment modalities and management strategies.

3.4.1 Physiotherapists Understanding of HMS in Paediatrics

3.4.1.2 Understanding of Entities, Causes, Characteristics and Consequences

The majority of physiotherapists believed that HMS is a distinct clinical entity, which is confirmed in clinical genetics (Tinkle et al., 2009) and physiotherapy literature (Scheper et al., 2013b) (Table 3.3). This finding is consistent with rheumatologists' understanding (Grahame and Bird, 2001), who scored similarly (92.0%). This demonstrates understanding among the two groups of medical professionals that HMS has a distinct existence, discrete from more rare and serious HDCTs (Beighton et al., 1998). Some physiotherapists remained unsure regarding HMS as a distinct pathological entity, as did a lower proportion of rheumatologists (39.0%), indicating some uncertainty among medical professionals. This has also recently been noted in the literature (Scheper et al., 2013a). The causes of HMS in paediatrics detailed in Table 3.4a correspond with the literature (Bird, 2005). HMS in children is characterised predominantly by multiple presenting physical symptoms and also positive Nine-Point Beighton Scores (Table 3.4b). Consequences of HMS, exemplified in sample quotes from content analysis of qualitative data in Table 3.4c, are also consistent with current literature (Adib et al., 2005, Murray, 2006, Fatoye et al., 2012). Data revealed

awareness among practitioners of the effects of HMS on physical, musculoskeletal, psychosocial, emotional and school functioning.

3.4.1.3 Understanding of Clinical Symptoms and Musculoskeletal Injury

From clinical experience, physiotherapists expressed musculoskeletal pain phenotypes to be highly prevalent clinical symptoms in paediatrics (Table 3.5). Multiple joint pain was the principal presenting symptom consistent with some of the current literature (Gurley-Green, 2001, Adib et al., 2005, Briggs et al., 2009). The data on pain reported in this present study conflicts with study findings previously discussed (Chapter 2, 2.8 Pain), which reported no association between GJH and persistence of musculoskeletal pain in pre-adolescents (Mikkelsson et al., 1996, Qvindesland and Jónsson, 1999, Leone et al., 2009). Conversely, data supports studies which reported pain experience in young people both with and without diagnoses of HMS (El-Metwally et al., 2004, Zapata et al., 2006, Ståhl et al., 2008, Mikkelsson et al., 2008, O'Sullivan et al., 2011, Fatoye et al., 2012, Tobias et al., 2013). The spectrum of clinical symptoms are acknowledged in Table 3.5 and correspond with those documented in the literature (Murray and Woo, 2001, Adib et al., 2005, Murray, 2006). Data revealed higher scoring symptoms to be articular rather than non-articular, although 'other' symptoms noted from content analysis of data included non-articular symptoms including:

'...forty percent experience issues with gastro-intestinal tract'

'...headaches'

'...bowel/bladder dysfunction e.g. recurrent urinary tract infections'

Symptoms included impaired motor coordination patterns, including gross, fine and hand-eye coordination, which together with functional limitations of joint instability (Hakim and Grahame, 2003a), decreased trunk stability, delayed motor development (Falkerslev et al., 2013) and reduced proprioception and muscle strength (Fatoye et al., 2009) can predispose

hypermobile joints to hyperextend (Keer and Grahame, 2003). This mechanism for injury and minor trauma results in injuries reported in Table 3.6 such as ligament sprains, joint subluxations and dislocations, muscle and tendon strains and subsequent musculoskeletal pain. Overuse and RSIs are documented as the predominant injury types in paediatrics with HMS (Junge et al., 2015a), consistent with literature on paediatric injuries (Hogan and Gross, 2003). Children at risk of sustaining injuries include those participating in sport, dance, performing arts (McCormack et al., 2004) and even in everyday tasks that require dynamic control such as running or walking on uneven surfaces or stair ascent and descent. Fracture, contusion and haematoma are injuries likely to occur from acute trips and falls that stem from poor gross motor coordination, balance, stability and proprioception. These injuries scored less prominently yet it is possible that patients attend general practitioner or accident and emergency clinics with these types of injuries (Rennie, 2007). Stress fracture, an overuse injury sustained as a consequence of repeated micro trauma and chronic sub maximal loading of tissues, was also reported by physiotherapists to present less in clinics although this type of injury may only become apparent in young adulthood. Slow healing, delayed recovery or only partial recovery of injuries contribute to recurrent injury of the same joints and/or continued patterns of injury at various other joints (Keer and Grahame, 2003, McCormack et al., 2004). This highlights the need for awareness of risk factors for injury among medical professionals as well as wider communities such as sports physiotherapists and rehabilitators, first aiders, accident and emergency doctors, general practitioners, coaches, dance teachers, school teachers and physical education teachers, who are likely to come into contact with children who sustain injuries.

Data on injury location in Table 3.7 are comparable with similar trends in published studies, which reported the same predominant symptomatic joints: knees (Pacey et al., 2013, Junge et al., 2015b, Junge et al., 2015a); knees and ankles (Kerr et al., 2000, Smith et al., 2005, Toker et al., 2010, Konopinski et al., 2012); knees, elbows, wrists, metacarpophalangeal joints and

ankles (Adib et al., 2005); ankles and feet (Leanderson et al., 2011, Nicholson et al., 2014); knee and shoulder joint subluxations (Simpson and Michael, 2006, Pantoja Zarza et al., 2014); recurrent shoulder joint dislocations (Muhammad et al., 2013); and the pelvis, specifically sacroiliac joint dysfunction (Vaughn and Nitsch, 2008). Other specific injuries documented in content analysis of qualitative data correspond with paediatric injury literature and included:

'...anterior knee pain – non-specific'

'...patella subluxations'

'...patellofemoral joint pain'

'...plantar fasciitis'

'...low back pain/postural pain'

'...pain with handwriting/typing'

'...clicking hips'

Common paediatric injuries that affect the knee include Osgood Schlatter's disease (Junge et al., 2015a) and Sinding-Larsen-Johansson syndrome, while Sever's disease affects the ankle/calcaneal structure (McLeod et al. 2011). Chronic Patellofemoral Pain Syndrome is documented in the literature as the most common disorder of the knee experienced most frequently by young physically active females (Paterno et al., 2013). Physiotherapists consider these growth-related injuries to be moderately prevalent among children with HMS. Content analysis of qualitative data indicated the relationship of these injuries to HMS is unclear, and they are not thought not to be a direct consequence of HMS, however young people with HMS may be at a greater risk of sustaining these injuries during adolescent growth spurts due to vulnerability of soft tissues. Despite how frequently children with HMS are reported in the literature as being at risk of sustaining injuries, systematic injury surveillance methods and injury rehabilitation in paediatrics are currently not well reported

in the literature. Data highlighted the overriding need for effective screening and management of symptoms and injury in paediatrics, to prevent continuing cycles of symptoms in adolescence and young adult life.

3.4.1.4 Understanding of Impact of HMS on Quality of Life in Paediatrics

Considering the impact of HMS on quality of life in patients, content analysis of qualitative data in Table 3.8 illustrated some of the reasons behind the ratings reported in Figure 3.2. The principal emerging theme influencing quality of life was 'severity/variability' of symptoms. A sample quote explains:

'…very variable between families, emotional response and coping abilities have a greater impact on QoL than the condition itself'

The majority of the sample of physiotherapists perceived the syndrome to have 'significant' effects on quality of life, while a 'serious' impact is understood to be connected to more severe cases, with associated chronic pain, negative mood, anxiety and depression (Maillard et al., 2014). Impact is believed to be 'minimal' in cases where it is understood and managed well, an opinion demonstrated in this sample quote:

'…with a good philosophy of self-management of the difficulties including a specific strengthening and fitness program, effective pain management strategies and a positive approach then the negative impact should be minimal and in many cases being hypermobile can be very positive'

Similar trends were evident in rheumatologists' responses on the impact of HMS on daily life: serious (1.0%), significant (50.0%) and minimal (45.0%), (Grahame and Bird, 2001). Quality of life as a treatment outcome measure in children with rheumatic diseases has been increasingly recognised (Epps et al., 2005, Duffy and Feldman, 2011), and pain and quality of life are also suggested to be important components of clinical examination for children diagnosed with HMS. Baseline values can help clinicians evaluate the effectiveness of

treatment and management interventions which, along with awareness among families, medical and wider communities, are key factors influencing quality of life in paediatrics.

3.4.2 Current Trends in Physiotherapy Practice: Diagnosis of HMS in Paediatrics

3.4.2.1 Usefulness of Patient Diagnoses

A diversity of opinion was expressed regarding whether (or not) patient diagnoses of HMS are helpful in terms of ongoing treatment plans (Figure 3.3). A slightly greater percentage of physiotherapists believed patient diagnoses of HMS to be 'very helpful', while a significant percentage believed patient diagnoses of HMS to be 'not very helpful' or 'useless'. Responses showed that diagnosis is a sensitive topic and can either work in a child's favour towards a management program, or be a precursor to further problems depending on how the diagnosis is approached, communicated and used. Content analysis of qualitative data in Table 3.11 illustrated diagnoses could have a positive or negative impact. For example, for some patients a diagnosis with appropriate action is helpful if the label is understood and used to modify activities and pacing accordingly. Acknowledgement of symptoms is considered to have a positive effect on young patients (Pacey et al., 2013). For others, a diagnosis can be a label that can create more problems and long-term disability, caused by anxiety and isolation from physical activities that are perceived to be risks for injury and pain.

Diagnoses are considered to be useful in that hypermobility could be a direct cause of musculoskeletal symptoms and/or a clinical sign pointing to a more complex medical condition such as an HDCT. Whether a diagnosis is of normal variation GJH with musculoskeletal pain and fatigue, JHS, HMS or EDS-HM, the symptoms need to be addressed. An understanding of symptomatology and co-morbidities is essential for a diagnosis and label to be given to a patient. However, a complete understanding of the

syndrome is not essential prior to treatment and management of existing symptoms, as this can delay access to and engagement with multidisciplinary therapy for those experiencing disabling symptoms. This is exemplified in a sample quote from content analysis of qualitative data:

'...If a diagnosis has not been given in a timely manner and a family are sent away generally QoL appears worse as symptoms spiral into cycle of on-going fatigue, lethargy and low confidence'

As GJH should only be diagnosed as HMS/HMS when it is clinically evaluated as being connected to chronic symptoms, namely widespread musculoskeletal pain and pathology, diagnoses of HMS are thought by some clinicians to be unwarranted due to the dangers of creating a fearful, anxious, hyper vigilant patient group. A physiotherapist's view is expressed in the qualitative data:

'...increased anxiety from families regarding the significance of the diagnosis which leads to more disability... some parents attribute symptoms which could have a psychosocial origin or are being maintained/created by a psychosocial issue to HMS which in the long-term is detrimental'

3.4.2.2 Number of Cases Diagnosed in the Previous 12 Months

Differences in observed clinical prevalence of HMS in a 12-month timeframe are evident among physiotherapists, among rheumatologists, and between the two groups of medical professionals (Table 3.9). Practitioners reported retrospectively, and an 11-year gap exists between studies. Physiotherapists answered the question considering paediatrics exclusively, while rheumatologists (Grahame and Bird, 2001) considered their patients who were predominantly adults: *"...rheumatologists were asked to respond in respect of whatever population they normally treated, some 5% or less would have responded in respect of their*

paediatric practice; the remainder were all adult rheumatologists" (H. Bird 2012, personal communication).

When physiotherapists were questioned about how many cases of HMS they had diagnosed in the last 12 months, higher numbers of them reported observing HMS in the regions of 11 to 25 cases, 26 to 50 cases or 50+ cases when compared with rheumatologists. A lower number of physiotherapists reported diagnosing fewer than 10 cases in the last 12 months, whereas when rheumatologists were questioned the majority of them had diagnosed fewer than 10 cases. It is possible that physiotherapists encounter more 'new' cases, due to GJH being more prevalent in paediatrics compared with adults, and due to the nature of their role in functional assessment and rehabilitation of patients. It is acknowledged in the literature that testing for GJH/HMS does not yet always form part of a rheumatologist's routine assessment/examination (Grahame and Bird, 2001), which may be a reason for the lower number of diagnoses made by rheumatologists. As previously discussed, it is possible that some cases can be missed (Ross and Grahame, 2011). In light of this, the new data on paediatrics adds to current literature and understanding of trends in diagnosis in the context of the UK.

3.4.2.3 Diagnostic Tools

Disparity exists among the use of available tools such as the Nine-Point Beighton Score (Beighton et al., 1973) and the perceived suitability of these for paediatrics. Gaps are also evident in physiotherapists' use of tools such as the Revised Brighton Criteria (Grahame et al., 2000) and the Five-Point Questionnaire (Hakim and Grahame, 2003b) (Table 3.10a). Despite the limitations of the Nine-Point Beighton Score reported in Table 3.10b and discussed in Section 2.6 Diagnosis, the tool is still used by the majority of physiotherapists. This is consistent with current literature summarised in Table 2.3, (Rikken-Bultman et al., 1997, Qvindesland and Jónsson, 1999, van der Giessen et al., 2001, Adib et al., 2005). A

striking finding is that ratings of perceived effectiveness of this tool revealed a higher proportion of physiotherapists considered it to be 'not very effective' and a minority reported not using it at all. Additional sample quotes from content analysis of qualitative data explained:

'...spinal component is useless in the presence of tight hamstrings. excludes hips and ankles which can be significantly symptomatic'

'...use as a quick measure but not as a conclusive as it is not sensitive or reliable in paediatrics'

The Revised Brighton Criteria are presently the only validated tool to encompass symptoms associated with HMS, although the criteria consider adult symptoms, not symptoms specific to paediatrics (documented in Table 3.5). Fifty percent of the sample of physiotherapists surveyed, reported not using this diagnostic tool, with reasons why extracted from the content analysis of qualitative data:

'...not certified for use in children and doesn't give enough consideration to how a child functions'

'...too complicated'

As less than half the sample declared using these criteria, it remains unknown how symptoms in paediatric patients are being diagnosed and acknowledged (Table 3.10a). In addition to a small proportion of physiotherapists using 'other' tools, this data implied that the current screening of symptoms is not standardised, and likely to vary between clinics and among practitioners (Table 3.10c). 'Other' tools for assessment detailed in Table 3.10c demonstrated more thorough methods of assessment and progressive practice, yet concerns exist that only a small sample reported using these, and how the majority are diagnosing symptoms remains unknown. The Five-Point Questionnaire (Hakim and Grahame, 2003b) proved not to be a popular choice among practitioners for reasons consistent with themes previously demonstrated. Implications of this data are differences in patient experience and

risks of symptoms remaining undiagnosed or not connected to GJH (Simmonds and Keer, 2007, Grahame, 2007b, Ross and Grahame, 2011a). This data revealed an overriding gap in suitable diagnostic tools, and underlined the urgent need for a validated paediatric version of the Revised Brighton Criteria, and the development of a new diagnostic tool to aid with classification and clinical assessment in paediatrics.

3.4.3 Trends in Physiotherapy Practice: Treatment and Management of HMS in Paediatrics

3.4.3.1 Treatment Modalities

Responses indicated a stark contrast in preferences for treatment modalities among medical professionals, and an overall lack of strategies that are perceived to be very effective for paediatric HMS patients. Education and physiotherapy interventions were reported as the highest scoring fundamental treatment modalities by physiotherapists (Figure 3.4). Data showed these preferences to be aligned with the current available evidence base (Russek, 2000, Kerr et al., 2000, Murray, 2006, Simpson and Michael, 2006, Kemp et al., 2010, Pacey et al., 2013, Maillard, 2014). Researchers acknowledge the lack of robust evidence-based physiotherapy programs for paediatric rheumatic or non-inflammatory musculoskeletal conditions (Kemp et al., 2010, Pacey et al., 2013). Content analysis of qualitative data revealed that these modalities are regarded as:

'…invaluable if parents and child know how to manage the condition, it can dramatically reduce the need for trips to hospital'

'…tools for self-management'

Reassurance is supported in the literature by LeBlanc and Houghton (2011). Content analysis revealed physiotherapists considered reassurance effective in addition to other treatment modalities but not alone, demonstrated with sample quotes:

'…always give home exercises in addition'

'…in mild cases especially when there is no pain'

'…confidence building and self-management'

Analgesics/NSAIDs, CBT and psychiatric referral were less favoured among rheumatologists (favoured by 14%, 4% and 1% respectively), whereas physiotherapists appeared open to a multidisciplinary approach. Pure analgesics are recommended in the literature for background pain control, and NSAIDs for inflammatory effusion, but only as part of a treatment program when required, not given alone (Eccelston et al., 2002, Davis and McDonagh, 2006, Simpson and Michael, 2006). Pharmacotherapy is reported as a modality for chronic musculoskeletal pain management in paediatrics, however the evidence base for the efficacy of such interventions is reported to be currently lacking (Clinch and Eccelston, 2009). CBT is reported as efficacious as a psychological intervention for chronic pain (Baeza-Velasco et al., 2011, Grahame and Kazkaz, 2014), and psychological assessment of patients is recommended for HMS patients (Baeza-Velasco et al., 2015) yet it is used by smaller proportions of medical professionals. Interestingly, content analysis revealed that access to these services depends on hospital resources and whether such expertise is available. The trend in responses showed more physiotherapists would use these services if they were available, demonstrated by sample quotes:

'…may be included if a specialist team is involved'

'…don't have access to a trained CBT but would be useful for those with chronic pain/other psychological issues'

'…some of our more severely affected patients have been treated with CBT at our children's centre and seem to have made some progress'

'...we are able to refer on to psychology if required, in these cases I have found it very effective in combination with physiotherapy'

Surgery and osteopathy/acupuncture were not favoured by medical professionals (Figure 3.4). 'Other' treatment modalities were reported to be used by a small percentage of physiotherapists. Themes from content analysis showed these to be hydrotherapy/aquatics, pain management, strength and conditioning, and occupational therapy, which was also suggested in the literature (Kuchta and Davidson, 2011). This data indicates a positive trend in combining methods in the treatment and management of HMS however, studies involving interventions and controlled trials are required to specifically test impact on paediatric HMS patients.

3.4.3.2 Physical Intervention Types

Within the present study, physical exercise interventions scored highly in perceived effectiveness for managing paediatric HMS, which is an expected finding, yet one that differs from rheumatologists' perceptions (Grahame and Bird, 2001), as previously discussed in Section 2.7. When carefully prescribed and supervised, exercise training for young people (Faigenbaum and Micheli, 2012) can be an appropriate intervention in both paediatric injury prevention and injury management programs to manage modifiable risk factors for musculoskeletal injury (Carter and Micheli, 2011). Physical interventions can also serve as strategies in the amelioration of symptoms such as pain and fatigue, which are sometimes initiated by deconditioning (Engelbert et al., 2006, Scheper et al., 2013a). As previously discussed, risk factors for symptoms and injury such as musculoskeletal instability, weakness, impaired coordination, impaired balance, reduced proprioception and endurance are modifiable with specific interventions, in contrast to non-modifiable risk factors such as genetics, gender and co-existing medical conditions.

Physiotherapists' preferences for physical interventions in Table 3.12 revealed the paramount importance of proprioception training (Fatoye et al., 2009, Pacey et al., 2014), balance training (Falkerslev et al., 2013) and muscular strength and endurance training (Kerr et al., 2000, Koutedakis et al., 2005, Pacey et al., 2013, Maillard, 2014, Junge et al., 2015b), in order to activate musculature in both neutral and hypermobile ranges of movement. This data corresponds with current literature as indicated however limitations of studies include the functional transferability of interventions to patients' lives, the unknown longer term impact due to relatively short interventions of 6 to 8 weeks, and the lack of longitudinal studies. Specific balance and postural stability training programs for HMS patients are currently recommended for children (Murray, 2006, Falkerslev et al., 2013) but have not been published to date. Core strengthening and conditioning to support the spine is recognised as important in the rheumatology literature (Bird, 2011), although to the author's knowledge, no intervention studies in paediatrics have been published to date. Stabilisation exercises engaging core musculature are recommended as part of a rehabilitation program to increase sacroiliac joint stability and reduce low back pain in a female tennis player (Vaughn and Nitsch, 2008). Key muscle groups targeted in a program designed to improve muscular endurance included transverse abdominis, rectus abdominis, internal and external obliques and multifidis. Similarly trunk stability training for a 16 year old male included muscles mentioned plus gluteal and pelvic floor muscles, lower and middle fibres of trapezius, serratus anterior and deep neck flexor muscles (Simmonds and Keer, 2008). The importance of core training is also illustrated in qualitative data:

'…especially postural endurance'

Aerobic/cardiovascular conditioning and flexibility training are advocated in the literature (Keer and Grahame, 2003, Grahame and Kazkaz, 2014), yet are considered very effective by slightly less than half the sample of physiotherapists, indicating these aspects of physical

conditioning are important as part of a program, but not as the key components. A sample quote from content analysis expressed understanding as follows:

'....effective to improve general fitness levels, plus confidence to return to exercise'

Manual therapy techniques such as remedial massage, soft-tissue release, muscle energy techniques, joint mobilisations and stretching to remove restrictions in tight, overactive musculature supporting hypermobile joints are used by a small proportion of respondents, yet are documented in the literature as beneficial interventions (Keer and Grahame, 2003, Simmonds and Keer, 2008, Vaughn and Nitsch, 2008, Toker et al., 2010). Specific applications drawn from qualitative data included:

'...we do a lot of work to release tight forearm pronators, transverse wrist arch and thumb adductors, also gently mobilise stiff thoracic spine'

'...massage and soft-tissue release for short-term relief only'

Heat packs and ice therapy are also recommended for symptomatic relief of pain and injury (Toker et al., 2010), while limited support is shown for the use of wrist and hand splints in paediatrics (Smith et al., 2014). Tape, proprioceptive neuromuscular facilitation (PNF) patterning, the use of mirrors (Simmonds and Keer, 2008) and Thera band (Pacey et al., 2013) in exercise training are reported to be beneficial in facilitating muscle activity and control of movement. Alternative interventions were disclosed by physiotherapists in qualitative responses and included:

'...hydrotherapy for the acute and severe patients where general strengthening and range of movement work can be carried out with reduced pain'

'orthotics'

'...advice, liaison with schools, referral to rehab group for graded increase in activities'

These strategies show positive diversity and creativity in clinical practice, yet to the author's knowledge these have not yet been formally tested in clinical trials.

The importance of physical exercise training is clear, yet due to the varying and fluctuating symptomatology, applying one exercise intervention to a group of paediatric HMS patients is problematic, unless the program is tailored to the developmental age and symptoms of children. Alternatively, case-by-case individualised management programs published in recent Case Reports (Vaughn and Nitsch, 2008, Kaux et al., 2013) allow greater specificity. It is highly likely that these programs are created and applied frequently in physiotherapy practice, although these are less frequently reported in the literature. While this results in lower levels of evidence, the interventions have shown merit and should not be disregarded. In any case, both intervention designs require needs analyses based upon accurate diagnosis and assessment of individual functional limitations and restrictions, which as previously discussed in Section 2.6, are currently not well defined.

3.4.3.3 Physical Interventions: Settings, Frequency and Challenges

Favoured settings for interventions showed a positive direction towards independence and development of skills in self-management (Table 3.13). As physiotherapy and rehabilitation professionals aim to work collaboratively with patients to enhance daily life, research agendas need to address the lived experiences of patients (Gibson and Martin, 2003) both within and outside physiotherapy clinic and hospital settings. A home exercise program is advocated in the literature (Pacey et al., 2013) with supplementary hand-outs of the physiotherapy program and use of an exercise diary completed by children and parents. It's important to bear in mind this is only possible for children if parents, medical and wider communities are aware of the importance of best practice in prevention and management of symptoms. This reinforces the need for education. Similarly, recommendations for frequency of exercise training reported in Table 3.14 point towards a high frequency, as also reported in the literature (Kemp et al., 2010, Pacey et al., 2013). However, awareness of

pacing is essential, in addition to the sensitive balance needed not to overdo the volume or intensity in home- and school-based sessions. This finding signifies the importance of regular paced exercise and conditioning for children to avoid cycles of deconditioning, fatigue and loss of stamina (Keer and Grahame, 2003). A guideline of 30 minutes per session of home-based exercises is given in a recent intervention study (Pacey et al., 2013). Existing challenges with compliance to programs and replicating correct exercise techniques reflected how important it is to embed exemplary practice in children and have them actively engaged in interventions (Table 3.15). Content analysis revealed more in-depth comments regarding challenges and issues with compliance to programs, which reflected those reported in current literature (Davis and McDonagh, 2006). Qualitative data disclosed:

'...home exercise programs seen as a chore'

'...meltdown and tiredness children experience after a full day at school trying to keep up with peers'

'...long term programs are difficult to maintain'

These comments from physiotherapists on the demanding nature of ongoing intensive physiotherapy are acknowledged in the literature (Simmonds and Keer, 2007) in addition to the importance of maintaining correct biomechanics through exercise and movement (Maillard, 2014). Physiotherapists' concerns about replicating correct exercise technique in home and school based programs are expressed in sample quotes from content analysis of data:

'...even with written programs patients can misunderstand advice and recommendations'

'...compliance, boredom, poor control and body awareness mean often done incorrectly'

'...we try to make exercises simple and provide detailed instructions with pictures, seeing patients every 6 to 8 weeks to ensure good technique'

Additional comments on the challenges of hospital, clinic or school-based interventions included:

'…missing school to attend hospital clinics and poor evidence for all physiotherapy management'

'…difficulty transferring to home (daily life) setting'

Further observations on challenges of home-based interventions revealed:

'…difficult to fit into routine if there are other children and busy parents'

'…time for teenagers and motivation for younger children'

3.4.4 Strengths and Limitations

To the author's knowledge, this is the first study to research understanding and trends in practice among the physiotherapy profession in the UK, following an initial report to the members journal of a professional body (Billings et al., 2012). The survey design advanced on previous quantitative-only research designs through the inclusion of open-ended questions. This design facilitated the return of in-depth, valuable, informative data in the form of individualised responses, which was previously recommended for clinical research in HMS (Bird, 2005, Simmonds and Keer, 2007). Overall findings are of genuine clinical relevance to medical professionals, patient groups and wider communities. Physical exercise interventions were explored in greater detail specific to the respondents' profession and expertise (Table 3.12).

It is acknowledged that this study has limitations. This survey of perceptions and experiences is based on a response rate of at least 28%, which yielded 102 completed surveys. Data attained from a lower response rate may be viewed as an inadequate reflection

of the profession and the author acknowledges that the research methodology has potentially not captured a full spectrum of practitioners. The overall response rate (ORR) in the present study compares with ORRs of 23% in a survey of paediatric occupational therapists (Baudinette et al., 2010), 28% ORR in a large-scale population postal survey to determine population prevalence of GJH and associations with reported musculoskeletal pain (Mulvey et al., 2013), and 29% ORR in an online survey of surgeons to determine the prevalence of alcohol abuse (Oreskovich et al., 2012). Online surveys typically achieve lower ORRs than paper-based surveys (Nulty, 2008), which have achieved higher response rates. In hypermobility studies, a 76% ORR was achieved using a paper-postal method of survey administration (Grahame and Bird, 2001), and in injury studies 80% ORR (Byhring and Bo, 2002) and 69% ORR (Briggs et al., 2009) were attained. In paediatric pain studies, 72% ORR was attained in a survey of non-specific neck pain in school children aged nine to twelve years old (Ståhl et al., 2008) and 82% ORR was achieved in a survey of chronic paediatric pain (Perquin et al., 2000).

Response bias in the data is possible due to people who do respond to surveys often providing different information to non-responders (Shank, 2012). Recall bias is also likely. As physiotherapists answered questions in retrospect, errors due to differences in accuracy or completeness of memory recall are possible. In depth information was attained using open-ended questions however these questions required more of the respondents' time to answer. While item twelve asked respondents for further comments on existing screening tools and an opportunity to report if alternative screening methods are used, only a small proportion of respondents engaged in giving additional detail. Physiotherapists were not specifically asked what they recommended or believed to be a better method of diagnosis and assessment of HMS in children, so there is a lack of data. The study would be strengthened with in-depth

data on sample physiotherapy programs and a more intensive inquiry into education, the highest scoring treatment modality.

3.5 Conclusions

The data serve as a needs analysis on which to focus developments in research and clinical practice. Furthermore, the data have answered the research questions presented in 3.1. Physiotherapists disclosed an accurate understanding of the causes, characteristics and consequences of HMS in paediatrics, clinical symptoms, injury and effects on quality of life. Trends in practice regarding diagnosis of HMS in paediatrics showed perceptions of current available tools being unsuitable for this population who require special considerations, while a 'gold standard' tool for functional assessment in paediatrics is yet to be established. Progressive positive trends were shown in treatment modalities, management programs and physical interventions but these require high quality evidence-based research focused on levels 1 and 2 of evidence.

Chapter 4: Study 2: Physical Assessment of HMS, Balance and Pain in Paediatrics

4.1 Introduction

An article has been published sharing preliminary findings from this study with research collaborators and study participants.

MOONEY, A. 2014. Hypermobility, Balance and Pain in Children. *Hypermobility Syndromes Association,* 2 Autumn/Winter, 41-44.

The study was conceived with supervisors Dr. Tony Turner and Dr. Simon Coleman. Alice Mooney developed the protocol, collected and analysed data and drafted the article.

In the preceding chapter 3, the current understanding of HMS in paediatrics among physiotherapists and current trends in physiotherapy practice were presented. This chapter comprises a second linked study, designed using the data in chapter 3 and published literature relating specifically to diagnosis of HMS in paediatrics. It has been shown that a higher proportion of physiotherapists perceive the current available diagnostic tools to be unsuitable for paediatric populations while a smaller proportion find the same tools to be effective. This study aimed to design and implement a novel screening tool by merging 4 existing tests that measure additional physical parameters, namely GJH, associated symptoms, balance skills and pain experience in paediatrics. These tests are detailed in 4.2.3.1 and 4.2.3.4. The Nine-Point Beighton Score (Beighton et al., 1973) and Revised Brighton Criteria (Grahame et al., 2000) were included as current "gold standard" assessments used in research in HMS in paediatrics (Evans et al., 2012, Nicholson et al., 2014, Soper et al., 2015) despite the known limitations. The Paediatric Balance Scale (PBS) (Franjoine et al., 2003) was included as a validated measure of balance in children considering the known challenges in balance and stability in this population, in addition to Study 1 results reported in Table 3.12 and discussed in 3.4.3.2 where 'Proprioception and Balance' training is the highest priority physical exercise intervention type recommended by

physiotherapists, also supported in the published literature (Fatoye et al., 2009, Pacey et al., 2014, Falkerslev et al., 2013). This signifies the importance of assessing and training this component of physical capacity in children with HMS. The PedsQL™ Paediatric Pain Questionnaire (PPQ) (Varni et al., 1987) was incorporated as a validated method of pain assessment in children. It's inclusion was deemed essential considering original data obtained in Study 1 regarding 'Clinical Symptoms' (Table 3.5) and 'Musculoskeletal Injury' (Table 3.6) in children with HMS and supported by current literature discussed in detail in 3.4.1.3. Tests were selected considering feasibility of time for the Principal Investigator to collect data working solo without assistance, also considering engagement of young children. This tool aimed to supplement current diagnostic tools with additional components of a test battery to capture a more complete profile of symptoms in the clinical and functional assessment of paediatrics, to uncover how HMS affects children, to determine the severity of symptoms and impairment and the extent of the impact of symptoms among this paediatric population. The study also aimed to use the tool to gather data on two groups of paediatrics, those with existing clinical diagnoses of hypermobility and children without diagnoses, and to measure differences between groups in a UK context.

