The short-term effect of a functional exercise program on the bilateral shoulder pain of a professional cellist: a case report

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Summary

Introduction:

The question asked in this case report is: what is the effect of a functional exercise program on a professional cellist with shoulder pain in terms of pain reduction and improvement in coordination, measured with the local perceived discomfort scale (LPD) and with the face validity of a video recording. Up to 87% of string instrument players have pain related musculoskeletal disorders (PRMDs). Recognition and adequate treatment of injuries in musicians can limit the impact of injury on a musician's career as well as improving treatment possibilities and reducing the costs of health care and disability. Cellists sustain high levels of injury in their shoulders, but little is known about the specific causes or treatments of cellists' injuries beyond clinical expertise.

Method:
A 48-year-old cellist in a professional orchestra in the Netherlands presented at a physical therapy practice with chronic playing-related bilateral shoulder pain of unknown origin. The Brighton criteria were positive for benign joint hypermobility syndrome (BJSS). Observation of video material of the patient playing showed that she was not in plumb alignment and that the shoulders seemed to have to work excessively hard. Spinal motion was not fluid and didn't always support the work load in the shoulders. When used, it mainly supported the changing of positions in the more static left arm and not the action of the dynamic bowing arm. The LPD was used to determine the location and level of pain in the upper extremity. It is hypothesized that a slight alteration in cello playing strategy, including using more integrated movement in the spine to facilitate movement in the shoulders, will reduce the work load on the shoulders by spreading the load across a maximal number of structures/joints. This can result not only in a reduction of pain but could literally take the focus off of the shoulders as the 'problem'. The patient received functional exercises, learning first how to utilize the full range of motion (ROM) of rotation in the trunk without the cello and then how to utilize this new movement pattern in her cello technique with cello specific exercises.

Results:
The patient did functional exercises for 10 days. The pain increased so dramatically that the patient had to stop playing and doing the exercises for a week. The LPD showed no minimal clinically important difference (MCID) in pain areas that were scored both in the baseline and effect measurements. It was able to describe a pain pattern, with more pain locations on the right and dorsal side of the body. Of the 26 areas of pain described in the baseline and effect LPD, 14 were either new areas of pain or areas where pain had disappeared. Video observation showed no absolute improvements in the integration of movement of the spine and shoulders.

Discussion:
This intervention's effects were likely limited by time constraints and patient compliance, but show potential for future research. An exercise program also focusing on scapular stability, shoulder strength and posture might have helped this patient. Analysis of movement patterns could be accomplished using more technological solutions. Future study should be devoted to causal factors of PRMDs in cellists as well as targeted interventions such as this one.

Key words: cello, shoulder pain, postural instruction, physical therapy, LPD

Introduction

A successful musical performance requires peak physical and mental performance under pressure. Inadequate treatment of injury can lead to a significant drop in the quality of life, the artistic achievement, the financial situation and ultimately the career of a musician. Recognition of the complex nature and impact of injury to musicians could substantially improve treatment possibilities and reduce the long-term costs of health care and disability.

Because of the paucity of research as well as ignorance amongst medical professionals of the complexity of the disorders, playing-related musculoskeletal disorders (PRMDs) are often inadequately recognized or treated (Kava et al, 2010). Though Performance Medicine is a growing field, management of occupational disorders in musicians continues to be based almost entirely on clinical experience rather than scientific evidence (Schuele, 2004).

Of the approximately 17,000 performing artists in the Netherlands, approximately 13,000 are professional musicians. Despite their small numbers, their reach is broad: performances by professional artists were attended by 21,5 million people in 2009, and the performing arts as a whole were responsible for 0.8% to 0.9% of the total number of jobs (Podiumpeiler, 2011). Estimates of the prevalence of PRMDs in adult instrumentalists range from 39% to 87%, with more recent studies showing higher prevalences (Stotijn, 2006; Zaza, 1998). Musicians also often suffer from entrapment neuropathies and focal dystonia, and multiple diagnoses are frequent (Paarup, 2011; Scheule, 2004; Dawson, 2002; Lederman, 1995; Middlestadt and Fishbein, 1989). However, the extant literature is unanimous about musculoskeletal problems being the most common source of pain and injury in instrumentalists.

The results of an internet search demonstrate that literature specifically about string instrument players, and in general about performing arts medicine, is sparse. Stotijn's literature review (2006) gives a good overview of health risks, injury and prevention in musicians. The problems of string players are included in several systematic reviews, many from the 1980's and 1990's, most of which looked at problems of orchestral musicians (Schuele & Lederman, 2004; Zaza,1992; Middlestadt & Fishbein,1989). However, the terminology and methods used for research on musicians makes comparison between studies difficult (Dawson, 1998).

Amongst orchestral musicians, string instrument players have the highest prevalence of PRMDs. In a survey of 48 orchestras (2212 respondents), 66% of the string players reported serious musculoskeletal injuries, significantly more than other instrument groups (Middlestadt & Fishbein, 1989). String players most commonly suffer PRMDs in the upper extremities. Women tend to have more, and more severe, PMRDs. (Paarup et al, 2012; Wilke et al, 2011; Middlestadt & Fishbein, 1989). Distribution of PMRDs is generally related to the size of the instrument as well as the required technique. Middlestadt & Fishbein (1989) found that cellists had the highest levels of severe musculoskeletal problems in string players, with the right shoulder, right neck, lower back and left hand the most common locations of injury.

Musicians' occupational disorders, with the exception of focal dystonia, tend to have good prognoses and don't often result in lasting disability.
Conservative treatment, usually involving rest, is often beneficial but is not always financially or psychologically possible. Insurance covering income lost because of playing-related injury is marginally available and not always affordable, especially for the self-employed musician (Schuele & Lederman, 2004;

Chmelar, 1990). Successful therapies for PRMDs in musicians will take note of all of these relevant factors and be based on the available research.

Theoretical construct

Playing-related musculoskeletal disorders can be seen as the result of a disbalance between the requirements of playing an instrument and performing, and the musician’s physical and mental capacity to meet these requirements. Asymmetric postures, inherent to the playing of an instrument, and rehearsal length are significant factors in the development of PRMDs (Wilke, 2011). Static positions and muscle tension can decrease blood flow to working tissues, contributing to tissue overload and microtrauma, both of which can lead to injury over time. Repetitious movement and limited recovery time also may contribute.

Hypermobility, which is more prevalent amongst musicians than in the general population, frequently contributes to musculoskeletal problems, including joint pain. It is often overlooked as a possible cause of PRMDs. The Brighton criteria, currently the instrument of choice in the diagnosis of benign joint hypermobility syndrome (BJHS) is quick, accurate and noninvasive (Dawson, 2001; Grahame, 2012; Middlestadt & Fishbein, 1989; Rickert, 2012; Brandfonbrenner, 1990).

Psychological factors play an important role in the development of PRMDs. Musicians are often subject to extreme pressure to perform at their best. Artistic achievement is the holy grail, both for the musician and his employer. Failure can be a stressful event, both in the personal and private domain, and can have serious financial consequences. Stress in various forms is inherent in the profession, and a performers’ ability to cope with stress has a direct impact on performance (Schmidt & Wrisberg, 2008) as well as on the performer’s experience of injury. Recent studies show that up to 70% of musicians suffer from stage fright (Brugués, 2011). Physical aspects of stage fright include muscle stiffening in an effort to maintain control, a loss of body awareness and a decreased capacity to differentiate movements, all of which can contribute to injury (Lee et al, 2012; Schmidt & Wrisberg, 2008; Burken & Swank, 2000). Psychological factors that affect or even cause injury, such as stage fright, are best treated preventatively (Brugués, 2011).

