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DAVID JOHNSON

# Classical Guitar and Playing-Related Musculoskeletal Problems

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A Systematic Review

**David Johnson**  
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Handledare: Stefan Östersjö

## Abstract:

Traditional classical guitar playing position — using a footstool for the left foot to elevate the leg — is considered by some guitar pedagogues to be an important risk factor for developing Playing-Related Musculoskeletal Disorders (PRMD) among guitarists; alternative supports for the classical guitar have emerged in the past three decades as a putatively more healthy method of sitting with the instrument. This review study aimed to determine what research currently exists concerning classical guitar playing position and the risk of PRMD, and of classical guitar and PRMD in general. A systematic search was performed on the online database Web of Knowledge and the Performance Arts Medicine Association (PAMA) online bibliography, and a manual search was performed on the journal, *Medical Problems of Performing Artists*. The search yielded a total of thirteen articles concerning classical guitar and PRMD, none of which specifically address playing position as a risk factor. The quality of the relevant articles was low; none were constructed to allow for analysis of basic epidemiological measures such as prevalence, incidence or relative risk. This study found that there was no conclusive scientific evidence that alternative supports are healthier or even as healthy as the traditional footstool.

Keywords: classical guitar, performance-related musculoskeletal injury, playing position, health.

## Sammanfattning

Den traditionella sittställningen för klassiskt gitarrspel med en fotpall under vänster fot som höjer upp vänster ben anses av vissa gitarrpedagoger vara en viktig riskfaktor för utvecklandet av spel-relaterade muskuloskeletala besvär. Alternativa hjälpmedel har utvecklats under de sista tre decennierna som ett påstått hälsosammare sätt att sitta med gitarren. Denna litteraturgranskande forskningsuppsats ämnade fastslå vilken vetenskaplig kunskap som finns angående ämnet klassiskt gitarrspelsätt och risk för relaterade muskuloskeletala besvär samt klassiskt gitarrspel och risk för muskuloskeletala besvär. En systematisk sökning genomfördes i vetenskapsdatabasen Web of Knowledge och online databasen för Performance Arts Medicine Association (PAMA). Det gjordes även en manuell sökning i tidskriften *Medical Problems of Performing artists*. Sammanlagt från dessa källor fanns tretton artiklar som rörde klassisk gitarr och muskuloskeletala besvär; inga av dessa behandlade sittställning som en specifik riskfaktor. Kvaliteten på de inkluderade artiklarna var låg; inga var konstruerade så att det gick att avgöra viktiga epidemiologiska mått såsom prevalens, incidens och relativ risk. Resultatet av denna studie var att det inte finns någon vetenskaplig evidens för att alternativa hjälpmedel är hälsosammare eller ens lika hälsosamma som den traditionella fotpallen.

Nyckelord: klassisk gitarr, spelrelaterade besvär, sittställning, hälsa.

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## 1. Introduction

Research shows that musicians are at risk for developing occupational disorders. Long hours spent sitting or standing in the same position, quick, complex, repetitive movements, and the stress of performance are potential dangers common to the workplace of all instrumentalists, including classical guitarists. Studies put the prevalence of Playing-Related Musculoskeletal Disorders (PRMD) at between 39% to 89% (Zaza, 1997); even young music students and amateur players have been shown to be at risk (Buckholder, 2004; Morse, 2000; Ranelli, 2008). The number of instrumentalists with playing-related illness who actually seek medical help is estimated to be as low as 15%, meaning that rates of illness may in fact be much higher (Buckholder, 2004). In "A Pilot Study of Playing-related Disorders in Musicians", Morse states that "playing a musical instrument may be second only to computer use in terms of population exposure to a risk factor for upper-extremity musculoskeletal disorders" (Morse, 2000, p.85). Writing in the *New England Journal of Medicine*, Lockwood (1989) draws an analogy between playing an instrument and playing contact sport: "It would be irresponsible for a football coach to ignore physical conditioning... the same could be said of music pedagogy" (Lockwood, 1989, p.226). If the study of an instrument means exposure to risk of injury, then the music teacher may be said to have a pedagogical as well as moral responsibility to help the student understand risks and avoid harm.

The study of music and music teaching has evolved in recent decades to include biomechanical and other health issues in learning an instrument. Wristen (2000) has developed in her study, "Avoiding Piano Injury", a "procedure for biomechanical analysis of piano technique". Such analyses aim to "identify potentially harmful motion in piano technique and theorize about normative motion patterns for selective skills" and replace traditional instruction methods that "typically relied on recommendations by skilled performers [...] based on individual, subjective experiences" (Wristen, 2000, p.55). This type of thinking implies a move away from the "master/disciple" type of relationship between teacher and student in the teaching of technique—where the student is expected to copy the teacher—towards a more "humanistic" approach which is based on natural laws and makes allowance for the uniqueness of each individual student.

For the classical guitar, this ideological shift has been accompanied by a proposed new and purportedly more healthy playing position which abandons the tradition of using a footstool in favour of various other alternative supports. The use of the footstool is now considered by many to be a risk for developing PRMD. Many students and teachers and even some well-regarded concert virtuosos have adopted the new supports, while the old footstool tradition still persists and remains dominant, at least on the concert stage. This has led guitar pedagogy to the unusual position where teachers may be advocating that students learn a playing position different from the one they themselves use in lessons or on stage.

In choices where students' health is concerned, the guitar teacher should be well informed of the risks involved with different playing positions. Opinion concerning footstand versus alternative supports should ideally be based on scientifically grounded, empirical research. To find such research, the pedagogue may look to a review article: that is, a type of scientific study where the researcher gathers

and analyzes all available literature within a certain field of study by using accepted search techniques. To date, no systematic review of existing research concerning classical guitar playing position and PRMD has been conducted. Such an analysis could help guitar teachers to make informed decisions about risks involved with different playing positions.

## 2. Aims

The aim of the present study is to systematically review and summarize existing research about PRMD related to classical guitar playing position and PRMD related to classical guitar in general. The study of relevant research should help us answer two important questions for the teacher and student of classical guitar: first, what is known about the relative health risks of using a footstool compared to alternative methods, and second, how should current research influence our attitudes and teaching methods concerning playing position?

### 3. Theory

#### 3.1 History of Classical Guitar playing position

The modern classical guitar as it is played and studied today can be said to originate in mid 19<sup>th</sup> century Spain with the development of a louder, larger instrument by the luthier Antonio de Torres (1817-1892), and with the first great virtuoso to use the Torres guitar, Francisco Tárrega (1852-1909). Torres' and Tárrega's innovations to the instrument and the instrument's repertoire and technique respectively were strongly influential in the establishment and codifying of an accepted playing style for the guitar. Tárrega's techniques can be seen as compiling, building upon, and giving a rationalized structure to the more diverse guitar styles of the Classical period virtuosos (Bobri, 1977).