Questions this study aimed to answer are presented below.

Research Question 1:

Is there a negative correlation between HMS and functional balance in paediatrics?

H_0 = There is no correlation between HMS and functional balance in paediatrics.

Hypothesis: There is a negative correlation between HMS and balance.

Research Question 2:

Is there a positive correlation between HMS and pain in paediatrics?

H_0 = There is no correlation between HMS and pain in paediatrics.

Hypothesis: There is a positive correlation between HMS and pain.

Research Question 3:

Is there a difference between clinical and control groups? I.e. do children with HMS exhibit lower functional balance skills and higher self-reported pain compared with children without HMS?

H_0 = There is no difference between groups.

Hypothesis: Children with HMS exhibit lower functional balance skills and higher self-reported pain when compared with age, gender and ethnicity matched children without HMS.

Research Question 4:

Is there disparity in trends of participation in physical activity, sport and dance among children in clinical and control groups?

H_0 = There is no difference between groups.

Hypothesis: Children with HMS engage in less hours and types of physical activities, sport and dance when compared with age, gender and ethnicity matched children without HMS.

4.2 Methods

4.2.1 Study Design

A cross-sectional, case control study design was employed, where study participants were tested on only one occasion, and data was examined at one point in time (Marino et al., 2012).

4.2.2 Participants

Two groups of study participants were recruited as convenience samples. Group 1 included children with clinical diagnoses of HMS and is referred to as the 'clinical' group. Group 2 included healthy children without HMS who were age and gender matched, and ethnicity matched (as far as possible) to children in group one and are referred to as the 'control' group. The recruitment of group 1 participants was achieved through collaboration with the HMSA (Appendix 5 and 6). A message requesting expressions of interest in taking part was circulated to HMSA members through the HMSA website, Facebook and Twitter, via the Senior Medical Liaison Officer and CEO. Interested parents/guardians of children with HMS responded confirming interest in being involved in the study.

Inclusion criteria for group one required participants to be:

1. Children (girls and boys) who received a clinical diagnosis of JHS, HMS, EDS-HM or GJH with pain and symptoms.
2. Children who had a formal letter confirming diagnosis from a clinician/physiotherapist/rheumatologist and who were able share a copy with the principal investigator in advance of testing.
3. Children aged 4 to 12 years old.
4. Children who could give verbal assent or written consent.
5. Children who were able to attend the HMSA Education Day for families (children and parents) on 26/07/2013 in London or 26/10/2013 in Leeds, or an additional testing day in Edinburgh or Glasgow.
6. Children who could speak and understand the English language.
7. Children who were in good health apart from symptoms of HMS.

Exclusion criteria for group one precluded:

1. Children without a clinical diagnosis of JHS, HMS, EDS-HM or GJH with pain and symptoms.

2. Children without a formal letter of diagnosis and/or who were unable to share a copy of a diagnosis letter with the principal investigator in advance of testing.

3. Children with other HDCTs distinct from JHS and EDS-HM, such as other variants of EDS, Marfans Syndrome and Osteogenesis Imperfecta.

4. Children younger than 4 years or older than 12 years old.

5. Children who were unable to give verbal assent or written consent.

6. Children who were unable to attend the HMSA Education Day for families on 26/07/2013 in London or 26/10/2013 in Leeds, or an additional testing day in Edinburgh or Glasgow.

7. Children who could not speak or understand the English language.

8. Children who were otherwise unwell, not in good health and/or for whom such a study would be contraindicated.

Recruitment of group two participants was organised through collaboration with Buckstone Primary School in Edinburgh, by contacting the Head Teacher and Deputy Head Teacher and requesting for the school's and students' involvement (n=20 students) (Appendix 16 and 17). A second wave of recruitment (n=5 students) took place with SIMMSAthletics at SIMMSport, St. Mary's University Twickenham, London, by contacting the Sport Development Officer. Additional inclusion criteria for group two necessitated participants to be children attending Buckstone Primary School in Edinburgh, Scotland, or SIMMSAthletics at SIMMSport, St. Mary's University Twickenham, London.

Table 4.1 Participant Characteristics

	Clinical (HMS) Group	Control Group
Cases	29	25
Gender (M & F) N (%)	14 M (48%) & 15 F (51%)	12 M (48%) & 13 F (51%)
Age Mean (SD)	8.11 (2.47) years (range 4 to 12)	
Ethnicity	White British (n=29)	White British/white Scottish (n=21), white Scottish Australian (n=1), white Scottish Dutch (n=1), black African (n=1) and Indian (n=1).

Note, there is missing data for two participants in the clinical group for the Nine-Point Beighton Score (Beighton et al., 1973) and the PBS (Franjoine et al., 2003) due to both participants being in lower limb cast/splint following injury.

4.2.3 Procedures

Ethical approval was obtained from the University of Edinburgh, Moray House School of Education Ethics Committee (Appendix 3 and 4). Disclosure was sought from the Protecting Vulnerable Groups (PVG) Scheme at Disclosure Scotland, confirming the principal investigator to be a PVG Scheme member in respect of regulated work with children. Both a 'Data Protection Agreement' and a 'Researcher Agreement to Share Data' document were signed for the HMSA, confirming that data handling would conform to the Data Protection Act (1998). A pack comprising hard copies of a Young Person Information Sheet (Appendix 7), a Young Person Informed Assent Form (Appendix 8), a Parent/Guardian Information Sheet (Appendix 9) and a Parent/Guardian Informed Consent Form (Appendix 10) was distributed to parents and children by post (Royal Mail) prior to testing. A Personal Details Form (Appendix 10) requested parents to share contact details including family post and

email addresses as well as further information including the child's age, gender and ethnicity, and participation in physical activities, sport and dance including the number of hours of activities per week separate to PE and any physiotherapy sessions, plus the types of physical activities. Additional information was requested from parents of group one participants through a simple questionnaire. It asked open-ended questions to retrieve details of HMS-related symptoms, current treatment and management plans, and musculoskeletal injury history including injury type and location. A database was created on receipt of returned documents. Further in-depth qualitative data was retrieved from parents/guardians via follow up email correspondence, and through one to one conversations in person at a subsequent HMSA Masterclass which the Principle Investigator was invited to share findings with families and medical professionals. Information Sheets and Informed Consent Forms detailed information about the study's aims, what would be involved in the proposed tests, and the possible risks and benefits. Children were required to understand the information given and to give verbal assent and/or written consent, in addition to the consent given by each child's parent/guardian by signing and returning the Parent/Guardian Informed Consent Form. The procedure reflected the guidelines published by the Ethics Working Group of the Confederation of European Specialists in Paediatrics (Gill et al., 2003). Steps taken ensured the study would respect the dignity of the child participants, safeguard the best interests of the children involved, protect the children from harm, assure and respect privacy, and protect confidentiality. Permission to use the PedsQL™ Paediatric Pain Questionnaire (Varni et al., 1987) was obtained from the MAPI Research Trust (Appendix 11) and a user agreement was signed. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement checklist (von Elm et al., 2007) was considered in reporting the present study.

4.2.3.1 Instruments

A. Nine-Point Beighton Score (Beighton et al., 1973) (Figure 2.1) assessed GJH.

B. Revised Brighton Criteria (Grahame et al., 2000) (Table 2.4) measured symptoms associated with HMS.

C. Paediatric Balance Scale (PBS) (Franjoine et al., 2003) (Appendix 13) measured functional static and dynamic balance in the context of everyday tasks, through a set of 14 short tests modified from the Berg Balance Scale (BBS) for adults (Berg et al., 1992).

D. PedsQL™ Paediatric Pain Questionnaire (PPQ) (Varni et al., 1987) (Appendix 14) measured the intensity and location of musculoskeletal pain experienced by children.

4.2.3.2 Skills Training

Range of movement of knee and elbow joints were measured using goniometry, and reliability testing (inter-rater and intra-rater) was completed in February 2011 using a convenience sample of university students. Subsequently, techniques were applied to a group of dance students (n=94) at Knightswood Dance School of Scotland in March 2011. The group included female (n=70) and male (n=23) students, ranging from age 11 to 17, with a mean (SD) age of 13.66 (1.57) years. The principal investigator also attended a training meeting with a Clinical Specialist Physiotherapist in paediatric rheumatology at the Royal Hospital for Sick Children, Edinburgh, Scotland, to confirm correct administration of the Nine-Point Beighton Score (Beighton et al., 1973). Each test was demonstrated then movement was passively assisted in each child so that range and quality of movement of the joints could be observed, including observations on feelings of laxity, looseness, emptiness, stiffness, restriction etc. Elbow joints were tested by extending each arm while the therapist supported either side of the joint. Knee joints were tested firstly with the child lying supine and lifting one leg while the therapist supported either side of the knee joint, and lastly the child reaching to touch their toes while standing with feet together and knees straight.

4.2.3.3 Pilot Study

In advance of the full study, the study protocol was administered to a small sample of children who were not involved in the later formal data collection. This gave the chance to practice instructions, to measure time taken per child and to gain feedback from children on the clarity of instructions and any difficulties or problems regarding understanding what they were being asked to do. Three girls aged 8, 10 and 11 who were members of a local football team were tested in July 2013. The children reported that activities in the PBS tests were difficult without using arms for support, that they found it useful to stare at a spot to keep balance and to use the foot prints provided. The PedsQL™ PPQ was the most difficult assessment for children to understand and complete. Instructions for the body map exercise on page two were confusing for all children. Adjustments were made to simplify the language used by the principal investigator. For example, when asking children to match a colour to each pain type, language was changed to *"...pick a colour that reminds you of a day you feel no pain, a little pain etc. and colour in the box with the colour you picked"*. When asking children to use chosen colours on the body map to reflect and illustrate the location of their pain, language was adjusted to, *"...using the red marker you picked that reminds you of feeling a lot of pain, colour in anywhere in the body picture that you feel this pain".*

4.2.3.4 Administration of Tests

Group one participants were tested while attending the HMSA Family Education Events. Children were accompanied by parents/guardians and testing was carried out parallel to education sessions on pain management, positive thinking about hypermobility and children's activities. Group two were tested at Buckstone Primary School while accompanied by a teacher, or at SIMMSAthletics sports camp while accompanied by a sports coach.

A. The Nine-Point Beighton Score was administered to each child individually. Due to the standardised protocol described by Juul-Kristensen et al. (2007) considering adults not paediatrics, the protocol used by the clinic was employed. Scoring was completed as described in 2.6.1 with a cut-off point for GJH of ≥ 4/9, and recorded on a form (Appendix 12).

B. The Revised Brighton Criteria were completed for each child individually by considering Nine-Point Beighton Scores and PPQ data, consulting the clinical diagnosis letters and medical history records, and through questions to the parent/guardian of each child. Scoring was calculated as described in 2.6.1. and recorded on a form (Appendix 12).

C. The PBS tests were carried out on each child individually using the protocol for PBS test administration and scoring described (Franjoine et al., 2003). The static balance tests included sitting to standing, standing to sitting, transfers, standing unsupported, sitting unsupported with back unsupported on the floor, standing unsupported with eyes closed, standing unsupported with feet together, standing unsupported in tandem stance, and standing on one leg. The dynamic balance tests were turning 360 degrees, turning to look behind over left and right shoulders while standing, picking up an object from the floor from a standing position, placing alternate feet on a step or stool for eight counts while standing unsupported, and reaching forward with outstretched arm while standing. Each test was measured on a scale of 0 to 4, where 0 indicates loss of balance or impaired balance and 4 indicates competent performance in the test. For example, in test 1 (sitting to standing), 4 indicates the participant being able to stand without using hands to stabilize independently, 3 indicates the ability to stand independently using hands, 2 indicates being able to stand using hands after several tries, 1 indicates the need for minimal aid to stand or

stabilize, and 0 indicates the need for moderate or maximal assistance to stand. Test scores are added together and there is a maximum possible score of 56 for accumulated test scores. The final score corresponds to one of three categories: 0–20 indicates high risk of balance impairments/instability, 21–40 indicates moderate risk and 41–56 indicates low risk.

D. The PedsQL™ PPQ was administered as a self-report questionnaire completed by each child, and a separate version was completed by their parent/guardian on what they consider is their child's pain experience. Pain intensity of both current pain/discomfort and the worst pain/discomfort experienced in the previous seven days were measured using a 0 to 10 centimetre VAS, with a happy face at 0 indicating no pain or hurt, and a sad face at 10 indicating maximum pain or hurt. Musculoskeletal pain location was recorded on a map of the body showing both anterior and posterior aspects. Children were asked to choose four colours that reminded them of the following: no pain or hurt, a little pain or hurt, a moderate amount of pain or hurt and a lot of pain or hurt. Children were then asked to shade each category using coloured markers, and to shade parts of the body where they experience pain using corresponding colours. Parents were asked to mark areas on the body map with an X, and to number areas in order of priority with number one being the part of the body where the most pain is experienced (Appendix 14). Two versions of the PedsQL™ PPQ exist, one for 5 to 7 year olds and another for 8 to 12 year olds. Both have corresponding parent/guardian questionnaires.

4.2.4 Data Analysis

Quantitative data were analysed using IBM SPSS Statistics 21. Due to the data being predominantly ordinal a selection of non-parametric tests were used in statistical analyses.

The Spearman Rank-Order Correlation Coefficient, also known as Spearman's Correlation, was used as a non-parametric measure of the strength and direction of correlation that existed between two variables without normal distributions, measured on an ordinal scale (Sedgwick, 2012b). The test assumes a monotonic relationship exists between two variables i.e. either the variables increase in value together, or as one variable value increases, the other variable value decreases. This test was used to measure correlations between hypermobility scores and balance scores, and hypermobility and pain intensity scores. The Mann-Whitney U Test was used to compare differences between two independent groups i.e. the clinical and control groups. It is a non-parametric or distribution-free method. The test makes no assumptions about the distribution of the data in the population or equality of variances between groups (Sedgwick, 2012a). Data are illustrated in box plots in the same format used in published research (Fatoye et al., 2012, Soper et al., 2015). Boxplots show median values, interquartile ranges and 'whiskers' above and below the box which indicate minimum and maximum values. The Independent Samples t-Test, a parametric method, was used to compare means of a variable i.e. Hours of Physical Activity between two independent groups (Sedgwick, 2010). It assumes a normal distribution in the population and equality of variances between groups. The Wilcoxon Signed-Rank Test, a nonparametric test that does not assume normality in the data, was used to compare two sets of scores from the same participants, and to measure any change in scores from one time point to another such as present pain intensity and pain intensity in the previous 7 days, also to measure the relationship between children's pain ratings compared with parent/guardians ratings of children's pain. The level of significance was set at $\alpha < 0.05$. Supplementary qualitative data obtained from parents/guardians of children with HMS via email correspondence and one to one conversations were interpreted in context of results data and are expressed using sample quotations with individual participant identification numbers.

4.3 Results

4.3.1 Frequency of GJH in Paediatrics

GJH was observed in paediatrics with a mean (SD) score of 4.86 (2.17) range 0-8/9. Specifically, 35/52 (67.3%) of children scored ≥4/9 and 17/52 (32.6%) scored <4/9 in the Nine-Point Beighton Score (Figure 4.1).

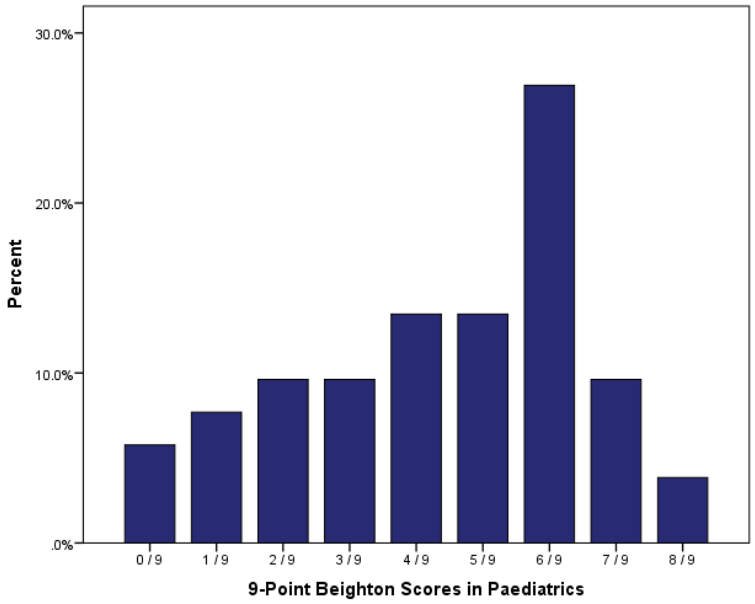


Figure 4.1 Frequency of Nine Point Beighton Scores for GJH in Paediatrics

The Mann-Whitney U test demonstrated a significant difference between the clinical and control groups ($Z = -5.348$, $P<0.001$) indicating higher Nine-Point Beighton Scores were observed in the clinical group (mean (SD) score 5.85 (1.19) range 3-8/9) when compared with the control group (mean (SD) score 2.76 (1.83) 0-6/9) (Figure 4.2).

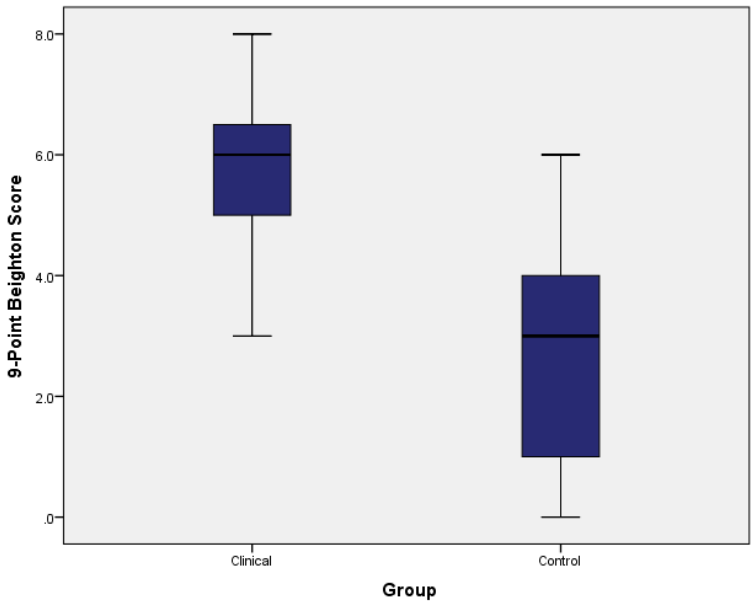


Figure 4.2 Nine-Point Beighton Scores in Clinical and Control Groups

4.3.2 Frequency of HMS in Paediatrics

As illustrated in Figure 4.3 and Table 4.2, 25/54 (46.2%) of paediatrics conform to the Revised Brighton Criteria for HMS on the basis of 2 major criteria, 1 major and 2 minor criteria or 4 minor criteria. This comprised 25/29 (86.2%) of children in the clinical group and 0/25 (0%) of the control group. The Mann-Whitney U test demonstrated a significant difference between groups ($Z = -5.396$, $P<0.001$).

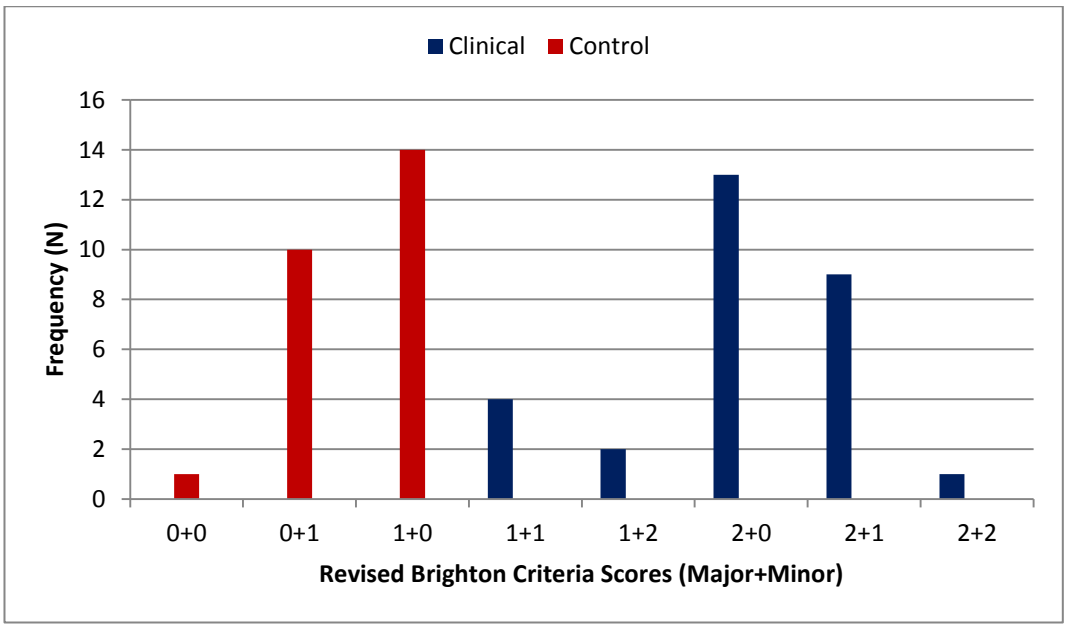


Figure 4.3 Frequency of Revised Brighton Criteria Scores for HMS in Paediatrics

Table 4.2 Revised Brighton Criteria Scores in Paediatrics

Revised Brighton Criteria		Clinical Group N (%)	Control Group N (%)
Major 1	Beighton Score ≥ 4/9	28 (96.5)	10 (40.0)
Major 2	Arthralgia > 3 months in ≥ 4 joints	25 (86.2)	0 (0.0)
Minor 1	Beighton Score of 1, 2, 3/9	1 (3.4)	9 (36)
Minor 2	Arthralgia ≥ 3 months in 1 to 3 joints *or* back pain ≥ 3 months	4 (13.7)	1 (4.0)
Minor 3	Dislocation/subluxation in 1+ joints *or* in 1 joint on 1+ occasions	10 (34.4)	0 (0.0)
Minor 4	Soft tissue rheumatism ≥ 3 lesions	0 (0.0)	0 (0.0)
Minor 5	Marfanoid habitus	0 (0.0)	0 (0.0)
Minor 6	Abnormal skin (striae, hyperextensibility, papyraceous scars)	3 (10.3)	0 (0.0)
Minor 7	Ocular signs (myopia, drooping eyelids)	0 (0.0)	0 (0.0)
Minor 8	Varicose veins *or* hernia *or* uterine/rectal prolapse	0 (0.0)	0 (0.0)

4.3.3 Functional Balance in Paediatrics

Paediatric Balance Scale scores among the sample revealed a significant difference between the clinical and control groups (Z = -5.470, P<0.001) confirmed by the Mann-Whitney U test. Children in the control group achieved a mean score of 42.8/56 indicating low risk, when compared with children with HMS whose mean score of 33.3/56 indicated predominantly moderate risk in addition to some high risk, low risk and children who were unable to complete the tests due to injury (n=2) (Figure 4.4).

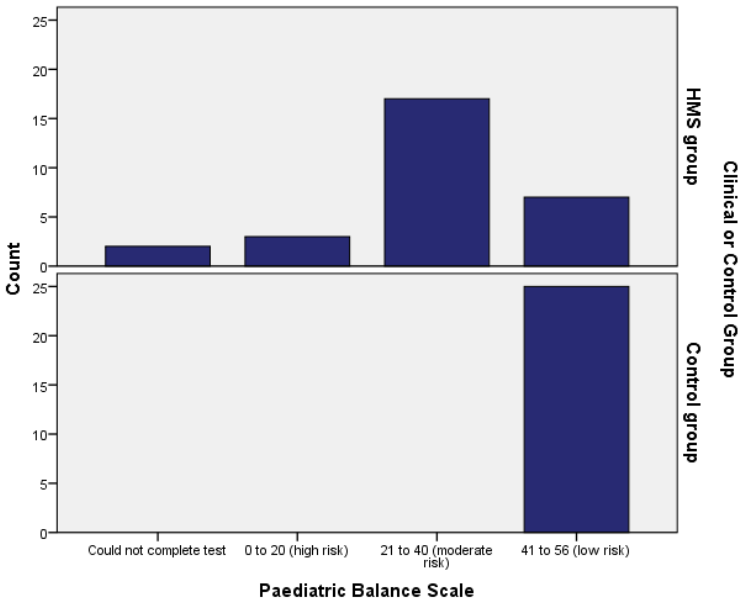


Figure 4.4 Frequency of PBS Scores in Paediatrics

PBS scores showed a significant negative correlation with Nine-Point Beighton Scores (r_s = -0.616, P<0.001) confirmed by Spearman Rank-Order Correlations (Figure 4.5). The data indicate that higher hypermobility scores are associated with lower functional balance skills. In addition, the correlation is almost zero if the clinical group is considered without the control group.

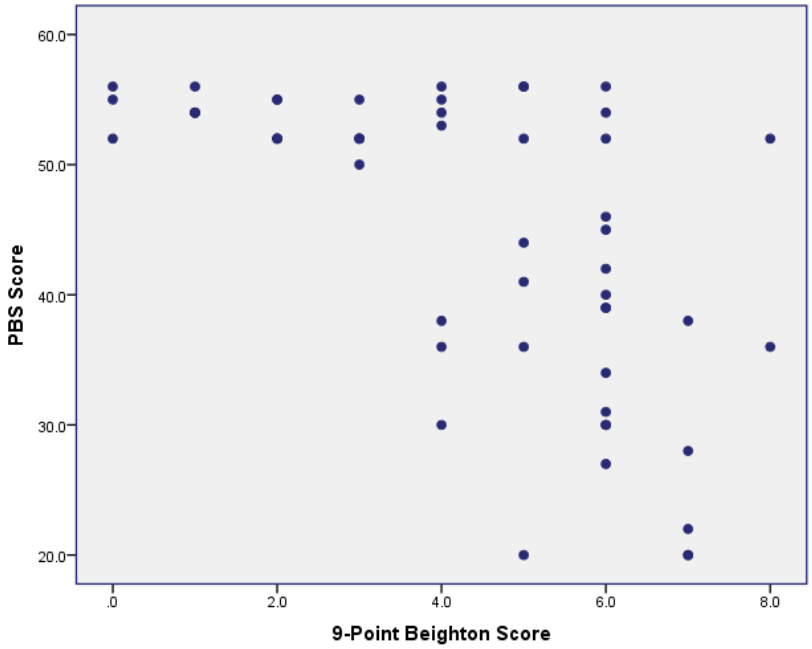


Figure 4.5 Nine-Point Beighton Score and Balance Correlation in Paediatrics

A significant negative correlation was found between Paediatric Balance Scale scores and Revised Brighton Criteria scores (r_s -0.836, P<0.001) confirmed by Spearman Rank-Order Correlations (Figure 4.6). Note many data points within t are overlapping. This revealed how children experiencing symptomatic hypermobility scoring major and minor criteria also demonstrate lower functional balance skills.

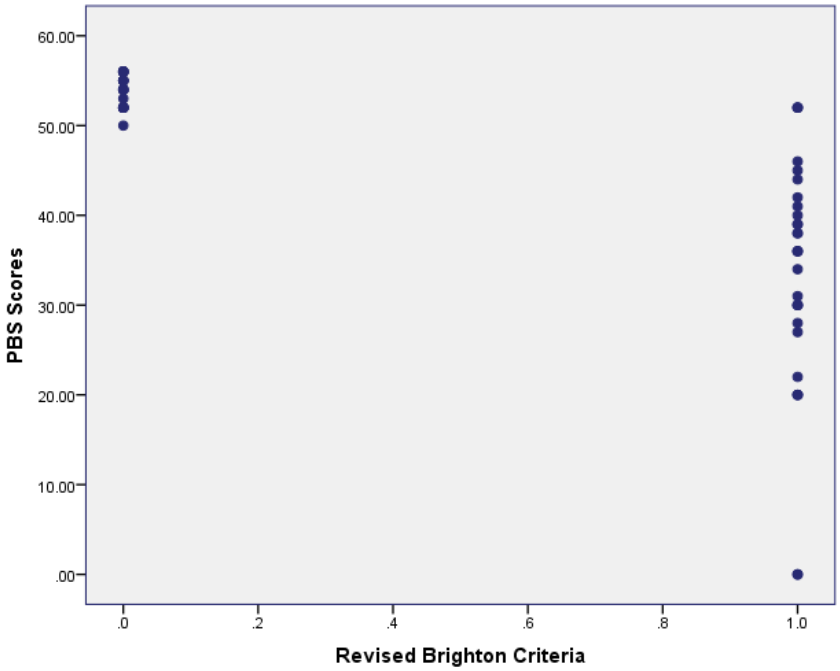


Figure 4.6 Revised Brighton Criteria and Balance Correlation in Paediatrics

4.3.4 Pain Intensity in Paediatrics

Present Pain Intensity in Paediatrics

Pain levels in the sample of children scored a mean (SD) of 2.24 (2.73), range 0-10. The Mann-Whitney U test demonstrated a significant difference between the clinical and control groups (Z = -4.339, P<0.001) indicating that on testing days, children with HMS reported higher levels of pain experience (mean (SD) score 3.51 (2.74), 0-10) when compared with controls (mean (SD) score 0.76 (1.85), 0-8) (Figure 4.7).