Whatever the cause, the resultant injury disrupts performance. Every instrumentalist develops his own strategy when confronted with a constraint such as shoulder injury. The strategy chosen is dependant on many factors, including past experiences (memory), the individuals’ physical ability to compensate for the injury, and work pressure. PRMDs limit the choice of movement strategies that a performer has. Movement strategies also change because pain. These changes can in turn lead to further injury.

As in top sport, instrumentalists’ movement strategies are learned early and refined for years. Though new movement strategies can minimize tissue overload and allow healing to take place, learning or adjusting a movement strategy can be difficult or impossible, may take time and will certainly affect performance, at least in the short term. Whether or not a new strategy will be successful is dependent on the performer’s abilities and motivation to change as well as on the demands of his career.

When PRMDs exist, several physical therapy treatment modalities may be useful. Coordination and strength training are typical interventions, counteracting the effects of repetitious movement and static postures. Periods of rest may be advised, allowing tissues to heal. Functional training is useful for instrumentalists, whose work requires a high degree of complexity.

While all instruments can be seen as constraints, literature shows that cellists suffer amongst the highest levels of PRMDs, perhaps because of the cello's shape and large size. As with most instruments, it is not possible to play the cello in a symmetrical way, nor can one eliminate the need for static postures or repetitious movement. In playing, the left arm tends to be relatively static, facilitating fine motor coordination in the left (fingering) hand. The right (bow) arm is used dynamically. In general the scapulae serve as a stable base, or punctum fixum, for arm movement, while movement in the thoracic and lumbar spine facilitates work in the shoulders. However, it is not always possible to stabilize the scapulae while playing the cello, as stabilization leads to limitations in the necessary range of motion (ROM) as well as in the transfer of power to the strings. Where static positions cannot be avoided, compensatory dynamic motion outside of playing can help reduce their negative effects. Learning to utilize the full movement chain, starting at the pelvis, can reduce the loading on each individual joint in the upper extremity, potentially reducing both the pain of the injured, or overloaded, joints as well as the danger of further compensatory overuse injuries.

Literature specifically about cellists with shoulder pain is virtually nonexistent. An internet search resulted in no systematic reviews. Rickert et al (2012), in the single RCT on this subject, attempted to propose a mechanism for disease and establish possible causal factors specific to shoulder pain in cellists, observing that, in professional cellists, both shoulders showed marked reduction of ROM for internal and external rotation, and concluding that this could be an indication of rotator cuff tightening due to microtrauma. This in turn could explain the increased pain and pathology seen in this group. Rickert et al suggest that targeted interventions for cellists with shoulder pain, such as exercises for the scapular stabilizers and muscles of the rotator cuff, could be effective, while noting the need for further research.

Shoulder pain is a common problem for professional cellists. Though musculoskeletal disorders of the shoulder have been highly researched in other fields, little is known about the causes or treatment of shoulder pain in cellists. The question asked in this case report is: what is the effect of a functional exercise program on a professional cellist with shoulder pain in terms of pain reduction and improvement in coordination, measured with the local perceived discomfort scale (LPD) and with the face validity of a video recording. Information regarding the success of a targeted treatment as well as indications for further research will add to the scarce literature on this subject.

Method

Case description

A 48-year-old professional cellist with a part-time job in a major symphony orchestra presented with chronic shoulder, neck and arm pain to a physical therapy practice. The pain is located in the neck, shoulder, lateral ribs, dorsal side of the arms and thenar side of the hand. It alternates between tolerable and unbearable, is always present, and is nearly always unilateral, switching sides for no apparent reason. For the past two years the pain was predominantly on the left side, but for the last three months, after a gardening incident, the pain has been mostly on the right. The patient can 'do everything' in her activities of daily living (ADL) but doesn't choose to, as even slight provocations can trigger pain, making playing impossible. For the last 2 months the pain in her shoulders has dramatically limited her practice time; she currently plays ½-1 hour per day on her days off (Paarup et al, 2012, found that the average playing time for orchestral musicians, including rehearsals, performances and individual practice, was 4.5 hours per day). The services in her orchestra last 2-5 hours and always result in an increase in pain levels, which she manages by ‘not thinking, just playing’. Practical adjustments, such as playing with a lighter bow, as well as adjustments in playing technique have made it possible for the patient to continue to play.

As a child her joints were very mobile and she has had pain complaints in the upper extremity since she was young. At the age of 12 her left 1st rib was excised because of pain. In puberty, around age 14, she became very stiff, which event corresponded with the advent of her current pain complaints. In the intervening years the patient has had recurrent pain complaints. She has seen many specialists, including orthopedists. With the exception of a frozen shoulder (right) in 2007, for which she had to take 3 years off from the orchestra, there has been no conclusive diagnosis.

The patient has undergone many forms of therapy, including extensive physical, postural and manual therapy as well as acupuncture. Nothing definitively improved her chronic shoulder pain, and exercise therapy had a negative effect on the pain. Anti-inflammatory pain medication, including diclofenac, has no effect on her pain. Medications for nerve pain have not been tried. Currently she is undergoing dry needling for myofacial pain, which she started in 2010; the success of this therapy is at present unclear, though the patient believes that triggerpoints in the mm. scalenii are responsible for a substantial portion of her pain problem. The patient is very motivated to play the cello but unwilling to try exercise therapy again. She is excellent at managing her ADL around her chronic pain situation but tends to want to do everything herself and finds it difficult to accept help. She hasn’t informed her colleagues in the orchestra about the extent of her continuing problems.

The patient hopes to achieve a reduction in shoulder pain so that she can continue playing cello.

Physical examination
The goal of the physical examination was:
- observation of posture and relevant abnormalities upon visual inspection
- to determine the active and passive ROM in the patient’s shoulders and spinal column
- to determine the presence of weakness or lack of coordination in the shoulder area
- to determine which movements trigger pain and the specific location and nature of the pain
- to determine the presence of shoulder impingement
- to determine the presence of BJHS, using the Brighton criteria
- to determine the quality of the patients’ movements while playing cello, using video observation

The above are necessary to be able to determine if and which intervention might help the patient.