##### 3.1.1 Guitar in the Classical era

While the family of plucked and fretted instruments to which the guitar belongs has existed in various forms since antiquity, the first six-string, single course instrument did not appear until the end of the 18<sup>th</sup> century. The six-stringed guitar probably originated in Italy or France, although there is no certain date or place of origin. Some scholars identify Obra para guitarra de seis ordenes (1780) of Antonio Ballestero as the first published piece of music written specifically for the six-stringed guitar (Avraam, 2009). The guitar of the Classical era shared with the modern instrument its hour-glass form, although the waist of the former was narrower relative to the two curved bouts. The instrument was smaller and quieter than the modern guitar.

There was a surge of interest in this new instrument at the end of the 18<sup>th</sup> and beginning of the 19<sup>th</sup> centuries, especially in Paris. It was deemed appropriate to write and perform contrapuntal music on this new guitar, whereas its older four- and five-string relatives were used more for strumming and accompaniment. Instruction in guitar experienced a vogue as a mark of cultural refinement among the upper-class, especially for women. This crest of popularity is witnessed by the plethora of instructional manuals and books of etudes written by contemporary guitar virtuosos such as Dionisio Aguado, Fernando Sor, Mauro Giuliani, and Matteo Carcassi, who all at some time earned their living as guitar teachers and performers in Paris. While much of the music produced by these performer/composers was of middling quality, it has served as the early foundations of a standard classical guitar repertoire; many of their ideas concerning the melodic, harmonic and timbral range of the guitar have had a lasting effect on the development of the instrument. Carcassi's 25 Melodic and Progressive Etudes have never been out of print since they were first published, and several works by Giuliani and especially Sor remain standard pieces in the classical guitar repertoire today.

Unsurprisingly, playing style and technique varied greatly from player to player on this new instrument. In general, we may assume a strong influence of lute technique, as evinced by the use by many Classical era guitarists of a lute-like playing posture for the right hand, with the little finger extended to stand on

the sounding board as a support. One consequence of this adaptation is the restriction of the use of the ring finger in plucking. As such, many virtuosos, Aguado and Sor among them, played almost exclusively with only thumb, index, and middle fingers, using left-hand slurs to perform fast scale passages. Others used all four digits in a manner more similar to modern technique. Some, such as Aguado, advocated using the nails of the plucking hand, while others like Sor played with the fingertips. When it comes to left hand technique, Giuliani fingered some bass notes by reaching around and using the left thumb.

There was a similar diversity in playing position during the Classical era. In *Den Klassiska Gitarren* ("The Classical Guitar"), Martin Giertz (1979) suggests that different techniques for sitting and playing the instrument fell roughly along national lines, with German guitarists holding the instrument over both knees, the Italians and French holding it angling upwards from between the knees, and the Spanish holding it nearly horizontally on the right leg (Giertz, 1979). Among other notably eccentric proposals, Sor suggests in his renowned method book that the guitarist rest the guitar's lower bout upon the right thigh, the upper bout upon the edge of a well positioned table; Aguado's method espouses a sort of 'stand' or tripod that holds the guitar so that it is not supported at any point by the body of the player.

### 3.1.2 Torres and Tárrega

The Torres guitar fundamentally altered the design of the Classical period instrument by greatly increasing its dynamic range. This was achieved by widening and lengthening the resonating body of the guitar, and by developing a more effective system of bracing struts beneath a thinner sounding board. These innovations further advanced the evolution of the guitar from its roots as a strumming instrument for accompanying song and dance towards becoming a true solo instrument for polyphonic music. While this new guitar could not compete with the piano in terms of volume, it was now sufficiently loud to move from performing in salons to larger venues and concert halls as a solo instrument. It can be said that Tárrega's playing style and technique developed partly in function of this new guitar's expressive possibilities (Giertz, 1979).

Tárrega's technique involved the use of thumb, index, middle and ring fingers of the right hand and all fingers (but never the thumb) of the left hand. Each note in a scale passage was articulated by the right hand (excluding desired slur effects) and performed by alternating the index and middle, or the middle and ring fingers. Tárrega further developed right hand technique by codifying two different angles of attack, one with the finger that strikes the string falling inwards towards the palm (*tirando*, free stroke), the other with the finger landing upon the next string lower to that being struck (*apoyando*, rest stroke). While Tárrega was forced in later years to abandon playing with nails because of a debilitating weakening of his nails, he advocated plucking with the nails of the right hand for most of his professional life. All of these innovations in style can be seen as a development of the guitar towards a more complete solo concert instrument, with the piano as a model. Much of Tárrega's musical output is in fact transcriptions of contemporary as well as Classical and Baroque piano music (Pujol, 1933).



### 3.1.3 The inception of the foot stool

The technical demands of the Tárrega style required that the player have both hands entirely free from holding the instrument. The use of all the fingers (save the left thumb and right little finger) and the playing of positions over the entire neck of the instrument meant that the guitar needed to be positioned high upon the chest and close to the player so as to bring the hands into a functional position. These exigencies led Tárrega to adopt a footstool for the left foot. By placing the guitar on the left thigh, the player now had three points of contact with the instrument (left thigh, chest, right arm), which held it in place without the use of the hands. The footstool also raised the guitar higher and closer to the player.

While Tárrega did not achieve great international renown as a performer and never himself wrote a guitar method, his technical innovations were propagated and quickly came to dominate classical guitar playing through the advocacy of his circle of students—most notably Emilio Pujol and Manuel Llobet, who championed his compositions and style of playing (Giertz, 1979).

## 3.2 Evolution of instruction concerning playing position

### 3.2.1 Tárrega/Pujol

Pujol's influential Guitar School (1933) method book briefly describes how the student should sit with the instrument according to the dictates of the Tárrega technique. He writes that the player should use a chair and foot stool of height "proportionate to his own". The stool should be angled, so that the front is higher than the back, and should be high enough so that the tuning pegs "do not pass the line of the shoulders". Pujol states that the player should place the toes of the left foot and not the whole foot on the stool. The player should lean forward into the guitar to find a position of "perfect stability", with the shoulders held in "a natural position". Pujol specifies the three points of contact with which the instrument is to be "lightly supported and controlled" (Pujol, 1933, p.52-53). This brief section on playing position is accompanied by a photograph of Tarrega sitting with the guitar as a demonstration. In sum, Pujol's method regarding playing position is mostly *descriptive*: that is, it coaches the student to imitate an accepted model, rather than arguing for a method based on reasons or principles. It explicitly follows a master/disciple pedagogical model, with Tarrega as the accepted master model for the student to imitate.

### 3.2.2 Segovia/Bobri

Andrés Segovia (1893- 1987) succeeded Tárrega as the dominant force and guiding model of classical guitar playing in the 20<sup>th</sup> century. One of the most popular classical musicians of the modern era, Segovia further established Tárrega's innovations as a codified and coherent approach to guitar playing

while increasing the popularity and number of practitioners of the instrument exponentially.