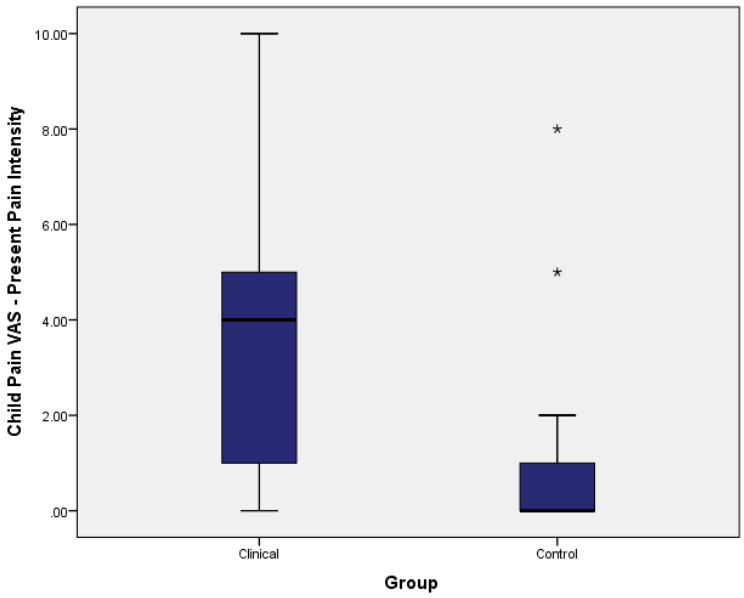


Figure 4.7 Present Pain Intensity in Clinical and Control Groups

Pain Intensity in the Previous 7 Days in Paediatrics

Self-reported pain experience in the previous 7 days was evident in the sample of children mean (SD) score of 4.44 (3.52), range 0-10. The Mann-Whitney U test demonstrated a significant difference between the clinical and control groups ($Z = -4.894$, $P<0.001$), where children with diagnoses of HMS exhibited higher pain VAS scores (mean (SD) 6.55 (2.72), range 1-10) when compared with non-hypermobile controls (mean (SD) score 2.0 (2.69), 0-8) (Figure 4.8).

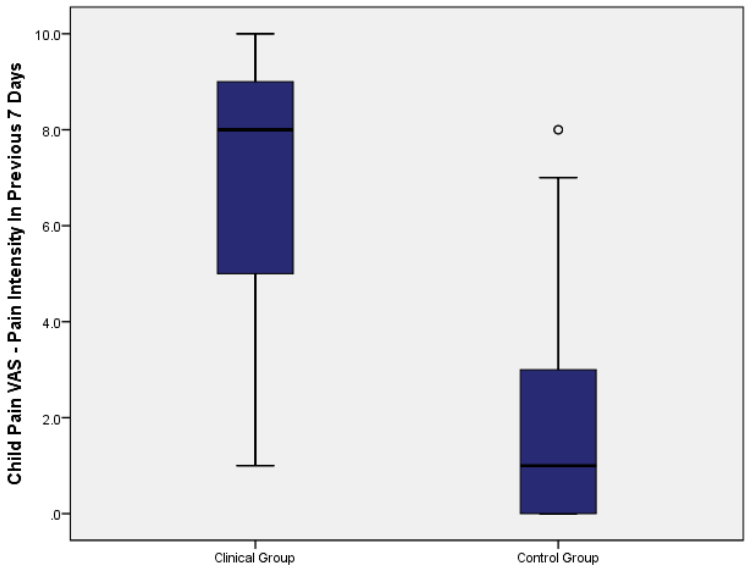


Figure 4.8 Pain Intensity in the Previous 7 Days in Clinical and Control Groups

Pain VAS scores were positively associated with Nine Point Beighton Scores (r_s 0.552, P<0.002) confirmed by Spearman Rank-Order Correlations, illustrated including a 'line of best fit' (Figure 4.9). This finding shows that increased pain intensity is associated with higher hypermobility scores. Note that some data points overlap.

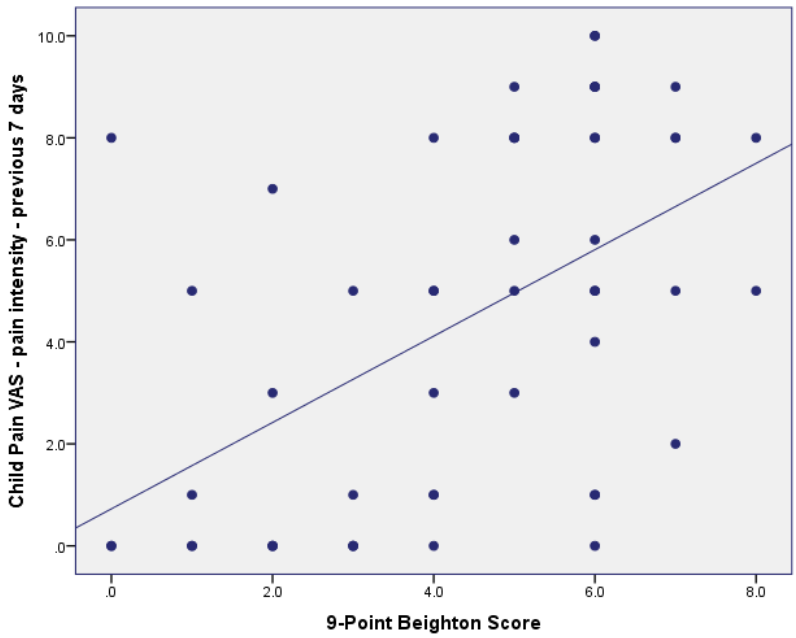


Figure 4.9 Nine-Point Beighton Score and Pain Intensity Correlation in Paediatrics

Pain VAS scores were positively associated with Revised Brighton Criteria Scores (r_s 0.672, p<0.001) confirmed by Spearman Rank-Order Correlations illustrated including a 'line of best fit' (Figure 4.10). Note that some data points are overlapping.

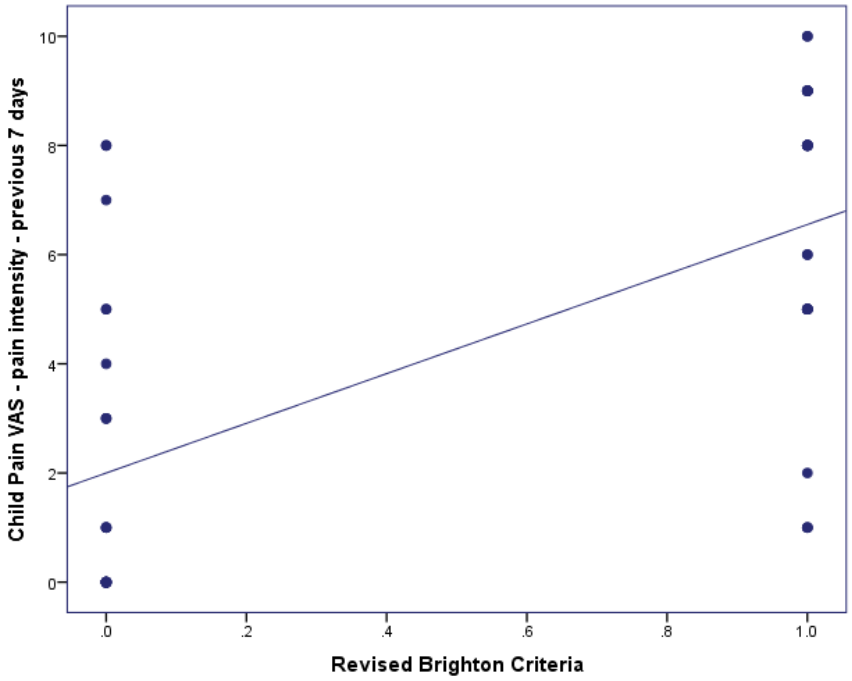


Figure 4.10 Revised Brighton Criteria Score and Pain Intensity Correlation in Paediatrics

Parent/Guardian Ratings of Present Pain Intensity in Paediatrics

Parents' pain VAS ratings of children with HMS exhibited higher mean (SD) scores of 4.0 (2.47), range 0-9 when compared with pain VAS ratings of parents of children in the control group (mean (SD) 0.56 (1.44), 0-6). A significant difference (Z = -5.373, P<0.001) was demonstrated between groups using the Mann-Whitney U test (Figure 4.11).

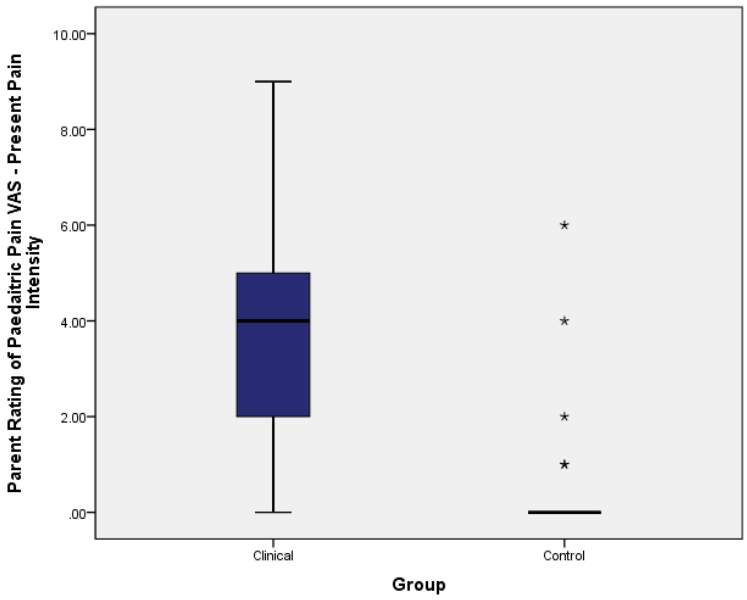


Figure 4.11 Parent/Guardian Ratings of Present Pain Intensity in Paediatrics

Parent/Guardian Ratings of Pain Intensity in the Previous 7 Days in Paediatrics

Parents' ratings of children's pain were higher among parents of children with HMS, mean (SD) VAS score of 7.03 (2.41) range 2-10 in contrast with parents of children in the control group (mean (SD) 0.88 (1.94) 0-6) (Figure 4.12). A significant difference ($Z = -5.932$, $P<0.001$) was demonstrated between groups confirmed by the Mann-Whitney U test.

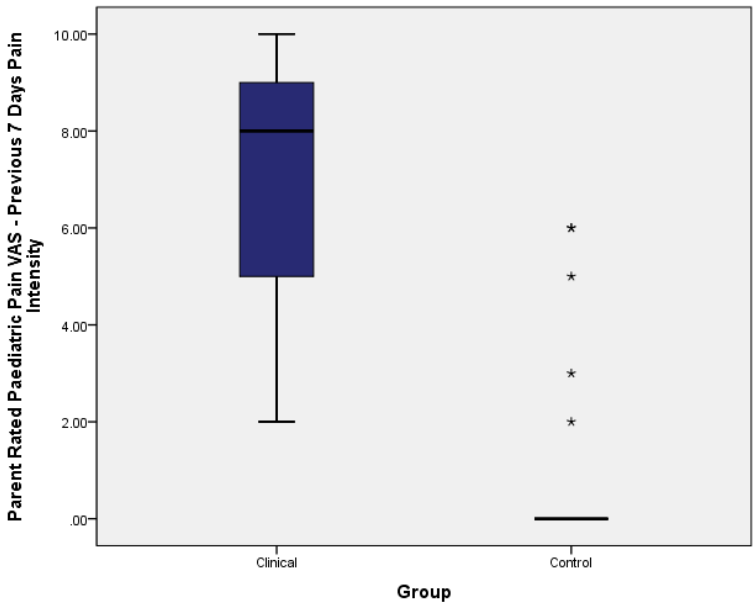


Figure 4.12 Parent/Guardian Ratings of Pain Intensity in the Previous 7 Days in Paediatrics

Correlation of Hypermobility and Parent/Guardians Rating of Children's Pain Intensity

Parent/Guardian 7 Days Pain VAS scores were positively associated with Nine Point Beighton Scores (r_s 0.571, P<0.001) confirmed by Spearman Rank-Order Correlation (Figure 4.13). This finding shows that higher pain intensity ratings by parents/guardians considering their children's pain are associated with higher hypermobility scores in children.

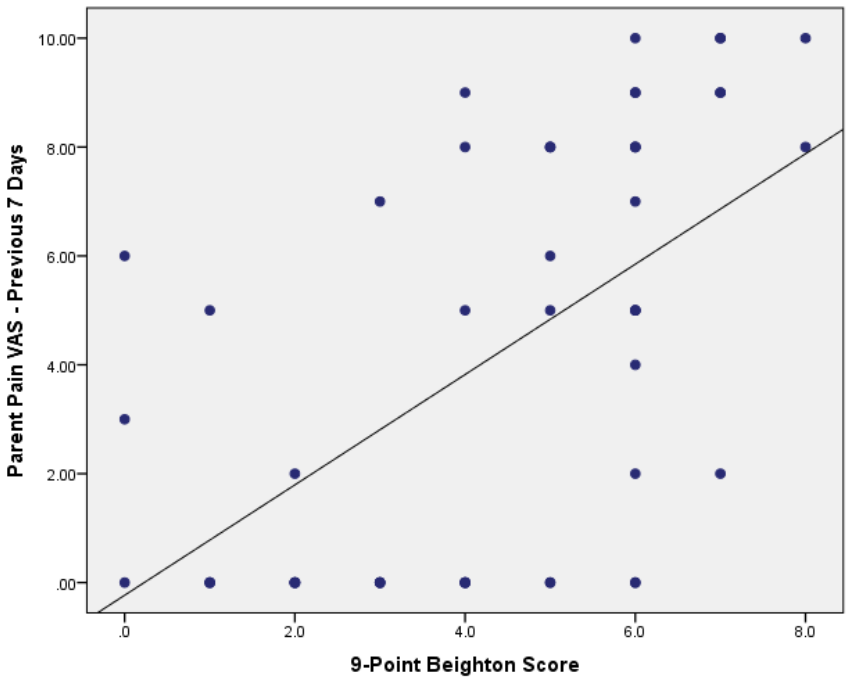


Figure 4.13 Correlation Between Hypermobility and Parent/Guardians Rating of Children's Pain Intensity.

Children's Ratings of Present Pain Intensity Compared to Parent/Guardian Ratings

The Wilcoxon Signed-Ranks Test revealed no significant difference between children's and parent/guardians pain VAS scores (Z = -946, P=0.344) suggesting parents of children in both clinical and control groups have a true awareness of children's pain intensity (Figure 4.14).

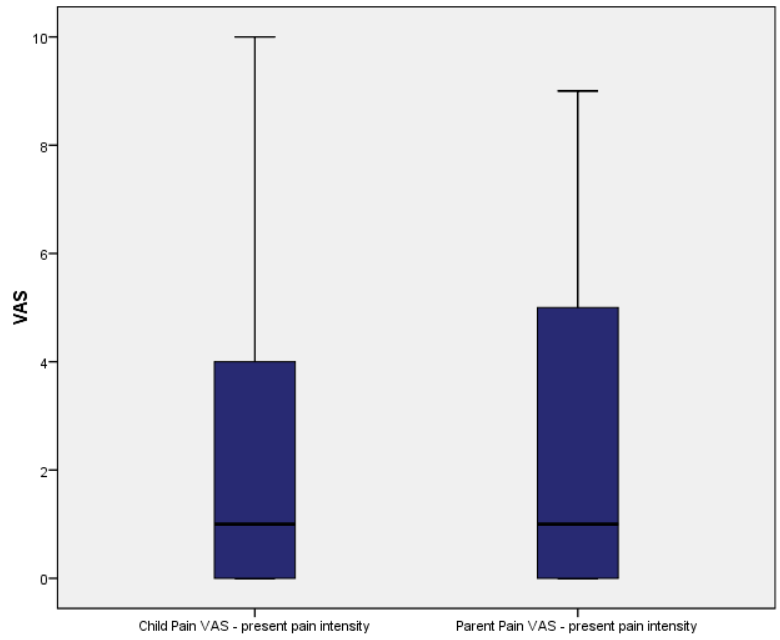


Figure 4.14 Children's Ratings of Present Pain Intensity Compared to Parent/Guardian Ratings

Children's Ratings of Pain Intensity in the Previous 7 Days Compared to Parent/Guardian Ratings

No significant difference was shown between children's and parent/guardians pain VAS scores (Z = -672, P=0.502) using the Wilcoxon Signed-Ranks Test (Figure 4.15). This suggests parents have an accurate awareness of their children's pain intensity.

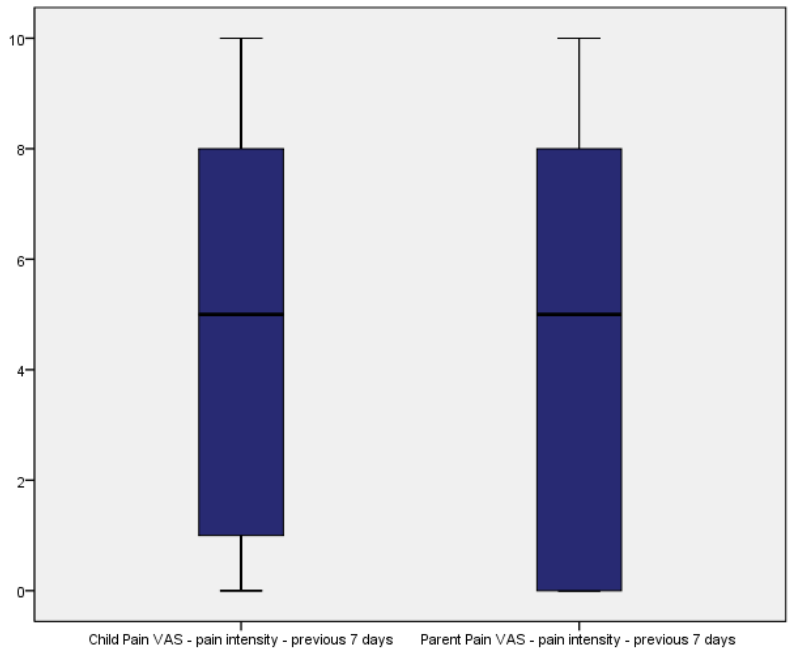


Figure 4.15 Children's Ratings of Pain Intensity in the Previous 7 Days Compared to Parent/Guardian Ratings

4.3.5 Pain Location in Paediatrics

A body map of child pain location in the parent version PedsQL™ PPQ was completed by 17/29 (72%) of parent/guardians of children in the clinical group (Table 4.3).

Table 4.3 Pain Location in Paediatrics with HMS Reported by Parent/Guardians

Pain Location	%
Knees	82
Ankles	70
Wrists	52
Elbows	35
Cervical spine (neck)	35
Lumbar spine (lower back)	29
Shoulders	23

Fingers, thumbs, hands	23
Stomach	17
Headache	11

A body map of illustrated expressions of pain location and pain category/level by colour was completed by all children in the child version PedsQL™ PPQ (Figure 4.16 and Table 4.4).

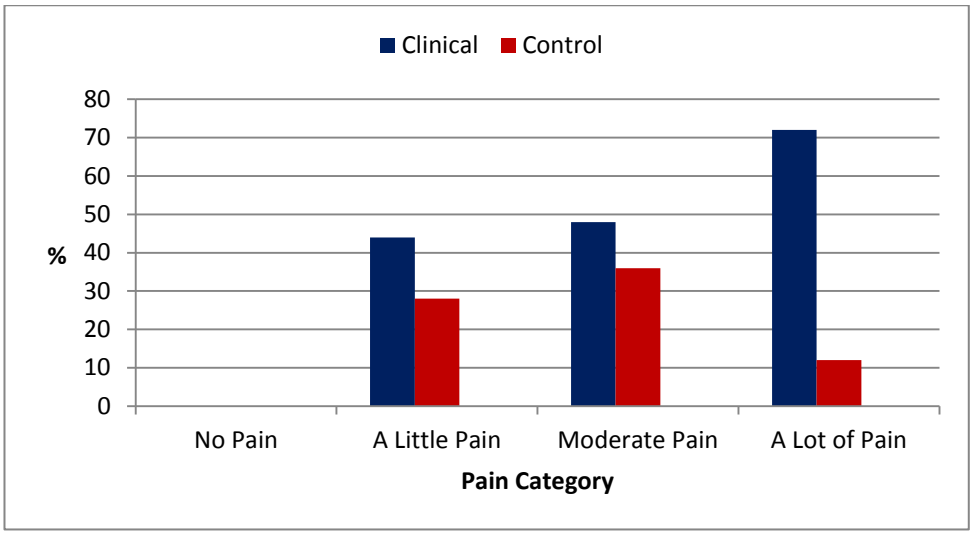


Figure 4.16 Pain Experience Reported by Paediatrics in Child Version PedsQL™ PPQ

Table 4.4 Number of Pain Locations Reported by Paediatrics in Child Version PedsQL™ PPQ

	N of Pain Locations	
	Clinical	Control
No Pain/Hurt	0	0
A Little Pain/Hurt	1-2	1
Moderate Pain/Hurt	1-4	1-2
A Lot of Pain/Hurt	2-10	1

More cases of pain and a higher number of pain locations in 3 categories were reported by the clinical group most strikingly in the ‘a lot of pain/hurt’ category (Table 4.4).

4.3.6 Trends in Physical Activity, Sport and Dance in Paediatrics

Number of Hours of Sport, Exercise, Dance Children Engaged in Per Week

An Independent Samples t-Test indicated a significant difference between clinical and control groups (P<0.001) where children with diagnoses of HMS engaged in markedly less hours of sport, exercise, dance per week (0-4 hours) compared to healthy controls (5-12 hours) (Figure 4.17).

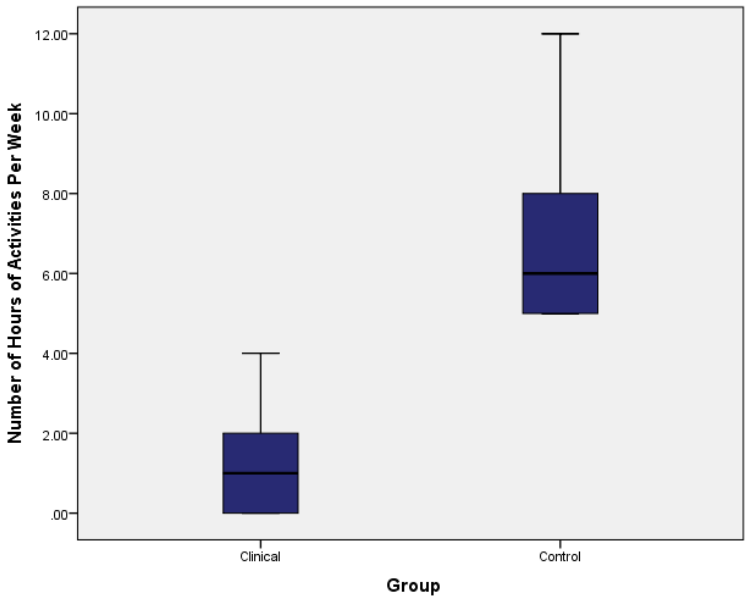


Figure 4.17 Number of Hours of Activities in Paediatrics

Number of Different Activities Children Engaged In

The Mann-Whitney U test revealed a significant difference between the clinical and control groups ($Z = -5.348$, $P<0.001$) indicating that children with HMS engaged in a distinctly narrower range of 0 to 3 activities when compared to control group participants who participated in 1 to 6 activities (Figure 4.18).

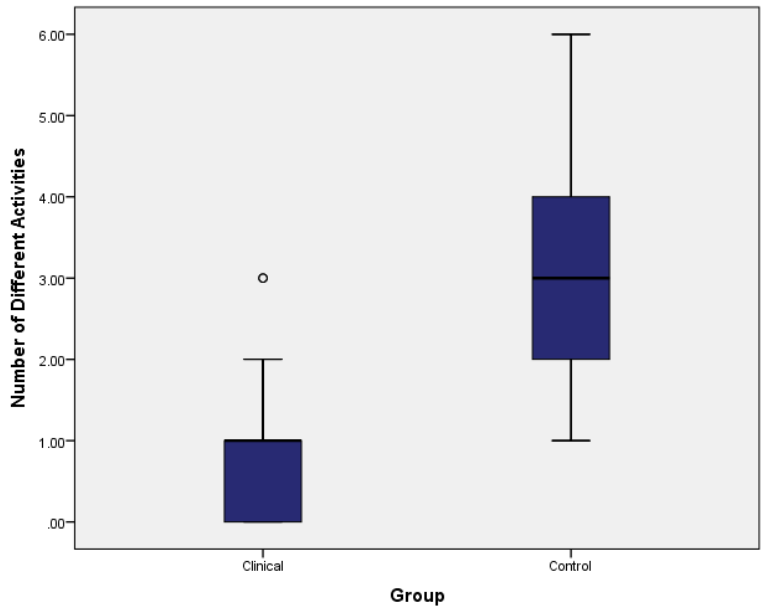


Figure 4.18 Number of Different Activities in Paediatrics

4.4 Discussion

This study set out to establish if hypermobility is associated with functional balance and pain in paediatrics with HMS, and if distinct differences are apparent in these children when compared with children without HMS. Statistically significant correlations were discovered for both functional balance and pain detailed in 4.4.2 and 4.4.3 and contrast was revealed between clinical and control groups in symptoms, function and trends in physical activity.

4.4.1 Prevalence of GJH and HMS in Paediatrics

The established prevalence of GJH ≥4/9 in 67.3% of paediatrics assessed is similar to other cohorts in published studies noted in Table 2.5 such as 64.4% in Dutch children (Smits-Engelsman et al., 2011), 58% in Danish children (Juul-Kristensen et al., 2009), 58% in Indian children (Hasija et al., 2008), 64.4% in Brazilian children (Lamari et al., 2005) and 63% in elite British netball players (Soper et al., 2015) although this last cohort comprised an older 16-24 year old age category. Prevalence in the present study was higher when compared with lower prevalence rates of 9.4% in Danish children (Gyldenkerne et al., 2007), 22.2% in Italian children (Leone et al., 2009) and 37% in Pakistani children (Qureshi et al., 2010). Trends in data showed the clinical group scored highly in major 1 and major 2 criteria, minor criteria 3 indicating injury and minor criteria 6 indicating scarring (Figure 4.3 and Table 4.2). The confirmation of HMS among 86.2% of children in the clinical group was anticipated (Figure 4.3 and Table 4.2). It is slightly less than studies which in the same way recruited paediatric patients with existing clinical diagnoses, detailed in Table 2.5, such as 94% in Australian children (Nicholson et al., 2014) and 94% in British children and adolescents <18 years (Adib et al., 2005). It was interesting that only 11/29 children with HMS were able to complete Nine-Point Beighton Score test 9 i.e. touching the floor with palms of hands while keeping knees straight. The principal investigator observed this finding in the presence of tight hamstring muscle groups. Tightness in hamstrings can present in overactive muscle fibres overused trying to support hypermobile knee and hip joints, and/or due to prolonged spells sitting at a desk at school. The presence of some level of GJH was revealed in 19/25 (76%) of paediatrics in the control group (Table 4.2) who scored frequently in major 1, minor 1 and minor 2 criteria indicating a prevalence of asymptomatic GJH. These findings related to GJH and HMS raise the question of how children in the present study will be affected as they grow and mature beyond 12 years old into adolescence and young adulthood. Only a longitudinal research study tracking patients

over time can answer this question, which is beyond the scope of the present study but is recommended for future research.

4.4.2 Functional Balance and HMS in Paediatrics

Nine-Point Beighton and Revised Brighton Criteria scores were significantly negatively associated with PBS scores (r_s = -0.608, P<0.001) and (r_s -0.751, P<0.001) respectively (Figure 4.5 and Figure 4.6). This finding indicates that increased GJH and HMS and reduced balance and stability are associated in paediatrics which rejects the null hypothesis and answers research question 1 regarding the negative correlation between hypermobility and functional balance in paediatrics. Data demonstrated a distinct difference between groups, whereby children with lower Nine-Point Beighton Scores of <4/9 showed enhanced static and dynamic balance skills with lower risk of instability (Figure 4.4). Components of the PBS children with HMS found particularly challenging were standing with eyes closed (PBS test 6), tandem balance (PBS test 8) and one leg standing (PBS test 9) which tested both static postural-stability and dynamic postural-control (Gribble et al., 2012). Impaired performance in tests is an indicator of reduced stability and possible risk factors for injury. Fatigue was apparent in the execution of PBS test 13 i.e. 8 alternate feet taps on a step, which is also reported in the literature (Scheper, 2014, Scheper et al., 2014). Dynamic balance during gait in children with GJH was investigated (Falkerslev et al., 2013) and decreased trunk stability and delayed loco-motor development was found when compared to children without GJH. This finding illustrates how motor coordination and movement patterns are affected in children with GJH. In addition, another study reported difficulties for children with HMS in physical activities that require balance and coordination such as cycling a bicycle (Schubert-Hjalmarsson et al., 2012). Qualitative data obtained from a parent in the present study supports these concerns about her son, a clinical group study participant as follows:

"…he is unable to kick a ball or ride a bicycle without stabilisers at 7 years old" (Parent of Participant No. 10, 2013 personal communication)

"…swimming I'm not sure if it helps, he really struggles to coordinate the movements and is exhausted afterwards so needs his chair as he physically can't walk after (Parent of Participant No. 7, 2013, personal communication).

Data on deficits reinforce the significance of proprioception, balance and strength training to restore motor control of lower limbs and assist in maintaining balance and function which is also advocated in the literature (Ferrell et al., 2004, Simmonds and Keer, 2007, Sahin et al., 2008, Kemp et al., 2010, Pacey et al., 2013, Pacey et al., 2014, Bale et al., 2014), also supported by UK physiotherapists surveyed in study 1 (Table 3.10). Further research on other symptomatic joints in addition to the knee, would add to the evidence base in this area.

4.4.3 Pain Intensity and HMS in Paediatrics

Significant positive correlations (r_s 0.552, P<0.002) and (r_s 0.672, p<0.001) confirmed between pain VAS scores and Nine-Point Beighton Scores for GJH and Revised Brighton Criteria for HMS respectively (Figure 4.8) reject the null hypothesis and answers research question 2 regarding a positive correlation between hypermobility and pain in paediatrics. Considering clinical and control groups separately, correlations were not statistically significant for the clinical group alone (r_s 0.031, P<0.879) or the control group alone (r_s 0.219, P<0.293). Pain experience among paediatrics in the present study is clearly evident and must not be dismissed. Contrast exists between children with HMS and those without supported by additional data (Figure 4.7, Figure 4.8, Figure 4.11, Figure 4.12) and relates to the current literature reviewed in section 2.8 and Table 2.8. A significant difference (Z = -4.480, P<0.007) between children's ratings of present pain intensity and pain intensity in the previous 7 days was confirmed by the Wilcoxon Signed-Ranks Test. Contributing factors influence differences in pain experience on the testing days which were a day off school vs.

regular school days with more demanding schedules for children. Higher pain intensity ratings by parents/guardians considering their children's pain are positively significantly associated with higher hypermobility scores in children (r_s 0.571, P<0.001) (Figure 411.). This interesting finding shows a consciousness among parents of children's pain experience. Considering children's ratings of present pain intensity compared to parent/guardian ratings (Figure 4.14), a close convergence of pain VAS scores was observed between children and parents. This finding was confirmed by no significant difference (Z = -946, P=0.344) using the Wilcoxon Signed-Ranks Test, and a similarly a close union of children's and parent/guardians previous 7 days pain VAS scores were found with no significant differences (Z = -672, P=0.502) suggesting parents have an accurate awareness of their children's pain intensity (Figure 4.15). These are positive discoveries, and confirm both the reliability of results gathered and the validity of the tests used. It is noteworthy that gaps in knowledge and practice still exist among some parents with regards to optimal strategies for managing pain and pacing. For example, the use of wheelchairs/buggies in an effort to reduce impact, but which at the same time promote harmful deconditioning and muscle weakness (Maillard, 2014).