Table 1
Instruments used in physical examination

Brighton Criteria	The Brighton criteria are the most current criteria for the diagnosis of benign joint hypermobility syndrome, BJHS, a common cause of musculoskeletal pain. The Brighton criteria make use of the Beighton scale as well as several other measurements, making it a more comprehensive scale than the Beighton, which was never intended to be used as a diagnostic instrument for hypermobility. It has been validated in adults 16 years and older. Both sensitivity and specificity are 93% (Simpson, 2006; Graham, 2012).
MRC: Medical Research Council scale	Muscle strength was measured using the 6 point MRC. There are many versions of this alphanumeric system of measuring the neuromusculoskeletal system, but most are essentially similar in the use of a 6 point non-linear scale, whereby 0 equals no movement and 5 equals normal strength. Despite wide usage it has been criticized: grades 1-3 may be too narrow, grade 4 too broad, and there is no operational definition of grade 5, 'normal' strength. Recent research suggests modification into a 4-point scale may reduce clinician error in reporting improvement (Vanhoutte et al, 2011; Florence et al, 1992; Kendall, 2005). A recent literature review showed that there is evidence for good reliability and validity in the use of manual muscle testing with neuromusculoskeletal dysfunction, and concluded that it is a clinically useful tool (Cuthbert & Goodheart Jr (2007).
ROM: Range of Motion	Active shoulder and neck ROM were estimated. Left/right differences in active spinal flexion and lateral flexion were measured as fingertip-to-floor distances in centimeters. Active rotation while sitting was measured with a goniometer. Lumbar flexion was measured with the modified Schöber method. Internal and external rotation of the arms were measured with a goniometer in a supine position, with the arms in 90° abduction. Estimating ROM using visual inspection is unreliable when precision and accuracy are required (Gajdosik & Bohannon, 1987) but is clinically practical. The measurement of ROM of the extremities with a universal goniometer generally has good to excellent reliability, though measurements of the spine tend to be less reliable than measurements of the extremities. The validity of goniometry is particularly dependent on the experience of the practitioner (Norkin & White, 2003). The use of a measuring tape to measure both lateral flexion and the combined ROM of hip, spine and shoulder girdle with fingertip-to-floor distance, has been shown to be reliable. The modified Schöber method has shown varying reliability. All of the tape measure tests have low validity as measures of spinal ROM but may be clinically useful (Clarkson, 2005).

NRS: Numeric Rating Scale	The NRS has been shown to be a reliable and valid instrument for measuring pain intensity for many populations (Ferriera-Valente et al, 2011) and has been shown to have higher compliance rates, better responsiveness and ease of use when compared to other common pain scales (Hjermstad et al, 2010). Changes in NRS scores for patients with high baseline levels of pain (>7) tend to be greater than for patients with lower baseline scores (<4). A NRS change of 2 and a percent change score of -33% represents a minimal clinically important difference (MCID) for patients with chronic musculoskeletal pain and are associated with a 'much better' improvement (Salaffi et al, 2004).

Conclusion based on results physical examination and observation of video material

The patient stands and sits slightly out of plumb alignment, with her weight toward the front of her feet in standing and on the ventral side of the tuburcula ischiadicum while sitting. There is a slight S-scoliose. The patient has winging scapulae in rest, L>R, the right scapula is laterally rotated in rest, and the scapulohumeral rhythm is unusually asymmetric. In active depression tingling was felt into the fingers, a neurological sign. There is end-range shoulder and neck pain in all passive ROM tests of shoulder, shoulder girdle and neck with the exception of adduction. All active shoulder and neck tests were painful except elevation. Active external rotation with the arm in neutral was limited on both the left and the right to, respectively, 40° and 35°. Passive internal and external rotation in 90° were also limited, especially on the right, where the total ROM for internal and external rotation in 90° equaled 141°. There was no reduction of strength on all resistance tests (MRC scale 5) with the exception of glenohumeral abduction, which was inhibited by pain. There was no evident difference in strength between the left and the right side. The dorsal capsule and the attachment tendons of the mm. supraspinatus, infraspinatus and biceps brachii pars longus were painful on palpation. The painful arc test was positive between 80°-90° on the right, Hawkins-Kennedy was positive L>R, Yocum was positive only on the left. Jobe's empty can was negative. The patient meets the Brighton criteria for BJHS with one major and 4 minor criteria (see appendix C).

Observation of the patient playing cello on video showed several notable features. The patient sits actively upright with the cello, with her lumbar spine in a demonstrable neutral position and an apparently flaccid stomach. The position of the cello's tuning pegs seems to force head placement far to the right in lateroflexion. Though head and pelvis are in plumb alignment, the spine deviates to the left of the plumb line, sometimes quite profoundly. Left convex thoracic curvature starts at the head, has an apex at ±T1, and ends between T1 and T4, depending on the playing activity.

The patient's movement patterns while playing are generally fluid and very proficient. Careful observation of the patterns shows that the pelvis, lumbar spine and head are generally held relatively statically, while the shoulders - particularly the scapulae - are used dynamically. The torso generally facilitates motions in the left, or fingering, arm. The right, or bowing, arm is facilitated by the torso only when the left arm can be left in a neutral position. When the patient plays in higher positions (more caudal in the left hand) or on low strings (the strings on the right side of the instrument), the left convex curvature is exaggerated and is coupled with a clockwise rotation. When the patient plays in very high positions (cranial with the left hand), an abrupt end point to the left convex curve becomes apparent in the vicinity of T-10. The apex of the curve is around T-7; under this point the spine and torso appear static, dissociated from the movement above T-10. When the patient returns to a low (more cranial) left hand position, there is sometimes minimal curvature in the thoracic spine to the right with an apex around T-3, which is coupled with counterclockwise rotation. Both scapulae are extremely active, mobile and often winged, and work independently of each other. Sometimes their movements seem dissociated from the torso as a whole. The rotator cuff musculature appears well developed. When the patient plays on the highest (most to the left) string at the tip of the bow, her right (bowing) arm sometimes approaches 110° abduction. On the lowest string (the string most to the right) her right arm passes through the frontal plane into flexion.

Interpretation
The results of the examination did not lead to a definitive conclusion about the cause of the patient’s shoulder pain. Several factors may play a role, including shoulder stability, general hypermobility in the past (as the Brighton criteria score would suggest), hypomobility of the shoulders and possibly of segments of the spinal column at present, and the long-term cumulative effects of playing the cello, including microtraumata. There may also be a rheumatologic or neurological component to her shoulder pain. The distribution of pain could represent myofacial referred pain patterns. Trigger points in the mm. levator scapula, serratus anterior and scalenii can account for all areas of pain reported by the patient (Travell, 1992, as cited in Davis, 2001). Inflammation of joints or connective tissue is possible but unlikely, as the patient doesn’t respond to anti-inflammatory medication. Medications for nerve pain have not been tried.

All active tests of the shoulder and neck were positive, which would suggest a problem with muscle or connective tissue. Passive adduction was the single pain-free passive shoulder test, which would suggest that there could be either a connective tissue or joint pathology, but no acromioclavicular joint pathology. The m. serratus anterior is largely responsible for winging of the shoulder blade, or scapula alata, and may be weak. However, winging may also have developed out of a functional need for scapular mobility while playing cello. Rotator cuff tightness, potentially a result of hypermobility or microtraumata, may be a cause of the patient’s pain. The rotator cuff tightness may also represent a functional need for stability while playing the cello.

Rickert et al (2012) suggest that an exercise program focusing on scapular and rotator cuff stability could be useful for cellists, and core stability exercises have been shown to be beneficial for musicians (Kava, 2010). Limiting the physical taxation of the shoulders could lead to a lessening of pain complaints. A functional intervention based on learning to utilize the movement possibilities of the whole torso could reduce the loading on the shoulders. This could be a simple and effective way to reduce the need for excessive shoulder activity, and therefore of shoulder pain, without having to address shoulder movement directly. The patient is a professional cellist. It is imperative to not undermine her existing technique if not absolutely necessary, as this could lead to non-compliance to the therapy as well as to the development of psychosocial problems such as stress and anxiety, both of which have been shown to play important roles in pain management. Addressing psychosocial factors falls outside of the scope of this case report because of time considerations.