While Segovia was to a significant degree self-taught, he met and was familiar with Tárrega and his disciples, and studied for a period under Llobet. Where Tárrega was an innovator, Segovia can be seen as a conservative force, advocating a strict adherence to principles of proper technique adopted more or less whole cloth from Tarrega and his school.

The Segovia Technique, first published in 1972, was a widely read and influential instructional work for the classical guitar. The method book, co-authored by guitar educator Vladimir Bobri and Andrés Segovia, is striking in its adherence to the same principles and often even the same language as that of the Pujol method concerning playing position. The front part of the left foot is placed on a footstool, although Segovia specifies a flat stool rather than Tárrega's angled one. They write that the guitar is to be angled so "the peg-head is at about the height of the collarbone", and the player is to lean forward, essentially following Pujol (Bobri, 1977, p. 32-35). To the three points of contact in the Pujol method, Segovia adds a fourth: the top of the right thigh. As in Pujol's method book, a picture of the model guitarist—in this case Segovia—is included.

Segovia's dominant influence in classical guitar during the first half of the 20<sup>th</sup> century cannot be overstated, and this popular and widely distributed method book further established his playing position as the model to follow. Like the Pujol method book, it can be said to be largely *descriptive*, and to assume a master/disciple approach to pedagogy, this time with Segovia as the virtuoso to be imitated and obeyed.

### 3.2.3 Contemporary guitar methods

Neither Julian Bream nor John Williams—the most popular virtuosos of the latter-half of the 20<sup>th</sup> century—have published formal guitar methods. Nor has any one guitarist dominated the concert stage and popular imagination in the manner of Segovia. At the same time, the number of methods and manuals has multiplied considerably. A look at a representative sample of some of the most widely read shows a general trend away from the master/disciple model of pedagogy towards a more reasoned and "humanistic" approach: that is, an approach that is based on scientific thought and natural laws rather than on an ideal 'master' model. This emerging school of thought has attempted to base correct playing position on an analysis of work and the effective use of force from the perspective of the natural sciences, and of what is considered to be natural for the human body, including concepts of balance and symmetry. There is also a new focus on 'healthy' versus 'unhealthy' or potentially damaging playing habits. This biomechanical approach has led some guitarists and guitar pedagogues to abandon the footstool in favour of different supports that allow for a putatively more 'natural' playing position.

This move away from the master/disciple model is explicitly articulated by the influential English guitar pedagogue and composer John Duarte in The Bases of Classical Guitar Technique (1975). Duarte says that while Segovia is a good example of the style he is describing, playing posture "cannot be effectively taught from the personal experience and characteristics of one player, no matter how great"

(Duarte, 1975, p.7). Duarte's descriptions are clearly an iteration of the familiar, Tárrega model: left foot elevated by a footstool, four points of contact with the instrument, "machine head level with the shoulders"(Duarte, 1975, p.11). But Duarte's method is *analytical* instead of being merely descriptive, like Pujol and to a large extent Bobri; rather than appealing to a master model to follow, Duarte uses scientific language to argue for the functionality of this approach. He describes the guitar and the player as two interacting parts in a mechanical system based on the physical principles of leverage and weight, stating that guitar playing—through an effective playing position—should amount to the "cultivated but natural use" of the human body. Playing position should be "as healthy as possible" (Duarte, 1975, p.10).

Very similar principles are echoed by Charles Duncan in The Art of Playing Classical Guitar (1980). While the book is a conscious attempt to "methodize the playing styles of the leading performers of the Segovia school", Duncan explains the basic elements of this style not in terms of a specific player as a model but rather as based on the principle of "functional tension", meaning the "application of force for a specific task"(Duncan, 1980, p.viii). Duncan also describes player and guitar as a mechanical system of joints and leverage, and considers good posture to be "an harmonious synthesis where forces are counterpoised" (Duncan, 1980, p.11). "Bodily symmetry" is stressed as an important consideration for playing position. Duncan therefore advocates that the guitar be angled more acutely than Tárrega's playing position in order to bring the fretboard closer to the left hand and reduce the need to lean to the left (Duncan, 1980).

In The Natural Classical Guitar (1984), Ryan Lee advocates a principle similar to Duncan's "functional tension" which he calls "dynamic relaxation". Balance and symmetry are both stressed as essential aspects of a "natural" guitar playing position. As with Duncan, Lee suggests the fretboard be positioned closer to the left hand, with the tuning pegs "approximately at ear level". Lee states that "the spine should be held straight" to avoid health problems: "the guitarist who is hunched over his instrument" risks "back aches and pinched nerves". Lee states that alternative supports to the traditional footstool can be considered in order to better achieve balance and symmetry for a healthier playing position (Lee, 1984, p.62).

### 3.3 Alternative supports

There is as yet no popular guitar method that advocates playing exclusively with an alternative support instead of the traditional footstool. This is possibly due to the fact that alternative supports are still a relatively recent development. It may also be a consequence of there being several, competing types of support available, which makes it difficult to represent them or choose between them in a method-type work. Nevertheless, several newer method books, like Lee's Natural Guitar, suggest that the player may choose between the footstool or an alternative support. Two recent representative Swedish examples—Första Gitarrboken (Strömberg, 1997) and Kom Igång (Jan Sejmo, 1997)—both choose to picture two guitarists with one using a foot stool and the other using an alternative support.

There are several different models of alternative guitar supports are now available. The *Dynarette*

company, for example, has produced their guitar rest for thirty years, and has sold over 50,000 according to company estimates (www.vamu.se, Nov. 16, 2009). All variants involve lifting and angling the guitar to bring the instrument up into playing position while allowing the left foot to remain resting on the floor. Alternative supports can be grouped into two classes: those like the *Gitano*, *Arm-n-track*, or *Ergoplay*, which attach onto the bottom of the lower bout of the guitar, or cushion-style supports—e.g., *Dynarette*—that are formed cushions designed to be placed between the left thigh and the lower side of the guitar waist. Some well-known leading classical guitarists use *Gitano* supports in concert, among them, Andrew York and Antigoni Goni (www.guitarsalon.com). Other well-known virtuosos such as Göran Söllscher and Scott Tennant alternate between footstool and alternative guitar supports.

Many makers of alternative support suggest in their promotional literature that alternative supports have biomechanical advantages: they allow the player to sit in what they refer to as “natural” posture and reduce risk of playing-related injury. The makers of *Dynarette* state that their cushion support allows the player to play “more comfortably and in perfect balance”, thereby “reducing stress and fatigue” (www.vamu.se, Nov. 16, 2009). The makers of *Ergoplay* state that their product provides a “natural sitting position” where “the back is straight” (www.ergoplay.de, Nov. 16, 2009). The makers of the *Janssen* alternative support claim their product “can reduce back, neck, and shoulder pain” (www.guitarrest.com, Nov. 16, 2009).