Qualitative data on musculoskeletal symptoms suggest potential origins of pain experience:

"…she has constant injury after injury, only just recovering from one, for another one to happen straight away. each injury has always taken a longer time than usual to heal. she also suffers constantly (especially at school) with back and neck pain" (Parent of Participant No. 15, 2013, personal communication)

"…his fingers, knees and hips sublux and it varies from a couple of times a day to a couple of time a week" (Parent of Participant No. 12, 2013, personal communication)

"…his elbow dislocated twice in two months, he also dislocated his ankles at the same time, as a baby his hips used to dislocate regularly, and his spine made horrible cracking noises when I picked him up and it still does. he struggles to walk the corridor to the school hall,

due to pain and fatigue. as the week goes on the fatigue gets worse, at the weekend he sleeps most of the time to be fit for the next week. he generally struggles with mobility, his legs frequently give way. daily movement and the pace at school do have an impact on fatigue and legs giving way. (Parent of Participant No. 7, 2013, personal communication)

"…she finds it hard to walk far without bad consequences such as extreme pain and fatigue which will last days. the wheelchair/buggy helps with pacing and rest, but if she didn't have it, she would need to be carried if walking any distance. elbow dislocations, subluxing knee and big problems with her ankles and feet well as core stability" (Parent of Participant Number 8, 2013, personal communication)

4.4.4 Pain Location and HMS in Paediatrics

Data on pain location in paediatrics rated by parents (Table 4.3) is comparable to children's self-reported pain locations and physiotherapists' responses in Study 1 (Table 3.3, 3.4 and 3.5) with knees and ankles mostly dominantly affected as lower limb joints followed by wrists, elbows and cervical spine. Pain in the aforementioned locations was unilateral in some children and bilateral in others. Differences in pain levels/categories (Figure 4.16) and number of locations pain experienced (Table 4.4) were apparent between clinical and control groups, with the most striking difference observed in the 'a lot of pain/hurt' category where children with HMS experienced pain symptoms in up to 10 areas of the body (Table 4.4). Children in the control group reported reasons for the origin of each pain experienced which were common ailments of childhood such as stomach bug, cough, ear infection, sore throat, loose tooth and verruca unlike some pain syndromes experienced by children with HMS with undefined origins. Interestingly, headache and exercise related pain were also experienced by some children in the control group, and when cross checked these children also attained high Nine-Point Beighton Scores for GJH and were active in gymnastics, dance, swimming and martial arts.

4.4.5 Trends in Physical Activity, Sport and Dance and HMS in Paediatrics

Disparity was found between children in clinical and control groups in terms of the number of hours children engage in physical activities, sport and dance (Figure 4.17) and the number of different activities children are involved in (Figure 4.18) rejecting the null hypothesis and answering research question 4. Children with HMS engaging in 0-4 hours of physical activities per week (Figure 4.14) is potentially less than the recommended 'daily' or '3+ times per week' by physiotherapists in Study 1 (Table 3.12). The 5-12 hours per week achieved by control group participants illustrates how much more a child can participate in the absence of symptoms like pain, fatigue, injury and high injury risk. Activities the clinical group reported engaging in include swimming, dance, ballet, kick boxing, hill walking, bike, skates, musical theatre, football, cricket and skiing which are positive. Moving forward physiotherapists surveyed in Study 1 recommend a blend of school, home, clinic, after school settings to integrate activity into daily life as much as possible (Table 3.11). Sports children in the clinical group reported being previously involved in but discontinued due to recurrent injury and symptoms include running, gymnastics, trampolining, rugby, football, netball, tennis, badminton, horse riding and skiing indicating these activities proved to be too high impact. This finding was exclusive to the clinical group where a significant difference ($Z = -2.390$, $P<0.017$) between groups was confirmed by the Mann-Whitney U test. The team sports noted are comparable to a study on GJH as a risk factor for recurrent shoulder dislocation. It disclosed that 58% of participants experiencing dislocation injuries were involved in contact sports and 55% played rugby specifically (Muhammad et al., 2013).

It has been reported in the literature that maximal exercise capacity is significantly lower in children with musculoskeletal pain-related syndromes especially in HMS when compared with age and gender matched healthy controls (Engelbert et al., 2006, Hanewinkel-van Kleef et al., 2009). Similarly, pain was linked to reduced participation in physical activity in 8 to

16 year olds (Schubert-Hjalmarsson et al., 2012) and significantly lower sport participation in adults with EDS-HM (Rombaut et al., 2010). While these behaviours may protect individuals from sustaining sports injuries, the inevitable deconditioning associated with a sedentary, inactive lifestyle poses more risks for pain, fatigue and reduced function plus longer term morbidities in adult life such as osteoporosis, overweight and obesity, type 2 diabetes mellitus, hypertension and cardiovascular disease (O'Donovan et al., 2010).

"…overall I think the level of activity (PE, swimming, dance, and bike) does help but the fatigue is hideous and she can really struggle" (Parent of Participant No. 26, 2013, personal communication)

"…he doesn't do any structured physical activity anymore. he did have swimming lessons for some time however due to fatigue and pain we were missing quite a few. The problems we had were a set 30 min for each lesson was sometimes too much, the resulting fatigue was having a negative effect on him and his ability to relax and enjoy his weekend time" (Parent of Participant No. 12, 2013, personal communication)

Children in the control group participate in a more diverse range of activities including swimming, diving, athletics, tennis, badminton, skiing, ballet, tap dancing, modern dance, gymnastics, trampolining, yoga, football, rugby, cricket, hockey, golf, triathlon, karate, scooter, bike, tag coach, brownies, cubs and violin, many of which require enhanced fine and gross motor control skills which are likely to be not well developed in children with HMS.

4.4.6 Strengths and Limitations

Despite limitations of using the Nine-Point Beighton Score and Revised Beighton Criteria in paediatric populations already discussed these tools have been used in the present study in combination with additional tools (i.e. the PBS and PPQ) as part of a novel physical assessment battery for paediatric HMS patients. The use of the Nine-Point Beighton Score as one component of an assessment battery in paediatrics is comparable to recent studies

(Evans et al., 2012, Nicholson et al., 2014, Soper et al., 2015). The present study involved individual participant screening with in-depth qualitative data also gathered from parents and children. The study design improved on previous studies (Ferrell et al., 2004, Fatoye et al., 2009, Pacey et al., 2014, Maillard et al., 2014) by including a control group (Ferrell et al., 2004, Pacey et al., 2014, Maillard et al., 2014), and by age and gender matching children in intervention and control groups (Fatoye et al., 2009). While the PBS has been employed in research studies on paediatrics with mild to moderate motor impairment (Franjoine et al., 2003), typically developing children (Franjoine et al., 2010) and paediatric cerebral palsy patients (Sival, 2012), the present study is the first study to use the PBS to gather data on a paediatric HMS population. The age range of 4 to 12 years for the PBS is quite a wide range meaning tests were very challenging for the 4 to 5 year olds and relatively simple for the 10-12 year olds. In future research, the use of more recently available functional balance tests could be investigated. The PedsQL™ PPQ was developed as a more comprehensive assessment tool to measure pain experience in children with chronic pain. The PedsQL™ PPQ was first used in a sample of children with juvenile rheumatoid arthritis (JRA) (Gragg et al., 1996) where the authors recommended further studies using the PedsQL™ PPQ to measure a variety of acute and chronic pain experiences in children across a diversity of settings. The present study is the first to apply the PedsQL™ PPQ to paediatric HMS patients and this data adds to the evidence base. Qualitative data revealed a parents preference of the more frequent use of the PedsQL™ PPQ which points towards the PedsQL™ PPQ not being currently used in physiotherapy, rheumatology or general practitioner clinics as follows:

'*...could I ask for a copy of the pain colouring sheet he did as I found this insightful as it gave us more of an idea of where he experiences and feels pain, and I think this would be a helpful tool for him to use to be able to tell us he is in pain, I'd really appreciate a copy of*

his completed one and a blank one if possible as it would be useful to use with him" (Parent of Participant No. 7, 2013, personal communication)

While previous studies have also used pain VAS of 0-10cm or 0-100mm scales to quantify pain intensity (Pacey et al., 2014, Scheper, 2014, Soper et al., 2015), the inclusion of pain location mapping by children and parents in the present study is original, and the first study to attain more detailed data from participants. Vulnerable times of day for musculoskeletal pain and fatigue, duration and frequency of pain episodes were not measured and are difficult to recall, but indications are given in the data such as neck, shoulder and wrist pain related to school days. Follow up correspondence with the parent who requested the PedsQL™ PPQ gave feedback of it being a beneficial and simple tool to communicate children's pain experience at home, school and in medical appointments as follows:

"…we have implemented the pain charts into daily life and school use them for guidance when he is complaining he is in pain and when the school need to call me to administer more pain relief. they are very good for us as well as we can use them to confirm his pain levels with the professionals involved" (Parent of Participant No. 7, 2013, personal communication)

When interpreting the presented results the following limitations should be taken into account. Specific age ranges have been identified as young child aged 4 to 7 years and child aged 8 to 12 years (Varni et al., 1987), though it is important to note that the occurrence of puberty followed by skeletal and biological maturity is a more important marker of musculoskeletal maturity and function than chronological age. The target sample size aimed for 40 children per group however the final number of children recruited was less. Reasons included the time, travel, money and possibly a day off work needed for parents and children to attend the HMSA Events. While Leeds as a location in the north of the UK and London as a location in the south of the UK for the HMSA Events, these locations were not in close

reach for families based in more remote parts of England, Scotland, Wales and Northern Ireland. It was not possible to attend additional HMSA Events to collect data due to lack of funding for research/travel costs. The control group sample was recruited in 3 waves and tested over 3 separate days due to difficulty for schools to offer time for children to be excused from class and be accompanied by a staff member. It was not possible to recruit 4 year old children at a primary school or sports camp so a smaller sample exists for control group data. Known challenges and difficulties recruiting paediatric patients are documented in the current literature (Kemp et al., 2010, Pacey et al., 2013). The analysis of trends in physical activity, sport and dance in children, and differences between clinical and control groups is somewhat confounded by some of the children in the control group being recruited from an after-school athletics activity camp. Response/participation bias is possible. Parents of children with HMS who attended the HMSA Events were concerned, vigilant and up to date with current knowledge. The study has not captured families who could not attend due to a lack of resources, families who were not aware of the event taking place or those who were simply not interested in attending.

The pain VAS, a component of the PedsQL™ PPQ is reported as a reliable measure of pain in children aged 7 years old and above (Shields et al., 2003) however for those young study participants aged 4 to 6 years old the pain VAS and PedsQL™ PPQ was quite complex to complete. The very young children used the body map as a colouring exercise however the parent version addressed any gaps in the child version. Children were shy to speak about pain experience on the testing day which is also acknowledged in the literature (Davis and McDonagh, 2006). Pain is often private or personal and spoken about among family and in medical appointments and this was the first time children met the principal investigator.

A small number of children came in wheelchairs or ’buggies’ as management aids and were not stable or coordinated enough to attempt some tests for example reaching hands to touch

the floor with knees straight and feet together in the Nine-Point Beighton Score (Beighton et al., 1973). Similarly, some children attended wearing ankle boots and/or orthotics for support which parents were not keen to remove due to concerns about loss of stability and perceived risk of injury, perhaps influenced by previous injury. Taking this into account, actual PBS test results are potentially overestimated if compared with test results of children completing the same tests in bare feet. The Revised Brighton Criteria (Grahame et al., 2000) were designed as a diagnostic tool for use among medical professionals. While the principal investigator has professional accreditation with the Sports Massage Association UK and 11 years clinical experience as a Remedial and Sports Massage Practitioner, some of the minor criteria for example minor criteria 5, marfanoid habitus, were outside the scope of practice to assess. Similarly, most parents found terminology in the minor criteria difficult to understand and would normally be diagnosed by a clinician. In any case some of the minor criteria are symptoms specific to adults not paediatrics, a limitation of using the tool for paediatrics. Dysautonomia and psychological impact were not specifically examined. A comprehensive insight to symptoms and injury by physiotherapists (in Study 1) and pain intensity and location by children and parents (in Study 2) was obtained, yet actual quantitative impact of HMS on QoL (Varni et al., 2001) and Multidimensional Fatigue (Varni et al., 2004) on children's lives (reported by patients themselves) were not captured in the data due to these components not being agreed as part of the study design.

4.5 Conclusions

The data give evidence of distinct differences between children with HMS and those without. This insight is unique from a UK perspective. The pilot work conducted in creating and implementing a Physical Assessment Battery for Paediatric Hypermobility demonstrates an updated tool that can supplement existing diagnostic tools by capturing a more complete profile of symptoms in the clinical and functional assessment of children.

This can assist in addressing the issues publicised in the current physiotherapy and rheumatology literature regarding easily missed cases, and give baseline values to direct the design of specific treatment and management programs to improve function and minimise disability. The Physical Assessment Battery for Paediatric Hypermobility needs continued progression, revision and collaboration to establish a clinically functional and standardised method.

Chapter 5: Discussion of Linked Studies

5.1 Introduction

The latest literature on interventions published from 2013 to present discussed in 2.9 and 2.10, indicate a positive shift towards assessment of function and capacity in patients. Studies 1 and 2 have shown that medical professionals and families are aware of the symptoms and implications, yet more specific training and knowledge is needed improve models of best practice and reduce variations in clinical practice in terms of assessment, treatment and management of symptoms. This could be in the form of master classes and continuing professional development training modules for clinicians and therapists.

5.2 Implications to Patients and Clinical Practice

It is alarming that children younger than 12 years of age are currently ceasing to participate in sport and physical activities in view of the consequences on physical health and social development. It is vital that physical interventions are supported with paced re-integration into sport and activities, and that the use of aids such as wheelchairs, that promote declines in physical function should be avoided (Maillard, 2014). Through research, collaboration and health commissioning, there are solutions to the issues evidenced in Study 1 and Study 2, if these are managed correctly. Health inequality must be reduced by removing hierarchy, and reducing the number of patients without treatment while on lengthy waiting lists for specific consultants. Increasing accessibility to allied health professionals, and creating new care pathways by integrating and collaborating with community based practitioners can be a valuable complement to more effectively and efficiently manage symptoms in the correct environment of daily life at school, home and play. Practitioners such as sport rehabilitators,

soft-tissue/remedial and sport massage therapists, yoga and Pilates instructors, swim coaches, dance teachers, walking groups, personal exercise trainers, sport and exercise scientists, podiatrists, osteopaths, hand occupational therapists, psychologists, cognitive behavioural therapists and guided relaxation/meditation classes can offer strategies for management when linking with medical professionals. Integrated approaches to practice and evaluation are also needed.

While available evidence is accumulating in the literature discussed in 2.9 and 2.10, continuing difficulties exist, among the medical and wider communities, in terms of disaggregating knowledge from published interventions and implementing the evidence as part of everyday practice, as discovered in searching for a local collaborator to recruit Study 2 control group participants from as follows:

> *"... I would also be very grateful if you could send me on any information that you gather from the study that you can share or a copy of your final report as, as well as being a dance teacher, I am also a physiotherapist and would find this research not only interesting but very valuable and informative for how I might be able to apply your findings to my current practice"* (A. Noble 2013, Dance Base Edinburgh, personal communication)

It is also paramount that clinical practice and patient experience of HMS such as the data obtained in Study 1 and Study 2 inform the evidence base even if some data is of a qualitative nature.

The implications of HMS being undiagnosed and symptoms unmanaged in paediatrics are a harmful progression of symptoms and dysfunction in young adulthood, illustrated by feedback from a client as follows:

"... because of my hypermobility I haven't been able to stand, walk, run or jump for any length of time without pain since I was 21. After playing badminton semi-professionally for seven years I have no cartilage left in both knees. On top of that I twisted my ankle so badly when I was sixteen that I ruptured three lateral ligaments in my left foot for good. Two and a half years ago I started to have severe back pain. It started with lower back pain then my neck and shoulders started to hurt too. A year and a half (and two physiotherapists who didn't know how to deal with my hypermobility) later your colleague X found out that my muscles had been tensing up so much, trying to keep my joints together, that I had amongst others several ribs out. Since then we are aiming at finding the balance between releasing the muscles and stabilising the joints - and putting ribs back in from time to time. Another thing is exercise: I had to stop playing badminton (and any other sport at that) when I was 21 because the pain in my knees was getting so bad that I couldn't sleep at night. Ever since then I have been trying to find a way to keep fit without making my condition worse. I joined the gym, took up water gymnastics, tai chi, rowing and swimming - everything that seemed to be joint-friendly but I don't seem to be able to keep up regular and sensible exercise that would help building up stamina and train the muscles around my joints, so if you have any pointers or ideas what I could do, I'd very much appreciate your help. After being fit and sporty for so long it is quite frustrating to do nothing at all" (D. Strohsahl 2013, Client Active X Osteopathy Clinic Edinburgh, personal communication).

5.3 Recommendations for Future Research and Clinical Practice

1. Revise the Physical Assessment Battery for Paediatric Hypermobility to include the Star Excursion Balance Test (Gribble et al., 2012) in place of the PBS as an updated functional measure of lower limb balance, stability and control and the 6 Minute Walk Test (Geiger et al., 2007) as a measure of functional exercise capacity.

2. Validate and stabilise the Physical Assessment Battery for Paediatric Hypermobility for use in clinical practice, and to test it in an intervention setting using 3 groups of paediatric participants as follows: group 1 comprising paediatric patients with clinical diagnoses of HMS, group 2 comprising children with asymptomatic GJH and group 3 comprising age and gender matched controls. This will involve quantifying the effectiveness of the tool to measure outcomes and to measure change in symptoms over time, and clinicians rating of the tool.
3. Validate and implement a paediatric specific version of the Brighton Criteria reflecting symptoms experienced by children presented in Table 3.3 and evidenced in the current literature.
4. Develop NICE guidelines for GJH and HMS in both paediatric and adolescent and adult populations.
5. Track patients longitudinally to measure functional declines or improvement in response to growth, interventions, treatment and management programs.
6. Investigate the influence of puberty, menarche and hormones in girls with HMS.

5.4 Conclusions

The research conducted and presented in this thesis offers a contribution to knowledge and understanding of GJH and HMS in paediatrics. The original data sets are key to advancing the clinical care of children experiencing symptoms. The validated Physical Assessment Battery for Paediatric Hypermobility has potential use in clinical practice including physiotherapy, rheumatology, general practice, rehabilitation, A and E, soft-tissue therapy, outpatients and pain management clinics. It may be utilised to standardise assessment in the UK and reduce variability in patient experience between clinics and practitioners. The impact on the patient group is, through specific interventions to address functional impairments identified, to reduce disability and symptoms of pain, fatigue and injury,

prevent deconditioning, prevent symptoms continuing into adolescence and young adult life, and improve quality of life in physical, psychological, social and school functioning elements in children.

References

AALTONEN, S., KARJALAINEN, H., HEINONEN, A., PARKKARI, J. & KUJALA, U. M. 2007. Prevention of Sports Injuries: Systematic Review of Randomized Controlled Trials. *Archives of Internal Medicine,* 167**,** 1585-1592.

ADIB, N., DAVIES, K., GRAHAME, R., WOO, P. & MURRAY, K. J. 2005. Joint hypermobility syndrome in childhood. A not so benign multisystem disorder? *Rheumatology (Oxford, England),* 44**,** 744-750.

AL-RAWI, Z. S., AL-ASZAWI, A. J. & AL-CHALABI, T. 1985. Joint mobility among university students in Iraq. *Rheumatology,* 24**,** 326-331.

BAEZA-VELASCO, C., GÉLY-NARGEOT, M., BULBENA VILARRASA, A. & BRAVO, J. 2011. Joint hypermobility syndrome: problems that require psychological intervention. *Rheumatology International,* 31**,** 1131-1136.

BAEZA-VELASCO, C., PAILHEZ, G., BULBENA, A. & BAGHDADLI, A. 2015. Joint hypermobility and the heritable disorders of connective tissue: clinical and empirical evidence of links with psychiatry. *General Hospital Psychiatry,* 37**,** 24-30.

BALE, P., EASTON, V., BACON, H., JERMAN, E. & ARMON, K. 2014. The efficacy and cost effectiveness of a multidisciplinary intervention strategy for the treatment of benign joint hypermobility syndrome (BJHS) in childhood. a randomised, single centre parallel group trial. (The bendy study). *Pediatric Rheumatology,* 12**,** P58.

BARBER FOSS, K. D., FORD, K. R., MYER, G. D. & HEWETT, T. E. 2009. Generalized joint laxity associated with increased medial foot loading in female athletes. *Journal of athletic training,* 44**,** 356-362.

BARBOUR, R. S. 2001. Checklists for improving rigour in qualitative research: a case of the tail wagging the dog? *BMJ,* 322**,** 1115-1117.

BARRY, C. A., BRITTEN, N., BARBER, N., BRADLEY, C. & STEVENSON, F. 1999. Using reflexivity to optimize teamwork in qualitative research. *Qual Health Res,* 9**,** 26-44.

BAUDINETTE, K., SPARKS, J. & KIRBY, A. 2010. Survey of paediatric occupational therapists' understanding of developmental coordination disorder, joint hypermobility syndrome and attention deficit hyperactivity disorder. *British Journal of Occupational Therapy,* 73**,** 366-372.

BEARDMORE, A., HANDCOCK, P. & REHRER, N. 2005. Return-to-play after injury: practices in New Zealand rugby union. *Physical Therapy in Sport,* 6**,** 24-30.

BEHRINGER, M., VOM HEEDE, A., YUE, Z. Y. & MESTER, J. 2010. Effects of Resistance Training in Children and Adolescents: a meta-analysis. *Pediatrics,* 126**,** E1199-E1210.

BEIGHTON, P., GRAHAME, R. & BIRD, H. 2012a. Assessment of Hypermobility. *Hypermobility of Joints.* Springer London.

BEIGHTON, P., GRAHAME, R. & BIRD, H. 2012b. Musculoskeletal Features of Hypermobility and Their Management. *Hypermobility of Joints.* Springer London.

BEIGHTON, P., GRAHAME, R. & BIRD, H. A. 1989. *Hypermobility of joints : with 71 figures / Peter Beighton, Rodney Grahame, Howard Bird,* London : Springer-Verlag, c1989.
2nd ed. / co-ordinating editor (second edition), Rodney Grahame.

BEIGHTON, P., PAEPE, A. D., STEINMANN, B., TSIPOURAS, P. & WENSTRUP, R. J. 1998. Ehlers-Danlos Syndromes: Revised Nosology, Villefranche, 1997. *American Journal of Medical Genetics,* 77**,** 31-37.

BEIGHTON, P., SOLOMON, L. & SOSKOLNE, C. L. 1973. Articular mobility in an African population. *Annals Of The Rheumatic Diseases,* 32**,** 413-418.

BEIGHTON, P. H., GRAHAME, R. & BIRD, H. 2012c. Extra-articular Manifestations of Hypermobility. Hypermobility of Joints. Springer London.

BENDIK, E. M., TINKLE, B. T., AL-SHUIK, E., LEVIN, L., MARTIN, A., THALER, R., ATZINGER, C. L., RUEGER, J. & MARTIN, V. T. 2011. Joint hypermobility syndrome: A common clinical disorder associated with migraine in women. *Cephalalgia,* 31**,** 603-613.

BERG, K. O., WOOD-DAUPHINEE, S. L., WILLIAMS, J. I. & MAKI, B. 1992. Measuring balance in the elderly: validation of an instrument. *Canadian journal of public health = Revue canadienne de sante publique,* 83 Suppl 2**,** S7-11.

BILLINGS, S., DEANE, J., BARTHOLOMEW, J. & SIMMONDS, J. 2012. Perceptions of Hypermobility and Hypermobility Syndrome amongst paediatric physiotherapists. *Association of Paediatric Chartered Physiotherapists Members Journal,* 4**,** 37-47.

BIN ABD RAZAK, H. R., BIN ALI, N. & HOWE, T. S. 2014. Generalized ligamentous laxity may be a predisposing factor for musculoskeletal injuries. *Journal of Science and Medicine in Sport,* 17**,** 474-478.

BIRD, H. A. 2005. Joint hypermobility in children. *Rheumatology,* 44**,** 703-704.

BIRD, H. A. 2011. Joint Disorders, Soft Tissue Rheumatism. Hypermobility - Does it Cause Joint Symptoms? *European Musculoskeletal Review,* 6**,** 34-7.

BIRD, H. A. & FOLEY, E. C. 2013. Hypermobility in dancers. *Rheumatology,* 52**,** 585-586.

BIRD, H. A. & KNIGHT, I. 2012. Joint Hypermobility in Musicians. *Foundations for Excellence: Promoting health and wellbeing in young dancers and musicians.* Exeter: South West Music School.

BOOSHANAM, D. S., CHERIAN, B., JOSEPH, C., MATHEW, J. & THOMAS, R. 2011. Evaluation of posture and pain in persons with benign joint hypermobility syndrome. *Rheumatology International,* 31**,** 1561-1565.

BOS. 2012. *Bristol Online Survey* [Online]. Bristol: University of Bristol. Available: http://www.survey.bris.ac.uk/ [Accessed 10th April 2012.

BOYLE, K. L., WITT, P. & RIEGGER-KRUGH, C. 2003. Intrarater and interrater reliability of the Beighton and Horan Joint Mobility Index. *Journal of Athletic Training,* 38**,** 281-285.

BRENNER, J. S., MEDICINE, A. T. C. O. S. & FITNESS 2007. Overuse Injuries, Overtraining, and Burnout in Child and Adolescent Athletes. *Pediatrics,* 119**,** 1242-1245.

BRIGGS, J., MCCORMACK, M., HAKIM, A. J. & GRAHAME, R. 2009. Injury and joint hypermobility syndrome in ballet dancers--a 5-year follow-up. *Rheumatology* 48**,** 1613-1614.

BUENEN, G. & MALINA, R. M. 1988. Physical growth, maturation and performance relative to the timimng of the adolescent growth spurt. *Exercise and Sport Sciences Reviews,* 16**,** 503-540.

BULBENA, A., DURÓ, J. C., PORTA, M., FAUS, S., VALLESCAR, R. & MARTÍN-SANTOS, R. 1992. Clinical assessment of hypermobility of joints: assembling criteria. *The Journal of Rheumatology,* 19**,** 115-122.

BYHRING, S. & BO, K. 2002. Musculoskeletal injuries in the Norwegian National Ballet: a prospective cohort study. / Traumatismes musculo-squelettiques dans l ' equipe du ballet national norvegien: etude prospective. *Scandinavian Journal of Medicine & Science in Sports,* 12**,** 365-370.

CARTER, C. & WILKINSON, J. 1964. Persistant joint laxity and congenital dislocation of the hip *Journal of Bone & Joint Surgery, British Volume,* 46-B**,** 40-45.

CARTER, C. W. & MICHELI, L. J. 2011. Training the child athlete: physical fitness, health and injury. *British Journal of Sports Medicine,* 45**,** 880-885.

CASTORI, M., MORLINO, S., CELLETTI, C., CELLI, M., MORRONE, A., COLOMBI, M., CAMEROTA, F. & GRAMMATICO, P. 2012. Management of pain and fatigue in the joint hypermobility syndrome (a.k.a. Ehlers–Danlos syndrome, hypermobility type): Principles and proposal for a multidisciplinary approach. *American Journal of Medical Genetics Part A,* 158A**,** 2055-2070.

CELLETTI, C., CASTORI, M., GRAMMATICO, P. & CAMEROTA, F. 2012a. Evaluation of lower limb disability in joint hypermobility syndrome. *Rheumatology International,* 32**,** 2577-2581.

CELLETTI, C., GALLI, M., CIMOLIN, V., CASTORI, M., ALBERTINI, G. & CAMEROTA, F. 2012b. Relationship between fatigue and gait abnormality in Joint Hypermobility Syndrome/Ehlers-Danlos Syndrome Hypermobility Type. *Research in Developmental Disabilities,* 33**,** 1914-1918.

CHILD, A. H. 1986. Joint hypermobility syndrome: inherited disorder of collagen synthesis. *Journal of Rheumatology,* 13**,** 239-243.

CLARK, C. Exploring Joint Hypermobility Syndrome, Developmental Coordination Disorder and Pain. Hypermobility Inter Professional Study Day 2012 Bournemouth University, UK.

CLARK, C. J., KHATTAB, A. D., CARR, E. C. J., PALMER, S. & SCHEPER, M. 2014. Chronic widespread pain and neurophysiological symptoms in joint hypermobility syndrome (JHS). *International Journal of Therapy & Rehabilitation,* 21**,** 60-68.

CLARK, C. J. & SIMMONDS, J. V. 2011. An exploration of the prevalence of hypermobility and joint hypermobility syndrome in Omani women attending a hospital physiotherapy service. *Musculoskeletal Care,* 9**,** 1-10.

CLINCH, J., DEERE, K., SAYERS, A., PALMER, S., C., R., J.H., T. & CLARK, E. M. 2011. Epidemiology of generalized joint laxity (hypermobility) in fourteen year old children from the UK. *Arthritis & Rheumatism,* 63**,** 2819-2827.

CLINCH, J. & ECCELSTON, C. 2009. Chronic musculoskeletal pain in children: assessment and management. *Rheumatology,* 48**,** 466-474.

COLLINGE, R. & SIMMONDS, J. V. 2009. Hypermobility, injury rate and rehabilitation in a professional football squad - A preliminary study. *Physical Therapy in Sport,* 10**,** 91-96.

CULPEPPER, L. & GILBERT, T. T. 1999. Evidence and ethics. *The Lancet,* 353**,** 829-831.

DAVIES, K. & COPEMAN, A. 2006. The spectrum of paediatric and adolescent rheumatology. *Best Practice & Research Clinical Rheumatology,* 20**,** 179-200.

DAVIS, P. J. C. & MCDONAGH, J. E. 2006. Principles of management of musculoskeletal conditions in children and young people. *Best Practice & Research Clinical Rheumatology,* 20**,** 263-278.

DE PAEPE, A., DEVEREUX, R. B., DIETZ, H. C., HENNEKAM, R. C. & PYERITZ, R. E. 1996. Revised diagnostic criteria for the Marfan syndrome. *Am J Med Genet,* 62**,** 417-26.