The goal of treatment
The goal of treatment is a reduction of this professional cellist's chronic shoulder pain, realized through a functional exercise program in which the patient learns a movement pattern that incorporates the torso into the movement pattern of the shoulders. It is hypothesized that this slight alteration in cello playing strategy can reduce the work load on the shoulders by spreading the load across a maximal number of structures and joints, resulting in a reduction of pain and taking the focus off of the shoulders as the 'problem'.

Baseline measurement
It was determined that the local perceived discomfort scale (LPD; see table 2 and appendix C), would be the most suitable primary outcome measure for pain. Additionally, video observation, a second primary outcome measure, was used to evaluate and document the patient's cello technique (see table 2).

The patient was seen three weeks after the physical examination at her home for baseline measurements. On the day of the baseline measurement the patient had already played for about an hour. She performed scales and a short piece for the video recording and then filled in the LPD for the upper extremity. The patient divided the regions on the LPD body chart into sub-regions in order to depict her pain more accurately. She also requested a second LPD form so that she could differentiate between pain in the front and in the back of her body.

The patient was then instructed in the basic movement of rotation as well as in incorporation of this movement into her cello practice (see table 3). She was instructed to do these two exercises every day for a total of approximately 5 minutes. After a period of 3 weeks the patient was to be re-evaluated.

Table 2
Instruments used as baseline and effect measurements

LPD	The LPD scale (local perceived discomfort; Dutch version LEO, *lokaal ervaren ongemak*) was used as a baseline and effect measurement for pain. The LPD is broadly used by occupational therapists in the Netherlands to measure the effect of interventions. It is a body chart divided into regions, originally based on a scale for discomfort and pain (Vink, 2005, 1994), and here expressed using the NRS scale (see table 1)**.** The body chart used is based on van der Grinten's regional divisions (Vink, 2005, cited in Konijn, 2008). The psychometric properties of the instrument are not known. There is no single instrument protocol. Commonly, researchers do statistical analysis on clusters of regions relevant to their subject.
Video observation	The face validity of video observation of the patient playing cello by an expert was used as a baseline and effect measurement for improvement in coordination.

Table 3
Intervention

The patient is instructed to spend approximately 5 minutes (1/6-1/12 of her total practice time each day) on the following functional exercises

Exercise 1: sitting rotation without cello	The patient is instructed to sit actively on her practice chair with her feet wide in 'cello stance' and her arms crossed over her chest. She is then to slowly rotate to the left and to the right around a vertical axis. Stomach muscles should be activated to achieve this movement. The muscle involvement and motion should start as low as possible in the torso. The patient is informed that the amount of rotation achieved is not important. The goal is awareness and control of full spinal ROM, as well as awareness and avoidance of habitual movement patterns.
Exercise 2: sitting rotation with the cello, combined with bowing (RH) and shifting (LH)	The patient is instructed to practice the above while playing a slow scale or shifting exercise (moving the left hand on the string from cranial to caudal or vice versa). Bowing direction corresponds with the spinal rotation practiced in exercise 1. It is not relevant at this stage whether the down-bow corresponds with a clockwise or a counterclockwise rotation: both may be experimented with. (A down-bow starts from the frog, or where the bow is held, and moves toward the tip of the bow. The bow moves ± horizontally to the ground). See Appendix D for exercise 2 written in musical notation.

THE CELLO

The cello is played in a seated position, rests against the chest and can be held between the knees. The instrument stands on an adjustable 'end pin'.
The right arm is used for bowing. Bowing requires dynamic strength from the internal rotators and the abductors of the shoulder as well as endurance strength from the stabilizers of the scapula.
The left arm and fingers are used to depress the strings. The strings are under high tension; depressing them requires endurance strength in the hand as well as - depending on the music being played - speed. The left shoulder is usually held relatively statically in abduction, as the left arm must provide a stable basis for the fine motor activity of the hand.

Figure 1 Cellist (Jacqueline du Pré) poised for an up-bow

Approximate right arm ROM requirements for normal cello playing

glenohumeral abduction:	0° - 110°
glenohumeral horizontal adduction:	-15° - 60°
glenohumeral external rotation:	0°
glenohumera internal rotation:	0°
elbow flexion:	10° - 90°

Figure 2 Cellist (painting by William Whitaker, 1999) prepared for a down-bow

Approximate left arm ROM requirements for normal cello playing

glenohumeral abduction:	30° - 90°
glenohumeral horizontal adduction:	-15° - 70°
glenohumeral external rotation:	0° - 20°
glenohumeral internal rotation:	0° - 40°
elbow flexion:	30° - max

Results

The patient was seen a second time three weeks after the initial session. She reported having done the exercises for 10 days, for approximately 5 or 10 minutes with the cello as well as 5 or 10 minutes without, commenting that she might have been a bit too 'enthusiastic'. The pain grew increasingly worse. By the 10^{th} day she was unable to play because of pain (NRS 7-8). After taking a break from playing for about a week she resumed playing the cello, but did not continue with the exercises. She did not think that exercise therapy was a suitable intervention for her unless it was 'hands-on and functional', and was not willing to continue a functional exercise intervention at present because the increase in pain negatively affected her playing. She also felt that the use of rotation with the cello limited her technique and didn't seem logical.

On the day of the effect measurement the patient had already played for an hour. She was filmed playing the same repertoire as in the baseline measurement, after which she again filled in the LPD for the upper extremity.

The first exercise, rotation in sit, had been done by the patient in 4 different ways: sitting on her swiveling office chair and using her legs to push off; at the swimming pool, standing in the water and using the edge of the pool to grab on to; on her cello stool, with her arms swinging loose from her body; and on her cello stool with her arms crossed across her chest. The last version, which corresponded with the given exercise, was the most problematic for her. She found it difficult to feel her stomach muscles working and only really felt them in the last (original) version of the exercise. Observation of the patient doing this exercise showed that she did it with a large element of lateral flexion. She was aware of this and could partially correct it.

The patient was able to do the second exercise, incorporating rotation with bowing and shifting, relatively fluidly when combining clockwise rotation with a down bow (rotation in the same direction as the bow and the shifting hand), commenting that this felt natural, whereas the combination of a down-bow with counterclockwise rotation felt unnatural. Observation of the exercise reflected this discomfort.

Analysis of the effect video showed no absolute differences when compared with the baseline measurement video. The patient sat out of plumb alignment and continued to use habitual patterns while playing, supporting position-shifting in the left hand with spinal motion and using spinal motion to support the movements of the right arm only when the left arm could remain neutral. The shoulders still carried a heavy load and the lower torso was still relatively non-participatory, though it appeared to play a more integrated role in her movement patterns when the patient played her short piece than when she played her scales.

Analysis of the LPD showed that the patient scored 12 pain locations in the upper extremity on the baseline LPD and 14 locations on the effect LPD. Of those locations there were 9 dorsal, 3 ventral, 10 right and 2 left on the baseline, and 11 dorsal, 3 ventral, 10 right and 4 left on the effect LPD. In the effect measurement 8 new areas of pain were described and 6 areas that had originally been painful were no longer painful.

The total average scores of the baseline and the effect LPD, respectively 3.79 and 3.36, showed no minimal clinically important difference (MCID) ≥ 2 points. The average scores were also calculated for body regions including the left and right sides of the body, the dorsal and ventral sides of the body, and the right dorsal, right frontal, left dorsal and left ventral sides of the body. Of the body region average scores, the only MCID, 2.25, was found for total left/total left dorsal. The score for left ventral was 0, the only region described with no pain.