### 3.4 Performing Arts Medicine

Performing Arts Medicine (PAM) is a relatively young field of scientific research and a medical specialty that addresses health problems of performing artists, such as dancers, actors, and musicians. Several prominent authors in Performing Arts Medicine date its inception from the early to mid-1980’s and describe PAM as a growing field (Lockwood 1988, Bejjani 1996, Dawson 2007). In his 2007 bibliography of PAM, Dawson notes that the number and variety of published articles related to the field has continuously increased when compared to earlier reviews. Bejjani argues that the fact that musicians now seek medical help closer to onset of symptoms reflects the growing awareness and importance of Performing Arts Medicine within the music community. The journal *Medical Problems of Performing Artists*—the first and most important clinical medical journal devoted to performing arts related medical issues—began publication in 1986. The Performing Arts Medicine Association (PAMA) was founded in 1989.

Much of the research within Performing Arts Medicine is conducted by clinicians and is often based on the researcher’s own clinical practice; a goal for such research is to address clinical issues to find “more effective methods of diagnosis, treatment, and prevention” of playing related health problems (Dawson, 2002, p.135). A significant drawback to this type of data gathering is that researchers cannot easily or reliably extrapolate from and compare results. Bejjani states that “the content of Arts Medicine literature does not permit a truly critical review “because the vast majority of research is not blinded, nor case controlled, and based on clinical experience” (Bejjani, 1996, p.406). He adds, “many authors support their statements with only their respective clinical experience”. In a review study of musculoskeletal disorders among musicians, Wu concludes that “because the majority of research

designs were of a cross-sectional survey nature, a temporal relationship between risk factors and the onset of [musculoskeletal] complaints could not be established" (Wu, 2007, p.43). Schuele and Lederman write that "the current management of occupational disorders in instrumental musicians is based almost entirely on clinical experience rather than scientific evidence" and that "available studies describe the outcome of their standard clinical practice without having an adequate control group or precise information of the natural history" (Schuele, 2007, p.125). Zaza describes the field of PAM in general as "under-researched" (Zaza, 1998). In the absence of scientific studies that employ standard research methods such as control groups, researchers cannot conclusively determine such basic measures as incidence and prevalence of health problems, relative risk of health problems, and the like. Dawson states that determining true prevalence rates of health problems in musicians, "would require obtaining data from a large series of practices, encompassing a wide spectrum of medical specialists and extending over long periods of time (at least a decade)" (Dawson, 2002, p.139). Such a study has not yet been undertaken in Performing Arts Medicine. We may therefore conclude that much of the current research concerning playing-related health problems is suggestive but ultimately inconclusive.

#### 3.4.1 Playing-Related Musculoskeletal Disorder (PRMD) in musicians

Several musculoskeletal disorders, i.e. health problems of the muscle-tendon system or bone, have been shown to be correlated to the playing of musical instruments. Playing-Related Musculoskeletal Disorder, or PRMD, is a category that encompasses all such ailments. The term also implies that the individual conditions that make up PRMDs "share several common etiological factors" (Zaza, 1998, p.1023): that is, PRMDs are all occasioned by the playing, handling, and performance of a musical instrument. Aspects of musicians' praxis commonly considered risk factors for developing PRMDs are: size, shape, weight, and type of instrument, playing technique, playing position and posture, amount of time and intensity of practice, repertoire, and the stress of performance. Certain intrinsic variables such as the individual musician's general health, gender, age, anthropometry, hypermobility and psychological characteristics are also considered possible predictors of PRMD (Branfonbrener 2002; Ranelli 2008). The relationship between musical praxis and sickness is thus multi-factorial, and the etiology of most PRMDs is uncertain. Morse states, "the exact pathomechanisms (of PRMDs) are yet to be established" (Morse, 2000, p.82).

In a review article, Zaza found the prevalence of PRMD among musicians to range from 39% to 87%, with a range from 34% to 62% for secondary school music students. Rates were lower when studies counting mild complaints were eliminated (Zaza, 1998). A benchmark study of orchestral musicians in the United States showed that 76% of musicians in the study reported at least one playing-related medical problem, with 58% reporting having a PRMD (Fishbein, 1988).

The rate of occupational disorder in musicians is comparable to other professions (Zaza, 1998). However, several authors suggest that occupational disorders should be considered in many cases to be more serious for the musician patient, since often even a small change in physical ability can result in a

significant limitation in playing ability (Bejjani, 1998; Zaza, 1998). Furthermore, the musician patient is often more driven to continue to work when injured for personal or professional reasons, putting them at a higher risk for re-injury. In this way, musician injuries can be compared to injuries to professional athletes (McCready, 2007). Several studies suggest that both amateur and professional musicians are at risk (Morse, 2000); even very young music students show a tendency to develop PRMDs (Burkholder 2004, Warrington 2002).

The most common PRMD in musicians is **overuse syndrome** (Lockwood, 1989, Bejjani, 1996). Like other pain syndromes, there is debate over the definition and etiology of overuse, and even over the physiological processes that underlie it. Lockwood defines overuse as “the cumulative effects on tissues of repetitive physical stress that exceeds physiological limits” and attributes it primarily to “hours of constant repetition and intense practice” (Lockwood, 1989, p.222). Bejjani adds to this definition the stipulation that the repetitive action leads to “some subsequent change” in the muscle-tendon unit. Bejjani (1996) points out that there is no “objective test or objective consensus” concerning the clinical features of the syndrome (Bejjani, 1996, p.407). Marques defines overuse as “any pain, functional inability, or problem with motor coordination that effects the upper-extremities or neck... correlated to playing [an] instrument” and attributes symptoms to “stretching of muscle fibres over their anatomical and physiological limits” (Marques, 2003, p.11). The most common symptom of overuse is pain, sometimes accompanied by swelling and numbness, and the most effective treatment is rest or decreased playing, sometimes accompanied by anti-inflammatory medication, physiotherapy, and a re-evaluation of instrument, technique, and playing habits.

**Tendonitis** and other inflammatory syndromes of the tendons, tendon sheaths and muscle-tendon unit are also common PRMDs in musicians. Several studies include tendon inflammation syndromes under the wider category of overuse syndrome, while other authors argue that they should be considered separately. Symptoms, cause, and treatment are similar to overuse syndrome (Lockwood, 1989).

**Neural-impingement** or **nerve entrapment** syndromes have also been shown to be a common playing-related health issue for musicians. Some researchers also consider nerve-entrapment an overuse injury (Lockwood, 1989). The most common entrapment neuropathy is Carpal Tunnel Syndrome (CTS), defined by Dawson as “a constellation of clinical symptoms and signs produced by compression of the median nerve within the carpal tunnel of the wrist” (Dawson, 1999, p.25). Treatment strategies for CTS are based on rest, splinting, and sometimes surgery.

**Focal dystonia** can be considered the least common but perhaps most difficult PRMD to treat. While some focal dystonias can be traced to brain lesions, there is no clear consensus on the etiology of idiopathic cases (i.e. cases that are task specific, such as ‘writers’ or ‘musicians’ cramp’). It manifests in patients as abnormalities of muscle control, usually painless, and with concurrent contraction of agonist and antagonist muscle groups. Lockwood suggests focal dystonia may also in some cases be the result of overuse (Lockwood, 1989). Interestingly, and in contrast to other PRMDs, there is a prevalence of 2 to 1 for males over females for focal dystonia (Lim, 2003; Lederman, 2003). Treatment for focal dystonia is experimental. Lim states that focal dystonia is often career-ending (Lim, 2003).

While there is a broad consensus over which physical demands involved in music-making are most likely to cause injury—e.g., asymmetrical working positions, repetitive arm and finger movements, stress of performance, sudden increase in amount or intensity of practice—the process that leads from these factors to illness is not well studied or understood. According to Lockwood (1989), “little is known of the pathology of their development”. Fjellman-Wiklund states that “research is needed to better understand the relative importance of these factors” (Fjellman-Wiklund, 2006, p.169).

Many studies note a significantly higher incidence of PRMDs among female musicians compared to males, some reporting as high a ratio as 2:1 (Lockwood 1988; Branfonbrener, 2002; Warrington, 2002). Warrington suggests that this overrepresentation could be due in part to women being smaller in stature and more prone to hypermobility (Warrington, 2002). Certain patterns of rates of injury relative to instrument family also emerge, with most studies finding piano and string instrument players to be the highest risk group, with brass and percussion players having the lowest risk. Little is known or understood concerning the underlying causes of these differences between instrument groups, and little research on injury related to a specific instrument or playing technique has been performed. Dawson describes a “relative lack of instrument-specific data” (Dawson, 2002, p.135). Lockwood states, “the reasons for instrument specific variations are complex and not fully understood” (Lockwood, 1989, 222). Branfonbrener (1990) stresses the importance of further identifying the specific risk factors of each instrument.

### 3.5 The field of epidemiology:

The field of epidemiology is defined by Rothman in his textbook, *Epidemiology*, as the study of the occurrence of illness (Rothman, 2000). The primary epidemiological measures are prevalence, incidence, and relative risk. The prevalence in a population is a measure of disease status, that is to say how much or how little a certain disease exists in a given population, for example 15 out of 100. Incidence measures frequency of disease onset, and is expressed as number of cases over time for a defined size of population, for example 100/100000 people in a year. Relative risk expresses the difference in probability of getting a disease between one group and another.

Several types of epidemiologic studies exist. Cohort studies are studies that choose a number of individuals, a cohort, and measure attributes of the individuals such as weight, age, or hours of practice per day. The individuals are then followed over time; as disease occurs in certain individuals, it is possible to calculate incidence, prevalence, and the relationship between a risk factor such as high volume of instrument practice and disease. A case-control study is based instead on finding a certain number of people with a specific disease, and then finding others that are similar, but healthy, to compare them to. This allows the researcher to search for differences between the diseased population and the healthy one, perhaps in this case a specific playing position. This analysis of difference between two populations results in a measure of relative risk. It is impossible to measure prevalence or incidence in a case control study. A third type of study design is the cross-sectional study. This chooses a population and describes its attributes. It can relate how the variables differ between the individuals in the cross-section who are sick, and those who are not. The quality of any attempt to transfer these

results to a larger population depends on how representative the cross-section is of the general population one is seeking to study (Rothman, 2000).

A review study is a scientific overview and analysis of existing literature in a given field of research. A review is performed by searching databases and journals. The data-gathering must be performed in a predetermined and reproducible fashion . A review may be said to be systematic when it organizes the information gathered and provides analyses concerning the quality of the articles examined: "systematic reviews comprehensively examine the medical literature, seeking to identify and synthesize all relevant information to formulate the best approach to diagnosis or treatment" (Siwek, 2002, p. 253).



## 4. Method

A systematic review of published literature regarding classical guitar and PRMD, specifically concerning the relationship between playing posture and risk of PRMD, was performed using accepted search techniques. The online database Web of Knowledge (ISI) was chosen as a reliable and comprehensive source for relevant research in PAM. It was chosen over Pubmed as it contains academic research in both the field of medicine and the Arts and Humanities. Keywords used in the search were "classic\* ", "guitar\*", "musculoskeletal disorder\*", "injur\*", "health", "malad\*", "music\*", "problem\*", "pain". The search was repeated several times between September 1, 2009 and November 15, 2009. A search of the PAMA website bibliography was also performed using the keyword "guitar" by the same person. Finally, a manual search of *Medical Problems of Performing Artists*, the leading PAM journal, was conducted by the same person. Reference lists of relevant articles were also searched manually for further related articles. All abstracts of the articles produced by the initial searches were reviewed and articles that involved analysis of several instruments or instrument groups were reviewed for data concerning classical guitar and guitar. This method has been used by other authors in similar review articles in PAM, for example Wu in her review article, "Occupational Risk Factors for Musculoskeletal Disorders in Musicians" (Wu, 2007) and Schuele in "Occupational Disorders in Instrumental Musicians" (Schuele, 2004).

Articles were ranked in order of relevance. The most relevant articles for this study were those that examined the relationship between classical guitar playing position and PRMD. Second most relevant were those articles which studied the relation between classical guitar and PRMD. Next most relevant were articles concerning guitar and PRMD. Articles that dealt with classical guitar in the context of a broader study of PRMD were ranked second last, and articles that dealt with guitar in the context of a broader study were ranked last. Case reports were discarded as they can provide no epidemiological measures.

All relevant articles were also ranked according to quality of study design in order to assess the strength of each article's findings: cohort studies were considered as having the best quality, case-control trials ranked second highest, third were cross-sectional surveys of defined populations, fourth were retrospective studies of clinical experience at a specific clinic. Cohort studies confer a measure of disease occurrence in a population, thus providing a measure of prevalence, incidence, and risk. Reviews were considered separately. The present study's ranking method adheres to standard epidemiological practice as outlined by Rothman in *Epidemiology* (Rothman, 2002). A similar ranking system is used by other authors in PAM such as Zaza in her review article of musculoskeletal disorders (Zaza, 1998) and Wu (2007).

## 5. Results

### 5.1 Ranking of relevance and quality

This search yielded a total of 13 articles that satisfied the criteria for inclusion in this review. Of those, no articles specifically studied the relationship between classical guitar playing position and PRMD. Just one article studied the relation between classical guitar and PRMD. A total of three articles studied the relation between guitar and PRMD. Just one article studied the classical guitar in the context of a broader study, while a total of five articles studied the guitar in the context of a broader study. A total of 4 articles were case reports. A chart listing relevant articles according to rank is included below as table 1:

**Table 1: Articles ranked according to relevance:**

Rank 1 (total=0)	Rank 2 (total= 1)	Rank 3 (total= 3)	Rank 4 (total= 1)	Rank 5 (total= 4)
	"Flamenco Guitar as a Risk Factor for Overuse Syndrome"	"Musculoskeletal and General Health Problems of Acoustic Guitar, Electric Guitar, Electric Bass, and Banjo Players"	"Instrument-specific Rates of Upper-extremity Injuries in Music Students "	"Musculoskeletal Disorders and Asymmetric Playing Postures of the Upper Extremity and Back in Music Teachers"
		"Median and Ulnar Neuropathies in University Guitarists"		"A Pilot Population Study of Musculoskeletal Disorders in Musicians"
		"Playing-related Injury in Guitarists Playing Popular Music"		"Upper-extremity Problems Caused by Playing Specific Instruments"
				"Musicians' Cramp"

None of the relevant articles found were either cohort studies or case control studies. A total of four articles found were case reports; these were not included in the ranking system, as they do not provide any relevant or reliable epidemiological results. A chart listing relevant articles according to quality of study design is included below as table 2:

**Table 2: Articles ranked in order of quality:**

1. Cohort studies	2. Case-control trials	3. Cross-sectional surveys	4. Retrospective studies of clinical experience
—	—	"Flamenco Guitar as a Risk Factor for Overuse Syndrome"	"Instrument-specific Rates of Upper-extremity Injuries in Music Students"
		"Musculoskeletal and General Health Problems of Acoustic Guitar, Electric Guitar, Electric Bass, and Banjo Players"	"Upper-extremity Problems Caused by Playing Specific Instruments"
		"Median and Ulnar Neuropathies in University Guitarists"	
		"Playing-related Injury in Guitarists Playing Popular Music"	
		"Musculoskeletal Disorders and Asymmetric Playing Postures of the Upper Extremity and Back in Music Teachers"	
		"A Pilot Population Study of Musculoskeletal Disorders in Musicians"	
		"Musicians' Cramp"	

## 5.2 Summary of relevant articles

“Flamenco Guitar as a Risk Factor for Overuse Syndrome” (Marques, 2003) is a cross-sectional study of 64 professional guitarists, half of whom played classical and half of whom played flamenco style guitar. The study sought to analyse and compare the prevalence of overuse syndrome among a group of guitarists practicing two different techniques of guitar. The method used was interviews with study participants. The study found that 75% of participants reported symptoms of overuse syndrome. Significantly more of the flamenco guitarists (87.5%) reported symptoms of overuse syndrome compared to the classical guitarists (62.5%). The authors attribute this to certain aspects of technique peculiar to flamenco guitar related to the need to play loudly in performance, leading the guitarist to fret more tightly with the left hand and strum and pluck with more force with the right hand compared to classical performers. They also note that flamenco players tend to use the plucking-hand wrist in a flexed position, partly due to the traditional flamenco playing position that sees the guitar angled to the right, and partly due to the unique technical demands placed on the thumb in the flamenco style. The authors conclude that “we believe that the basis of the differences [in the prevalence of overuse syndrome among flamenco and classical players] do correspond to difference in playing techniques” (Marques, 2003, p.13). *Published in Medical Problems of Performing Artists (MPPA)*

“Musculoskeletal and General Health Problems of Acoustic Guitar, Electric Guitar, Electric Bass, and Banjo Players” (Fjellman-Wiklund, 2006) is a cross-sectional study based on data from the University of North Texas Musician Health Survey (UNTMHS). The authors analysed the study’s population of musicians who played an instrument from the guitar family to determine prevalence of PRMDs in the sample group; the group was also analysed by gender. The study determined that 81% of respondents reported one or more PRMD; highest prevalence was among the acoustic guitar group (steel-string and nylon string)= 83%. Most frequent anatomical locations for PRMD were on the left side: problems with the left fingers, left wrist, and left hand. They state that “comparisons between classical guitarists and non-classical guitarists showed that classical guitarists reported significantly more musculoskeletal problems” (Fjellman-Wiklund, 2006, p.171), with a p-value of 0.027 (total acoustic guitar players were 213, classical guitar 19). Not included however is the percentage of classical guitarists reporting PRMD, or any further analysis of differences between the two populations. Classical guitarists represented just 6% of the total population studied. The authors conclude that PRMD is a “major concern for the guitar community” and that further research is necessary to explain why classical guitarists reported more PRMD than nonclassical (Fjellman-Wiklund, 2006, p.169). *Published in MPPA*

“Median and Ulnar Neuropathies in University Guitarists” (Kennedy, 2006) is a descriptive cross-sectional study of 24 guitarists (bass, steelstring, electric and classical players) from two university music programs. The study sought to determine if any of the guitarists had median or ulnar neuropathies, based on the premise that guitarists and other string pluckers are at risk for nerve-entrapment problems such as Carpal Tunnel Syndrome (CTS). All the subjects identified guitar as their primary instrument; the authors did not however identify how many of the participants primarily played classical guitar. The study was performed using interviews, a physical exam, and a Nerve Conduction Study (NCS). The result of the study showed that 4 subjects (17%) displayed electrophysiologic

evidence of median neuropathy at the wrist: i.e. decreased electrical conduction potential along those nerves, without any other symptoms of nerve entrapment such as numbness or tingling. Otherwise the subjects were shown to have normal neural and musculoskeletal health. The authors suggest that it would be useful to follow up these patients in 5 to 10 years to see how their conditions had evolved. They also recommend that “future studies address the guitarists’ playing position”, as factors such as wrist angle when playing may be an important risk factor. (Kennedy, 2006, p.109). *Published in Journal of Orthopedic and Sports Physiotherapy*

“Playing-related Injury in Guitarists Playing Popular Music” (Rigg, 2003) is a cross-sectional study based on a mail survey of 261 amateur, professional and student guitarists who play predominantly popular music. The study aimed to determine the most common anatomical location of pain and to identify possible etiological factors leading to injury. Of the respondents, 61.3% reported playing related pain; left hand and wrist (41.8%) was the most common location for pain; back and neck (17.2%) was the next most common location. There was a correlation between players who suffered from problems of the left-hand and sitting or standing playing position; players who stand were more likely to have left-hand and wrist injury. The authors speculate that this may be attributable to “extreme flexion of fretting wrist” by guitarists who tend to adjust their shoulder strap so the guitar sits too low. The authors conclude that their study “reflects that a substantial number of guitarists are experiencing playing related pain” (Rigg, 2003, p.52). *Published in MPPA*

“Instrument-specific Rates of Upper-extremity Injuries in Music Students” (Cayea et al., 1998) is a retrospective study of clinical experience based on 14 years of patient records from a university’s health service. All performance majors who presented to the health service with performance-related upper-extremity injuries were included. The authors analysed the data according to incidence of disease per instrument type. The aim of the study was to describe injury rates for performers playing a broad range of individual instruments. The results showed an overall incidence of 8.3 injuries per 100 student years. The rate for women (8.9) was higher than for men (5.9). The instrument with the highest injury rate was the harp (17.1), followed by the classical guitar (13.7) and the piano (13.1). Brass and woodwinds had the lowest rates. All guitarists in this study were classical guitarists; however, as the university in question began instruction in guitar only in the middle of this survey period, the guitar data is based on a very small sample of guitarists (total= 44) and small sample of guitarists with PRMD (6). The injury rate for the organ (7.2) was significantly lower than for the piano, leading the authors to consider them separately. (Cayea et al., 1998). *Published in MPPA*

“Musculoskeletal Disorders and Asymmetric Playing Postures of the Upper Extremity and Back in Music Teachers” (Wahlström Edling, 2009) is a cross-sectional pilot study of 47 music teachers at a Swedish municipal music school. The results were based on a questionnaire that included questions concerning instrument (s) taught, total playing time, and symptoms of musculoskeletal disorders. The authors analysed the instruments taught in terms of whether they were played in a symmetrical (violin, cello, double bass, trombone, flute, guitar) or asymmetrical (clarinet, oboe, bassoon, trumpet, recorder, keyboard/piano, percussion) playing position. The aim of the study was to assess the relation between physical workload as defined by hours of playing per week and playing posture and PRMD at this music

school. The authors do not differentiate between guitar types studied. Of the total participants, 77% reported PRMD in the previous 12 months. None of the individual results concerning location of PRMD showed a significant difference between symmetrical and asymmetrical groups, although a composite of neck, shoulder, and upper and lower back pain calculated a statistically significant difference in prevalence of 63% among asymmetrical versus 30% in the symmetrical group. The authors do not discuss how this composite measure is arrived at; nor does the article provide a justification for the choice of this constellation over other possible constellations of symptoms. The authors conclude that the study “demonstrates that an asymmetric playing position may affect the amount of musculoskeletal disorders in the upper-extremity and back” (Wahlström Edling, 2009, p.113). *Published in MPPA*

“A Pilot Population Study of Musculoskeletal Disorders in Musicians” (Morse, 2000) is a cross-sectional pilot study based on a telephone survey of 949 respondents. Participants were asked if they played a musical instrument and, if so, did they experience playing-related symptoms of PRMD. The aim of the study was to obtain estimates of the number of people who play musical instruments and of the prevalence of PRMD among those who play musical instruments. Of those who answered that they played a musical instrument, 21% reported upper-extremity pain. Highest percentage of PRMD according to instrument was piano (33%), followed by guitar (30%). The study did not distinguish between different kinds or techniques of guitar played. The authors note that the constrained number of questions limits the study’s usefulness, and that more extensive research is needed (Morse, 2000). *Published in MPPA*

“Upper-extremity Problems Caused by Playing Specific Instruments” (Dawson, 2002) is a retrospective study of clinical experience based on 167 patients from a hand surgical practice. All patients who reported music-making as the source of their injury were included in the study. The patients were classed according to type of instrument played. The aim was to determine the prevalence of PRMD relative to different instruments. Keyboard (38.9%) and strings (37.7%) were the instrument groups most frequently represented, accounting for 76.6% of all cases. Of the 63 string player patients, 24 were guitarists. Dawson does not specify type or style of guitar played. The study found muscle strain (37%) to be the most common injury among guitarists, followed by muscle and tendon sprain (21.9%), and CTS and focal dystonia (15.6%). Problems of the left and right side were equally represented. The study concludes that players of the same instrument type developed similar types of problems, but that problems were not instrument specific: that is, that all instrument types were susceptible to all types of PRMD (Dawson, 2002). *Published in MPPA*

“Musicians’ Cramp” (Lim, 2003) is a cross-sectional comparative study of focal dystonia (musicians’ cramp) among German music students. Patient data from the Institute for Music Physiology and Music Medicine in Hannover, Germany, dating from 1994-2000 was searched for information concerning number of patients with focal dystonia, their gender and the instrument played. This data was then compared to the number of music students enrolled at eight German music conservatories also analysed according to instrument and gender. The aim of the study was to determine whether one gender or certain instruments were overrepresented as risk factors for developing focal dystonia. The

study found that woodwind and guitar instrumentalists were more likely to develop focal dystonia, while string and percussion players were less likely to develop the condition. Of total focal dystonia patients, 34 were guitarists, which was significantly greater than the number expected (15) based on numbers of guitarists enrolled in music conservatories relative to other instruments. Type or style of guitar was not specified. Males were far more likely to develop focal dystonia (6:1). The authors conclude that there is a "clear association between instrumental groups and the presentation of certain symptoms" of focal dystonia (Lim, 2003, p.26). *Published in MPPA*

## 6. Discussion

### 6.1 Limitations of the current research and suggestions for future studies

This review found no current research that specifically addresses the relation between classical guitar playing posture and PRMD. Furthermore, the research that does exist concerning the broader question of classical guitar and PRMD is very limited in both quantity and quality. These findings were in keeping with similar reviews conducted in the field of Performing Arts Medicine. The review, "Occupational Risk Factors for Musculoskeletal Disorders in Musicians" (Wu, 2007), found only eight articles in the literature that fit their inclusion standards; Wu states, "the best available evidence for risk indicators in developing [PRMD] in musicians is not of generally high quality" (Wu, 2007, p.44). The review, "Playing-related Musculoskeletal Disorders in Musicians" (Zaza, 1997), found a total of eight articles that satisfied criteria for inclusion. Zaza states, "it is difficult to summarize the burden of illness from a problem that is not defined clearly or rigorously examined in the primary studies" (Zaza, 1997, p.1024).

One of the most serious methodological limitations of the articles reviewed was that they studied small or poorly defined samples of classical guitarists. Classical guitar was considered separately from other guitar types in just three articles (Marques, 2000; Cayea, 1998; Fjellman-Wiklund, 2006). In Fjellman-Wiklund, classical guitar was not consistently analysed as a separate group. The numbers of classical guitarists studied in each article were low: 32, 44, and 19, respectively. None of these studies included an analysis of the individual guitarist's playing position.

Another limitation of several of the included studies was choice of the study sample—the group chosen for study. For research to yield significant findings, the study sample must be shown to accurately represent a larger population. Two of the articles included are retrospective studies based on clinical experience; one obvious problem with this sample-type is that it represents only those who sought medical attention, which may be a small and unrepresentative fraction of those who are affected. Cross-sectional studies can yield more meaningful findings, but their quality rests upon how representative the studied group can be said to be of the larger population. The choice of cross-section is not adequately defined or motivated and can therefore be said to be of low quality in the articles by Fjellman-Wiklund (2006) and Wahlström Edling (2009). As "Median and Ulnar Neuropathies in University Guitarists" (Kennedy, 2006) is intended to be a descriptive study, the choice of study sample is not intended to be representative of a larger population.

The most serious limitation in all these studies is that none of them are constructed to allow us to determine causal effect between playing position and PRMD as they do not follow their study sample over time. As Kennedy (2006) writes in the conclusions of "Median and Ulnar Neuropathies in University Guitarists", a "valuable extension of this study would be to re-evaluate these guitarists in 5 to 10 years to determine whether these individuals who presented with early electro diagnostic findings [...] later develop symptomatic carpal tunnel syndrome". Kennedy further recommends that "future studies



address the guitarists' playing position as part of the evaluation process" (Kennedy, 2006, p.109). There is a general consensus among researchers that the etiology of PRMD is multi-factorial—instrument size and weight, playing time and intensity of play, playing position, and gender are all important variables—but that further research is needed to determine *what* risk factors lead to what diseases and *why*, and *how long* it takes for these factors to lead to disease. Wristen summarizes the problem succinctly: "though biomechanical and ergonomic studies have theorized that certain physical motions contribute to injury development, it has yet to be determined how frequently and for what durations these motions must be used in order for injury to result" (Wristen, 2000, p.63). A large, well-funded cohort-type study of classical guitarists would be the most important first step towards answering these basic questions. Research to quantify the number of guitarists who currently use alternative support would be a useful pilot study in this endeavour. A well constructed case-control study could be a quicker and less expensive means of determining the relative risk of being afflicted by PRMD between different playing positions, and between different styles of guitar.

The current state of affairs in research on guitarists' health is perhaps not surprising considering that the wider field of Performing Arts Medicine is itself only about 30 years old. Several prominent researchers in PAM have stated that further instrument-specific research is crucial towards understanding PRMD in musicians (Branfonbrener, 2002; Dawson, 2002; Bejjani, 1997).

## 6.2. Implications for today's classical guitar teacher

Where does this leave today's classical guitar teacher? The most obvious conclusion is that current scientific research has nothing definitive to say concerning classical guitar playing position. This is not, however, an entirely anodyne finding. These results should serve as a rejoinder to and protection against fads and trends in guitar pedagogy that seek legitimacy in quasi-scientific theories. For example, we may conclude that while alternative supports may be comfortable or convenient, claims to their being healthier or even *as healthy as* the traditional footstool find no support in scientific literature. This is not to say that they aren't healthier. It may be the case that alternative supports do lead to a healthier but still no less injury-prone playing-position, depending on the true origin of PRMD in classical guitarists. That is, asymmetric playing-position may not be the most important factor leading to PRMD in guitarists. The fact that piano is in several studies found to be comparable to guitar relative to risk of injury (Cayea, 1998; Morse, 2000) is intriguing in this regard: namely, piano and guitar share the biomechanical factor of rapid, precise finger movements, but are entirely dissimilar in most aspects of how the player sits with the instrument. Indeed, the only commonality is the fact that the two performers both sit. If it were the case that long periods of sitting or specific operations of the fingers were the most significant factors leading to PRMD in guitarists, then choice of footstool or alternative support might be a relatively unimportant factor in prevention of injury. This possible correlation between piano and classical guitar techniques and injury rates is interesting but entirely speculative. Again, a study with a sufficiently large cohort is required to answer questions such as these.

The classical guitar teacher is left then with a kind of "Socratic ignorance"—that is, the knowledge that we know nothing, or at least can say very little definitively about playing position and risk of PRMD. In

this, the guitarist is no different from instrumentalists in the rest of the instrument family, although the relatively short history (and until recently, the impopularity) of the classical guitar means that fewer technical and theoretical works have been written on it compared to violin or piano. This has made the classical guitar's stunning emergence in the last century as a respected concert instrument on the coattails of Segovia a "Cinderella success", as Duncan writes in The Art of Playing Guitar (Duncan, 1980). While the guitar has become more prominent, "guitar instructional literature is not as sophisticated as that of other instruments" (Duncan, 1980). Duncan recommends that guitar pedagogues look to the rich resource of piano and violin theoretical writings as a basis for further study in the guitar.

Wristen (2000) in "Avoiding Piano-related Injury" suggests a checklist-style technique for what she calls a bio-mechanical analysis of piano technique (Wristen, 2000). This type of analysis could be a starting point for biomechanical thinking in the classroom, and could be applied equally well to the classical guitar. She begins from the premise that healthy playing habits *in general* are those where the motions involved in playing allow the participation of as many muscle groups as possible, allow the joints to remain in as neutral a position as possible, and motions that are as curvilinear as possible. Conversely, motions that are restricted to smaller sets of muscle groups, motions that involve holding joints at acute angles, and angular motions are considered *in general* to be unhealthy. She then compiles a list of the basic gestures—"theoretical motion pattern norms"—involved in the most common elements of piano-playing, e.g., octaves, scale runs, arpeggios, etc. The student is then observed performing these different technical tasks and evaluated according to a checklist (Wristen, 2000). This method is built not on a certainty of which practices lead to PRMD, but rather a basic analysis of how the human body functions to most efficiently perform a task: "all human beings are constructed in basically the same way [...] therefore it is possible to derive general biomechanical observations that may apply to all pianists and can potentially aid in building appropriate technique, which should hypothetically lower the risk of injury by avoiding potentially hazardous motions" (Wristen, 2000, p.62).

Such an analysis could be equally informative for the guitarist. While such a "biomechanical approach to guitar playing" would not be based on a definitive knowledge of relative risks, it would be a possibly fertile starting point for student and teacher, especially for the student who already shows symptoms of PRMD or whose playing position involves relatively extreme deviations from neutral posture. It is also a useful place for the researcher to begin parsing the different elements of playing technique and playing posture in terms of risk. However, where this type of rationalized movement analysis clashes with tradition or with a performer's playing posture, we need to be aware that putatively "unhealthy" habits such as acute wrist postures and asymmetrical sitting positions may not be significant factors leading to injury. We have virtually no scientific evidence in the field of classical guitar playing; we do, however, have a playing tradition that informs today's guitarist how others have successfully mastered the instrument in the past. We may in any case follow Wristen's example and study the different basic movements involved in playing the guitar as an analytical tool. The teacher can use the categories of "theoretical motion pattern norms" to explain to the student what works for them and what has worked for others, and try to lead them towards finding a playing position and technique that both sounds and feels good.

Blind obedience to any method or model in guitar pedagogy is based on ignorance and can lead to students tiring of the guitar and in some cases even to injury. It is clear that the master/disciple model of teaching is waning, and perhaps rightfully so. Still, there is in every tradition a store of accumulated knowledge that may never have been proved in theory but which has worked in practice. It would seem a shame to throw out the already abbreviated tradition of the classical guitar, especially if it is in favour of new models which are as yet unproven. While a guitar method should aim to be *analytical* rather than purely *descriptive*, the shortage of reliable, scientific knowledge available to the classical guitar teacher makes tradition and personal experience an invaluable teaching tool.

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