DECOSTER, L. C., BERNIER, J. N., LINDSAY, R. H. & VAILAS, J. C. 1999. Generalized joint hypermobility and its relationship to injury patterns among NCAA lacrosse players. *Journal of Athletic Training,* 34**,** 99-105.

DECOSTER, L. C., VAILAS, J. C., LINDSAY, R. H. & WILLIAMS, G. R. 1997. Prevalence and features of joint hypermobility among adolescent athletes. *Archives Of Pediatrics & Adolescent Medicine,* 151**,** 989-992.

DIFIORI, J. P. 2010. Evaluation of Overuse Injuries in Children and Adolescents. *Current Sports Medicine Reports (American College of Sports Medicine),* 9**,** 372-378.

DU TOIT, P. J., KRUGER, P. E., TERBLANCHE, H. C., RENSBURG, D. C. J. V., GOVENDER, C., MERCIER, J., PREEZ, T. J.-D. & KLEYNHANS, M. 2011. Sex differences in the nine-point Beighton hypermobility test scores. *African Journal for Physical, Health Education, Recreation & Dance,* 17**,** 603-611.

DUFFY, C. M. & FELDMAN, B. M. 2011. Chapter 8: Assessment of health status, fucntion and quality of life outcomes. *In:* CASSIDY, J. T., PETTY, R. E., LAXER, R. M. & LINDSLEY, C. B. (eds.) *Textbook of Pediatric Rheumatology (Sixth Edition).* Philadelphia: W.B. Saunders.

ECCELSTON, C., MORLEY, S., WILLIAMS, A. & AL., E. 2002. Systematic review of randomized control trials of psychological therapy for chronic pain in children and adolescents, with a sub-set meta-analysis of pain relief. *Pain,* 99**,** 157-165.

EL-METWALLY, A., SALMINEN, J., AUVINEN, A., MACFARLANE, G. & MIKKELSSON, M. 2007. Risk factors for development of non-specific musculoskeletal pain in preteens and early adolescents: a prospective 1-year follow-up study. *BMC Musculoskeletal Disorders,* 8**,** 46.

EL-METWALLY, A., SALMINEN, J. J., AUVINEN, A., KAUTIAINEN, H. & MIKKELSSON, M. 2004. Prognosis of non-specific musculoskeletal pain in preadolescents: A prospective 4-year follow-up study till adolescence. *Pain,* 110**,** 550-559.

ENGELBERT, R. H., KOOIJMANS, F. T., VAN RIET, A. M., FEITSMA, T. M., UITERWAAL, C. S. & HELDERS, P. J. 2005. The relationship between generalized joint hypermobility and motor development. *Pediatric Physical Therapy,* 17**,** 258-263.

ENGELBERT, R. H. H. & SCHEPER, M. C. 2011. Joint hypermobility with and without musculoskeletal complaints: a physiotherapeutic approach. *International Musculoskeletal Medicine,* 33**,** 146-151.

ENGELBERT, R. H. H., VAN BERGEN, M., HENNEKEN, T., HELDERS, P. J. M. & TAKKEN, T. 2006. Exercise Tolerance in Children and Adolescents With Musculoskeletal Pain in Joint Hypermobility and Joint Hypomobility Syndrome. *Pediatrics,* 118**,** e690-e696.

EPPS, H., GINNELLY, L., UTLEY, M., SOUTHWOOD, T., GALLIVAN, S., SCULPHER, M. & WOO, P. 2005. Is hydrotherapy cost-effective? A randomised controlled trial of combined hydrotherapy programmes compared with physiotherapy land techniques in children with juvenile idiopathic arthritis. *Health Technol Assess,* 9**,** iii-i59.

EVANS, A. M., ROME, K. & PEET, L. 2012. The foot posture index, ankle lunge test, Beighton scale and the lower limb assessment score in healthy children: a reliability study. *Journal Of Foot And Ankle Research,* 5**,** 1-1.

FAIGENBAUM, A. D. & MICHELI, L. J. 2012. ACSM Current Comment, Preseason Conditioning for Young Athletes. Indiana: American College of Sports Medicine.

FALKERSLEV, S., BAAGØ, C., ALKJÆR, T., REMVIG, L., HALKJÆR-KRISTENSEN, J., LARSEN, P. K., JUUL-KRISTENSEN, B. & SIMONSEN, E. B. 2013. Dynamic balance during gait in children and adults with Generalized Joint Hypermobility. *Clinical Biomechanics (Bristol, Avon)*.

FATOYE, F., PALMER, S., MACMILLAN, F., ROWE, P. & LINDEN, M. 2012. Pain intensity and quality of life perception in children with hypermobility syndrome. *Rheumatology International,* 32**,** 1277-1284.

FATOYE, F., PALMER, S., MACMILLAN, F., ROWE, P. & LINDEN, M. V. D. 2009. Proprioception and muscle torque deficits in children with hypermobility syndrome. *Rheumatology,* 48**,** 152-157.

FERRARI, J., PARSLOW, C., LIM, E. & HAYWARD, A. 2005. Joint hypermobility: the use of a new assessment tool to measure lower limb hypermobility. *Clin Exp Rheumatol,* 23**,** 413-20.

FERRELL, W. R., TENNANT, N., STURROCK, R. D., ASHTON, L., CREED, G., BRYDSON, G. & RAFFERTY, D. 2004. Amelioration of symptoms by enhancement of proprioception in patients with joint hypermobility syndrome. *Arthritis and Rheumatism,* 50**,** 3323-3328.

FITHIAN, D. C., PAXTON, E. W., STONE, M. L., SILVA, P., DAVIS, D. K., ELIAS, D. A. & WHITE, L. M. 2004. Epidemiology and Natural History of Acute Patellar Dislocation. *The American Journal of Sports Medicine,* 32**,** 1114-1121.

FONG, D. T.-P., HONG, Y., LAP-KI, C., YUNG, P. S.-H. & KAI-MING, C. 2007. A Systematic Review on Ankle Injury and Ankle Sprain in Sports. *Sports Medicine,* 37**,** 73-94.

FORD, P., COLLINS, D., BAILEY, R., MACNAMARA, Á., PEARCE, G. & TOMS, M. 2012. Participant development in sport and physical activity: The impact of biological maturation. *European Journal of Sport Science,* 12**,** 515-526.

FOSTER, H. E. & CABRAL, D. A. 2006. Is musculoskeletal history and examination so different in paediatrics? *Best Practice & Research Clinical Rheumatology,* 20**,** 241-262.

FOSTER, H. E., ELTRINGHAM, M. S., KAY, L. J., FRISWELL, M., ABINUN, M. & MYERS, A. 2007. Delay in access to appropriate care for children presenting with musculoskeletal symptoms and ultimately diagnosed with juvenile idiopathic arthritis. *Arthritis Care & Research,* 57**,** 921-927.

FRANJOINE, M. R., DARR, N., HELD, S. L., KOTT, K. & YOUNG, B. L. 2010. The performance of children developing typically on the pediatric balance scale. *Pediatric Physical Therapy: The Official Publication Of The Section On Pediatrics Of The American Physical Therapy Association,* 22**,** 350-359.

FRANJOINE, M. R., GUNTHER, J. S. & TAYLOR, M. J. 2003. Pediatric Balance Scale: A Modified Version of the Berg Balance Scale for the School-Age Child with Mild to Moderate Motor Impairment. *Pediatric Physical Therapy,* 15**,** 114-128.

GARCIA-CAMPAYO, J., ASSO, E. & ALDA, M. 2011. Joint Hypermobility and Anxiety: The State of the Art (clinical report). *Current Psychiatry Reports*, 18.

GAZIT, Y., NAHIR, A. M., GRAHAME, R. & JACOB, G. 2003. Dysautonomia in the joint hypermobility syndrome. *The American Journal of Medicine,* 115**,** 33-40.

GEDALIA, A. & BREWER, E. J. 1993. Joint Hypermobility in Pediatric Practice - a Review. *Journal of Rheumatology,* 20**,** 371-374.

GEIGER, R., STRASAK, A., TREML, B., GASSER, K., KLEINSASSER, A., FISCHER, V., GEIGER, H., LOECKINGER, A. & STEIN, J. I. 2007. Six-minute walk test in children and adolescents. *J Pediatr,* 150**,** 395-9, 399.e1-2.

GERBER, R. J., WILKS, T. & ERDIE-LALENA, C. 2010. Developmental Milestones: Motor Development. *Pediatrics in Review,* 31**,** 267-277.

GHARBIYA, M., MORAMARCO, A., CASTORI, M., PARISI, F., CELLETTI, C., MARENCO, M., MARIANI, I., GRAMMATICO, P. & CAMEROTA, F. 2012. Ocular Features in Joint Hypermobility Syndrome/Ehlers-Danlos Syndrome Hypermobility Type: A Clinical and In Vivo Confocal Microscopy Study. *American Journal of Ophthalmology,* 154**,** 593-600.e1.

GIBSON, B. E. & MARTIN, D. K. 2003. Qualitative Research and Evidence-based Physiotherapy Practice. *Physiotherapy,* 89**,** 350-358.

GILL, D., CRAWLEY, F., LOGIUDICE, M., GROSEK, S., KURZ, R. & DE LOURDES-LEVY, M. 2003. Guidelines for informed conset in biomedical research involving paediatric populations as research participants. *European Journal Pediatrics,* 162**,** 445-458.

GLAZIER, R. H., DALBY, D. M., BADLEY, E. M., HAWKER, G. A., BELL, M. J. & BUCHBINDER, R. 1996. Determinants of physician confidence in the primary care management of musculoskeletal disorders. *The Journal of rheumatology,* 23**,** 351-356.

GRAGG, R. A., RAPOFF, M. A., DANOVSKY, M. B., LINDSLEY, C. B., VARNI, J. W., WALDRON, S. A. & BERNSTEIN, B. H. 1996. Assessing Chronic Musculoskeletal Pain Associated with Rheumatic Disease: Further Validation of the Pediatric Pain Questionnaire. *Journal of Pediatric Psychology,* 21**,** 237-250.

GRAHAME, R. 1993. Joint Hypermobility and the Performing Musician. *New England Journal of Medicine,* 329**,** 1120-1121.

GRAHAME, R. 1999. Joint hypermobility and genetic collagen disorders: are they related? *Archives of Disease in Childhood,* 80**,** 188-191.

GRAHAME, R. 2000. Pain, distress and joint hyperlaxity. *Joint, bone, spine : revue du rhumatisme,* 67**,** 157-63.

GRAHAME, R. 2007a. Joint hypermobility is a liability for the performing artist. *International Symposium on Performance Science.* AEC.

GRAHAME, R. 2007b. The need to take a fresh look at criteria for hypermobility. *J Rheumatol,* 34**,** 664-665.

GRAHAME, R. 2008. Hypermobility: an important but often neglected area within rheumatology. *Nature Clinical Practice. Rheumatology,* 4**,** 522-524.

GRAHAME, R. 2009. Joint hypermobility syndrome pain. *Current Pain And Headache Reports,* 13**,** 427-433.

GRAHAME, R. & BIRD, H. 2001. British consultant rheumatologists' perceptions about the hypermobility syndrome: a national survey. *Rheumatology,* 40**,** 559.

GRAHAME, R., BIRD, H. A. & CHILD, A. 2000. The Revised (Brighton 1998) Criteria for the Diagnosis of Benign Joint Hypermobility Syndrome (BJHS). *Journal of Rheumatology,* 27**,** 1777-1779.

GRAHAME, R. & HAKIM, A. J. 2008. Hypermobility. *Current Opinion in Rheumatology,* 20**,** 106-110.

GRAHAME, R. & HAKIM, A. J. 2010. The rheumatological heritable disorders of connective tissue. *Medicine,* 38**,** 205.

GRAHAME, R. & KAZKAZ, H. 2014. The rheumatological heritable disorders of connective tissue. *Medicine,* 42**,** 275-278.

GRANATA, G., PADUA, L., CELLETTI, C., CASTORI, M., SARACENI, V. M. & CAMEROTA, F. 2013. Entrapment neuropathies and polyneuropathies in joint hypermobility syndrome/Ehlers–Danlos syndrome. *Clinical Neurophysiology,* 124**,** 1689-1694.

GREENWOOD, N. L., DUFFELL, L. D., ALEXANDER, C. M. & MCGREGOR, A. H. 2011. Electromyographic activity of pelvic and lower limb muscles during postural tasks in people with benign joint hypermobility syndrome and non hypermobile people. A pilot study. *Manual Therapy,* 16**,** 623-628.

GRIBBLE, P. A., HERTEL, J. & PLISKY, P. 2012. Using the Star Excursion Balance Test to Assess Dynamic Postural-Control Deficits and Outcomes in Lower Extremity Injury: A Literature and Systematic Review. *Journal of Athletic Training,* 47**,** 339-357.

GURLEY-GREEN, S. 2001. Living with the hypermobility syndrome. *Rheumatology,* 40**,** 487-489.

GYLDENKERNE, B., IVERSEN, K., ROEGIND, H., FASTRUP, D., HALL, K. & REMVIG, L. 2007. Prevalence of general hypermobility in 12-13-year-old school children and impact of an intervention against injury and pain incidence. *Advances in Physiotherapy,* 9**,** 10-15.

HAKIM, A. & GRAHAME, R. 2003a. 6: Joint hypermobility. *Best Practice & Research: Clinical Rheumatology,* 17**,** 989-1004.

HAKIM, A. J. & GRAHAME, R. 2003b. A simple questionnaire to detect hypermobility: an adjunct to the assessment of patients with diffuse musculoskeletal pain. *International Journal of Clinical Practice,* 57**,** 163-166.

HAKIM, A. J. & SAHOTA, A. 2006. Joint hypermobility and skin elasticity: the hereditary disorders of connective tissue. *Clinics in Dermatology,* 24**,** 521-533.

HANEWINKEL-VAN KLEEF, Y. B., HELDERS, P. J. M., TAKKEN, T. & ENGELBERT, R. H. 2009. Motor Performance in Children with Generalized Hypermobility: The Influence of Muscle Strength and Exercise Capacity. *Pediatric Physical Therapy,* 21**,** 194-200 10.1097/PEP.0b013e3181a3ac5f.

HARRIS, P., RANSON, C. & ROBERTSON, A. 2014. *Anatomy for problem solving in sports medicine: the knee.*, M&K Publishing.

HASIJA, R. P., KHUBCHANDANI, R. P. & SHENOI, S. 2008. Joint hypermobility in Indian children. *Clinical and Experimental Rheumatology,* 26**,** 146-150.

HENNRIKUS, W. & PYLAWKA, T. 2013. Patellofemoral instability in skeletally immature athletes. *Instructional course lectures,* 62**,** 445-453.

HINCAPIE, C. A., MORTON, E. J. & CASSIDY, J. D. 2008. Musculoskeletal Injuries and Pain in Dancers: A Systematic Review. *Archives of Physical Medicine and Rehabilitation,* 89**,** 1819-1829.

HMSA. 2013. *Hypermobility Syndromes Association (HMSA) Charity* [Online]. Available: http://hypermobility.org/ [Accessed 10/10/2013.

HOGAN, K. A. & GROSS, R. H. 2003. Overuse injuries in pediatric athletes. *Orthop Clin North Am,* 34**,** 405-15.

HOLMES, A. & DELAHUNT, E. 2009. Treatment of Common Deficits Associated with Chronic Ankle Instability. *Sports Medicine,* 39**,** 207-224.

HUDSON, N., STARR, M. R., ESDAILE, J. M. & FITZCHARLES, M. A. 1995. Diagnostic associations with hypermobility in rheumatology patients. *British Journal Of Rheumatology,* 34**,** 1157-1161.

HUGUET, A. & MIRÓ, J. 2008. The Severity of Chronic Pediatric Pain: An Epidemiological Study. *The Journal of Pain,* 9**,** 226-236.

IASP 1979. International Association for the Study of Pain, Pain terms: a list with definitions and notes on usage: recommended by the IASP sub-committee on taxonomy *Pain,* 6**,** 249-252.

JANDIAL, S., MYERS, A., WISE, E. & FOSTER, H. E. 2009a. Doctors Likely to Encounter Children with Musculoskeletal Complaints Have Low Confidence in Their Clinical Skills. *The Journal of Pediatrics,* 154**,** 267-271.

JANDIAL, S., RAPLEY, T. & FOSTER, H. 2009b. Current teaching of paediatric musculoskeletal medicine within UK medical schools—a need for change. *Rheumatology,* 48**,** 587-590.

JANSSON, A., SAARTOK, T., WERNER, S. & RENSTRÖM, P. 2004. General joint laxity in 1845 Swedish school children of different ages: age- and gender-specific distributions. *Acta Pædiatrica,* 93**,** 1202-1206.

JENSEN, M. P. 2011. Psychosocial approaches to pain management: An organizational framework. *Pain,* 152**,** 717-725.

JOHNSON, R. & WATERFIELD, J. 2004. Making words count: the value of qualitative research. *Physiotherapy Research International,* 9**,** 121-131.

JOHNSON, S. M. & ROBINSON, C. M. 2010. Shoulder Instability in Patients with Joint Hyperlaxity. *The Journal of Bone & Joint Surgery,* 92**,** 1545-1557.

JONSSON, H., VALTYSDOTTIR, S. T., KJARTANSSON, O. & BREKKAN, A. 1996. Hypermobility associated with osteoarthritis of the thumb: a clinical and radiological subset of hand osteoarthritis. *Annals of Rheumatic Disease,* 55**,** 540-543.

JUNGE, T., LARSEN, L., JUUL-KRISTENSEN, B. & WEDDERKOPP, N. 2015a. The extent and risk of knee injuries in children aged 9-14 with Generalised Joint Hypermobility and knee jointt hypermobility - the CHAMPS-study Denmark. *BMC Musculoskeletal Disorders,* 16.

JUNGE, T., WEDDERKOPP, N., THORLUND, J. B. & SØGAARD, K. 2015b. Altered knee joint neuromuscular control during landing from a jump in 10-15year old children with Generalised Joint Hypermobility. A substudy of the CHAMPS-study Denmark. *Journal of electromyography and kinesiology,* 25**,** 501-507.

JUUL-KRISTENSEN, B., HANSEN, H., SIMONSEN, E. B., ALKJÆR, T., KRISTENSEN, J. H., JENSEN, B. R. & REMVIG, L. 2012. Knee function in 10-year-old children and adults with Generalised Joint Hypermobility. *Knee,* 19**,** 773-778.

JUUL-KRISTENSEN, B., KRISTENSEN, J. H., FRAUSING, B., JENSEN, D. V., ROGIND, H. & REMVIG, L. 2009. Motor Competence and Physical Activity in 8-Year-Old School Children With Generalized Joint Hypermobility. *Pediatrics,* 124**,** 1380-1387.

JUUL-KRISTENSEN, B., RÃ¸GIND, H., JENSEN, D. V. & REMVIG, L. 2007. Inter-examiner reproducibility of tests and criteria for generalized joint hypermobility and benign joint hypermobility syndrome. *Rheumatology,* 46**,** 1835.

JUUL-KRISTENSEN, B., SOHRBECK-NØHR, O., BOYLE, E., KRISTENSEN, J. H. & REMVIG, L. 2014. Generalized joint hypermobility in childhood is both a contributive and predictive risk factor for pain development in adolescence: a cohort study. *Osteoarthritis and Cartilage,* 22, Supplement**,** S216.

KAUX, J., DELVAUX, F., FORTHOMME, B., MARGUERITE, F., FRANÇOIS, D., CRIELAARD, J. & CROISIER, J. 2013. Eccentric training for elbow hypermobility. *Journal of Novel Physiotherapies,* 3**,** 3-6.

KEER, R. & GRAHAME, R. 2003. *Hypermobility Syndrome: recognition and management for physiotherapists,* Edinburgh, Butterworth-Heinemann
Elsevier Ltd.

KEER, R. & SIMMONDS, J. 2011. Joint protection and physical rehabilitation of the adult with hypermobility syndrome. *Current Opinion in Rheumatology,* 23**,** 131-136.

KELLY, L. & HUDSON, Z. 2010. A preliminary study of the prevalence of hypermobility in junior elite england hockey players and its potential influence on injury. *SportEX Medicine***,** 17-22.

KEMP, S., GAMBLE, C., WILKINSON, S., DAVIDSON, J. E., BAILDAM, E. M., CLEARY, A. G., MCCANN, L. J., BERESFORD, M. W. & ROBERTS, I. 2010. A randomized comparative trial of generalized vs targeted physiotherapy in the management of childhood hypermobility. *Rheumatology,* 49**,** 315.

KERR, A., MACMILLAN, C. E., UTTLEY, W. S. & LUQMANI, R. A. 2000. Professional articles: Physiotherapy for Children with Hypermobility Syndrome. *Physiotherapy,* 86**,** 313-317.

KING, S., CHAMBERS, C. T., HUGUET, A., MACNEVIN, R. C., MCGRATH, P. J., PARKER, L. & MACDONALD, A. J. 2011. The epidemiology of chronic pain in children and adolescents revisited: A systematic review. *Pain,* 152**,** 2729-2738.

KIRBY, A. & DAVIES, R. 2007. Developmental Coordination Disorder and Joint Hypermobility Syndrome – overlapping disorders? Implications for research and clinical practice. *Child: Care, Health and Development,* 33**,** 513-519.

KIRK, J. A., ANSELL, B. M. & BYWATERS, E. G. 1967. The Hypermobility Syndrome. Musculoskeletal complaints associated with generalized joint hypermobility. *Annals Of The Rheumatic Diseases,* 26**,** 419-425.

KLEMP, P. & LEARMONTH, I. D. 1984. Hypermobility and injuries in a professional ballet company. *British Journal of Sports Medicine,* 18**,** 143-148.

KLEMP, P., STEVENS, J. E. & ISAACS, S. 1984. A hypermobility study in ballet dancers. *The Journal Of Rheumatology,* 11**,** 692-696.

KLEMP, P., WILLIAMS, S. M. & STANSFIELD, S. A. 2002. Articular mobility in Maori and European New Zealanders. *Rheumatology,* 41**,** 554-557.

KNIGHT, I. & BIRD, H. 2010. Joint hypermobility syndrome. *BMJ,* 341**,** DOI: 278-279.

KOLDAŞ DOĞAN, S., TANER, Y. & EVCİK, D. 2011. Benign Joint Hypermobility Syndrome in Patients with Attention Deficit/Hyperactivity Disorders. *Turkish Journal of Rheumatology. ,* 26**,** 187-192.

KONOPINSKI, M. D., JONES, G. J. & JOHNSON, M. I. 2012. The Effect of Hypermobility on the Incidence of Injuries in Elite-Level Professional Soccer Players: A Cohort Study. *American Journal of Sports Medicine,* 40**,** 763-769.

KOUTEDAKIS, Y., STAVROPOULOS-KALINOGLOU, A. & METSIOS, G. 2005. The Significance of Muscular Strength in Dance. *Journal of Dance Medicine and Science,* 9**,** 29-34.

KOVACIC, K., CHELIMSKY, T. C., SOOD, M. R. & SIMPSON, P. 2014. Joint Hypermobility: A Common Association with Complex Functional Gastrointestinal Disorders. *The Journal of pediatrics,* 165**,** 973-978.

KRIPPENDORF, K. 2004. *Content Analysis: an introduction to its methodology,* California, Sage Publications Ltd.

KUCHTA, G. & DAVIDSON, I. 2011. Chapter 12: Occupational and physical therapy for childhood rheumatic diseases *In:* CASSIDY, J. T., PETTY, R. E., LAXER, R. M. & LINDSLEY, C. B. (eds.) *Textbook of Pediatric Rheumatology (Sixth Edition).* Philadelphia: W.B. Saunders.

LAMARI, N. M., CHUEIRE, A. G. & CORDEIRO, J. A. 2005. Analysis of joint mobility patterns among preschool children. *Sao Paulo Medical Journal,* 123**,** 119-123.

LARSSON, L.-G., BAUM, J., MUDHOLKAR, G. S. & SRIVASTAVA, D. K. 1993. Hypermobility: prevalence and features in a Swedish population. *British Journal of Rheumatology,* 32**,** 116-119.

LEANDERSON, C., LEANDERSON, J., WYKMAN, A., STRENDER, L. E., JOHANSSON, S. E. & SUNDQUIST, K. 2011. Musculoskeletal injuries in young ballet dancers. *Knee Surgery, Sports Traumatology, Arthroscopy,* 19**,** 1531-1535.

LEBLANC, C. & HOUGHTON, K. 2011. Chapter 47: Noninflammatory musculoskeletal pain conditions *In:* CASSIDY, J. T., PETTY, R. E., LAXER, R. M. & LINDSLEY, C. B. (eds.) *Textbook of Pediatric Rheumatology (Sixth Edition).* Philadelphia: W.B. Saunders.

LEONE, V., TORNESE, G., ZERIAL, M., LOCATELLI, C., CIAMBRA, R., BENSA, M. & POCECCO, M. 2009. Joint hypermobility and its relationship to musculoskeletal pain in schoolchildren: a cross-sectional study. *Archives of Disease in Childhood,* 94**,** 627-632.

LEWKONIA, R. M. & ANSELL, B. M. 1983. Articular hypermobility simulating chronic rheumatic disease. *Archives of Disease in Childhood,* 58**,** 988-992.

LYSENS, R. J., OSTYN, M. S., AUWEELE, Y. V., LEFEVRE, J., VUYLSTEKE, M. & RENSON, L. 1989. The accident-prone and overuse-prone profiles of the young athlete. / Profil du jeune athlete sujet aux accidents et au surmenage. *American Journal of Sports Medicine,* 17**,** 612-619.

MACAULEY, D. (ed.) 2007. *Oxford Handbook of Sport and Exercise Medicine,* Oxford: Oxford University Press.

MAILLARD, S. 2014. An update of the managment of hypermobility in children. *Pediatric Rheumatology,* 12**,** I25.

MAILLARD, S., LIOSSI, C., SCHOTH, D., HOWARD, R. & WALKER, S. 2014. Factors associated with pain in children with hypermobility - a pilot study. *Pediatric Rheumatology,* 12**,** P100.

MALFAIT, F., HAKIM, A. J., DE PAEPE, A. & GRAHAME, R. 2006. The genetic basis of the joint hypermobility syndromes. *Rheumatology,* 45**,** 502-507.

MALINA, R. M. 2010. Early Sport Specialization: Roots, Effectiveness, Risks. *Current Sports Medicine Reports,* 9**,** 364-371 10.1249/JSR.0b013e3181fe3166.

MALINA, R. M., BOUCHARD, C. & BAR-OR, O. 2004. *Growth, maturation and physical activity,* Human Kinetics.

MARINO, R. J., PATRICK, M., ALBRIGHT, W., LEIBY, B. E., MULCAHEY, M., SCHMIDT-READ, M. & KERN, S. B. 2012. Development of an objective test of upper-limb function in tetraplegia: the capabilities of upper extremity test. *Am J Phys Med Rehabil,* 91**,** 478-86.

MCCLUSKEY, G., O'KANE, E., HANN, D., WEEKES, J. & ROONEY, M. 2012. Hypermobility and musculoskeletal pain in children: a systematic review. *Scandinavian Journal of Rheumatology,* 41**,** 329-338.

MCCORMACK, M. 2010. Teaching the Hypermobile Dancer. *The IADMS Bulletin for Teachers.* London: The Royal Ballet Company.

MCCORMACK, M. & BRIGGS, J. 2002. Impact of Joint Laxity in Ballet Dancers Over the Full Age Spectrum From 11 Years Old to Dancers in a Professional Ballet Company Available: http://www.nureyev-medical.org/articles/impact-of-joint-laxity-in-ballet-dancers-.

MCCORMACK, M., BRIGGS, J., HAKIM, A. & GRAHAME, R. 2002. *Injury and Benign Joint Hypermobility Syndrome in Student Classical Ballet Dancers*.

MCCORMACK, M., BRIGGS, J., HAKIM, A. J. & GRAHAME, R. 2004. Joint laxity and the benign joint hypermobility syndrome in student and professional ballet dancers. *The Journal Of Rheumatology,* 31**,** 173-178.

MCGRATH, P. A. & HOLAHAN, A. 2003. Psychological interventions with children and adolescents: evidence for their effectiveness in treating chronic pain. *Seminars in Pain Medicine,* 1**,** 99-109.

MENENDEZ ALEJO, F. M., DIAZ LAZAGA, D., TORREZ CARDENAS, V. & MATINEZ RODRIGUEZ, V. 2009. The joint hypermobility syndrome in a Cuban juvenile population. *Reumatologia Clinica,* 5**,** 244-247.

MERSKEY, H. 1986. Classification of chronic pain: Descriptions of chronic pain syndromes and definitions of pain terms. *Pain,* Suppl 3**,** 226.

MIKKELSSON, M., EL-METWALLY, A., KAUTIAINEN, H., AUVINEN, A., MACFARLANE, G. J. & SALMINEN, J. J. 2008. Onset, prognosis and risk factors for widespread pain in schoolchildren: A prospective 4-year follow-up study. *Pain,* 138**,** 681-687.

MIKKELSSON, M., SALMINEN, J. J. & KAUTIAINEN, H. 1996. Joint hypermobility is not a contributing factor to musculoskeletal pain in pre-adolescents. *The Journal of Rheumatology,* 23**,** 1963-1967.

MIKKELSSON, M., SALMINEN, J. J., SOURANDER, A. & KAUTIAINEN, H. 1998. Contributing factors to the persistence of musculoskeletal pain in preadolescents: a prospective 1-year follow-up study. *Pain,* 77**,** 67-72.

MORRIS, C., DOLL, H., WAINWRIGHT, A., THEOLOGIS, T. & FITZPATRICK, R. 2008. The Oxford ankle foot questionnaire for children: scaling, reliability and validity. *Journal Bone Joint Surgery (British Volume),* 90**,** 1451-1456.

MORRISON, S. & FERRARI, J. 2009. Inter-rater reliability of the Foot Posture Index (FPI-6) in the assessment of the paediatric foot. *Journal of Foot and Ankle Research,* 2**,** 26.

MUHAMMAD, A. A., JENKINS, P., ASHTON, F. & CHRISTOPHER, M. R. 2013. Hypermobility - A risk factor for recurrent shoulder dislocations. *British Journal of Sports Medicine,* 47**,** 4-5.

MULVEY, M. R., MACFARLANE, G. J., BEASLEY, M., SYMMONS, D. P. M., LOVELL, K., KEELEY, P., WOBY, S. & MCBETH, J. 2013. Modest Association of Joint Hypermobility With Disabling and Limiting Musculoskeletal Pain: Results From a Large-Scale General Population–Based Survey. *Arthritis Care & Research,* 65**,** 1325-1333.