None of the individual scores with both a baseline and an effect measurement, a total of 6 areas, showed a MCID of ≥ 2. A MCID of ≥ 2 did exist for all of the new pain areas (areas that were not present on the original baseline measurement), as well as the areas that were present in the baseline measurement but not in the effect measurement, as the baseline respectively effect measurement was then 0.

For the actual results see figures 3, 4 and 5, table 3 and appendix C.

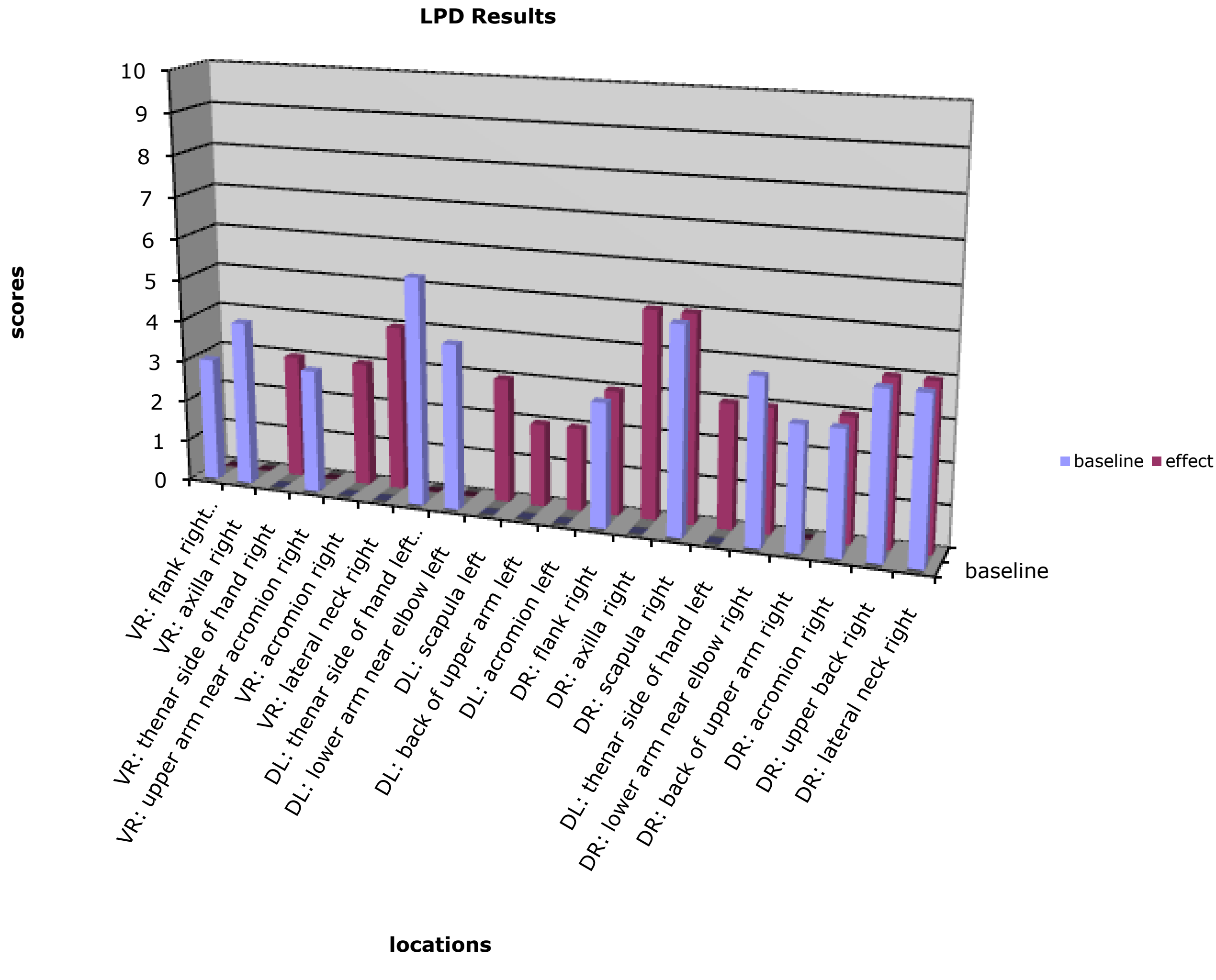

Figure 3 Results LPD

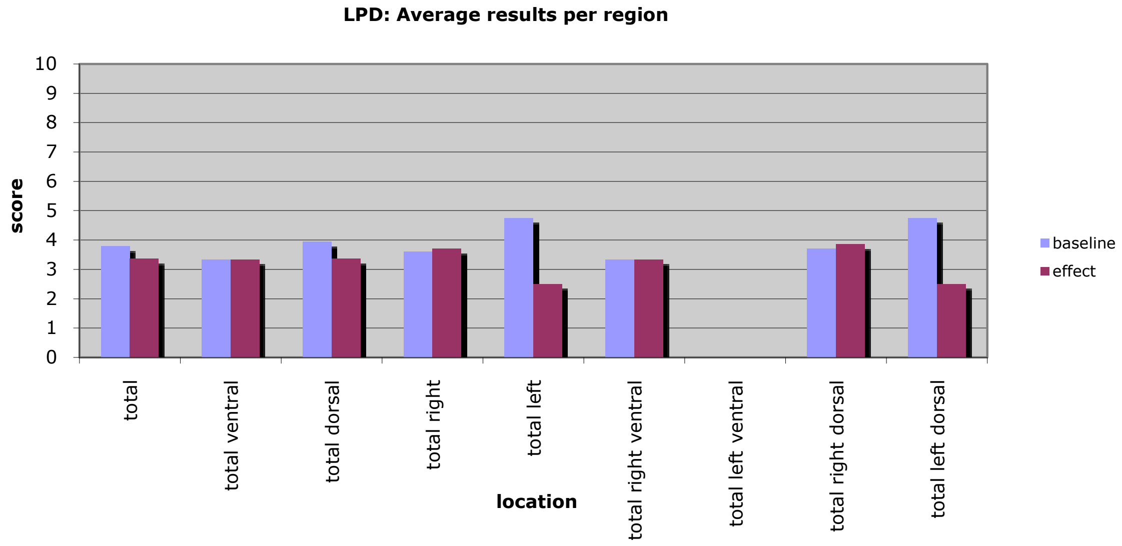

Figure 4 average results LPD per region

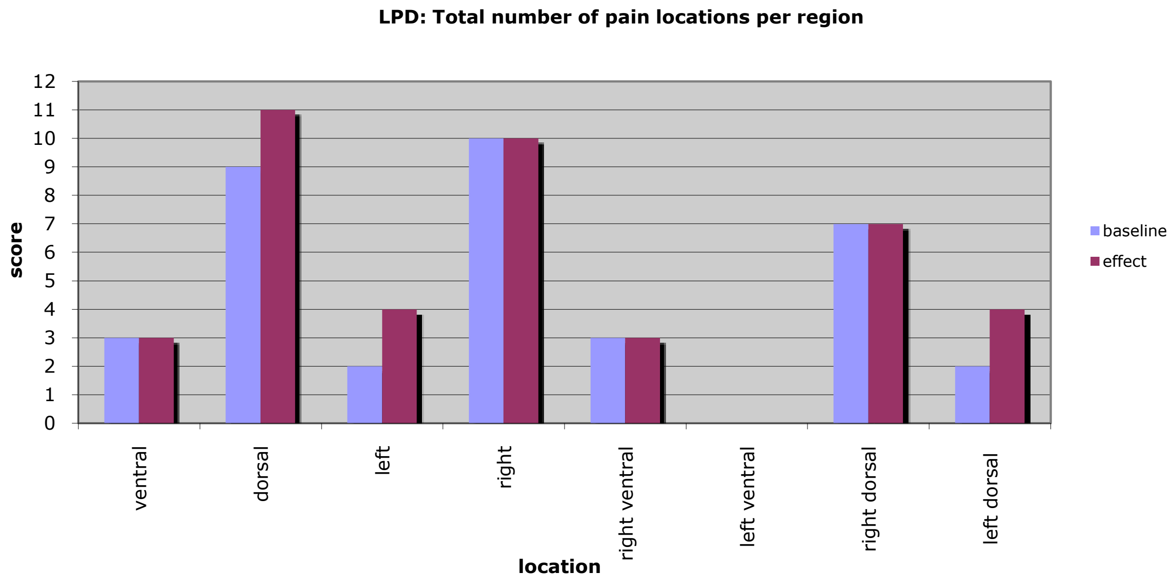

Figure 5 Total number of pain locations per region

Table 3
Results LPD

baseline measurement 7/2/2012		**effect measurement 7/23/2012**	
dorsal		**dorsal**	
DR:lateral neck right	4		4
DR:upper back right	4		4
DR: acromion right	3		3
DR: back of upper arm right	3	-	-
DR: lower arm near elbow right	4		3
-	-	DL: thenar side of hand left	3
DR: scapula right	5		5
-	-	DR: axilla right	5
DR: flank right	3		3
-	-	DL: acromion left	2
-	-	DL: back of upper arm left	2
-	-	DL: scapula left	3
DL: lower arm near elbow left	4	-	-
DL: thenar side of hand left	5.5	-	-
ventral		**ventral**	
-	-	VR: lateral neck right	4
-	-	VR: acromion right	3
VR: upper arm near acromion right	3	-	-
-	-	VR: thenar side of hand right	3
VR: axilla right	4	-	-
VR: flank right	3	-	-
totals	**score/locations (average)**	**totals**	**score/locations (average)**
total	45.5/12 (3.79)	total	47/14 (3.36)
total ventral	10/3 (3.33)	total ventral	10/3 (3.33)
total dorsal	35.5/9 (3.94)	total dorsal	37/11 (3.36)
total right	36/10 (3.6)	total right	37/10 (3.7)
total left	9.5/2 (4.75)	total left	10/4 (2.5)
total right ventral	10/3 (3.33)	total right ventral	10/3 (3.33)
total left ventral	0	total left ventral	0
total right dorsal	26/7 (3.71)	total right dorsal	27/7 (3.85)
total left dorsal	9.5/2 (4.75)	total left dorsal	10/4 (2.5)

Discussion

The question asked in this case report is: what is the effect of a functional exercise program on a professional cellist with shoulder pain in terms of pain reduction and improvement in coordination, measured with the local perceived discomfort scale (LPD) and with the face validity of a video recording. This question has not been posed by other researchers and cannot be compared with their results.

The LPD showed no minimal clinically important difference (MCID) in pain areas that were scored as baseline and effect measurements. It was able to describe a pain pattern, with more pain locations on the right and dorsal side of the body. The LPD was also able to capture the fickle nature of the patient's pain: of the 26 areas of pain described in the baseline and effect LPD, 14 were either new areas of pain or areas where pain had disappeared. Video observation showed no absolute improvements in the integration of movement of the spine and shoulders.

There are several possible explanations for these results. The choice of intervention and the success of an intervention is dependent upon knowing the diagnosis or cause of pain, which in this case was unclear. As noted by Rickert et al (2012), though cellists are prone to severe shoulder problems, causal factors specifically for this group have not been researched. Given the nature and history of the patient's complaints it is possible that her shoulder pain is related to a complex or systemic disorder and not just to playing the cello. It also seems plausible that central sensitization, in which increased central neuronal responsiveness leads to chronic widespread pain (Meeus and Nijs, 2006), could account for part or most of the pain experienced by this patient, as her pain is chronic, not acutely nociceptive, and can be triggered by relatively innocuous stimuli. The patient's lack of response to NSAIDs would seem to confirm this supposition.

That so many pain locations on the LPD were variable would appear to support the theory of central sensitization. It seems unlikely that the locations would have changed so dramatically or that the pain would have become so severe (NRS 7-8) in so short a time solely as a result of doing the functional exercises, though the fact that the patient did not precisely comply with the instructions in doing the functional exercises - spending more time on her exercises than was suggested and substantially altering the content of exercise 1, rotation without a cello - may have played a role. Her conviction that exercises would not help her as well as her past and present experience with pain might have limited her ability to 'play around' with the new movement patterns in a relaxed way and could also have contributed to the results.

There were 6 locations on the LPD in which there was both a baseline and an effect measurement: the lateral side of the neck, the upper back, the acromion, the scapula, the flank and the lower arm near the elbow - all dorsal and all on the right side. All of these locations had no MCID. It is possible that this specific constellation of complaints is related to the patient's history of frozen shoulder on the right side. A longer treatment period could confirm how stable these areas of pain are and how they react to different stimuli, which in turn could result in a more finely tuned intervention.

There are several weak points in the intervention that may have influenced its success. The exercises given in the intervention were intended to reduce this cellist's chronic shoulder pain by introducing new movement patterns integrating the torso with the shoulders, thereby reducing the work load on the shoulders.

The contact time with the patient and the intervention's duration may have been too short to adequately explain a new neuromuscular movement strategy and for the patient to incorporate the strategy into her advanced cello-playing technique. It seems important to eventually address the patient's playing posture, including the positioning of the patient's head with respect to the cello, as well as her long end pin, which placed the cello high on the chest and which could have promoted the left convex lateral flexion and interfered with her use of rotation. The existence of hypomobile segments in the spinal column should also be investigated. Neither the existence of nor the treatment of pain as a result of central sensitization was addressed but should be in the future, as treatment strategies for patients whose pain may be a consequence of central sensitization are very different than strategies for the treatment of nociceptive pain.

Gender and age could both be factors in this patient's PRMDs. In many studies of musicians it has been shown that women tend to have more, and more severe, PRMDs than men (Paarup et al, 2011; Middlestadt & Fishbein, 1989). The role of age in the development of PRMDs, however, has not been addressed in any of the larger studies about PRMDs. Professional athletes and dancers, also an elite group of highly trained performers, generally stop in their thirties or early forties. A musicians' career can last for decades longer. It seems reasonable to expect that additional years of playing in combination with the effects of aging will lead to specific problems, another question that could be answered by adequate research.

A basic exercise program seemed a logical biomechanical intervention in this case. Exercises for dynamic functional coordination, endurance and strength for the right shoulder and static functional coordination, endurance and strength for the left would be the most cello specific program for shoulder strength. Additional dynamic exercise outside of playing is necessary to maintain the health of tissues that are statically loaded during playing, as well as sufficient rest. Several authors have described the success of core stability and upper extremity endurance programs in the treatment of musicians (Lee et al, 2012; Kava et al, 2010). An exercise program based on Graded Activity is a well-documented intervention for patients with chronic pain. None of these interventions has been evaluated in cellists with shoulder pain and should be a subject for future research.