MURRAY, K. J. 2006. Hypermobility disorders in children and adolescents. *BEST PRACTICE AND RESEARCH CLINICAL RHEUMATOLOGY,* 20**,** 329-351.

MURRAY, K. J. & WOO, P. 2001. Benign joint hypermobility in childhood. *Rheumatology,* 40**,** 489-491.

MYERS, A., MCDONAGH, J. E., GUPTA, K., HULL, R., BARKER, D., KAY, L. J. & FOSTER, H. E. 2004. More 'cries from the joints': assessment of the musculoskeletal system is poorly documented in routine paediatric clerking. *Rheumatology,* 43**,** 1045-1049.

NICHOLSON, L., PACEY, V., TOFTS, L., MUNNS, C. & ADAMS, R. 2014. Signs and symptoms of foot and ankle dysfunction in children with joint hypermobility. *Journal of Foot and Ankle Research,* 7**,** A61.

NULTY, D. D. 2008. The Adequacy of Response Rates to Online and Paper Surveys: What Can Be Done? *Assessment & Evaluation in Higher Education,* 33**,** 301-314.

O'DONOVAN, G., BLAZEVICH, A. J., BOREHAM, C., COOPER, A. R., CRANK, H., EKELUND, U., FOX, K. R., GATELY, P., GILES-CORTI, B., GILL, J. M. R., HAMER, M., MCDERMOTT, I., MURPHY, M., MUTRIE, N., REILLY, J. J., SAXTON, J. M. & STAMATAKIS, E. 2010. The ABC of Physical Activity for Health: A consensus statement from the British Association of Sport and Exercise Sciences. *Journal of Sports Sciences,* 28**,** 573-591.

O'SHEA, S. & GRAFTON, K. 2013. The intra and inter-rater reliability of a modified weight-bearing lunge measure of ankle dorsiflexion. *Manual therapy,* 18**,** 264-268.

O'SULLIVAN, P., BEALES, D., JENSEN, L., MURRAY, K. & MYERS, T. 2011. Characteristics of chronic non-specific musculoskeletal pain in children and adolescents attending a rheumatology outpatients clinic: a cross-sectional study. *Pediatric Rheumatology,* 9**,** 3.

ORESKOVICH, M. R., KAUPS, K. L., BALCH, C. M. & ET AL. 2012. Prevalence of alcohol use disorders among american surgeons. *Archives of Surgery,* 147**,** 168-174.

PACEY, V., ADAMS, R. D., TOFTS, L., MUNNS, C. F. & NICHOLSON, L. L. 2014. Proprioceptive acuity into knee hypermobile range in children with joint hypermobility syndrome. *Pediatr Rheumatol Online J,* 12**,** 40.

PACEY, V., NICHOLSON, L. L., ADAMS, R. D., MUNN, J. & MUNNS, C. F. 2010. Generalized Joint Hypermobility and Risk of Lower Limb Joint Injury During Sport. *American Journal of Sports Medicine,* 38**,** 1487-1497.

PACEY, V., TOFTS, L., ADAMS, R., MUNNS, C. & NICHOLSON, L. 2013. Exercise in children with joint hypermobility syndrome and knee pain: a randomised controlled trial comparing exercise into hypermobile versus neutral knee extension. *Pediatric Rheumatology,* 11**,** 30.

PALERMO, T. M. & ECCLESTON, C. 2009. Parents of children and adolescents with chronic pain. *Pain,* 146**,** 15-17.

PALMER, S., BAILEY, S., BARKER, L., BARNEY, L. & ELLIOTT, A. 2013. The effectiveness of therapeutic exercise for joint hypermobility syndrome: a systematic review. *Physiotherapy,* In Press.

PALMER, S., BAILEY, S., BARKER, L., BARNEY, L. & ELLIOTT, A. 2014. The effectiveness of therapeutic exercise for joint hypermobility syndrome: a systematic review. *Physiotherapy,* 100**,** 220-227.

PANTOJA ZARZA, L., DÍEZ MORRONDO, C. & ALEXIS, D. 2014. Hyperlax Ehlers-Danlos Syndrome: Benign Hypermobility? *Reumatología Clínica (English Edition),* 10**,** 189-190.

PARR, S. & MAY, S. 2013. Do musculoskeletal physiotherapists believe the NICE guidelines for the management of non-specific LBP are practical and relevant to their practice? *Physiotherapy,* In Press.

PATERNO, M. V., TAYLOR-HAAS, J. A., MYER, G. D. & HEWETT, T. E. 2013. Prevention of Overuse Sports Injuries in the Young Athlete. *Orthopedic Clinics of North America,* 44**,** 553-564.

PEARCE, P. Z. 2006. Prehabilitation: Preparing young athletes for sports. *Current Sports Medicine Reports,* 5**,** 155-160.

PERQUIN, C. W., HAZEBROEK-KAMPSCHREUR, A. J. M., HUNFELD, J. A. M., BOHNEN, A. M., VAN SUIJLEKOM-SMIT, L. W. A., PASSCHIER, J. & VAN DER WOUDEN, J. C. 2000. Pain in children and adolescents: a common experience. *Pain,* 87**,** 51-58.

QUATMAN, C. E., FORD, K. R., MYER, G. D., PATERNO, M. V. & HEWETT, T. E. 2008. The effects of gender and pubertal status on generalized joint laxity in young athletes. *Journal of Science and Medicine in Sport,* 11**,** 257-263.

QURESHI, A. U., MAALIK, A. & AHMAD, T. M. 2010. Relationship of joint hypermobility and musculoskeletal problems and frequency of benign joint hypermobility syndrome in children. *Journal Of Ayub Medical College, Abbottabad: JAMC,* 22**,** 150-154.

QVINDESLAND, A. & JÓNSSON, H. 1999. Articular hypermobility in Icelandic 12-year-olds. *Rheumatology,* 38**,** 1014-1016.

RAPOFF, M. A. & LINDSLEY, C. B. 2000. The pain puzzle: a visual and conceptual metaphor for understanding and treating pain in paediatric rheumatic disease. *Journal of Rheumatology,* 58**,** 29-33.

REMVIG, L., ENGELBERT, R. H., BERGLUND, B., BULBENA, A., BYERS, P. H., GRAHAME, R., JUUL-KRISTENSEN, B., LINDGREN, K.-A., UITTO, J. & WEKRE, L. L. 2011. Need for a consensus on the methods by which to measure joint mobility and the definition of norms for hypermobility that reflect age, gender and ethnic-dependent variation: is revision of criteria for joint hypermobility syndrome and Ehlers-Danlos syndrome hypermobility type indicated? *Rheumatology (Oxford, England),* 50**,** 1169-1171.

REMVIG, L. & JENSEN, D. V. 2005. Generalised joint hypermobility and benign joint hypermobility syndrome. II: epidemiology and clinical criteria. *Ugeskrift for laeger,* 167**,** 4449-4454.

REMVIG, L., JENSEN, D. V. & WARD, R. C. 2007a. Are diagnostic criteria for general joint hypermobility and benign joint hypermobility syndrome based on reproducible and valid tests? A review of the literature. *Journal of Rheumatology,* 34**,** 798-803.

REMVIG, L., JENSEN, D. V. & WARD, R. C. 2007b. Epidemiology of general joint hypermobility and basis for the proposed criteria for benign joint hypermobility syndrome: review of the literature. *Journal of Rheumatology,* 34**,** 804-809.

RENNIE, L., COURT-BROWN, C.M., MOK, J.Y.Q., BEATTIE, T.F. 2007. The epidemiology of fractures in children. *International Journal of the Care of the Injured,* 38**,** 913-922.

RIKKEN-BULTMAN, D. G. A., WELLINK, L. & VAN DONGEN, P. W. J. 1997. Hypermobility in two Dutch school poulations. *European Journal of Obstetrics & Gynecology and Reproductive Biology,* 73**,** 189-192.

RITCHIE, J. E. 1999. Using qualitative research to enhance the evidence-based practice of health care providers. *Aust J Physiother,* 45**,** 251-256.

ROBERTSON, A., NUTTON, R. & KEATING, J. 2006. Dislocation of the knee. *The Journal of Bone & Joint Surgery,* 88**,** 706-11.

ROMBAUT, L., MALFAIT, F., COOLS, A., DE PAEPE, A. & CALDERS, P. 2010. Musculoskeletal complaints, physical activity and health-related quality of life among patients with the Ehlers–Danlos syndrome hypermobility type. *Disability and Rehabilitation,* 32**,** 1339-1345.

ROSS, J. & GRAHAME, R. 2011a. Easily Missed? Joint Hypermobility Syndrome. *BMJ: British Medical Journal (Overseas & Retired Doctors Edition),* 342**,** 275-277.

ROSS, J. & GRAHAME, R. 2011b. Joint hypermobility syndrome. *BMJ (Clinical Research Ed.),* 342**,** c7167-c7167.

ROZEN, T., ROTH, J. & DENENBERG, N. 2006. Cervical Spine Joint Hypermobility: A Possible Predisposing Factor for New Daily Persistent Headache. *Cephalalgia,* 26**,** 1182-1185.

RUSSEK, L. N. 2000. Examination and Treatment of a Patient With Hypermobility Syndrome. *Physical Therapy,* 80**,** 386-398.

RUSSEK, L. N. & ERRICO, D. M. 2015. Prevalence, injury rate and, symptom frequency in generalized joint laxity and joint hypermobility syndrome in a "healthy" college population. *Clin Rheumatol*.

RUSSEK, L. N., LASHOMB, E. A., WARE, A. M., WESNER, S. M. & WESTCOTT, V. 2014. United States Physical Therapists' Knowledge About Joint Hypermobility Syndrome Compared with Fibromyalgia and Rheumatoid Arthritis. *Physiotherapy Research International***,** n/a-n/a.

SACHETI, A., SZEMERE, J., BERNSTEIN, B., TAFAS, T., SCHECHTER, N. & TSIPOURAS, P. 1997. Chronic pain is a manifestation of the Ehlers-Danlos syndrome. *Journal of Pain and Symptom Management,* 14**,** 88-93.

SAHIN, N., BASKENT, A., CAKMAK, A., SALLI, A., UGURLU, H. & BERKER, E. 2008. Evaluation of knee proprioception and effects of proprioception exercise in patients with benign joint hypermobility syndrome. *Rheumatology International,* 28**,** 995-1000.

SANCHES, S. B., OLIVEIRA, G. M., OSORIO, F. L., CRIPPA, J. A. & MARTIN-SANTOS, R. 2015. Hypermobility and joint hypermobility syndrome in Brazilian students and teachers of ballet dance. *Rheumatol Int,* 35**,** 741-7.

SANDOW, M. & GOODFELLOW, J. 1985. The natural history of anterior knee pain in adolescents. *J Bone Joint Surg,* 67-B**,** 36-38.

SCHEPER, M., DE VRIES, J., JUUL-KRISTENSEN, B., NOLLET, F. & ENGELBERT, R. H. 2014. The functional consequences of Generalized Joint Hypermobility: a cross-sectional study. *BMC Musculoskeletal Disorders,* 15**,** 243.

SCHEPER, M. C. 2014. The association between muscle weakness and activity limitations in patients with Ehlers Danlos (Hypermobility Type): the impact of proprioception. *Osteoarthritis and cartilage,* 22**,** S201.

SCHEPER, M. C., DE VRIES, J. E., DE VOS, R., VERBUNT, J., NOLLET, F. & ENGELBERT, R. H. H. 2013a. Generalized joint hypermobility in professional dancers: a sign of talent or vulnerability? *Rheumatology,* 52**,** 651-658.

SCHEPER, M. C., ENGELBERT, R. H. H., RAMECKERS, E. A. A., VERBUNT, J., REMVIG, L. & JUUL-KRISTENSEN, B. 2013b. Children with Generalised Joint Hypermobility and Musculoskeletal Complaints: State of the Art on Diagnostics, Clinical Characteristics, and Treatment. *BioMed Research International,* 2013**,** 13.

SCHUBERT-HJALMARSSON, E., ÖHMAN, A., KYLLERMAN, M. & BECKUNG, E. 2012. Pain, balance, activity, and participation in children with hypermobility syndrome. *Pediatric Physical Therapy: The Official Publication Of The Section On Pediatrics Of The American Physical Therapy Association,* 24**,** 339-344.

SEÇKIN, Ü., TUR, B., YıLMAZ, Ö., YAĞCı, İ., BODUR, H. & ARASıL, T. 2005. The prevalence of joint hypermobility among high school students. *Rheumatology International,* 25**,** 260-263.

SEDGWICK, P. 2010. Independent samples t test. *BMJ,* 340.

SEDGWICK, P. 2012a. Parametric v non-parametric statistical tests. *BMJ,* 344.

SEDGWICK, P. 2012b. Pearson's correlation coefficient. *BMJ,* 345.

SHANK, P. 2012. Getting the Answers You Need: Designing Good Surveys and Survey Questions. *Canadian Learning Journal,* 16**,** 15-17.

SHIELDS, B. J., PALERMO, T. M., POWERS, J. D., GREWE, S. D. & SMITH, G. A. 2003. Predictors of a child's ability to use a visual analogue scale. *Child: Care, Health & Development,* 29**,** 281.

SHUBIN STEIN, B. E. & AHMAD, C. S. 2007. The Management of Patellar Instability in the Skeletally Immature Patient. *Operative Techniques in Orthopaedics,* 17**,** 250-256.

SIMMONDS, J. V. & KEER, R. J. 2007. Hypermobility and the hypermobility syndrome. *Manual Therapy,* 12**,** 298-309.

SIMMONDS, J. V. & KEER, R. J. 2008. Hypermobility and the hypermobility syndrome, part 2: assessment and management of hypermobility syndrome: illustrated via case studies. *Manual Therapy,* 13**,** e1-e11.

SIMONSEN, E. B., TEGNER, H., ALKJÆR, T., LARSEN, P. K., KRISTENSEN, J. H., JENSEN, B. R., REMVIG, L. & JUUL-KRISTENSEN, B. 2012. Gait analysis of adults with generalised joint hypermobility. *Clinical Biomechanics,* 27**,** 573-577.

SIMPSON, M. A. J. & MICHAEL, R. 2006. Benign Joint Hypermobility Syndrome: Evaluation, Diagnosis, and Management. *JAOA: Journal of the American Osteopathic Association,* 106**,** 531-536.

SIVAL, D. A. 2012. Application of Pediatric Balance Scales in Children with Cerebral Palsy. *Neuropediatrics*.

SMITH, R., DAMODARAN, A. K., SWAMINATHAN, S., CAMPBELL, R. & BARNSLEY, L. 2005. Hypermobility and sports injuries in junior netball players. *British Journal of Sports Medicine,* 39**,** 628-631.

SMITH, T. O., BACON, H., JERMAN, E. & EASTON, V. 2014. Physiotherapy and occupational therapy interventions for people with benign joint hypermobility syndrome: a systematic review of clinical trials. *Disability and rehabilitation,* 36**,** 797-803.

SMITH, T. O., BACON, H., JERMAN, E., EASTON, V., ARMON, K., POLAND, F. & MACGREGOR, A. J. 2013a. Physiotherapy and occupational therapy interventions for people with benign joint hypermobility syndrome: a systematic review of clinical trials. *Disability and Rehabilitation,* 0**,** 1-7.

SMITH, T. O., EASTON, V., BACON, H., JERMAN, E., ARMON, K., POLAND, F. & MACGREGOR, A. J. 2013b. The relationship between benign joint hypermobility syndrome and psychological distress: a systematic review and meta-analyses. *Rheumatology*.

SMITS-ENGELSMAN, B., KLERKS, M. & KIRBY, A. 2011. Beighton Score: A Valid Measure for Generalized Hypermobility in Children. *The Journal of Paediatrics,* 7**,** 119-123.

SOPER, K., SIMMONDS, J. V., KAZ KAZ, H. & NINIS, N. 2015. The influence of joint hypermobility on functional movement control in an elite netball population: A preliminary cohort study. *Physical Therapy in Sport,* 16**,** 127-134.

SOPRANO, J. V. 2005. Musculoskeletal injuries in the paediatric and adolescent athlete. *Current Sports Medicine Reports,* 4**,** 329-334s.

SOPRANO, J. V. & FUCHS, S. M. 2007. Common Overuse Injuries in the Pediatric and Adolescent Athlete. *Clinical Pediatric Emergency Medicine,* 8**,** 7-14.

STÅHL, M., KAUTIAINEN, H., EL-METWALLY, A., HÄKKINEN, A., YLINEN, J., SALMINEN, J. J. & MIKKELSSON, M. 2008. Non-specific neck pain in schoolchildren: Prognosis and risk factors for occurrence and persistence. A 4-year follow-up study. *Pain,* 137**,** 316-322.

STEWART, D. R. & BURDEN, S. B. 2004. Does generalised ligamentous laxity increase seasonal incidence of injuries in male first division club rugby players? *British Journal of Sports Medicine,* 38**,** 457-460.

STINSON, J. N., KAVANAGH, T., YAMADA, J., GILL, N. & STEVENS, B. 2006. Systematic review of the psychometric properties, interpretability and feasibility of self-report pain intensity measures for use in clinical trials in children and adolescents. *Pain,* 125**,** 143-157.

TINKLE, B. T., BIRD, H. A., GRAHAME, R., LAVALLEE, M., LEVY, H. P. & SILLENCE, D. 2009. The Lack of Clinical Distinction Between the Hypermobility Type of Ehlers-Danlos Syndrome and the Joint Hypermobility Syndrome (a.k.a. Hypermobility Syndrome). *American Journal of Medical Genetics,* 149A**,** 2368-2370.

TOBIAS, J. H., DEERE, K., PALMER, S., CLARK, E. M. & CLINCH, J. 2013. Joint Hypermobility Is a Risk Factor for Musculoskeletal Pain During Adolescence: Findings of a Prospective Cohort Study. *Arthritis & Rheumatism,* 65**,** 1107-1115.

TOFTS, L., ELLIOTT, E., MUNNS, C., PACEY, V. & SILLENCE, D. 2009. The differential diagnosis of children with joint hypermobility: a review of the literature. *Pediatric Rheumatology,* 7**,** 1.

TOKER, S., SOYUCEN, E., GULCAN, E., KABAY, S., OZBEK, O., AKSAKALLI, E. & CIMBIZ, A. 2010. Presentation of two cases with hypermobility syndrome and review of literature. *European Journal of Physical and Rehabilitation Medicine,* 46**,** 89-94.

VAN DE PUTTE, E. M., UITERWAAL, C. S. P. M., BOTS, M. L., KUIS, W., KIMPEN, J. L. L. & ENGELBERT, R. H. H. 2005. Is Chronic Fatigue Syndrome a Connective Tissue Disorder? A Cross-Sectional Study in Adolescents. *Pediatrics,* 115**,** e415-e422.

VAN DER GIESSEN, L. J., LIEKENS, D., RUTGERS, K. J., HARTMAN, A., MULDER, P. G. & ORANJE, A. P. 2001. Validation of beighton score and prevalence of connective tissue signs in 773 Dutch children. *The Journal of Rheumatology,* 28**,** 2726-2730.

VARNI, J. W., BURWINKLE, T. M. & SZER, I. S. 2004. The PedsQL Multidimensional Fatigue Scale in pediatric rheumatology: reliability and validity. *The Journal of Rheumatology,* 31**,** 2494-2500.

VARNI, J. W., SEID, M. & KURTIN, P. S. 2001. PedsQL™ 4.0: Reliability and Validity of the Pediatric Quality of Life Inventory™ Version 4.0 Generic Core Scales in Healthy and Patient Populations. *Medical Care,* 39**,** 800-812.

VARNI, J. W., THOMPSON, K. L. & HANSON, V. 1987. The Varni/Thompson Pediatric Pain Questionnaire: I. Chronic musculoskeletal pain in juvenile rheumatoid arthritis. *Pain,* 28**,** 27-38.

VAUGHN, H. T. & NITSCH, W. 2008. Ilial Anterior Rotation Hypermobility in a Female Collegiate Tennis Player. *Physical Therapy,* 88**,** 1578-1590.

VISSER, J., GEUZE, R. H. & KALVERBOER, A. F. 1998. The relationship between physical growth, the level of activity and the development of motor skills in adolescence: Differences between children with DCD and controls. *Human Movement Science,* 17**,** 573-608.

VISWANATHAN, V. & KHUBCHANDANI, R. P. 2008. Joint hypermobility and growing pains in school children. *Clinical and experimental rheumatology,* 26**,** 962-966.

VLAEYEN, J. W. S. & LINTON, S. J. 2000. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain,* 85**,** 317-332.

VOERMANS, N. C. & KNOOP, H. 2011. Both pain and fatigue are important possible determinants of disability in patients with the Ehlers-Danlos syndrome hypermobility type. *Disability and Rehabilitation,* 33**,** 706-707.

VON ELM, E., ALTMAN, D. G., EGGER, M., POCOCK, S. J., GØTZSCHE, P. C. & VANDENBROUCKE, J. P. 2007. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. *Preventive Medicine,* 45**,** 247-251.

WARYASZ, G., GREGORY, R. W. & ANN, Y. M. 2008. Patellofemoral pain syndrome (PFPS): a systematic review of anatomy and potential risk factors. *Dynamic medicine DM,* 7**,** 9.

WEBER, R. P. 1990. *Basic content analysis,* Sage Publications, Inc.

WEDDERKOPP, N., JESPERSEN, E., FRANZ, C., KLAKK, H., HEIDEMANN, M., CHRISTIANSEN, C., MOLLER, N. & LEBOEUF-YDE, C. 2012. Study protocol.

The Childhood Health, Activity, and Motor Performance School Study Denmark (The CHAMPS-study DK). *BMC Pediatrics,* 12**,** 128.

WHO & MULTICENTRE GROWTH REFERENCE STUDY, G. D. O., MERCEDES 2006. Relationship between physical growth and motor development in the WHO Child Growth Standards. *Acta Pædiatrica,* 95**,** 96-101.

WILD, C. Y., STEELE, J. R. & MUNRO, B. J. 2013. Musculoskeletal and Estrogen Changes during the Adolescent Growth Spurt in Girls. *Medicine & Science in Sports & Exercise,* 45**,** 138-145.

WOLF, J. M., CAMERON, K. L. & OWENS, B. D. 2011. Impact of Joint Laxity and Hypermobility on the Musculoskeletal System. *Journal of the American Academy of Orthopaedic Surgeons,* 19**,** 463-471.

YAZGAN, P., GEYIKLI, İ., ZEYREK, D., BAKTIROGLU, L. & KURCER, M. 2008. Is joint hypermobility important in prepubertal children? *Rheumatology International,* 28**,** 445-451.

ZAPATA, A. L., MORAES, A. J. P., LEONE, C., DORIA-FILHO, U. & SILVA, C. A. A. 2006. Adolescent health brief: Pain and musculoskeletal pain syndromes in adolescents. *Journal of Adolescent Health,* 38**,** 769-771.

ZARATE, N., FARMER, A. D., GRAHAME, R., MOHAMMED, S. D., KNOWLES, C. H., SCOTT, S. M. & AZIZ, Q. 2010. Unexplained gastrointestinal symptoms and joint hypermobility: is connective tissue the missing link? *Neurogastroenterology and Motility: The Official Journal Of The European Gastrointestinal Motility Society,* 22**,** 252-e78.

ZWEERS, M. C., BRISTOW, J. & STEIJLEN, P. M. 2003. Haploinsufficiency of TNXB is associated with hypermobility type of Ehlers-Danlos syndrome. *American Journal of Human Genetics,* 73**,** 214-217.

ZWEERS, M. C., KUCHAREKOVA, M. & SCHALKWIJK, J. 2005. Tenascin-X: a candidate gene for benign joint hypermobility syndrome and hypermobility type Ehlers-Danlos syndrome? *Ann Rheum Dis,* 64**,** 504-5.

Appendices

Appendix 1: Survey

'Physiotherapists' Perspectives of Paediatric Hypermobility Syndromes'

Section 1

1. In your current job, where are you based in the UK? (Please select one answer)			
Scotland:			
England:			
N. Ireland:			
Wales:			

2. In your current job, what specialist area of physiotherapy do you practice in?			
Musculoskeletal physiotherapy:			
Rehabilitative physiotherapy:			
Extended scope physiotherapy (ESP):			
Neuromuscular physiotherapy:			
Cardio-respiratory physiotherapy:			
Research physiotherapy:			

3. In your current job, what is the professional level of your current post? (Please select one answer)			
Physiotherapist - Band 5:			
Physiotherapist - Band 6:			
Physiotherapist - Band 6 -			

Specialist:			
Physiotherapist - Band 7:			
Physiotherapist - Band 7 - Advanced:			

4. How many years of experience do you have working as a physiotherapist? (Select one answer)			
0-5:			
6-15:			
15+:			

5. Do you believe in HMS as distinct clinical entities? (Select one answer)			
Yes:			
No:			
Don't know:			

6. Do you believe in HMS as distinct pathological entities? (Select one answer)			
Yes:			
No:			
Don't know:			

7. In your opinion, how helpful is a patient diagnosis of HMS in terms of on-going treatment plans? (Please select one answer)			
Very helpful:			
Not very helpful:			
Useless:			
Don't know:			

8. What is your understanding of HMS in children? Please comment on each aspect in the boxes below.
8.a. Causes of HMS: -- Please write your answers here:
8.b. Consequences of HMS: -- Please write your answers here:
8.c. Characteristics of HMS: -- Please write your answers here:

9. How do you rate the impact of HMS on **patient's quality of life** in most cases? (Please select one answer)			
Serious:			
Significant:			
Minimal:			
None:			

9.a. Please add **any further comments on quality of life** here:

Section 2

10. What are the **most common symptoms** that children with HMS present with at your clinic?			
10.a. Arthralgia -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.a.i. Arthralgia -- Please add any further comments here if you wish to:			
10.b. Myalgia -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.b.i. Myalgia -- Please add any further comments here if you wish to:			
10.c. Multiple Joint Pain -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.c.i. Multiple Joint Pain -- Please add any further comments here if you wish to:			
10.d. Chronic Lower Back Pain (CLBP) -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.d.i. Chronic Lower Back Pain (CLBP) -- Please add any further comments here if you wish to:			
10.e. Musculoskeletal Injury -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.e.i. Musculoskeletal Injury -- Please add any further comments here if you wish to:			
10.f. Exercise related joint pain -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.f.i. Exercise related joint pain -- Please add any further comments here if you wish to:			
10.g. Post exercise related joint pain -- Please select one answer for each symptom here:			
Yes:			

No:			
Don't Know:			
10.g.i. Post exercise related joint pain -- Please add any further comments here if you wish to:			
10.h. 'Growing Pains' -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.h.i. 'Growing Pains' -- Please add any further comments here if you wish to:			
10.i. Nocturnal Leg Pains -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.i.i. Nocturnal Leg Pains -- Please add any further comments here if you wish to:			
10.j. Tiring easily -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.j.i. Tiring easily -- Please add any further comments here if you wish to:			
10.k. Chronic Fatigue Syndrome -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.k.i. Chronic Fatigue Syndrome -- Please add any further comments here if you wish to:			
10.l. Bruising easily -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.l.i. Bruising easily -- Please add any further comments here if you wish to:			
10.m. Poor Gross Motor Coordination e.g. running -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.m.i. Poor Gross Motor Coordination e.g. running -- Please add any further comments here if you wish to:			
10.n. Poor Fine Motor Coordination e.g. handwriting -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			

10.n.i. Poor Fine Motor Coordination e.g. handwriting -- Please add any further comments here if you wish to:			
10.o. Poor Hand-Eye Coordination -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.o.i. Poor Hand-Eye Coordination -- Please add any further comments here if you wish to:			
10.p. Developmental Coordination Disorder (DCD) -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.p.i. Developmental Coordination Disorder (DCD) -- Please add any further comments here if you wish to:			
10.q. Hypotension -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.q.i. Hypotension -- Please add any further comments here if you wish to:			
10.r. Dysautonomia of Autonomic Nervous System i.e. dizziness, syncope, light-headedness -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.r.i. Dysautonomia of Autonomic Nervous System i.e. dizziness, syncope, light-headedness -- Please add any further comments here if you wish to:			
10.s. ADHD -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.s.i. ADHD -- Please add any further comments here if you wish to:			
10.t. Gastrointestinal Issues -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.t.i. Gastrointestinal Issues -- Please add any further comments here if you wish to:			
10.u. Other(s) -- Please select one answer for each symptom here:			
Yes:			
No:			
Don't Know:			
10.u.i. Other(s) -- Please add any further comments here if you wish to:			

Section 3

11. What **screening methods do you currently use to measure Joint Hypermobility and HMS** in paediatric patients at your clinic?			
11.a. Nine-Point Beighton Score -- Please select one answer:			
Yes:			
No:			
11.a.i. Nine-Point Beighton Score -- Please include any further comments on screening methods here if you wish:			
11.b. 1998 Revised Brighton Criteria -- Please select one answer:			
Yes:			
No:			
11.b.i. 1998 Revised Brighton Criteria -- Please include any further comments on screening methods here if you wish:			
11.c. Five-Point Questionnaire for Hypermobility -- Please select one answer:			
Yes:			
No:			
11.c.i. Five-Point Questionnaire for Hypermobility -- Please include any further comments on screening methods here if you wish:			
11.d. Not using any screening methods -- Please select one answer:			
Yes:			
No:			
11.d.i. Not using any screening methods -- Please include any further comments on screening methods here if you wish:			
11.e. Other(s) Please specify in the comments box --> -- Please select one answer:			
Yes:			
No:			
11.e.i. Other(s) Please specify in the comments box --> -- Please include any further comments on screening methods here if you wish:			

12. From your experience using **current screening methods** in diagnosing children with Joint Hypermobility and/or HMS, **do you find the methods effective or not?**			
12.a. Nine-Point Beighton Score -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Do Not Use:			
12.a.i. Nine-Point Beighton Score -- Add any further comments here if you wish:			
12.b. 1998 Revised Brighton Criteria -- Please select one answer for each:			
Very Effective:			

Not Very Effective:			
Useless:			
Do Not Use:			
12.b.i. 1998 Revised Brighton Criteria -- Add any further comments here if you wish:			
12.c. Five-Point Questionnaire for Hypermobility -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Do Not Use:			
12.c.i. Five-Point Questionnaire for Hypermobility -- Add any further comments here if you wish:			
12.d. Not using any screening methods -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Do Not Use:			
12.d.i. Not using any screening methods -- Add any further comments here if you wish:			
12.e. Other(s) Please specify in the comments box --> -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Do Not Use:			
12.e.i. Other(s) Please specify in the comments box --> -- Add any further comments here if you wish:			

13. Approximately **how many cases of HMS** in paediatric patients have you observed, diagnosed or treated in the past 12 months? (Please select one answer)			
None:			
<10:			
11-25:			
26-50:			
50+:			

14. Please rate the effectiveness of the following treatment modalities that may be used with paediatric patients presenting with HMS.			
14.a. Reassurance only -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			

Don't use:			
14.a.i. Reassurance only -- Please include any further comments here if you wish:			
14.b. Physiotherapy/Physical Therapy/Manual Therapy -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.b.i. Physiotherapy/Physical Therapy/Manual Therapy -- Please include any further comments here if you wish:			
14.c. Education -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.c.i. Education -- Please include any further comments here if you wish:			
14.d. Simple Analgesics/NSAID's -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.d.i. Simple Analgesics/NSAID's -- Please include any further comments here if you wish:			
14.e. Osteopathy/Acupuncture/Homeopathy -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.e.i. Osteopathy/Acupuncture/Homeopathy -- Please include any further comments here if you wish:			
14.f. Surgery -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.f.i. Surgery -- Please include any further comments here if you wish:			
14.g. Cognitive Behavioural Therapy -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			

Don't use:			
14.g.i. Cognitive Behavioural Therapy -- Please include any further comments here if you wish:			
14.h. Psychiatric referral -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.h.i. Psychiatric referral -- Please include any further comments here if you wish:			
14.i. Other(s) Please specify in the comments box --> -- Please rate effectiveness for each here:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't use:			
14.i.i. Other(s) Please specify in the comments box --> -- Please include any further comments here if you wish:			

Section 4

15. Approximately **how many musculoskeletal injuries** have you seen in paediatric patients presenting with HMS at your clinic, in the past 12 months? (Please select one answer)			
None:			
<10:			
11-25:			
26-50:			
50+:			

16. What type of musculoskeletal injuries do paediatric HMS patients present with at your clinic?			
16.a. Joint Dislocation -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.a.i. Joint Dislocation -- Please add any further comments here if you wish:			
16.b. Joint Subluxation -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.b.i. Joint Subluxation -- Please add any further comments here if you wish:			
16.c. Ligament Sprain -- Please select one answer for each injury:			

Yes:			
No:			
Don't know:			
16.c.i. Ligament Sprain -- Please add any further comments here if you wish:			
16.d. Ligament Rupture -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.d.i. Ligament Rupture -- Please add any further comments here if you wish:			
16.e. Muscle Strain - Grade 1, 2 or 3 -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.e.i. Muscle Strain - Grade 1, 2 or 3 -- Please add any further comments here if you wish:			
16.f. Tendon Strain -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.f.i. Tendon Strain -- Please add any further comments here if you wish:			
16.g. Tendon Rupture -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.g.i. Tendon Rupture -- Please add any further comments here if you wish:			
16.h. Chronic Tendinopathy (Tendonitis, Tendinosis) -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.h.i. Chronic Tendinopathy (Tendonitis, Tendinosis) -- Please add any further comments here if you wish:			
16.i. Bursitis -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.i.i. Bursitis -- Please add any further comments here if you wish:			
16.j. Spondylosis -- Please select one answer for each injury:			
Yes:			
No:			

Don't know:			
16.j.i. Spondylosis -- Please add any further comments here if you wish:			
16.k. Apophysitis -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.k.i. Apophysitis -- Please add any further comments here if you wish:			
16.l. Contusion -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.l.i. Contusion -- Please add any further comments here if you wish:			
16.m. Haematoma -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.m.i. Haematoma -- Please add any further comments here if you wish:			
16.n. Disc Prolapse -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.n.i. Disc Prolapse -- Please add any further comments here if you wish:			
16.o. Growth Plate Injury -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.o.i. Growth Plate Injury -- Please add any further comments here if you wish:			
16.p. Stress Fracture -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.p.i. Stress Fracture -- Please add any further comments here if you wish:			
16.q. Fracture -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.q.i. Fracture -- Please add any further comments here if you wish:			

16.r. Sever's Disease (calcaneal apophysitis) -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.r.i. Sever's Disease (calcaneal apophysitis) -- Please add any further comments here if you wish:			
16.s. Osgood Schlatter's -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.s.i. Osgood Schlatter's -- Please add any further comments here if you wish:			
16.t. Little Leaguer's Injury -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.t.i. Little Leaguer's Injury -- Please add any further comments here if you wish:			
16.u. Sinding-Larsen-Johansson Syndrome -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.u.i. Sinding-Larsen-Johansson Syndrome -- Please add any further comments here if you wish:			
16.v. Pain Syndromes -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.v.i. Pain Syndromes -- Please add any further comments here if you wish:			
16.w. Other(s) please specify -- Please select one answer for each injury:			
Yes:			
No:			
Don't know:			
16.w.i. Other(s) please specify -- Please add any further comments here if you wish:			

17. What are the most common musculoskeletal injury sites in paediatric HMS patients at your clinic?			
17.a. Cervical Spine -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.a.i. Cervical Spine -- Please include any extra comments here if you wish to:			

17.b. Shoulders -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.b.i. Shoulders -- Please include any extra comments here if you wish to:			
17.c. Thoracic Spine -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.c.i. Thoracic Spine -- Please include any extra comments here if you wish to:			
17.d. Elbows -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.d.i. Elbows -- Please include any extra comments here if you wish to:			
17.e. Lumbar Spine -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.e.i. Lumbar Spine -- Please include any extra comments here if you wish to:			
17.f. Wrists -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.f.i. Wrists -- Please include any extra comments here if you wish to:			
17.g. Metacarpals -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.g.i. Metacarpals -- Please include any extra comments here if you wish to:			
17.h. Finger Phalanges -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.h.i. Finger Phalanges -- Please include any extra comments here if you wish to:			
17.i. Hips -- Please select one answer for each:			
Yes:			

No:			
Don't know:			
17.i.i. Hips -- Please include any extra comments here if you wish to:			
17.j. Pelvis -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.j.i. Pelvis -- Please include any extra comments here if you wish to:			
17.k. Knees -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.k.i. Knees -- Please include any extra comments here if you wish to:			
17.l. Ankles -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.l.i. Ankles -- Please include any extra comments here if you wish to:			
17.m. Metatarsals -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.m.i. Metatarsals -- Please include any extra comments here if you wish to:			
17.n. Toe Phalanges -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.n.i. Toe Phalanges -- Please include any extra comments here if you wish to:			
17.o. Other(s) please specify -- Please select one answer for each:			
Yes:			
No:			
Don't know:			
17.o.i. Other(s) please specify -- Please include any extra comments here if you wish to:			

Section 5

18. Do you recommend physical therapy and/or exercise training to paediatric HMS patients? (Please select

one answer)			
Yes:			
No:			

19. From your experience, **please rate the effectiveness of the following physical interventions** that may be used with paediatric patients presenting with HMS at your clinic.			
19.a. Muscular strength training -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.a.i. Muscular strength training -- Please add any further comments on physical interventions here if you wish:			
19.b. Muscular endurance training -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.b.i. Muscular endurance training -- Please add any further comments on physical interventions here if you wish:			
19.c. Proprioception and balance training -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.c.i. Proprioception and balance training -- Please add any further comments on physical interventions here if you wish:			
19.d. Core/Trunk strength and stability training -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.d.i. Core/Trunk strength and stability training -- Please add any further comments on physical interventions here if you wish:			
19.e. Flexibility training (e.g. stretching, warm up drills) -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			

19.e.i. Flexibility training (e.g. stretching, warm up drills) -- Please add any further comments on physical interventions here if you wish:			
19.f. Aerobic (cardiovascular) training -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.f.i. Aerobic (cardiovascular) training -- Please add any further comments on physical interventions here if you wish:			
19.g. Manual therapy techniques (e.g. massage, soft-tissue release, mobilisations) -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.g.i. Manual therapy techniques (e.g. massage, soft-tissue release, mobilisations) -- Please add any further comments on physical interventions here if you wish:			
19.h. Other(s) please specify -- Please select one answer for each:			
Very Effective:			
Not Very Effective:			
Useless:			
Don't Use:			
19.h.i. Other(s) please specify -- Please add any further comments on physical interventions here if you wish:			

20. From your experience, **where** do you recommend physical interventions for children to take place? (Please select one answer)			
At a hospital clinic under the supervision of a physiotherapist:			
At home under the supervision of a parent or guardian:			
At school:			
A combination of hospital based, school based and home based:			

21. From your experience, **what are the challenges that children commonly experience** with the physical interventions given to them to do at home, school or in hospital?			
21.a. Hospital, clinic or school based interventions -- Please select one answer for each:			
Yes:			
No:			

Don't Know:			
21.a.i. Hospital, clinic or school based interventions -- Please add any further comments **on challenges** here if you wish to:			
21.b. Home based interventions -- Please select one answer for each:			
Yes:			
No:			
Don't Know:			
21.b.i. Home based interventions -- Please add any further comments **on challenges** here if you wish to:			
21.c. Compliance to the intervention -- Please select one answer for each:			
Yes:			
No:			
Don't Know:			
21.c.i. Compliance to the intervention -- Please add any further comments **on challenges** here if you wish to:			
21.d. Replicating correct exercise techniques -- Please select one answer for each:			
Yes:			
No:			
Don't Know:			
21.d.i. Replicating correct exercise techniques -- Please add any further comments **on challenges** here if you wish to:			

22. From your experience, **how often** are children with HMS recommended to complete the physical interventions, given to them to do at home or in hospital? (Please select one answer)			
Daily:			
1 per week:			
2 per week:			
3+ per week:			
22.a. Please add any further comments on **frequency of physical therapy and training interventions** for children here if you wish to:			

Research & Knowledge Exchange
MORAY HOUSE SCHOOL of EDUCATION

The University of Edinburgh
Old Moray House
Holyrood Road
Edinburgh EH8 8AQ

Direct Dial 0131 651 6388
Switchboard 0131 650 1000
Email rke-education@ed.ac.uk
http://www.ed.ac.uk

Alice Mooney
SPEHS
Room 2.23
St Leonard's Land

17 April 2012

Dear Alice

Joint Hypermobility Syndrome, Injury Prevention and Management in Children

The School of Education Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the above application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 1 criterion. This is defined as"'straightforward' non-intervention, observational research (e.g. analysis of archived data, classroom observation, use of standardised questionnaires)".

A standard condition of this ethical approval is that you are required to notify the Committee, of any significant proposed deviation from the original protocol. The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Yours sincerely

S Cunningham

Dr S Bayne
Convener, School Ethics Sub-Committee

Research & Knowledge Exchange
MORAY HOUSE SCHOOL of EDUCATION

The University of Edinburgh
Old Moray House
Holyrood Road
Edinburgh EH8 8AQ

Direct Dial 0131 651 6388
Switchboard 0131 650 1000
Email rke-education@ed.ac.uk
http://www.ed.ac.uk

Alice Mooney
SPEHS
Room 2.23
St Leonards Land

11 July 2013

Dear Alice

Joint Hypermobility Syndrome, Balance and Pain in Paediatrics

The School of Education Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 3 criterion. This is defined as"applied to research which is potentially problematic in that it may incorporate an inherent physical or emotional risk to participants".

You are reminded that if the research changes in anyway from that described on your application form, you may need to re-apply for approval.

Yours sincerely

S Cunningham

pp Dr Sian Bayne
Convener, School Ethics Sub-Committee

Research & Knowledge Exchange
MORAY HOUSE SCHOOL of EDUCATION

The University of Edinburgh
Old Moray House
Holyrood Road
Edinburgh EH8 8AQ

Direct Dial 0131 651 6388
Switchboard 0131 650 1000
Email rke-education@ed.ac.uk
http://www.ed.ac.uk

Alice Mooney
SPEHS
Room 2.23
St Leonards Land

22 October 2013

Dear Alice

Joint Hypermobility Syndrome, Balance and Pain in Paediatrics – Control Group

The School of Education Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 3 criterion. This is defined as"applied to research which is potentially problematic in that it may incorporate an inherent physical or emotional risk to participants".

You are reminded that if the research changes in anyway from that described on your application form, you may need to re-apply for approval.

Yours sincerely

S Cunningham

Dr Sian Bayne
Convener, School Ethics Sub-Committee

THE UNIVERSITY of EDINBURGH

Alice Mooney
Office 2.23
Institute of Sport, Physical Education and Health Sciences
University of Edinburgh
Holyrood Road
EDINBURGH
EH8 8AQ
Scotland.

E: a.m.mooney@sms.ed.ac.uk

M: +44 (0) 7771695476

29/04/2013

Dear Donna,

Following our email exchanges on 11/04/2013 and our discussion by phone call regarding recruitment of HMSA members as study participants, I write to request formal approval from the HMSA for this collaboration.

Can you please confirm in writing (letter or email) if the HMSA approve? Please also advise me if there are any ethical procedures or requirements for an application to an ethics committee associated with the HMSA?

To confirm, I as principal investigator for the study intend to recruit a paediatric population sample of 40+ children clinically diagnosed with Joint Hypermobility Syndrome, age range four to twelve years and to carry out testing in July 2013 at the HMSA family days for children and parents. The proposed protocol is using four instruments to collect data on children with HMS as follows:

1. Nine-Point Beighton Score(Beighton et al., 1973) to measure generalised joint hypermobility
2. Brighton Criteria (Grahame et al., 2000) to measure symptoms associated with HMS.
3. Paediatric Balance Scale (Franjoine et al., 2010) to measure functional, static and dynamic balance in children.
4. Paediatric Pain Questionnaire Visual Analogue Scale (VAS) (Varni et al., 1987) to measure musculoskeletal pain associated with HMS in children.

Thank you for your time and help in being involved in this research.

Please do not hesitate to contact me with any questions.

Sincerely,

Alice Mooney
Office 2.23
Institute of Sport, Physical Education and Health Sciences
University of Edinburgh
Holyrood Road
EDINBURGH
EH8 8AQ
Scotland.

15th May 2013

Dear Alice,

Thank you for asking the Hypermobility Syndrome Association to assist with the recruitment of for your research.

There are no specific ethical considerations on behalf of the HMSA which would not have been covered by your own ethics committee.

The only additional thing we would ask is that you would sign a Data Protection form to enable us to share data with yourself and your team. We ask that you only use the data provided by ourselves in connection with the research as you have previously outlined to me. Any deviations would need to be agreed before using the data.

We would also ask that the HMSA is acknowledged in your research and in your final publication and that we also receive a copy of that publication to disseminate the information to our members.

Once the research participants are recruited we will need packs supplied by you with SAE to your address to send out. We will include a covering letter explaining our involvement and the sharing of data. Consent will be confirmed by the return of the information you need via the SAE. We have discussed costs to the HMSA and dependent on these we may invoice you for postage once the recruitment phase is complete.

The HMSA will assist in recruitment by;

Advertising amongst our membership that there is a need for recruitment within the parameters set out and agreed with the HMSA

We will also advertise on the forum, website, Twitter and the HMSA main Facebook pages.

We will set up a Fun Day for families in July in North London, to allow parents to bring children to you and also to allow us to work with the families on managing HMS in a positive way.

We will incorporate additional aspects of our work into the day.

We will make a small charge to families attending but we may need to ask for a small amount of money from you to support the event. Please advise if this will be difficult.

If this event does not bring in the 40+ children you need we will assist in setting up an additional research recruitment day in the North of England but this will be later in the year.

We are excited about working with you on this project. If you require any further assistance please do not hesitate to contact me. I have attached a Data Protection Form which I will need returned prior to sharing of data.

Yours sincerely,

Donna

Donna Wicks

(HMSA Senior Medical Liaison Officer)

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Hypermobility Syndrome, Balance and Pain

Principal Investigator: Miss Alice M. Mooney, PhD candidate, University of Edinburgh.

Young Person Information Sheet

Hello,
Would you like to join in some tests on the HMSA family fun day to help find the answer to the question:

Does Hypermobility Syndrome (HMS) affect your balance and pain?

Before you decide if you want to join in, it is important to understand why the tests are being done and what you will have to do. Please read this carefully with your parent/guardian. I am happy to answer any extra questions you have on the day or before this. I can be reached by email: a.m.mooney@sms.ed.ac.uk or phone: 01316516593 / 07771695476. If you would like to ask somebody outside the research team please ask Donna Wicks phone: 0845 345 4465.

WHO ARE WE?
Alice Mooney and Anne Martin, researchers from the University of Edinburgh, Scotland.

WHY DO WE WANT TO DO THIS STUDY?
Balance is important to protect your body every day when you move and in games and sports but it is sometimes different in children who have HMS. Pain is sometimes felt around the body by children who have HMS too. Information from tests will help us to understand how HMS affects you as children.

WHY HAVE I BEEN INVITED TO TAKE PART IN THIS STUDY?
You have been invited because you are a member of the HMSA, you have HMS and you are aged between 4 and 12 years old.

DO I HAVE TO TAKE PART?
No. It is your choice. You can also stop taking part in the study at anytime without giving a reason and this is OK.

WHAT DO I HAVE TO DO IF I WANT TO TAKE PART?
The study is very simple. At the HMSA family event day in 2013 you will have a chat with Alice in a group with other children who have HMS who you may already know from the HMSA.

Alice will measure your hypermobility by asking you to do some movements such as touching your toes and stretching your baby finger. Next Alice will measure your balance while you are standing still such as standing on one leg and in some movements such as turning around in a circle. In the last part, Alice will measure your pain through a short set of questions using a map of the body and faces on paper which you can draw your answers on to show if you feel pain, what parts of your body you feel pain in and how much pain you feel.

If you prefer not to do any of the exercises, this is OK. Anne will work with Alice writing down answers and these will be kept safely. Your name won't be linked to any of your answers. Don't worry about how well or badly you think you can do the exercises, as this does not matter.

Tests will take about 20 minutes. After this you can take part in fun activities organised by the HMSA for other children and parents with HMS, like learning how to think in a happy way and how to manage pain.

WILL OTHER INFORMATION BE COLLECTED?
Yes. A letter from your doctor who first noticed your hypermobility needs to be shared with Alice. This will not be shown to anyone else.

ARE THERE ANY BENEFITS OR HARM AND RISKS OF TAKING PART?
Taking part may not help you straight away, but the information will help us to understand how HMS affects children. You may have fun meeting other children with the same condition as you and you may make new friends!

There are no big risks involved in taking part in to this study, but you may feel uncomfortable doing some exercises. If this happens you can stop or take a rest. We will try to make the exercises quick and fun for you. There is a small risk of falling during the balance tests but researchers will help you if needed.

WHAT IF THERE IS A PROBLEM?
If you do not feel happy about something related to this study please tell us or your parents. Your parents will then tell us and we will work on ways to help you. If you need further help related to your hypermobility please contact your family doctor, physiotherapist or the HMSA.

WHAT WILL HAPPEN WITH THE INFORMATION FROM THE STUDY?
All information collected will be part of Alice's work as a researcher. We will share our findings of this study with other researchers, a report for the HMSA newsletter and another article. We will make sure that nobody can tell that you have been taking part.

If you are happy to take part, please let your parent know and/or sign the letter called "Young Person Assent Form" with your parent.

I look forward to meeting you at the HMSA family education day!

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Hypermobility Syndrome, Balance and Pain

Young Person Assent Form

Please draw a circle around the answers you agree with:

Has somebody else explained this study to you?	Yes /	No
Do you understand what this study is about?	Yes /	No
Have you asked all the questions you want?	Yes /	No
Have you had your questions answered in a way you can understand?	Yes /	No
Do you understand it's OK to stop taking part at any time?	Yes /	No
Are you happy to take part in the study?	Yes /	No

If any answers are "no" or you don't want to take part, don't sign your name.

If you do want to take part, you can tell your parent you are happy to do so and write your name below:

Your Name	Date	Signature

The researcher who explained this project to you needs to sign too:

Name of Researcher	Date	Signature

Thank you for your help. Please give this form to your parent/guardian to return this by post in the envelope provided or via email to a.m.mooney@sms.ed.ac.uk. **Tel: 07771695476.**

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Hypermobility Syndromes, Balance and Pain in Paediatrics

Principal Investigator: Miss Alice M. Mooney, PhD candidate, University of Edinburgh.

Parent/Guardian Information Sheet

Hello,

We are asking if you would like to join in a research project to find the answer to the question:

Does Hypermobility Syndrome (HMS) affect balance and pain in children?

Before you decide if you want to participate, it is important to understand what is involved and what you and your child will be asked to do. Please read this leaflet carefully. We are happy to answer any extra questions you have on the day or in advance so please do not hesitate to get in touch by email: a.m.mooney@sms.ed.ac.uk or phone: 0131 6516593 / 07771695476. If you like to ask somebody outside the research team please ask Donna Wicks phone: 0845 345 4455.

WHO ARE WE?

Alice M. Mooney, a Ph.D researcher with clinical experience in Remedial and Sports Massage from the University of Edinburgh, Scotland.

WHY DO WE WANT TO DO THIS STUDY?

Balance is important to protect the human body in everyday movement, activity, games and sports but it is sometimes compromised in people who have HMS, predisposing them to instability and injury such as trips and ankle sprains. Pain is experienced by children who have HMS but this is less understood in children, meaning it can be poorly managed and continue into adolescence and adult life. I wish to make a more complete assessment of a child with HMS, by gaining additional information about physical characteristics of balance skills and pain. This data will allow a better understanding of how HMS affects children, and to inform research on treatment and management strategies for children.

WHY HAVE MY CHILD AND I BEEN INVITED TO TAKE PART IN THIS STUDY?

As you expressed interest recently, you are members of the HMSA and your child has HMS and is aged between 4 and 12 years old.

DO I HAVE TO TAKE PART?

No. It is your choice. You and your child can also stop taking part in the study at any time without giving a reason why and this will not affect either of you.

WHAT DO MY CHILD AND I HAVE TO DO IF WE WANT TO TAKE PART?

At the HMSA family event day in July / October 2013 you will meet the researcher, Alice in a group with other children and parents who have HMS, who you may already know from the HMSA. Alice will measure your child's hypermobility using the Nine-Point Beighton Score, a series of nine short tests to measure generalised joint

hypermobility and the Brighton Criteria, a report used to measure symptoms associated with HMS. Balance will be measured using the Paediatric Balance Scale, a series of short tests to measure functional, static and dynamic balance skills in children such as standing on one foot and turning around in a circle. Pain associated with HMS in children will be measured using a self-report Paediatric Pain Questionnaire in which intensity and location of pain experienced will be recorded using scales of smiley faces and maps of the body. There is a parent and child version of this assessment so you are also asked to complete the Parent Form. Tests will take about 20 minutes. During the rest of the day, you can take part in activities and seminars organised by the HMSA such as positive thinking and pain management.

WHAT WILL HAPPEN TO THE RESULTS?

Your child's results will be kept confidentially for the researchers use only. Your name or your child's name will not appear in any written information, reports, articles or thesis chapters produced following the study.

WILL OTHER INFORMATION BE COLLECTED?

Yes. If you agree, a copy of a clinical diagnosis letter from the doctor/physiotherapist who diagnosed your child's hypermobility is required by Alice. This will be filed confidentially and not shared with anyone else.

ARE THERE ANY BENEFITS OR HARM AND RISKS OF TAKING PART?

Taking part in this study may not help your child directly, but it will help develop understanding of how HMS affects children. You and your child may find the sessions as part of the day informative and interesting and the gathering is hoped to provide a supportive network to families.

There are not many risks to this study, but your child may feel uncomfortable doing some exercises. If this happens your child can stop at any time. We will try to make the exercises quick, comfortable and fun. As the testing happens in a group setting you are welcome to be present while your child is completing the tests. There may be a small risk of injury during the balance tests such as losing balance and falling.

WHAT IF THERE IS A PROBLEM?

If you do not feel happy about something related to this study please tell Alice or the HMSA. The issue will be addressed following appropriate procedures. If you need further help related to your child's hypermobility please contact your family doctor/physiotherapist or the HMSA who have information on paediatric hypermobility clinics in the UK.

WHAT WILL HAPPEN WITH THE INFORMATION FROM THE STUDY?

All information collected will be part of Alice Mooney's work as a researcher. Findings of this study will be shared in a report for the HMSA newsletter. The study will also be written into a chapter within Alice's Ph.D thesis, a journal article and possibly a conference presentation. You and your child's names and data will remain anonymous.

Your child also has information about this study in a letter called "Young Person Information Sheet". Please read this with them and if you are both happy to take part in the study, please read, sign and return the "Young Person Assent Form" and "Parent/Guardian Informed Consent Form" to Alice at the HMSA event.

Thank you, your participation in the study is greatly appreciated!

Alice M. Mooney

I

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Hypermobility Syndrome, Balance and Pain in Paediatrics

Principal Investigator: Miss Alice M. Mooney, PhD Candidate, University of Edinburgh.

Parent/Guardian Informed Consent Form

I confirm that I have read and understand the information sheet for the above study and I have had the opportunity to ask questions.	YES / NO
I understand that participation is voluntary and that my child and I are free to withdraw at any time, without giving a reason.	YES / NO
I give my consent for my child to take part in the above study.	YES / NO
I agree that data gathered in this study may be stored securely (after it has been anonymised) for up to 5 years, and used for future research in HMS.	YES / NO
I give my consent for anonymised findings to be used in publications and presentations relating to the research.	YES / NO

Your Childs Name

Your Name (Parent/Guardian)	Date	Signature
Name of Researcher	Date	Signature

Thank you for your help. Please also complete questions on reverse page two, and return this by post in the SAE provided or via email to a.m.mooney@sms.ed.ac.uk. Tel: 07771695476.

1

This information will kept confidentially and securely by the principal investigator Alice Mooney, and it will enable me to send you a summary report when the study is complete.

Parent Contact Email Address:

Parent Contact Post Address:

Child's Age:

Child's Ethnicity:

Child's Gender:

Male / Female

Does your child take part in activities, sport and/or dance? Can you give details? e.g. type, duration of sessions etc.

YES / NO

Details:

Does your child have a treatment/management plan for HMS? Can you give details? e.g. exercise, rest, meds, physio

YES / NO

Details:

What symptoms of HMS does your child most commonly experience? Can you give details? e.g. pain, fatigue, injury

Does your child have a history of musculoskeletal injury? Can you give details? E.g. injury type, severity, location

YES / NO

Details:

From: Severine CUCHET <Scuchet@mapigroup.com>
Sent: 28 February 2013 13:18
To: MOONEY Alice Margaret
Subject: RE: 31585: Enquiry: PedsQL

Dear Alice

Thank you for your message. My name is Séverine Cuchet and I am pleased to be dealing with your request.

We will be pleased to provide you with the PedsQL scale but first I would ask you to complete and sign the User Agreement that can be downloaded from the PedsQL website at: http://www.pedsql.org/conditions.html
.

Once this is completed, please send it to us by regular mail to the address below. (A scanned copy may also be accepted to speed up the process as long as it is signed and that the original signed hardcopy is also sent by regular mail, we need it for our records).

Regarding access and use, I would like to inform you that the cost depends whether your study is funded or not. Indeed, the use of the PedsQL in the framework of a non-funded academic research study is free of charge. However, the fees to access and use the PedsQL in a funded academic research study are of 990 USD per study (including one module, regardless of age-groups and language version), an additional fee of 330 USD (for another module) and an additional fee of 25 USD for bank expenses is required.

Please note that review copies are available at: http://www.mapi-trust.org/services/questionnairelicensing/catalogquestionnaires/84-pedsql

The joint hypermobility seems to be referenced as a Musculoskeletal Disease in the MeSH.

I hope this is clear for you. Please do not hesitate to contact me should you need any additional information or have any other questions.

We look forward to hearing from you.

Best regards,
Séverine

New! It is now possible to pay your invoice online with a credit card. It is quick, easy and secure. Don’t hesitate to ask me should you be interested.

Séverine CUCHET
Project Assistant - PRO Information Support
MAPI Research Trust
27 rue de la Villette | 69003 LYON | FRANCE
Tel.: +33 (0)4 27 44 58 66 | Fax: +33 (0)4 72 13 55 73
scuchet@mapigroup.com | www.mapigroup.com | www.mapi-trust.org | www.proqolid.org | www.mapi-prolabels.org | www.mapi-pmr.org | www.mapi-store.com

Scoring Sheet for Nine-Point Beighton Score for Hypermobility

Name: _____

Age: _____ Date of Birth: _____

Diagnosis: _____

1. passive dorsiflexion 5th metacarpophalangeal joint to ≥ 90º (R)
2. passive dorsiflexion 5th metacarpophalangeal joint to ≥ 90º (L)
3. passive opposition of the thumb to volar aspect of ipsilateral forearm (R)
4. passive opposition of the thumb to volar aspect of ipsilateral forearm (L)
5. hyperextension of elbow to ≥ 10º (R)
6. hyperextension of elbow to ≥ 10º (L)
7. hyperextension of knee to ≥ 10º (R)
8. hyperextension of knee to ≥ 10º (L)
9. placing hands flat on the floor with feet together without bending knees

Test	Right	Left	**Total**
1. passive dorsiflexion 5th metacarpophalangeal joint to ≥ 90º	/1	/1	
2. passive thumb to forearm	/1	/1	
3. hyperextension of elbow to ≥ 10º	/1	/1	
4. hyperextension of knee to ≥ 10	/1	/1	
5. two hands flat on floor with straight knees	/1		**/9**

1998 Revised Brighton Criteria for Diagnosis of HMS

Please read the criteria below and indicate to the best of your knowledge which criteria/symptoms your child experiences and indicate these by circling YES or NO for each.

Major Criteria

1. Beighton score ≥ 4 of 9 (currently or historically) YES / NO
2. Arthralgia (joint pain) for longer than 3 months in ≥ 4 joints YES / NO

Minor Criteria

1. Beighton score = 1, 2 or 3 of 9 YES / NO
2. Arthralgia (≥ 3 months) in 1 to 3 joints, or back pain (≥ 3 months), spondylosis, spondylolysis/spondylolisthesis YES / NO
3. Dislocation/subluxation in more than 1 joint, or in 1 joint on more than 1 occasion YES / NO
4. Soft tissue rheumatism, ≥ 3 lesions (e.g., epicondylitis, tenosynovitis, bursitis) YES / NO
5. Marfanoid habitus (tall, slim, span/height ratio > 1.03, upper: lower segment ratio < 0.89, arachnodactily (positive Steinberg/wrist signs) YES / NO
6. Abnormal skin: striae, hyper extensibility, thin skin, papyraceous scarring YES / NO
7. Eye signs: drooping eyelids or myopia or antimongoloid slant YES / NO
8. Varicose veins or hernia or uterine/rectal prolapse YES / NO

Total Score: _____ Major and _____ Minor

Using this set of criteria an individual needs to score two major criteria or one major plus two minor criteria or four minor criteria. Two minor criteria are accepted where there is an unequivocally affected first-degree relative. HMS is excluded by presence of Marfan or Ehlers-Danlos Syndromes apart from the EDS-HM

A

PEDIATRIC BALANCE SCALE

Name: _____ Date: _____

Location: _____ Examiner: _____

Item Description		Score *0 - 4*	Seconds *optional*
1.	Sitting to standing	_____	
2.	Standing to sitting	_____	
3.	Transfers	_____	
4.	Standing unsupported	_____	_____
5.	Sitting unsupported	_____	_____
6.	Standing with eyes closed	_____	_____
7.	Standing with feet together	_____	_____
8.	Standing with one foot in front	_____	_____
9.	Standing on one foot	_____	_____
10.	Turning 360 degrees	_____	_____
11.	Turning to look behind	_____	
12.	Retrieving object from floor	_____	
13.	Placing alternate foot on stool	_____	_____
14.	Reaching forward with outstretched arm	_____	
	Total Test Score	_____	

General Instructions

1. Demonstrate each task and give instructions as written. A child may receive a practice trial on each item. If the child is unable to complete the task based on their ability to understand the directions, a second practice trial may be given. Verbal and visual directions may be clarified through the use of physical prompts.