The choice of intervention, the amount of time the patient was asked to practice, and the short duration of the intervention were strategically made choices in an effort to promote patient compliance. Taking the focus away from the shoulders, the primary source of pain, was thought to improve the intervention's chance of success. The chance of success would likely have been the greatest had the intervention been presented with frequent instruction over a longer period of time, as well as with an element of patient education about the nature of chronic pain. Though the patient was highly motivated to keep playing the cello, she was trepidatious about trying new things, not illogical given her history. An intervention that was likely to cause extra pain, take a lot of time and attention, threaten her established pattern of coping with pain, or interfere with her already limited practice time would almost certainly have failed.

Quantitative results from the movement study could have been obtained using any of a number of other methods. A 'time study' - Wakely (1998) has adapted Vink's method of counting movements per unit of time for use with musicians - would have given data about which, and how often, high risk movements were being done, as well being predictive for future problems. General 3-D movement analysis software is available from many different companies. Lee et al (2012) made use of an eight-camera Vicon tm motion analysis system in combination with 2 AMTI multi-axis force plates to collect and analyze data of a cellist playing and suggested that more research should be done with this method.

Face validity was chosen for the movement study because of time and expense considerations, as well as the author's expertise as a cellist. Further development of software specifically for the analysis of cellists' movements, such as the protocol developed for the bowing arm of string players using the MacReflex 3-D analysis system (Turner-Stokes, 1998) could contribute to a database with which causative factors of injury in cellists could eventually be analyzed.

The patient specific complaints questionnaire (PSC) and the disabilities of the arm, shoulder and hand questionnaire (DASH) are both valid instruments. The DASH has a specific section for sport and/or performing artists, and the PSC can be filled in in a way specific to the situation of this patient. Nevertheless, they were not suitable instruments in this case, being too non-specific about location, provocation and kinds of pain, as well as focused on limitations that were not relevant to this patient's situation.

The use of the LPD scale to measure the intervention's effect was a fine choice of instrument for musicians. Unlike most pain scales, the LPD includes a body chart, which gives the patient a chance to differentiate pain levels in different areas, necessary as musicians often have more than one PRMD (Dawson, 2002). Though the LPD has been used extensively in occupational therapy research, there is no official protocol for its use. This patient created a 'front' LPD body chart to accompany the 'back' LPD body chart. She also created her own subdivisions in the given regions on the LPD. Further research could explore the viability of weighting the scale, of making it applicable to front and back, and of either dividing the chart into more cello-specific regions or allowing patients to determine the regions themselves.

Lee et al (2012) have developed a questionnaire relating to playing-related body awareness, showing that an improvement in body awareness correlated to an increase in physical efficacy. Unfortunately this was not known to the author until after the first patient contact. It could have been a good questionnaire for this subject, and it should be investigated by other authors working with musicians.

It seems reasonable to expect that many of the PRMDs that affect professional cellists will also affect amateurs. Exact figures are not known, but of the approximately 3,750,000 amateur musicians active in the Netherlands, some must play cello (Bork, 2007; AVO-Cultuur Onderzoek 2009), making the pool of cellists that could be helped by research into this area even greater.

Conclusion

The movement intervention chosen to address this patient’s chronic, playing-related shoulder pain is theoretically sound and has great potential. Given more time to work with the patient, it is likely that a functional exercise intervention would have been more successful in reducing the work load on her shoulders from playing cello. It is unclear if this biomechanical approach would be able to reduce this patient’s chronic shoulder pain, as the cause of her pain is unknown and the existence of central sensitization is a real possibility.

The LPD is a good instrument for evaluating PRMDs in musicians. The benefits of weighting the regions and making the LPD body chart cello-specific should be investigated. More research is needed to identify causal factors of PRMDs in cellists, including posture, age, gender, hypermobility and cello-specific movement patterns as well as the impact of factors such as stage fright and body awareness. An instrument investigating the impact of body awareness on playing, such as the one proposed by Lee, should be further developed. Though face validity of video analysis is a valuable tool, quantitative movement analysis would be useful for future research into movement strategies specific to cello playing. Targeted and validated treatments for PRMDs in cellists are also needed, including functional exercise programs that address problems arising from the disbalance between static and dynamic motion that is inherent to playing the cello, as well as problems resulting from the heavy loading of the shoulders.

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Appendix A: Informed consent form

INFORMED CONSENT:
Toestemmingsformulier om uw gegevens te gebruiken voor een onderzoek.

Waar gaat het case report over?
In het kader van een afstudeerstudie voor de opleiding fysiotherapie wil ik graag de gegevens van het onderzoek en de behandeling van uw schouderklachten gebruiken voor het schrijven van een case report.

Wat betekent dit voor u?
De behandeling blijft steeds in het teken staan van het nastreven van een zo goed mogelijk herstel van uw schouderklachten en uw hulpvraag.
De gegevens worden verzameld gedurende het fysiotherapeutisch onderzoek, de behandeling en door middel van vragenlijsten.
Een aantal onderzoeken en vragenlijsten zullen tussendoor of aan het einde van de behandeling nogmaals herhaald worden om het effect van de behandeling inzichtelijk te maken.
In het kader van houdingsonderzoek zal tevens gebruik gemaakt worden van video opnames.
Dit onderzoek voor het case report zal maximaal een periode van 6 tot 8 weken beslaan, wat niet wil zeggen dat daarna de behandeling automatisch stopt.

Privacy
De onderzoeksresultaten en behandelstrategie zullen volledig anoniem vastgelegd worden in een case report. Dit case report zal in het kader van mijn afstuderen als fysiotherapeut gepresenteerd worden aan docenten en geïnteresseerden op Avans hogeschool te Breda. Voor de presentatie wil ik graag, in overleg met u, beeldmateriaal gebruiken.

Medewerking
Door dit document te ondertekenen geeft u te kennen dat u akkoord gaat met de inzameling van uw gegevens, het onderzoek, de behandeling, de video opnames. het publiek maken van deze case report en de presentatie ervan op Avans Hogeschool. Ook na ondertekening behoudt u het recht om, zonder opgave van reden, tijdens het onderzoek- en behandelperiode alsnog af te zien van uw medewerking. U heeft het recht op inzage in het einddocument.

Ik,

Naam:

Adres:

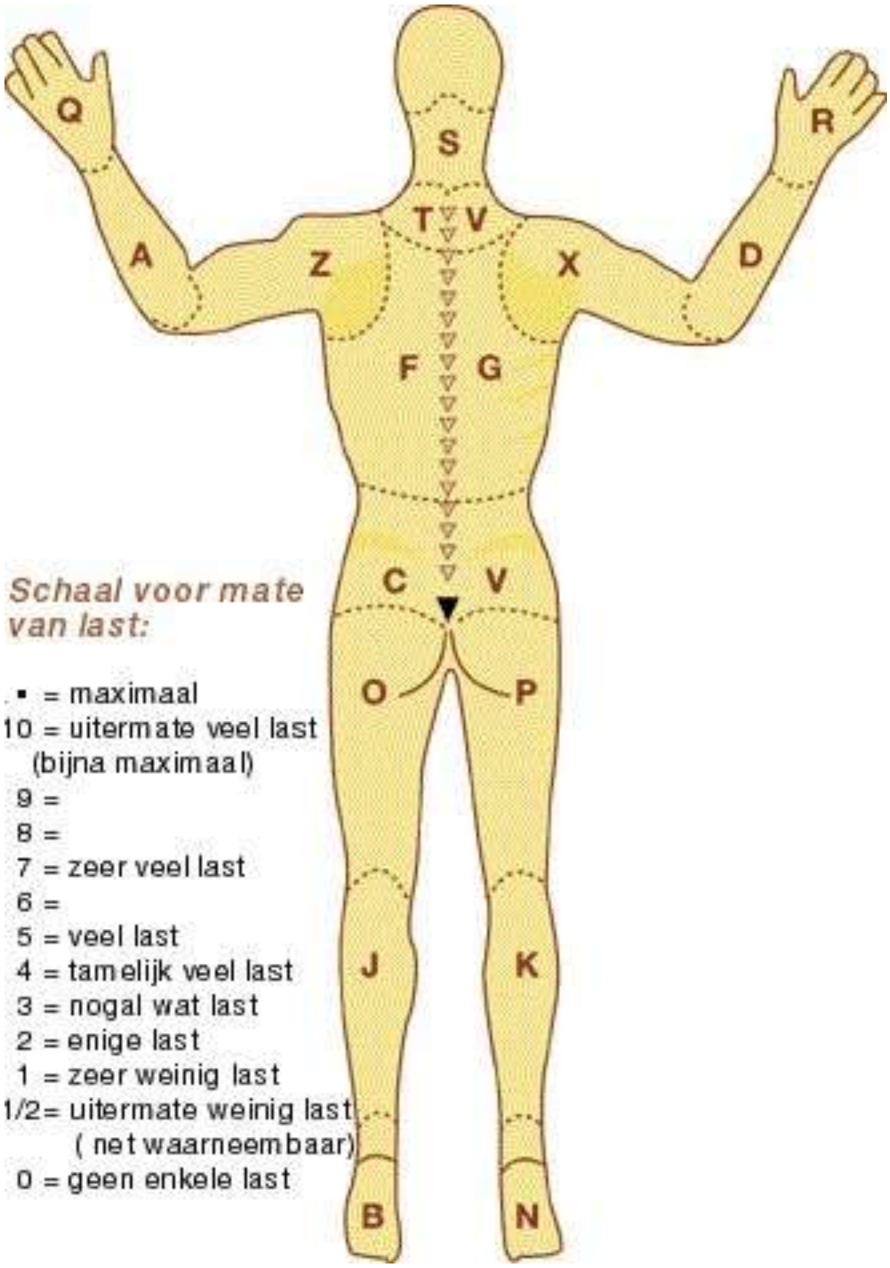
begrijp dat in het kader van dit onderzoek gegevens worden ingezameld welke gebruikt worden voor een case report. Dit onderzoek zal de behandeling van de schouderklachten geenszins in de weg staan. Ik ga hier vrijwillig mee akkoord.

Datum: 2012

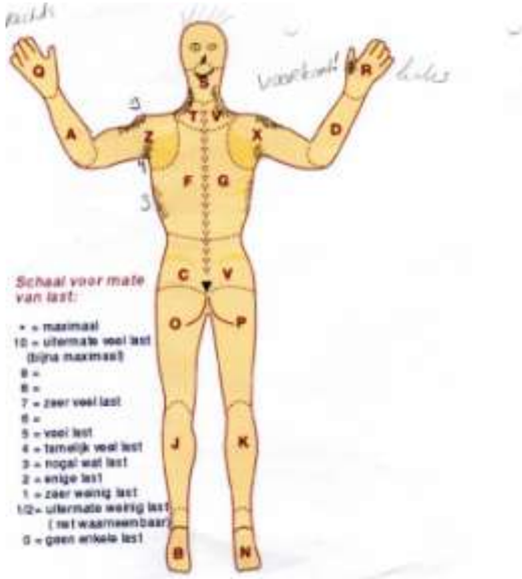
Plaats:

Handtekening:

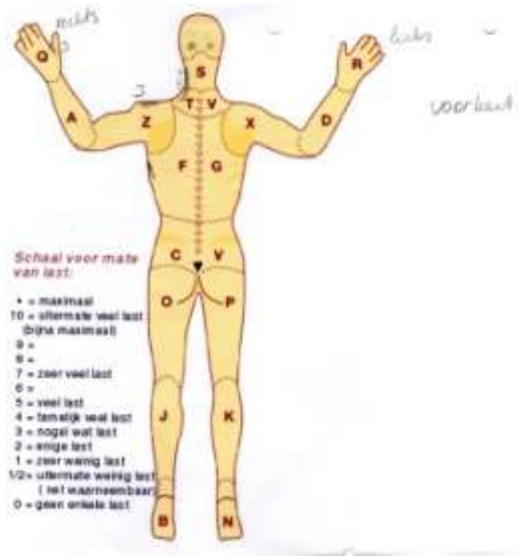
Appendix B:
LEO/LPD scale

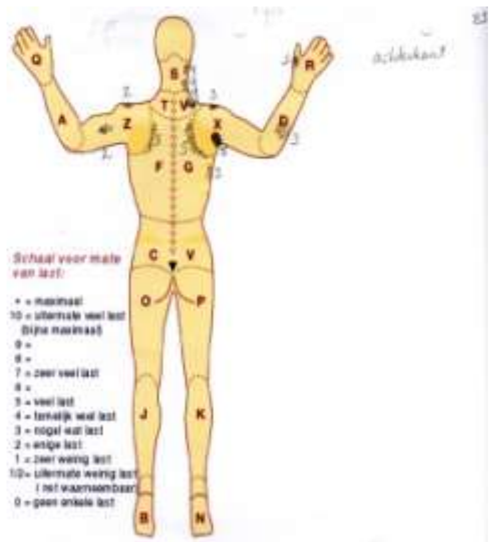


LEO: baseline measurement, 2-7-2012



LEO: effect measurement, 23-7-2012





Appendix C:
Revised diagnostic criteria for benign joint hypermobility syndrome (BJHS)

Major Criteria

- A Beighton score of 4/9 or greater (either currently or historically)
- Arthralgia for longer than 3 months in 4 or more joints

Minor Criteria

- A Beighton score of 1, 2 or 3/9 (0, 1, 2 or 3 if aged 50+)
- Arthralgia (> 3 months) in one to three joints or back pain (> 3 months), spondylosis, spondylolysis/spondylolisthesis.
- Dislocation/subluxation in more than one joint, or in one joint on more than one occasion.
- Soft tissue rheumatism. > 3 lesions (e.g. epicondylitis, tenosynovitis, bursitis).
- Marfanoid habitus (tall, slim, span/height ratio >1.03, upper: lower segment ratio less than 0.89, arachnodactyly [positive Steinberg/wrist signs].
- Abnormal skin: striae, hyperextensibility, thin skin, papyraceous scarring.
- Eye signs: drooping eyelids or myopia or antimongoloid slant.
- Varicose veins or hernia or uterine/rectal prolapse.

The BJHS is diagnosed in the presence two major criteria, or one major and two minor criteria, or four minor criteria. Two minor criteria will suffice where there is an unequivocally affected first-degree relative.
BJHS is excluded by presence of Marfan or Ehlers-Danlos syndromes (other than the EDS Hypermobility type (formerly EDS III) as defined by the Ghent 1996 (8) and the Villefranche 1998 (9) criteria respectively). Criteria Major 1 and Minor 1 are mutually exclusive as are Major 2 and Minor 2.

Appendix D:
Exercise used in intervention written in music notation