2. Each item should be scored utilizing the 0 to 4 scale. Multiple trials are allowed on many of the items. The child's performance should be scored based upon the lowest criteria, which describes the child's best performance. If on the first trial a child receives the maximal score of 4, additional trials need not be administered. Several items require the child to maintain a given position for a specific time. Progressively, more points are deducted if the time or distance requirements are not met; if the subject's performance warrants supervision; or if the subject touches an external support or receives assistance from the examiner. Subjects should understand that they must maintain their balance while attempting the tasks. The choice, of which leg stand on or how far to reach, is left to the subject. Poor judgement will adversely influence the performance and the scoring. In addition to scoring items 4, 5, 6, 7, 8, 9, 10, and 13, the examiner may choose to record the exact time in seconds.

Figure. No caption available.

Paediatric Balance Scale: Protocol and Scoring Sheet

Total Score: ____ / 56 [Categories: 41-56 = low fall risk, 21-40 = medium fall risk, 0 –20 = high fall risk].

TEST	INSTRUCTION & EQUIPMENT	SCORING
1. SITTING TO STANDING	INSTRUCTIONS: Ask child to "HOLD ARMS UP AND STAND UP" EQUIPMENT: Bench	( ) 4 able to stand without using hands and stabilize independently ( ) 3 able to stand independently using hands ( ) 2 able to stand using hands after several tries ( ) 1 needs minimal aid to stand or stabilize ( ) 0 needs moderate or maximal assist to stand
2. STANDING TO SITTING	Ask child to "SIT DOWN SLOWLY WITHOUT USE OF HANDS" Bench	( ) 4 sits safely with minimal use of hands ( ) 3 controls descent by using hands ( ) 2 uses back of legs against chair to control descent ( ) 1 sits independently but has uncontrolled descent ( ) 0 needs assistance to sit
3. TRANSFERS	Arrange chairs for a standing pivot transfer, touching at 45 degree angle. Ask child to "TRANSFER ONE WAY TOWARD A SEAT WITH ARMRESTS & TRANSFER ONE WAY TOWARD A SEAT WITHOUT ARMRESTS"	( ) 4 able to transfer safely with minor use of hands ( ) 3 able to transfer safely definite need of hands ( ) 2 able to transfer with verbal cuing and/or

	2 Chairs (1 with armrests) or 1 chair + 1 bench	supervision ( ) 1 needs one person to assist ( ) 0 needs two people to assist or supervise to be safe
4. STANDING UNSUPPORTED	Ask child to "STAND FOR 30 SECONDS WITHOUT HOLDING ON OR MOVING FEET". Footprints may be placed on the floor to help maintain stationary position. Weight shifting and equilibrium responses in feet are acceptable. Movement of feet off surface indicates end of timed test. Stopwatch and 2 footprints placed shoulder width apart.	( ) 4 able to stand safely for 30 seconds ( ) 3 able to stand for 30 seconds with supervision ( ) 2 able to stand for 15 seconds unsupported ( ) 1 needs several tries to stand for 10 seconds unsupported ( ) 0 unable to stand for 10 seconds unassisted Time in seconds: _____
5. SITTING UNSUPPORTED WITH BACK UNSUPPOSRTED ON THE FLOOR	Ask child to "SIT WITH ARMS FOLDED ON CHEST FOR 30 SECONDS". Protective reactions observed in trunk or upper limbs indicates end of timed test. Stopwatch + bench	( ) 4 able to sit safely and securely for 30 seconds ( ) 3 able to sit 30 seconds under supervision ( ) 2 able to able to sit for 15 seconds ( ) 1 able to sit for 10 seconds ( ) 0 unable to sit without support for 10 seconds
6. STANDING UNSUPPORTED WITH EYES CLOSED	Ask child to "STAND WITH FEET SHOULDER WIDTH APART AND CLOSE EYES FOR 10 SECONDS". Footprints may be placed on the floor to help maintain stationary position. Weight shifting and equilibrium responses in feet are acceptable.	( ) 4 able to stand for 10 seconds safely ( ) 3 able to stand for 10 seconds with supervision ( ) 2 able to stand for 3 seconds

	Movement of feet off surface indicates end of timed test. Stopwatch + 2 footprints placed shoulder width apart + blindfold.	( ) 1 unable to keep eyes closed for 3 seconds but stays safely ( ) 0 needs help to keep from falling Time in seconds: _____
7. STANDING UNSUPPORTED WITH FEET TOGETHER	Ask child to "PLACE FEET TOGETHER AND STAND STILL WITHOUT HOLDING ON". Footprints may be placed on the floor to help maintain stationary position. Weight shifting and equilibrium responses in feet are acceptable. Movement of feet off surface indicates end of timed test. Stopwatch + 2 footprints placed together	( ) 4 able to place feet together independently and stand for 30 seconds safely ( ) 3 able to place feet together independently and stand for 30 seconds with supervision ( ) 2 able to place feet together independently but unable to hold for 30 seconds ( ) 1 needs help to attain position but able to stand for 30 seconds feet together ( ) 0 needs help to attain position and unable to hold for 30 seconds. Time in seconds: _____
8. STANDING UNSUPPORTED ONE FOOT IN FRONT	Ask child to "STAND WITH ONE FOOT DIRECTLY IN FRONT OF THE OTHER, HEEL TO TOE" (i.e. tandem position). Footprints may be placed on the floor to help maintain stationary position. Weight shifting and equilibrium responses in feet are acceptable. Movement of feet off surface and/or upper limbs used for support indicates end of timed test.	( ) 4 able to place foot tandem independently and hold for 30 seconds ( ) 3 able to place foot ahead independently and hold for 30 seconds ( ) 2 able to take small step independently and hold

	Stopwatch + 2 footprints placed heel to toe	for 30 seconds ( ) 1 needs help to step but can hold for 15 seconds ( ) 0 loses balance while stepping or standing Time in seconds: _____
9. STANDING ON ONE LEG	Ask child to "STAND ON ONE LEG FOR AS LONG AS THEY ARE ABLE TO WITHOUT HOLDING ON". Footprints may be placed on the floor to help maintain stationary position. Weight shifting and equilibrium responses in feet are acceptable. Movement of feet off surface and/or upper limbs used for support indicates end of timed test. Stopwatch + 2 footprints placed heel to toe	( ) 4 able to lift leg independently and hold for > 10 seconds ( ) 3 able to lift leg independently and hold for 5 to 9 seconds ( ) 2 able to lift leg independently and hold for 3 to 4 seconds ( ) 1 tries to lift leg unable to hold for 3 seconds but remains standing independently ( ) 0 unable to try of needs assist to prevent fall
10. TURN 360 DEGREES	Ask child to "TURN COMPLETELY AROUND IN A FULL CIRCLE, STOP AND THEN TURN A FULL CIRCLE IN THE OTHER DIRECTION". Stopwatch	( ) 4 able to turn 360 degrees safely in 4 seconds or less ( ) 3 able to turn 360 degrees safely one side only 4 seconds or less ( ) 2 able to turn 360 degrees safely but slowly ( ) 1 needs close supervision or constant verbal

		cuing ( ) 0 needs assistance while turning Time in seconds: _____
11. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING	Ask child to "STAND WITH FEET STILL FIXED IN ONE PLACE, FOLLOW OBJECT AS I LOVE IT, KEEP WATCHING BUT DON'T MOVE YOUR FEET". A brightly coloured object + 2 footprints placed shoulder width apart	( ) 4 looks behind/over each shoulder, from both sides, weight shifts include trunk rotation ( ) 3 looks behind/over one shoulder with trunk rotation, one side only other side shows less weight shift ( ) 2 turns head to look to level of shoulder, no trunk rotation but maintains balance ( ) 1 needs supervision when turning ( ) 0 needs assist to keep from losing balance or falling
12. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION	Ask child to "PICK UP A SOFT BALL PLACED APPROX. THE LENGTH OF THEIR FOOT IN FRONT OF THEIR DOMINANT FOOT". Soft ball + Footprints	( ) 4 able to pick up soft ball safely and easily ( ) 3 able to pick up soft ball but needs supervision ( ) 2 unable to pick up soft ball but reaches 2-5 cm (1-2 inches) from … and keeps balance independently ( ) 1 unable to pick up soft ball and needs supervision while trying

		( ) 0 unable to try/needs assistance to keep from losing balance or falling
13. PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED	Ask child to "PLACE EACH FOOT ALTERNATELY ON THE STEP/STOOL AND CONTINUE UNTIL EACH FOOT HAS TOUCHED THE STEP/STOOL 4 TIMES" A step/stool (4 inches in height) + stopwatch	( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds ( ) 3 able to stand independently and complete 8 steps in > 20 seconds ( ) 2 able to complete 4 steps without aid with supervision ( ) 1 able to complete > 2 steps needs minimal assistance ( ) 0 needs assistance to maintain balance or keep from falling or unable to try Time in seconds: ____
14. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING	Set up: Fix ruler to a wall via blutac/velcro strips. Footprints used to maintain a stationary foot position. Ask child to "LIFT ARMS UP, STRETCH OUT FINGERS AND MAKE A FIST, AND REACH FORWARD AS FAR AS YOU CAN WITHOUT MOVING YOUR FEET OFF FOOTPRINTS OR FALLING". Support may not be given in the reaching process. A ruler + footprints + a level	( ) 4 can reach forward confidently > 25 cm (10 inches) ( ) 3 can reach forward > 12 cm (5 inches) ( ) 2 can reach forward 5 cm (2 inches) ( ) 1 reaches forward but needs supervision ( ) 0 loses balance while trying/requires external support

PedsQL™

Paediatric Pain Questionnaire™

Young Child Form (5-7 years of age)

Name: _____

Date: _____ **Record Number:** _____

What words would you use to describe your pain or hurt?

_____

_____

_____

1. Put a mark on the line that best shows **how you feel now**. If you have no pain or hurt, you would put a mark at the end of the line by the happy face. If you have some pain or hurt, you would put a mark near the middle of the line. If you have a lot of pain or hurt, you would put a mark by the sad face.

Not hurting
No discomfort
No pain

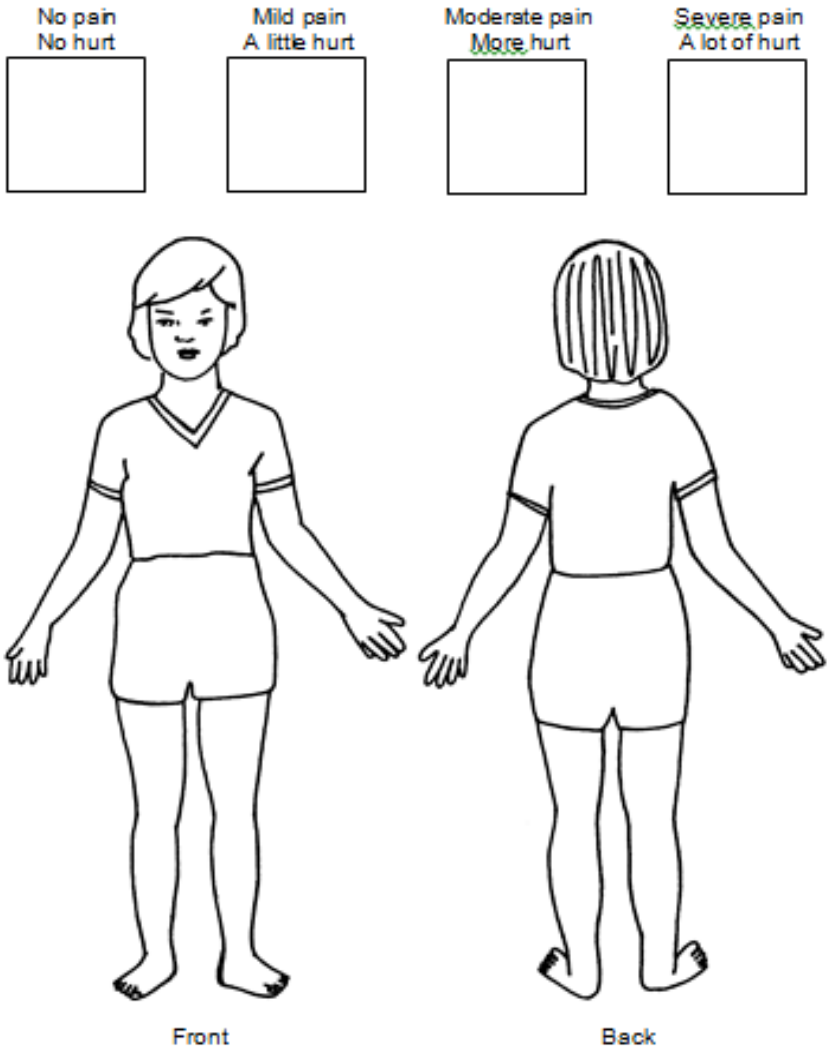
Hurting a lot
Very uncomfortable
Severe Pain

2. Put a mark on the line that best shows what was the **worst pain you had over the last 7 days**. If you had no pain or hurt over the last 7 days, you would put a mark at the end of the line by the happy face. If you had some pain or hurt, you would put a mark by the middle of the line. If the worst pain you had was a lot of pain, you would put a mark by the sad face.

Not hurting
No discomfort
No pain

Hurting a lot
Very uncomfortable
Severe Pain

Pick the colours that mean **No hurt, A little hurt, More hurt,** and **A lot of hurt** to you and colour in the boxes. Now, using these colours, colour in the body to show how you feel. Where you have no hurt, use the **No hurt** colour to colour in your body. If you have hurt or pain, use the colour that tells how much hurt you have.



(Varni et al., 1987) Questionnaire reproduced with permission (Appendix 11).

PedsQL™

Pediatric Pain Questionnaire™

Parent of Young Child Form (5-7 years of age)

Name: _____

Date: _____ **Record Number:** _____

What words would you use to describe your child's pain or hurt?

_____

_____

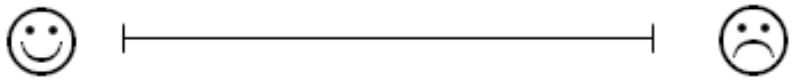
_____

1. Please rate how much pain you think your child is having **at the present time** by placing a mark somewhere on the line.

Not hurting
No discomfort
No pain

Hurting a whole lot
Very uncomfortable
Severe Pain

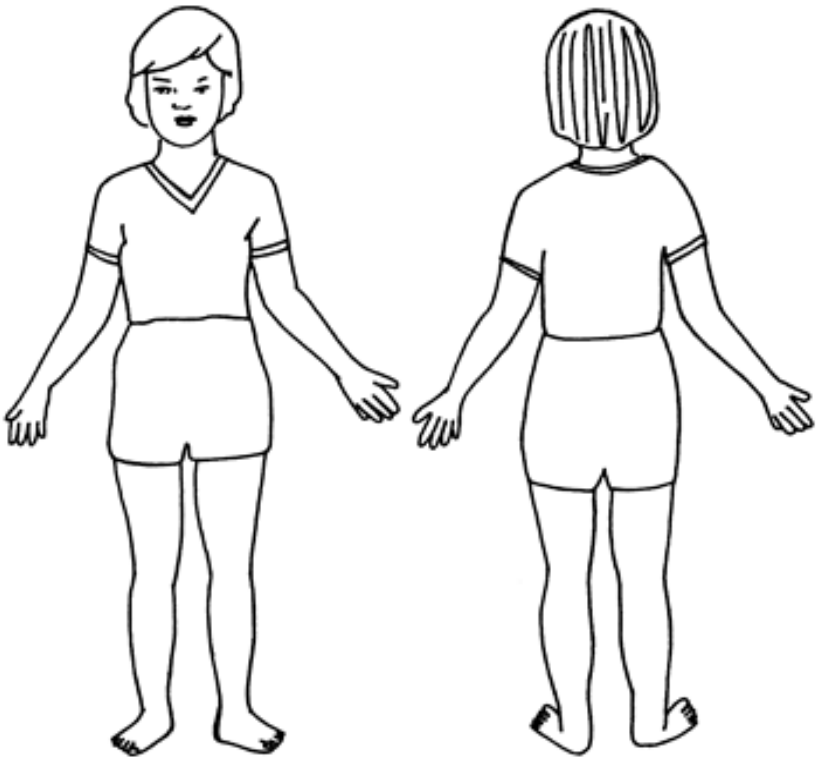
2. Please rate how severe the **worst pain** your child had **in the past week** (7 days) by placing a mark somewhere on the line.



Not hurting
No discomfort
No pain

Hurting a whole lot
Very uncomfortable
Severe Pain

Please mark an **X** on the **exact** place where you think your child is having pain now. If there is more than one painful place, mark them '1', '2', '3', etc., starting with the most painful place as '1'.



Front Back

(Varni et al., 1987) Questionnaire reproduced with permission (Appendix 11).

THE UNIVERSITY of EDINBURGH

Alice Mooney
Institute of Sport, Physical Education and Health Sciences,
University of Edinburgh
Holyrood Road
EDINBURGH
EH8 8AQ
Scotland.

E: a.m.mooney@sms.ed.ac.uk

M: +44 (0) 7771695476

20/09/2013

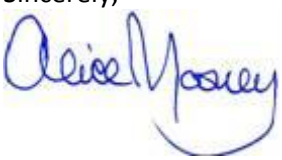
Dear Diane,
Following our discussion by phone call today regarding the recruitment of students of Buckstone Primary School, Edinburgh as study participants, I write to request formal approval from the school for this collaboration.

Can you please confirm in writing (letter or email) if the school approve? Please also advise me if there are any ethical procedures or requirements for an application to an ethics committee associated with Buckstone Primary School?

To confirm, I as principal investigator for the study intend to recruit a paediatric population sample of 30+ children, age range four to twelve years and to carry out testing in October 2013 at the school. The proposed protocol is detailed in the Young Person and Parent/Guardian Information Sheets.

Thank you for your time and help in being involved in this research. Please do not hesitate to contact me with any questions.

Sincerely,



RE: Request for Collaboration
Diane Donnelly Diane.Donnelly@buckstone.edin.sch.uk

Sent: Sun 29/09/2013 22:58
To: Alice Mooney

Dear Alice,
Buckstone Primary School are happy to put forward pupils to take part in your study under the following conditions; no interactions with pupils will take place without full parental consent, you will provide a proposed protocol which you will detail in the young person and parent information sheets. All communication with parents regarding the study will be held by you but be available to Senior Management at Buckstone Primary School if requested.
I confirm that your disclosure certificate is recent and appropriate and I have viewed all initial details being sent to parents and pupils.
Yours Sincerely
Diane Donnelly

Diane Donnelly
Depute Head Teacher
Buckstone Primary School

From: Alice Mooney [a.m.mooney@sms.ed.ac.uk]
Sent: Friday, September 20, 2013 1:51 PM
To: Diane Donnelly
Subject: Request for Collaboration

Dear Diane,
Please see letter attached, which requests written approval from Buckstone Primary School regarding participation in the research study.
A brief reply by email or letter would be very much appreciated so I can forward to my ethics committee.
Many Thanks,
Alice

~~
Alice Mooney, M.Sc., MSMA, PG CE
Institute of Sport, Physical Education and Health Sciences
University of Edinburgh
Holyrood Road
Edinburgh EH8 8AQ
Scotland.

e: a.m.mooney@sms.ed.ac.uk
t: 0044 (0) 1316516593
m: 0044 (0) 7771695476
Skype: alice.mooney1
Twitter @alicemooney14
--

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Mobility, Balance and Pain

Principal Investigator: Miss Alice M. Mooney, PhD candidate, University of Edinburgh.

Young Person Information Sheet

Hello,
Would you like to join in a study as part of a project to help find the answer to the question:

Does Hypermobility Syndrome (HMS) affect your balance and pain?

Before you decide if you want to join in, it is important to understand why the tests are being done and what you will have to do. Please read this carefully with your parent/guardian. I am happy to answer any extra questions you have on the day or before this. I can be reached by email: a.m.mooney@sms.ed.ac.uk or phone: 01316516593 / 07771695476. If you would like to ask somebody outside the research team please ask Donna Wicks phone: 0845 345 4465.

WHO AM I?
Alice Mooney, a researcher from the University of Edinburgh, Scotland.

WHY DO WE WANT TO DO THIS STUDY?
The study is taking place to measure joint range of movement, balance and pain in children as part of study on joint hypermobility. Balance is important to protect your body every day when you move and in games and sports but it is sometimes different in children who have hypermobility. Pain is sometimes felt around the body by children who have hypermobility too. Information from tests will help us to understand how hypermobility affects children, and the differences between them and healthy children, like you, who do not have hypermobility.

WHY HAVE I BEEN INVITED TO TAKE PART IN THIS STUDY?
You have been invited because you are aged between 4 and 12 years old and attend a school in Edinburgh. N.B. you do not need to be hypermobile to take part in the pilot study.

DO I HAVE TO TAKE PART?
No. It is your choice. You can also stop taking part in the study at any time without giving a reason and this is OK.

WHAT DO I HAVE TO DO IF I WANT TO TAKE PART?
The study is very simple. You will have a chat with Alice in a group with other children at your school.

Alice will measure your hypermobility by asking you to do some movements such as touching your toes and holding your arm out straight. Next Alice will measure your balance while you are standing still such as standing on one leg, and in some movements such as turning around in a circle. In the last part, Alice will measure your pain through a short set of questions using a map of the body and faces on paper which you can draw your answers on to show if you feel pain, what parts of your body you feel pain in, and how much pain you feel.

If you prefer not to do any of the exercises, this is OK. Your answers will be kept safely and your name won't be linked to any of your answers. Don't worry about how well or badly you think you can do the exercises, as this does not matter. Tests will take about 15 to 20 minutes.

WILL OTHER INFORMATION BE COLLECTED?
Yes. If you agree, some extra details such as your age and family contact details are required by Alice. This will be filed safely and not shared with anyone else.

ARE THERE ANY BENEFITS OR HARM AND RISKS OF TAKING PART?
Taking part may not help you straight away, but the information will help us to understand how hypermobility affects children. There are no big risks involved in taking part in to this study, but you may feel uncomfortable doing some exercises. If this happens you can stop or take a rest. We will try to make the exercises quick and fun for you. There is a small risk of falling during the balance tests but researcher will help you if needed.

WHAT IF THERE IS A PROBLEM?
If you do not feel happy about something related to this study please tell us or your parents. Your parents will then tell us and we will work on ways to help you. If you show any signs of being very flexible with pain or struggles with your balance, I will write to your parent/guardian to let them know, and advise you visit your family doctor or physiotherapist to have this checked.

WHAT WILL HAPPEN WITH THE INFORMATION FROM THE STUDY?
All information collected will be part of Alice's work as a researcher. We will share our findings of the overall study with a report and an article. We will make sure that nobody can tell that you have been taking part.

If you are happy to take part, please let your parent know and/or sign the letter called "Young Person Assent Form" with your parent.

I look forward to meeting you.

Thank you!

Alice M. Mooney

I

THE UNIVERSITY
of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Mobility, Balance and Pain

Young Person Assent Form

Please draw a circle around the answers you agree with:

Has somebody else explained this study to you?	Yes /	No
Do you understand what this study is about?	Yes /	No
Have you asked all the questions you want?	Yes /	No
Have you had your questions answered in a way you can understand?	Yes /	No
Do you understand it's OK to stop taking part at any time?	Yes /	No
Are you happy to take part in the study?	Yes /	No

If any answers are "no" or you don't want to take part, don't sign your name.

If you do want to take part, you can tell your parent you are happy to do so and write your name below.

Your Name	Date	Signature

The researcher who explained this project to you needs to sign too:

Name of Researcher	Date	Signature

Thank you for your help. Please give this form to your parent/guardian to return this by post in the envelope provided or via email to a.m.mooney@sms.ed.ac.uk. Tel: 07771695476.

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Mobility, Balance and Pain in Paediatrics

Principal Investigator: Miss Alice M. Mooney, PhD candidate, University of Edinburgh.

Parent/Guardian Information Sheet

Hello,
I'm in touch to ask if you would like to join in a study as part of a research project being carried out to find the answer to the question:

Does Hypermobility Syndrome (HMS) affect balance and pain in children?

Before you decide if you want to participate, it is important to understand what is involved and what you and your child will be asked to do. Please read this leaflet carefully. I am happy to answer any extra questions you have so please do not hesitate to contact me by email: a.m.mooney@sms.ed.ac.uk or phone: 0131 6516593 / 07771695476. If you would like to ask somebody outside the research team please ask Donna Wicks phone: 0845 345 4465.

WHO AM I?
Alice Mooney, a PhD researcher with clinical experience in Remedial and Sports Massage from the University of Edinburgh, Scotland. I am working under the supervision of Dr. Tony Turner and Dr. Simon Coleman.

WHY DO WE WANT TO DO THIS STUDY?
The purpose of the current study is to measure joint range of movement, balance and pain in children. Balance is important to protect the human body in everyday movement, activity, games and sports but it is sometimes compromised in children who have hypermobile joints, predisposing them to instability and injury. Musculoskeletal pain is experienced by children who have hypermobility and can continue into adolescence and adult life. We wish to make a more complete assessment of a child with hypermobility, by gaining additional information about physical characteristics of balance skills and pain. This data will allow a better understanding of how hypermobility affects children, and to inform research on treatment and management strategies for children. It is necessary to measure healthy children without hypermobility to test for differences between groups.

WHY HAVE MY CHILD AND I BEEN INVITED TO TAKE PART IN THIS STUDY?
As your child is aged between 4 and 12 years old and attends a school in Edinburgh. N.B. Your child does not need to be hypermobile.

DO I HAVE TO TAKE PART?
No. It is your choice. You and your child can also stop taking part in the study at any time without giving a reason why.

WHAT DO MY CHILD AND I HAVE TO DO IF WE WANT TO TAKE PART?
Your child will meet the researcher, Alice in September 2013, in a group with other children from school.

Alice will measure your child's hypermobility using the Nine-Point Beighton Score, a series of nine short tests to measure generalised joint hypermobility and the Brighton Criteria, a report used to measure symptoms associated with HMS. Balance will be measured using the Paediatric Balance Scale, a series of short tests to measure functional, static and dynamic balance skills in children such as standing on one foot and turning around in a circle.

Pain in children will be measured using a self-report Paediatric Pain Questionnaire in which intensity and location of any pain experienced will be recorded using scales of smiley faces and maps of the body. There is a parent and child version of this assessment so you are also asked to complete the Parent Form. Tests will take about 20 minutes.

WHAT WILL HAPPEN TO THE RESULTS?

Your child's results will be kept confidentially in password protected electronic files for the researchers use only. Your name or your child's name will not appear in any written information, reports, articles or thesis chapters produced following the study.

WILL OTHER INFORMATION BE COLLECTED?

Yes. If you agree, some extra details such as your child's age and family contact details i.e. post and email addresses are required by Alice. This will be filed confidentially and not shared with anyone else.

ARE THERE ANY BENEFITS OR HARM AND RISKS OF TAKING PART?

Taking part in this study may not help your child directly, but it will help to develop understanding of how hypermobility affects children. There are no serious risks involved in taking part in this study, but your child may feel uncomfortable doing some exercises. If this happens your child can stop at any time. We will try to make the exercises quick, comfortable and fun. As the testing happens in a group setting you are welcome to be present while your child is completing the tests. There may be a small risk of injury during the balance tests such as losing balance and falling but Alice will help if needed.

WHAT IF THERE IS A PROBLEM?

If you do not feel happy about something related to this study please tell Alice. Your child may withdraw at any time. The issue will be addressed following appropriate procedures. If your child shows attributes for a positive diagnoses of generalised joint hypermobility, impairments in balance and/or symptoms of musculoskeletal pain, I will inform you through a letter/email, advising that results from the preliminary tests carried out suggest the presence of symptoms. A visit to a medical professional such as a GP or paediatric physiotherapist will also be advised.

WHAT WILL HAPPEN WITH THE INFORMATION FROM THE STUDY?

All information collected will be part of Alice's work as a researcher. Findings of this study will be shared with you in a summary report. The study will also be written into a chapter within Alice's PhD thesis. You and your child's names and data will remain anonymous.

Please read this with your child and if you are both happy to take part in the study, please read, sign and return the "Young Person Assent Form" and "Parent/Guardian Informed Consent Form & Details Form" on the day or by email to a.m.mooney@sms.ed.ac.uk.

Thank you. Your participation in the study is greatly appreciated!

Alice M. Mooney

I

THE UNIVERSITY of EDINBURGH

Institute of Sport, Physical Education and Health Sciences

HMSA The Hypermobility Syndrome Association

Mobility, Balance and Pain in Paediatrics

Principal Investigator: Miss Alice M. Mooney, PhD Candidate, University of Edinburgh.

Parent/Guardian Informed Consent Form

I confirm that I have read and understand the information sheet for the above study and I have had the opportunity to ask questions.	YES / NO
I understand that participation is voluntary and that my child and I are free to withdraw at any time, without giving a reason.	YES / NO
I give my consent for my child to take part in the above study.	YES / NO
I agree that data gathered in this study may be stored securely (after it has been anonymised) for up to 5 years, and used for future research in hypermobility.	YES / NO

Your Childs Name

Your Name (Parent/Guardian) Date Signature

Name of Researcher Date Signature

Thank you for your help. Please also complete questions on reverse page two, and return this at the testing day or via email to a.m.mooney@sms.ed.ac.uk. Tel: 07771695476.

1

This information will kept confidentially and securely by the principal investigator Alice Mooney and it will enable a summary report to be sent to you when the study is complete.

Parent Contact Email Address:

Parent Contact Post Address:

Child's Age:

Child's Ethnicity:

Child's Gender:

Male / Female

Does your child take part in activities, sport and/or dance? Can you give details? e.g. type, duration of sessions etc.

YES / NO

Details: