MUSICIANSHIP AND TEACHING

Aspects of musculoskeletal disorders, physical and psychosocial work factors in musicians with focus on music teachers

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MUSICIANSHIP AND TEACHING
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Abstract
Musculoskeletal disorders are common among musicians at all levels of performance. Since music teachers train our future musicians it is important to understand their work environment. By creating good examples of a healthy work environment, they can teach their students how to stay healthy and to prevent pain. The aim of this thesis was to study the work environment of music teachers at municipal music schools, with regard to physical and psychosocial factors and musculoskeletal disorders with the focus on neck and shoulder disorders. An additional aim was to investigate the variability of the playing technique in string players and to investigate if they could play with greater variation in the trapezius muscle activity pattern after a training intervention program.

In a cross-sectional study at 23 municipal music schools, 171 out of the 208 (82%) music teachers reported that they had experienced work related musculoskeletal disorders (WMSDs) during the previous year. Women reported significantly more symptoms in the neck, the shoulders and the upper back compared to men. Both physical and psychosocial work factors were associated with neck and shoulder disorders. For women “high mental work demands” and “teaching at many schools” could be seen as risk factors and for men “lifting”, “playing the guitar” and “low social support at work” were risk factors.

The occurrence of WMSDs was also investigated, over an eight-year period, in music teachers at one music school. The result showed that neck, shoulder and lower back disorders were common and tended to be of long duration and to increase over the years.

In an interview study, nine music teachers focused on what they perceived to be important for their health and well-being. Replenishing and using up energy was found to be the core category. Creativity in the music and working with other musicians were perceived as sources of energy, while the goals of the organisation were experienced as stressful and used up energy. Whether the work was regarded as pedagogical or musical could affect the perception of health and the strategies for dealing with the strains of work.

In two studies using electromyography, the variation in the trapezius muscle activity pattern in string musicians was investigated. The results suggested that each musician could repeat their muscular activity pattern in a similar way between two playing sessions. No difference was found in the trapezius muscle activity between five violinists who trained basic Body Awareness Therapy (BAT), a technique having its roots in Tai Chi Chuan tradition, compared to a reference group of nine violinists who did not take part in any training. However, the training group perceived positive changes in breathing, muscular tension, postural control and concentration during practice sessions.

Neck and shoulder disorders were associated with physical and psychosocial factors at work. A process of replenishing and using up energy was important for music teachers’ health. The playing technique in string musicians seemed to be repeatable but difficult to affect over a short-term period. For future musicians it is crucial to learn good working technique at an early age. In the learning process the music teacher is a vital role model.

Keywords: music; musician; teaching; occupational; musculoskeletal; psychosocial aspect; mind-body; tai chi chuan; basic body awareness therapy; electromyography
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Annchristine Fjellman-Wiklund
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"Min själv är en hemlig orkester, jag vet inte vilka instrument som klingar och ljuder, strängar och harpor, trummor och pukor, inom mig. Jag känner bara mig själv som symfoni."

(Fernando Pessoa)

To Benkt, Erika and Peter
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Annncristine FjeUman-Wiklund, RPT, MSc, Department of Community Medicine and Rehabilitation, Physiotherapy, Umeå University SE-901 87 Umeå, Sweden

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Keywords: music; musician; teaching; occupational; musculoskeletal; psychosocial aspect; mind-body; tai chi chuan; basic body awareness therapy; electromyography
SVENSK SAMMANFATTNING
MUSIK OCH UNDERVISNING I SAMSPEL

Aspekter av muskuloskelettala besvär, fysiska och psykosociala arbetsmiljöfaktorer hos musiker med fokus på musiklärare

Ann Christine Fjellman-Wiklund, Lgr. sjukgymnast, Institutionen för
Samhällsmedicin och Rehabilitering, Sjukgymnastik, Umeå universitet

Muskuloskelettala besvär är vanliga bland musiker och hos musiklärare. Syftet med denna avhandling var att studera den fysiska och psykosociala arbetsmiljön i relation till nack- och skulderbesvär hos musiklärare verksamma i kommunala musikskolan. Vidare syftade avhandlingen till att hos stråkmusiker studera trapeziusmuskelns aktivitetsmönster med elektromyografi (EMG) vid spelande av samma musikstycke vid två tillfällen och att genom en intervention med kroppskännedomsträning, studera om muskelaktivitetsmönstret kunde förändras.

I en tvärsnittstudie vid 23 kommunala musikskolor angav 171 av 208 (82 %) av de svarande att de upplevt muskulära besvär under det senaste året. Signifikant fler kvinnor än män rapporterade besvär i nacke, skuldror och bröstrygg. Både fysiska och psykosociala arbetsmiljöfaktorer var associerade till nack- och skulderbesvär. För kvinnorna var höga krav i arbetet och att undervisa vid många skolor riskfaktorer och bland männen lyft av instrument, gitarr som huvudinstrument och lågt socialt stöd. Nack- och skulderbesvären undersöktes vidare under en åttaårsperiod vid en musikskola. Besvären tenderade att vara ihållande och att öka över tid.

I en intervjustudie fokuserades på faktorer om hälsa och välbefinnande ur ett salutogenet perspektiv. Samspelet med andra och kreativiteten i musiken upplevdes som kärnan i arbetet och positivt berikande medan organisationens mål var stressande och krävde energi. Huruvida arbetet ansågs som pedagogiskt eller musikaliskt påverkade upplevelsen av hälsan och strategier för att hantera stressen.

I två studier undersökt muskelaktivitetsmönstret, medd EMG på trapezius muskeln, hos stråkmusiker som spelade samma musikstycke vid två tillfällen. Resultaten pekade på att muskelaktivitetsmönstret var upprepbart inom individen vid de två tillfällena, men varierade mellan individer. En intervention gjordes i form av en åtta-veckors kroppskännedomsträning, en teknik med rötter i Tai Chi Chuan-traditionen. EMG-mätningar visade inga skillnader i aktivitetsmönster mellan fem violinister i en träningsgrupp och nio violinister i en kontrollgrupp, vilket indikerar att ett spelmönster som är införlivat i personens spelstil kan vara svårt att förändra. Träningsgruppen upplevde positiva förändringar i andning, muskelspänning, balans och koncentration. En ergonomiskt riktig spelstil är viktig att lära in tidigt under den musikaliska skolningen och musikläraren spelar här en viktig roll som positiv förebild.
## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
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<tr>
<td>BAT</td>
<td>Body awareness therapy</td>
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<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>CI</td>
<td>Confidence interval</td>
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<td>EMG</td>
<td>Electromyography</td>
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<td>EVA</td>
<td>Exposure variation analysis</td>
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<td>MPA</td>
<td>Musical performance anxiety</td>
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<tr>
<td>MVC</td>
<td>Maximal voluntary contraction</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio</td>
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<tr>
<td>PC</td>
<td>Principal component</td>
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<tr>
<td>PCA</td>
<td>Principal component analysis</td>
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<td>PAMA</td>
<td>Performing arts medicine association</td>
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<td>RMS</td>
<td>Root-mean square</td>
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<tr>
<td>RVC</td>
<td>Reference voluntary contraction</td>
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<tr>
<td>RVE</td>
<td>Reference voluntary electrical activity</td>
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<td>WMSDs</td>
<td>Work related musculoskeletal disorders</td>
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The present thesis is based on the following papers, which will be referred to by their Roman numerals:


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INTRODUCTION

Work related musculoskeletal disorders (WMSDs), especially of the upper limb and the back, are a significant problem in the industrialised world. (Hagberg et al. 1995; Buckle and Devereux 1999; Lagerlöf 2000). It is likely that the problem will increase since workers are becoming more exposed to workplace risk factors that affect the disorders (Buckle and Devereux 1999). In Sweden the majority of all work related illnesses is made up of musculoskeletal disorders (Statistics Sweden 2002a). The disorders are the most common reason for sick leave and disability pension in Sweden (Folkhälsorapport 2001). The prevalence of self-reported neck and upper limb disorders varies between 14-46% within the European countries (Buckle and Devereux 1999). Lost work-time and rehabilitation involve considerable costs both to the individual, the employers and to society as well as a reduced quality of life, and suffering for the individual. Although the knowledge of the actual cost of the disorders is limited some evidence suggests that the total cost in the Nordic countries is approximately 0.5-2% of the Gross National Product (Buckle and Devereux 1999). This underlines the urgency of preventing and minimising the consequences of the WMSDs.

WMSDs are common in a number of professions and musicians are no exception. The health problems of musicians remain under-recognised and under-researched. Little is known about the magnitude of the problems, the factors that place musicians at risk, what therapies that are effective and appropriate for musicians, and how to prevent the problems. It is important to see musicians' occupational health problems as "serious concerns instead of intriguing oddities" (Zaza 1998a).

Among musicians, music teachers form a group worthy of special interest. They educate and stimulate our future musicians to found practice habits, attitudes and values on which to develop into skilled musicians. An important part of music teachers' job is to act as positive role models in their playing. By creating good examples of a healthy work environment, students learn how to stay healthy and to prevent WMSDs. Thus, this thesis focuses on a music teacher's work environment and WMSDs.
Performing arts medicine

The Italian physician Ramazzini made the first summary of occupational diseases of musicians in the early 1700s. In the 18th and the beginning of the 19th centuries, the interest in arts medicine was “sporadic at best” (Harman 1998). Few published reports in the medical literature of the time led to any real study in the music medicine field. In the beginning of the 1920s the German physician and musician Kurt Singer founded the first medical clinic for musicians (Altenmüller 2002). A few years later he published a monography on disorders in professional musicians, which discussed both the physical and psychological ailments of musicians (Harman 1998).

Not until the middle of the 1960s did there arise a growing interest in many aspects of music medicine worldwide. A new medical speciality called performing arts medicine, evolved at this time in the USA, in Australia and in Europe (Brandfonbrener 2002a). The speciality included medical issues concerning musicians, dancers and actors. In the middle of the 1970s the first steps were taken to set up a network for referrals among American physicians with the subspecialty musical medicine (Harman 1998).

In 1983, Alice Brandfonbrener organised the first Medical Problems of Musicians Conference in Aspen, Colorado, USA. The conference was held in conjunction with the Aspen Colorado Music Festival, which is a large summer music school for talented music students, with professional musical performers as teachers. This format has made it possible for musicians and music educators as well as health care professionals, to come together and share interest in and experiences of treating the ailments that affect musicians. The conference is an annual event, which now also includes the medical problems of dancers (Brandfonbrener 2002a).

At the same period in the 1980s, in Australia Hunter J H Fry founded the Performing Arts Medicine Society as a section of the Australian Medical Association. Fry and his colleagues presented a large number of studies important to the field of music medicine (Fry 1986a; 1986b; Fry 1987).
Introduction

Organisations and networks

During the whole of the 1980s organisations of performing arts medicine were founded, such as the International Arts Medicine Association (IAMA), the British Performing Arts Medicine Trust (BPAMT) and the Performing Arts Medicine Association (PAMA). They all focused on gathering knowledge in the field and worked towards creating quality medical care for performing artists (Harman 1998). During the last ten years Canada, New Zealand, France, Germany and Finland have followed suit and founded organisations for music and performing arts medicine (Harman 2001). Many of the organisations and networks have published journals and newsletters for their members and they have their own websites.

As yet there is no formal organisation in Sweden. A conference called “Artister–Hälsa– Arbetsmiljö” was held in the year 2000 with the goal of building a network of people interested in performing arts medicine and inspiring research in the artists’ work environment in order to prevent ill health among performers (Theorell 2001).

In order to spread information of the field an important step was taken in 1986 when the journal Medical Problems of Performing Artists (MPPA) began publication, with Alice Brandfonbrener as editor. Since 1993 the journal has been the official publication of Performing Arts Medicine Association. The MPPA is a peer reviewed, scientific journal encouraging not only health care professionals but also teachers and performers to contribute to the published materials. The journal is considered to be at the cutting edge of the music medicine field. MPPA publishes the majority of articles in the performing arts field (Harman 1998).

The increasing interest in performing arts medicine has also led to a growing number of arts medicine clinics opening in all of the above mentioned countries which have established arts organisations (Performing Arts Medicine Association 2002a). In Sweden there are two music medicine clinics, one in Göteborg and one in Malmö. Both clinics have connections with university education in music. There are also a number of health care professionals throughout the whole of Sweden who have a great interest in research on WMSDs and the treatment of musicians.
Definition and goals of performing arts medicine

The term *performing arts medicine* has been defined as “the etiology and the management of musicians’, singers’, actors’ and dancers’ health problems” (Zaza 1995). Performing arts medicine should provide information not only for the performers themselves but also for the performers’ teachers and health care professionals interested in the field (Sataloff et al. 1998). As an example of this work the PAMA (Performing Arts Medicine Association 2002b) states that the organisation is dedicated to improving the health care and treatment of performing artists through:

- Developing educational programs to provide informed and appropriate medical care for performing artists
- Promoting communication of health-related information between health care professionals, performers and teachers in the performing arts
- Fostering research on etiology, prevention and treatment of the health problems common to the performing arts

The future of performing arts medicine has its place in the interaction between medical science and pedagogy “if the health maintenance and care of musicians are to become more consistent and effective” (Brandfonbrener and Kjelland 2002).

Music teachers

The music teacher education

Until recently the Swedish music teacher education has been a four-year study program at the university. The training program has been divided into the following four variants: a) teacher in primary and secondary school with class teaching in music and some other subject, b) teacher in primary and secondary school with class teaching in music, c) teacher in voluntary music education with eurhythmics and ensemble teaching, d) teacher in voluntary music education, foremost in the municipal music schools and other voluntary work in music, with instrumental and ensemble teaching.
In the academic year 2001-2002 music teacher education was revised and various topics were amalgamated into one education (SOU 1999:63). This has meant that there is no longer one music teacher education, but a program focusing on special topics, for example music. Thus, the above mentioned four variants of music teacher education no longer exist. The "new" education program enables the student to combine his/her own choice of subjects (Bladh 2002). Since the new education started recently no teachers have yet graduated from it. This thesis focuses primarily on music teachers from the municipal music schools and involved in other voluntary work in instrumental and ensemble music teaching.

Music teachers in education and at work

Most music teacher students come from high socio-economic environments (Brändström and Wiklund 1995). One of three music teacher students comes from a home where one of the parents works as a teacher. In the academic year 1990-1991 two of three music teacher students were intending to become music teachers in primary and secondary school while there were an equal number of male and female students intending to become music teachers in municipal music schools (Brändström and Wiklund 1995). Female music teacher students seem to be more interested in subjects geared to contact with pupils while male music teacher students are interested in the subjects that develop their own musical skills (Bouij 1998; Bladh 2002).

Music teachers in Sweden have two main venues of work, class room teaching in the compulsory school and the upper secondary school, and voluntary instrumental education in the municipal music school and other non-compulsory music education (Bouij 1998). The music teacher profession has been described as a low status job with low pay. The newly qualified music teacher often combines playing professionally in an orchestra and music teaching, or music teaching at several levels and school forms into obtain full time work (Bouij 1998; Bladh 2002). It is mainly at the municipal music schools that there is an opportunity to get full time work. Since the workplaces are spread throughout the municipality and sometimes in different municipalities, the work includes lots of travelling every day. Bladh (2002) found in his study that 46% of the music teachers had to travel by car to be able to work. Travelling between schools also included
much handling of music instruments and equipment necessary for the teaching. Both the driving and the handling of equipment were perceived as stressful. Bouij (1998) and Bladh (2002) concluded that the music teacher work was perceived as stressful and not always meaningful. After being a qualified music teacher for a few years almost 50% of the music teachers expressed negative opinions or doubt about their profession.

Practice as a goal for the music teacher

When someone is going to learn how to play an instrument practice is vital for the result. Jørgensen (1997) has defined practice as different kinds of activities depending on the perspective. Practice could be a learning activity, an artistic activity, a muscle activity or an activity leading to a developed personality.

The “ultimate” goal for a musician is a beautifully-played sound that is produced through an optimal playing technique (Bejjani et al. 1990). The optimal playing technique includes efficient motion patterns and with minimum tension of the involved muscles during playing. A primary goal for the music teacher is to teach the student how to play an instrument with an optimal playing technique (Kaladjev 2000). The goal includes teaching how to play more effectively by reducing unnecessary movements and muscle activity and equipping students with a method for practicing that is both time-effective and in harmony with the body. Further, the habits the student acquires during the studies are the basis of the professional music life. It applies both to bodily habits and to attitudes and values. A precondition for the music teacher to integrate the playing and practice into the teaching process is to integrate the knowledge into his/her own body (Bouij 1998). By doing that the music teacher can both make proper decisions of ergonomics and be an influential role model for children and young people in the learning process.

Practice is a precondition for playing music, and practicing includes “by nature” muscle activity (Levy et al. 1992; Kaladjev 2000). To play with more variation in the muscle activity pattern is also a precondition for reaching a higher professional level regardless of being a performer or a music teacher. Practice is necessary in order to acquire skills that a music teacher should have (Bouij 1998). At the
same time it can lead to occupational injuries and stress. Too much practice may lead to pain. Studies among music students at higher-level education have shown that the students find it hard to talk about pain, aches and discomfort (Bouij 1998; Kaladjev 2000). To talk about it may create a feeling of inferiority and the students may be met with suspicion by other music students and their teachers. WMSDs may not be accepted and furthermore it can lead to a threat of the music student’s identity as a musician. A career as a musician may be at stake and the student may be forced to discontinue the music education and to change career plans. Kaladjev (2000) mentions that there exist some romantic ideas among music students to the effect that in order to become a great artist it is necessary to suffer. This makes it even harder to talk about having aches and pain.

The municipal music school

The municipal music school is an unique Scandinavian phenomenon. The concept municipal music school has been defined as a “voluntary, organised music teaching, entirely or partly financed by the municipality, on a local basis” (Persson 2001). The first Swedish music schools were founded during the 1930s on a small scale and expanded during the 1940s and 1950s. The growing industrialism with concepts of social responsibility for all people, together with liberal ideas of personal development, led to an increasing interest and a need for instrumental teaching (Persson 2001). Furthermore, ideas of democracy, including opportunities for cultural equality, together with a raising concern about young people’s use of their leisure time also contributed to the development of music education. As a result individual music enthusiasts with relations to local government initiated and institutionalised municipal music teaching.

The principal idea for the music school was, and mostly still is, that every child who is interested should be afforded the opportunity to learn to play an instrument or to sing regardless of the financial situation, the social status or the musicality of the parents (Brändström and Wiklund 1995). During the 1960s and 1970s the music school had its greatest expansion with a music school in almost every Swedish municipality. During the 1990s the majority of music schools were faced by threats of closure mostly due to lack of funding (Persson 2001). The threats were seldom effected but led to positive
media attention and resulted in public inquiries and increasing pedagogic research. The music schools are now developing into culture schools, embracing dance, acting and art as well (Sveriges musik- och kulturskoleråd 2002).

Today, nearly all students at higher–level music institutions in Sweden have received their basic music education in a music school. The municipality is not obliged to have a music school. During the period January–March 2002, 282 of Sweden’s 289 municipalities had a music school (Sveriges musik- och kulturskoleråd 2002). Educational associations run a few of these. Each music school works under different conditions. It depends on the political party in power, finances, goals, and local music traditions and the size and geography of the municipality. The Swedish municipal music school has no admission test contrary to music schools in many other countries. The majority of music schools charge a fee and the mean fee for a term in the year 2002 was SEK 508. Five music schools were free of charge. In the spring term 2002 all the music schools in Sweden organised 376 000 students.

### Work related musculoskeletal disorders in musicians

#### Definitions

The term *Work related MusculoSkeletal Disorders* (WMSDs) is by definition related to work and the work situation. The World Health Organization has stated that WMSDs arise when exposed to work activities and work conditions which significantly promote their development but do not act as the sole determinant of causation (World Health Organization 1985). The term WMSDs is regarded as an umbrella term for specific work related musculoskeletal disorders (Hagberg et al. 1995). Further, WMSDs correspond to repeated efforts (movements and postures), static work, continuous loading of tissue structures or lack of recovery time which trigger or cause a pathological process that may result in musculoskeletal symptoms.

When discussing WMSDs in musicians the term *playing related musculoskeletal disorders* (PRMD) (Zaza 1995) has sometimes been used in the same way as WMSDs. Since musculoskeletal disorders in
musicians may develop from other work related factors than solely the playing of an instrument the term WMSD is used in this thesis. WMSD in this thesis is defined as pain, aches and/or discomfort as a result of or associated with work. Sometimes the term work related musculoskeletal discomfort in this thesis is used synonymously with the term work related musculoskeletal disorders. Pain, fatigue and discomfort are the most common first symptoms associated with WMSDs according to Hagberg et al. (1995). Pain has been defined as an unpleasant sensory and emotional experience associated with actual or possible tissue damage. Hagberg et al. (1995) defined the concept discomfort as “a perceptual and subjective phenomenon more diffuse than pain”.

However, there is a lack of knowledge as to how possible mechanisms of pain and how musculoskeletal disorders develop (Sluiter et al. 2000). The current problem lies in there being too many definitions and concepts, a lack of criteria to define the disorders and to determine work relatedness as well as an uncertainty concerning the pathophysiological mechanisms.

Musculoskeletal syndromes

WMSDs describe a wide range of inflammatory and degenerative diseases and disorders that result in pain and functional impairment (Kilbom et al. 1996). The most common medical problems in musicians are a) musculoskeletal pain syndromes such as tendinitis, tenosynovitis or epicondylitis, b) nerve entrapment syndromes such as carpal tunnel syndrome and thoracic outlet syndrome and c) focal dystonia (occupational cramps) (Brandfonbrener and Kjelland 2002; Bengtson and Schutt 1992; Dawson 2001a; 2001b). Upper-extremity problems among instrumentalists tend to fall into the above-mentioned categories. The majority of problems seem to reflect the effects of repetitive and forceful movements of the body together with the biomechanical demands and ergonomics of each instrument. Muscle and tendon strain are most common in pianists, guitarists, upper string players, and reed instrumentalists. Nerve entrapments and focal dystonia are less common although more prevalent among flutists and guitarists than in other groups (Dawson 2002).
The diagnose overuse syndrome has often been used for the musculoskeletal problems of musicians. The term is defined as pain and loss of function in muscle groups and ligaments as a result of excessive use (Fry 1986a; 1986b) or as a condition caused by tissues being stressed beyond their anatomic and physiological limits (Lederman and Calabrese 1986; Hoppmann and Patrone 1989). There is no clear consensus with respect to clinical examination, criteria for diagnosis, or treatment of the overuse syndrome (Bejjani et al. 1996). Further, the overuse syndrome diagnosis could be used as a general term for disuse or misuse or to all kinds of tendinitis, tenosynovitis or focal dystonia. A scale-system for grading the severity of overuse syndrome was developed by Fry (1986a). The lowest grade is when pain is limited to one site and brought on by playing the instrument. The highest grade is when the musician has no functional use and a career is seriously threatened. The five-graded scale has been used for measuring treatments and interventions in musicians. However, diagnoses are valuable for treatment purposes but for epidemiological research and prevention, information as to whether a person suffers from pain or disorders is usually enough (Fredriksson 2000). The importance of considering WMSDs without a specific diagnosis or pathology in health monitoring and surveillance systems has been emphasised in a recent report from the European Agency for Safety and Health at Work (Buckle and Devereux 1999).

Prevalence and incidence of musculoskeletal disorders

Musculoskeletal disorders are the most common work related problems among musicians regardless of the level of performance (Fishbein et al. 1988; Zaza 1998a; Sataloff et al. 1998). The prevalence of WMSDs in musicians is consistent with the prevalence of disorders in other occupational groups that do repetitive work (Zaza 1998b). In 1988 one of the first larger surveys was made on health of 2212 professional orchestra musicians from the USA (Fishbein et al. 1988; Middlestadt and Fishbein 1989). The results indicated that 82% reported a medical problem and 76% listed at least one problem so severe that it affected their playing. Few studies have investigated WMSDs in music teachers. Pfalzer and Walker (1999) studied upper extremity problems in piano teachers. In some studies music teachers have been a part of a larger study group. An overview of prevalence studies of musicians’ WMSDs is presented in Table 1.
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Prevalence (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fry et al. 1988</td>
<td>98 secondary school music students</td>
<td>34 % point prevalence, 56 % lifetime prevalence of music-related pain</td>
<td>72 % response rate</td>
</tr>
<tr>
<td>Lockwood 1988</td>
<td>120 secondary school music students</td>
<td>49 % prevalence of instrument-related problems</td>
<td>100 % response rate</td>
</tr>
<tr>
<td>Fry &amp; Rowley 1989</td>
<td>169 secondary school music students</td>
<td>71 % lifetime prevalence of music-related upper limb pain</td>
<td>100 % response rate</td>
</tr>
<tr>
<td>Grieco et al. 1989</td>
<td>117 conservatory piano students</td>
<td>62 % prevalence of musculoskeletal complaints</td>
<td>75 % response rate</td>
</tr>
<tr>
<td>Hartsell &amp; Tata 1991</td>
<td>122 undergraduate music students</td>
<td>54 % prevalence of music-related musculoskeletal symptoms</td>
<td>41 % response rate, incorrect calculations in paper</td>
</tr>
<tr>
<td>Pratt et al. 1992</td>
<td>246 university music students</td>
<td>87 % prevalence of performance-related pain</td>
<td>Response rate not reported</td>
</tr>
<tr>
<td>Zaza 1992</td>
<td>300 university music students</td>
<td>43 % lifetime prevalence of playing-related health problems</td>
<td>100 % response rate</td>
</tr>
<tr>
<td>Larsson et al. 1993</td>
<td>660 university music students and staff</td>
<td>67 % prevalence of musculoskeletal symptoms</td>
<td>80 % response rate, numbers do not add up correctly, mixed sample</td>
</tr>
<tr>
<td>Kivimäki &amp; Jokinen 1994</td>
<td>93 orchestra musicians</td>
<td>47 % prevalence of neck and shoulder pain</td>
<td>50 % response rate</td>
</tr>
<tr>
<td>Roach et al. 1994</td>
<td>90 university music students</td>
<td>67 % one-month prevalence of musculoskeletal complaints</td>
<td>99 % response rate</td>
</tr>
<tr>
<td>Shoup 1995</td>
<td>425 high school and junior high school music students</td>
<td>33 % prevalence of musculoskeletal performance-related problems</td>
<td>Response rate unclear</td>
</tr>
<tr>
<td>Hagglund &amp; Jacobs 1996</td>
<td>45 university music students</td>
<td>65 % prevalence of music-related injuries</td>
<td>15 % response rate</td>
</tr>
<tr>
<td>Zaza &amp; Farewell 1997</td>
<td>281 professional musicians and university music students</td>
<td>39 % prevalence of playing-related musculoskeletal disorders</td>
<td>67 % response rate, mixed sample</td>
</tr>
<tr>
<td>Zetterberg et al. 1998</td>
<td>227 university music students</td>
<td>89 % one-year prevalence of musculoskeletal problems</td>
<td>97 % response rate</td>
</tr>
</tbody>
</table>
Table 1 (continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Prevalence (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pflaer &amp; Walker 1999 USA</td>
<td>326 piano teachers and piano performers</td>
<td>47 % prevalence of upper quadrant overuse injury</td>
<td>Response rate unclear, pool of data, mixed sample</td>
</tr>
<tr>
<td>Yeung et al. 1999 Hong Kong</td>
<td>39 professional orchestral musicians</td>
<td>64 % one-year prevalence of playing-related musculoskeletal complaints</td>
<td>23 % response rate</td>
</tr>
<tr>
<td>Guptill et al. 2000 USA</td>
<td>117 university music students</td>
<td>88 % lifetime prevalence of playing-related musculoskeletal injury</td>
<td>92 % response rate</td>
</tr>
<tr>
<td>Morse et al. 2000 USA</td>
<td>954 musicians in general population</td>
<td>29 % one-year prevalence of upper extremity musculoskeletal disorders</td>
<td>36 % response rate</td>
</tr>
<tr>
<td>Roset-Llobet et al. 2000 Spain</td>
<td>1639 professional musicians and music students</td>
<td>88 % prevalence of playing-related musculoskeletal health problem</td>
<td>17 % response rate, mixed sample</td>
</tr>
<tr>
<td>Shields &amp; Dockrell 2000 Ireland</td>
<td>159 university piano students</td>
<td>26 % lifetime prevalence of playing-related injury</td>
<td>87 % response rate</td>
</tr>
<tr>
<td>Liljeholm Johansson &amp; Theorell 2001 Sweden</td>
<td>250 orchestral musicians</td>
<td>78 % one-year prevalence of musculoskeletal symptoms</td>
<td>78 % response rate</td>
</tr>
<tr>
<td>Pak &amp; Chesky 2001 USA</td>
<td>455 keyboard instrumentalists</td>
<td>58 % prevalence of musculoskeletal problems</td>
<td>Data from the pool of the UNT-MHS survey</td>
</tr>
<tr>
<td>Spence 2001 USA</td>
<td>369 flutists</td>
<td>prevalence of all upper extremity musculoskeletal problems reported</td>
<td>Pool of two data sets</td>
</tr>
<tr>
<td>Trasher &amp; Chesky 2001 USA</td>
<td>135 double reed performers (oboe and bassoon)</td>
<td>72 % oboists, 80 % bassoonists prevalence of musculoskeletal problems</td>
<td>Data from the pool of the UNT-MHS survey</td>
</tr>
<tr>
<td>Chesky et al. 2002 USA</td>
<td>739 brass instrumentalists</td>
<td>61 % prevalence of musculoskeletal problems</td>
<td>Data from the pool of the UNT-MHS survey</td>
</tr>
<tr>
<td>Spahn et al. 2002 Germany</td>
<td>197 conservatory music students</td>
<td>68 % prevalence of playing-related symptoms</td>
<td>36 % response rate</td>
</tr>
<tr>
<td>Davies &amp; Mangion 2002 Australia</td>
<td>240 professional instrumental musicians</td>
<td>50 % prevalence of playing-related musculoskeletal pain and symptoms</td>
<td>45 % response rate</td>
</tr>
</tbody>
</table>
In professional musicians and university music students the lifetime prevalence ranged from 43% to 88% (Zaza 1992; Gupill et al. 2000). The point prevalence of musculoskeletal problems in these musician groups varied from 39% to 89% (Zaza and Farewell 1997; Zetterberg et al. 1998). In adolescent music students the lifetime prevalence of WMSDs ranged from 56% to 71% (Fry et al. 1988; Fry and Rowley 1989) and the point prevalence ranged from 33% to 56% (Fry et al. 1988; Shoup 1995). In amateur musicians the one-year prevalence of upper extremity musculoskeletal disorders was estimated at 29% (Morse et al. 2000). In studies comparing the prevalence of WMSDs in music students to non-music students the results seem to be inconsistent. Three studies have found that the prevalence was higher in music students than in non-music students (Fry et al. 1988; Fry and Rowley 1989; Pratt et al. 1992). The prevalence ranged from 34% to 87%. A study by Roach et al. (1994) found no differences in prevalence of WMSDs between musicians (67%) and non-musicians (65%).

String players are often affected by neck, shoulder, especially the left side, and hand problems (Fishbein et al. 1988; Manchester 1988; Grieco et al. 1989; Manchester and Flieder 1991; Larsson et al. 1993; Zaza and Farewell 1997; Brandfonbrener 1998; Cayea and Manchester 1998). Keyboardists experience problems in wrists, fingers and forearms and sometimes in the shoulder and the neck (Fry and Rowley 1988; Manchester 1988; Zaza 1992; Manchester and Flieder 1991; Brandfonbrener 1998; Pfalzer and Walker 1999; Pak and Chesky 2001). Woodwind players have neck, upper back, shoulder and wrist problems (Trasher and Chesky 2001; Spence 2001). Brass players experience problems that involve the facial muscles such as focal dystonia and neck, shoulder and lower back problems (Chesky et al. 2002).

Only a few studies have reported the incidence of upper-extremity musculoskeletal problems in musicians (Manchester 1988; Manchester and Flieder 1991; Cayea and Manchester 1998). The authors reported incidence from three retrospective cohort studies among university music students during 1982-1996. The annual overall incidence was 8.3 episodes of musculoskeletal problems per 100 university music students.
Reviews of musicians' musculoskeletal problems have pointed out some of the difficulties with the above mentioned studies (Bejjani et al. 1996; Zaza 1998a). The authors argued that the reported studies appeared not to have been randomised and controlled and many studies have methodological weaknesses such as low response rate, unsystematical collection of data and omission of the number of musicians surveyed. Some authors have supported their statements with only their respective clinical experiences. In recent studies on musicians' health (Chesky and Hippe 1999; Pak and Chesky 2001; Spence 2001; Trasher and Chesky 2001; Chesky et al. 2002) data was extracted from the University of North Texas Musician Health Survey (UNT-MHS) data set. The data responses for the survey were collected via the Internet, from a large, heterogeneous group of musicians (approximately 4100) who primarily perform on a variety of musical instruments (Spence 2001). The survey has been compared demographically to the U.S. population but still the validity of the data is uncertain due to the administration over the Internet. So far, no study has sought to validate the online survey.

Work exposure in this thesis

Physical work factors

The National Research Council (NRC) of USA has presented a conceptual framework for the understanding of WMSDs (NRC 1999). The model includes work, social and individual factors as well as non-work related activities that might affect the development of WMSDs. Other models have mainly focused on biomechanical forces. Winkel and Mathiassen (1994) outlined that mechanical forces arise in the body during work (mechanical exposure). These mechanical forces contribute to pathophysiological changes and may cause WMSDs. The mechanical exposure should be considered from the dimensions duration (time), level (amplitude) and frequency (repetitiveness). Armstrong et al. (1993) developed a model of how mechanical exposure repeated over time induces biomechanical and physiological effects that explain the cumulative nature of neck and upper limb musculoskeletal disorders. Van der Beek and Frings-Dresen (1998) expanded the model to include work requirements such as the actual working method, posture and movements during
work, exerted forces of the work and the working situation. The working situation was described as the work decision latitude, and work demands.

**Psychosocial work factors**

The concepts *work demands* and *work decision latitude* were basically introduced by Karasek (1979) and Karasek and Theorell (1990) in their demand-control model. The model describes the interaction between stress and work. It is based on psychosocial characteristics of work and comprises the two components psychological work demands and decision latitude. Psychological work demands refer to the workload mainly in terms of the effort required to perform the work, time pressure and role conflict. Influence on the work situation, also called decision latitude, refers to the individual’s ability to control the work situation in two dimensions; the authority to make decisions at work (decision authority) and the possibility of developing competence (skill discretion). The model is built on the idea that both demands and decision latitude could be seen as risk factors (Eriksson 1996). Further, the higher the demands the greater the risk for ill health and the higher the decision latitude the lower risk of ill health. There is also an interaction between the dimensions. The model predicts that work with high work demands and low authority over decisions, called high-strain jobs, leads to physiological and psychological strain that may cause sickness and ill health such as WMSDs. Another hypothesis is that a work with high work demands and high decision latitude creates feelings of motivation, learning and activity. These feelings of being in command inhibit strain and stress. The model was developed to include *social support* from colleagues and management (Johnson and Hall 1988). The interaction between demands and decision are still valid but could be modified by social support. The model predicts that low social support could strengthen the strain while high social support could weaken it.

Theorell (2000) has identified three kinds of mechanisms that may relate the demand-control-support model to WMSDs. The mechanisms are a) physiological mechanisms leading to organic changes b) physiological mechanisms may influence pain perception and c) sociopsychological conditions that are of significance to the individual’s possibility of coping with WMSDs. Some criticism has
been directed to the demand-control-support model, described in a review by Eriksson (1996). The model has been claimed to be too simple and that two dimensions are not enough to capture the psychosocial work environment. Another criticism is that the model disregards individual differences in susceptibility and coping behaviour. The model might be less suitable for measuring work in education, health and social sectors and communication. However, the model has been extensively used and tested in several studies.

All of the mentioned models show considerable agreement and serve as a useful basis for an understanding of the pathogenesis and relationship of disorders and work (Buckle and Devereux 1999). Not all of the factors are considered in this thesis though it is important to widen the perspective for understanding how musculoskeletal disorders occur and the relationship between disorders, work and leisure time activities.

**Risk factors in musicians**

Certain work or certain factors at work are connected to the risks of getting WMSDs, compared to other population groups that are not exposed to the same risk factors (Hagberg et al. 1995). The term risk factor has been defined as a characteristic that is more prevalent among subjects who develop a given disease or outcome than among subjects who do not (Dawson-Saunders and Trapp 1994). A risk factor is not always causal but does increase the probability of an outcome, in this case suffering from WMSDs (Buckle and Devereux 1999). The association between certain factors and WMSDs are, in most cases, first observed empirically and later confirmed through epidemiological studies. Risk factors may be linked directly to the physiological process of WMSDs but they may also trigger the process or may create conditions that initiate WMSDs (Hagberg et al. 1995). Risk factors for WMSDs seem to be interrelated with each other, and among musicians most WMSDs do not come from a single episode but are cumulative and caused by the interaction of several factors (Brandfonbrener and Kjelland 2002). The identification of a risk factor can create a better understanding of the pathways to a disease and consequently lead to better preventive strategies (Greenberg et al. 1996). Many studies among musicians have claimed to investigate risk factors but many of them seem to have basic
methodological flaws. The majority of studies have used descriptive statistics to show factors that are connected to WMSDs. To my knowledge only three studies on risk factors and WMSDs in musicians have applied the multiple logistic regression modelling (Zaza and Farewell 1997; Zetterberg et al. 1998; Davies and Mangion 2002). In the multiple logistic regression modelling several independent variables are used to explain or predict the values of a single response (Dawson-Saunders and Trapp 1994), in this case WMSDs.

**Individual risk factors**

Female musicians have a higher risk of WMSDs than their male colleagues (Zaza and Farewell 1997; Fishbein et al. 1988; Fry et al. 1988; Manchester 1988; Manchester and Flieder 1991; Larsson et al. 1993; Cayea and Manchester 1998; Liljeholm Johansson and Theorell 2001; Pak and Chesky 2001; Davies and Mangion 2002). Many studies indicate that women have a higher musculoskeletal morbidity than men. This has been found in studies on the general population as well as in different occupational groups (Kilbom and Messing 1998; Fredriksson 2000; De Zwart et al. 2001).

Body mass index (BMI) has been found to give a slight increase in WMSDs in a study by Zaza and Farewell 1997. The authors argued that the result was difficult to interpret and inconsistent with a study by Roach et al. 1994 that found no association with WMSDs.

Hypermobility may be a risk factor in instrumentalists (Hoppmann 1998). Brandfonbrener (2002b) found in a study of 1300 musicians that about 25% had hand and arm injuries that could be related to hypermobility. Larsson et al. (1993) have argued that the hypermobility in musicians may be an asset if the joint in question is involved in repetitive movements, and a liability if the joint is to provide support. Other researchers have found hypermobile professional musicians to be at a lower risk for WMSDs compared with other occupational groups (Zaza and Farewell 1997). Contrary to the above-mentioned studies a recent study in music students found no relationship between upper limb pain and hypermobile, small or weak hands (Miller et al. 2002).
Physical risk factors

In many studies string players and keyboard players have been shown to have a high risk for WMSDs (Fishbein et al. 1988; Fry and Rowley 1988; Manchester 1988; Manchester and Flieder 1991; Zaza 1992; Zaza and Farwell 1997; Cayea and Manchester 1998; Zetterberg et al. 1998; Dawson 2001a; Davies and Mangion 2002). The reasons for this are not entirely clear but some factors have been put forward as explanations. Brandfonbrener (1998) has categorised the critical factors into a) awkward postures while playing, b) the weight of the instrument and if it is held, c) the pressure of the instrument and its contact with the body, d) repetitive movements and required force, and e) physiological demands of the instrument such as breath control. Each instrument presents unique demands in all of these factors.

Practice habits seem to be important factors that could contribute to upper extremity disorders and especially a sudden increase in practice time or playing intensity (Manchester and Flieder 1991; Zetterberg et al. 1998). Sudden changes in teacher, repertoire, instrument or playing technique may also increase the risk of WMSDs (Brandfonbrener 1998). Practicing and playing for several hours without interruption have been discussed as a risk.

Psychosocial risk factors, stress and performance anxiety

Psychosocial work factors have been found to increase the risk of contracting WMSDs. Liljeholm Johansson and Theorell (1999) have found that orchestra musicians experienced high demands, especially on the quality of their work, and a social pressure to be good musicians, which may lead to stress and tension and an increased risk of contracting WMSD. In a recent study among orchestra musicians, satisfaction with work-related tasks was the factor that had the most consistent and strongest association with both the total symptom score of health and WMSDs (Liljeholm Johansson and Theorell 2001). In a study by Zetterberg et al. (1998) neck pain in male music students was associated with low decision latitude at work in accordance with the demand-control-support model while neck pain in female music students was associated with low social support. Theorell et al. (1991) in a study on male symphony musicians found
that they had high blood pressure, and tensed muscles. The psychosocial work was characterised by low decision latitude and high levels of motivation for the work, and ability to collaborate with other musicians.

General life stress and/or work or study stress as well as high anxiety have been mentioned as risk factors for WMSDs in musicians (Zaza and Farwell 1997; Davies and Mangion 2002). Zaza and Farewell’s study (1997) showed no association between WMSDs and compulsiveness or perfectionism.

Musical performance anxiety (MPA) has been reported to be one of the most prevalent medical problems among orchestra musicians (Fishbein et al. 1988). MPA include symptoms such as tremor, sweating, muscle tension and other effects of elevated sympathetic nervous system activity with depressed parasympathetic activity (Lederman 1999). Engquist et al. (2000) found that about 40% of professional musicians and music students had experienced MPA and that the complex interplay of physical and mental load may be a risk factor for WMSDs. A recent study among orchestra musicians showed that a low level of MPA was associated with a high ability to screen out irrelevant information and to attend and process information in unrehearsed ways (Rife et al. 2000). Musicians have shown to be more mentally vigorous and social, to have higher self-confidence, but also higher self-imposed pressure than the general population (Bejjani and Snow 1990). Kivimäki and Jokinen (1994) in their study found that orchestra musicians were extremely satisfied with their work and had a high skill variety but at the same time they perceived MPA, neck and shoulder pain, high stress and strain symptoms.

In a criteria document for evaluation of WMSDs of the upper extremity, Sluiter et al. (2000) found significant evidence for work factors and musculoskeletal symptoms. Some of these factors seem highly relevant to musicians and support the findings on risk factors in musicians. Neck and shoulder complaints were associated with physical work factors such as static, extreme and asymmetrical postures of the head and shoulders, highly repetitive work especially in precision movements, forceful exertions of the arm and hand and medium/high lifting. Psychosocial factors of relevance to musicians could be high mental demands, low decision latitude, low social
Introduction

support, stress and worry tendency, overtime work, limited rest break opportunity and a high work role ambiguity.

Prevention of musculoskeletal disorders

Preventive actions that are effective can reduce suffering for the individual as well as costs both to the individual, the employers and to society. Different levels of prevention can be defined. Primary prevention is directed towards a healthy person in order to prevent the disorder in question. Secondary prevention attempts to detect and treat the disorder in question and aims at reducing the prevalence. The prevention of neck and back disorders is sometimes difficult to define as primary or secondary (Linton and van Tulder 2000). Since WMSDs are of a complex and multifactorial nature these disorders require a multifactorial preventive strategy. No single action alone would be sufficient to eliminate WMSDs (Hagberg et al. 1995).

The best time to prevent musicians’ disorders is during the early stages of education (Kaladjev 2000; Brandfonbrener and Kjelland 2002). Prevention from the very first lessons puts into place efficient performance techniques, postural habits, a positive attitude and a healthy lifestyle. Parents and early teachers play a crucial role in the development of musicians during their learning years (Spaulding 1988). Further, the parents and the teachers should be afforded whatever information and support they need in these matters. For older music students, (in the mid-twenties) playing habits are significantly more difficult to affect with new prevention techniques (Spaulding 1988).

Prevention programs

Prevention programs have been developed for groups of musicians. Unfortunately, very few studies have documented the effectiveness of the programs (Brandfonbrener and Kjelland 2002). The content is similar in most of the programs including educating the musician about etiology, biomechanics, neurophysiology and musculoskeletal injuries (Dommerholt et al. 1998). Another important part is to lower both muscular and emotional excessive tension during work (Brandfonbrener and Kjelland 2002). The first part includes teaching
practice habits such as warming up, cooling down, stretching, posture corrections and corrections of playing technique. Different schools of body awareness techniques such as the Basic Body Awareness Therapy (BAT) (Roxendal 1985), the Feldenkrais method (Feldenkrais 1972), the Alexander technique (Alexander 1932), Qi Gong and Tai Chi Chuan (Cheng Man Ching and Smith 1967) are some methods that are helpful in modifying tension.

In Norway, Spaulding (1988) described a prevention program developed at a music conservatory. The main purpose was to motivate and to instruct music students to monitor their own practice and playing habits. The program consisted of an obligatory first part and an optional second on postural balance, ergonomics of playing, stress management, playing practice and relaxation. Zaza (1994; 1998b) proposed a prevention program based on giving musicians complete control over their own behaviour in individual practice sessions. The program included a physical warm up of the body and a musical warm up with the instrument before practice, taking breaks regularly, and pacing and cognitive (mental) practice. Pacing meant working according to a pre-determined schedule instead of working until pain and fatigue made the musician stop. The concept included a gradual increase of practice time and variation of the practice by rotating what was to be practiced. In USA, Branfonbrener (1997) set up a larger prevention with symphony orchestra musicians. The prevention program combined short lectures on playing postures, knowledge of risk factors for injuries and doing warm-ups and cool downs. Each participant was given specific exercises with emphasis on strengthening and flexibility. The study had a very low attendance rate, almost 40% of the participants dropped out and no conclusions could be drawn. The reasons for the withdrawals were time limitations and a feeling that the program was "just one thing too much". If management were to provide time for exercise the musicians would endorse the training. The dropouts also perceived that even thinking about injuries was negative in itself, which might make them more vulnerable to disorders. Spahn et al. (2001) compared a preventive course of playing-related health issues in a group of music students at a conservatory with a control group. The goal was to increase competence with regard to the physiology of playing and self-management in everyday practice. The course consisted of lectures and practical exercises with preventive topics relevant to musicians. The evaluation showed that musculoskeletal
symptoms, general symptom frequency, as well as emotional disturbances and anxiety decreased. Furthermore, coping at work and security in performance situations improved.

For individual musicians, exercise has been proposed as a way to help in the physically demanding tasks of playing an instrument (Brandfonbrener 1998). An exercise program with either strength or endurance training was tested during six weeks in 18 undergraduate music students (Ackermann et al. 2002a). The results indicated that the perceived exertion of playing, evaluated by the Borg scale, was significantly reduced through endurance training as opposed to strength training. Muscular strength, measured with a Cybex dynamometer, increased with both training programs. The exercises that bore closest resemblance to the music playing act were the most effective in achieving strength gains.

Taping the scapula in violinists has been suggested as a method for improving the scapula position and the muscular efficiency of the shoulder girdle during playing (Ackermann et al. 2000b). The scapula taping increased electromyographic activity by 50-60% in the left trapezius muscle during playing depending on how demanding the piece of music was. Furthermore, the violinists reported negative effects on concentration and comfort and taping was not well tolerated.

**Basic Body Awareness Therapy**

In practical sessions special body-oriented techniques, playing and working with optimal postures and movements have been recommended for university music students, to assist during long periods of practising and playing (Spaulding 1988; Brandfonbrener and Kjelland 2002). However, there is limited scientific evidence supporting these approaches (Dommerholt et al. 1998). For university music students in Sweden one of the most common techniques is the Basic BAT. It is based on a holistic perspective - core elements are body and movement awareness and the technique focuses on the experience of body-as-a-whole rather than specific separate movements (Malmgren-Olsson et al. 2001). The method, Basic BAT, was established in Scandinavia by Roxendal (1985), inspired by Feldenkrais pedagogy and Dropsy's movement system (1975).
Dropsy, in his turn, was influenced by both western traditions such as the Alexander technique and the Feldenkrais pedagogy and eastern traditions of Tai Chi Chuan and Zen meditation. Originally Basic BAT was developed as a treatment modality within psychiatric physiotherapy (Roxendal 1985; Roxendal and Winberg 2002) and it is now also used for patients with chronic pain and musculoskeletal disorders (Grahn et al. 1998; Ahlgren et al. 2001; Malmgren-Olsson et al. 2001).

The aim of the Basic BAT is to improve the postural control of the body, through working with the relation to the ground (grounding) and the postural line as well as the total co-ordination and integrating the breathing with movements (Roxendal 1985; Roxendal and Winberg 2002). Dropsy (1975) propose that the movement pattern, and as a consequence, the muscle activity of different movements can change, which may lead to lower muscle tension and less pain.

Rationale for this thesis

Why do music teachers keep on playing despite muscle aches and pain? Why do they wait so long before seeking medical help? Why do they suffer from musculoskeletal disorders? Do they require other kinds of physiotherapy treatment compared to other occupational groups? Can we prevent them from contracting pain? The work on this thesis started out with a number of questions based on my clinical experience as a physiotherapist at an occupational health care centre working with music teachers. The process of learning about the health problems of musicians made me realise that music medicine was a new field of medicine and that questions concerning music teachers’ health and work had not been much focused in music medicine research even though they are a crucial group of people, since they educate, stimulate and develop the skills of our future musicians. By being good role models in a good environment, they can help their students stay healthy and prevent WMSDs.

Work related musculoskeletal disorders are common both among professional musicians and music students. Musicians, and among them music teachers, are often very motivated to play and to practice. Periods of sick leave due to WMSDs may have detrimental effects on a musician’s career since it is vital for musicians to practice daily to
maintain skill level. Consequential transfers to new jobs may prove difficult to arrange and are costly, both to the individual and to society. Therefore it is important to prevent musicians contracting WMSDs and enabling them to stay healthy at work. Since WMSDs seem to develop over time it implies that prevention should be targeted at an early stage in a musician’s life, preferably in childhood. Music teachers are therefore extremely important in the prevention process when educating young musicians.

Aches and pain can very well be perceived by musicians as a sign of weakness and they may find it hard to talk about their problems. During the last decade attitudes have changed somewhat and musicians are more open to learning about special rehabilitation and prevention activities. However, both the prevention and rehabilitation process would benefit from regarding musicians’ health problems as a serious matter of social concern and not only as a personal issue or an intriguing oddity.
The general purpose of the present thesis was to study the work environment of music teachers at municipal music schools, with regard to physical and psychosocial work factors and musculoskeletal disorders with the focus on neck and shoulder complaints. Furthermore the aim was to study the effects of an intervention program on playing technique.

The specific aims were to

- investigate the prevalence of self-reported work related musculoskeletal disorders in music teachers and to analyse the association between neck and shoulder disorders and the physical and psychosocial factors of the work environment.

- describe the development of work related musculoskeletal disorders in music teachers, in an eight-year perspective, and to quantify upper-arm elevations of violin teachers during a working day.

- gain a deeper understanding of what factors music teachers perceived to be important for their health and well-being.

- investigate the variability of the trapezius muscle activity pattern in a group of cello, violin and viola players, performing the same piece of music, at two playing sessions.

- evaluate whether a group of violinists could play with greater variation in the trapezius muscle activity pattern after a training intervention program with Basic Body Awareness Therapy.
SUBJECTS AND METHODS

Subjects

Three main samples were included in this thesis. Two samples consisted of music teachers employed at municipal music schools in the northern Sweden (Sample I and II) and one sample consisted of string musicians (Sample III) (Figure 1). Background data for each sample are given in Table 2.

Figure 1  Illustration of the samples in Papers I-V

Paper I

The first sample consisted of music teachers employed at all 23 municipal music schools in the two northernmost counties of Sweden, Norrbotten and Västerbotten. The municipal music schools ranged from small schools with less than five teachers to larger ones with about 60 teachers. Out of 287 music teachers, 208 agreed to participate, 88 women and 120 men which represent a participation rate of 72.5% (Figure 1).
Table 2 Characteristics of the musicians in Papers I - V

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<tbody>
<tr>
<td></td>
<td>Total group</td>
<td>Total group</td>
<td>Violinist group</td>
<td>Total group</td>
<td>Total group</td>
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<td></td>
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<td>n=36</td>
<td>n=5</td>
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<td>120</td>
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<td>19</td>
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<td>Age (years) (mean, ± SD)</td>
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<td>41±8.1</td>
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<td>Started playing at age (years) (mean, ±SD)</td>
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<td>-</td>
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<td>8.1±1</td>
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<td>4.6±3.5*</td>
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<td>Job experience (years) (mean, ± SD)</td>
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<th>Men</th>
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<th>Men</th>
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<td>5</td>
<td>0</td>
<td>2</td>
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<td>1</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

* Playing hours in leisure time in 1988  
** Job experience in 1988  

Subjects and Methods
Papers II and III

The second sample comprised all, in 1988, 62 music teachers employed at one of the larger municipal music schools in the county of Västerbotten. One music teacher did not respond, which resulted in a study group of 61 teachers, 27 women and 34 men. Eight years later, in 1996, a follow up study was carried out. Of the original 61 respondents, 36 accepted to participate, 17 women and 19 men. The dropouts were 10 women and 15 men of whom 21 had left the music school for other employment, two had taken leave of absence and two declined to participate in the study. The dropouts did not differ regarding age, height, weight and job experience at present work from the remaining music teacher group. Results will be presented from the 36 music teachers that participated in both 1988 and 1996. Besides participating in the survey, all nine violin teachers were asked to participate in a measurement of repetitive work of the shoulders. Three of the violin teachers were disqualified due to leave of absence and long-term sick leave and one to failure of the technical measurements, resulting in a study group of five violin teachers (Paper II) (Figure 1).

From the 36 subjects participating in the follow-up study 1988-1996 (Paper II), nine music teachers, five women and four men were strategically chosen for a qualitative study (Paper III). The snowball sampling procedure was used to locate key individuals who named other likely informants (WHO 1994). The snowball sampling was chosen to avoid the insider perspective. An emergent research design was adopted which means that the focus of the music teachers' opinions was at hand and the sample developed throughout the data collection period (Lincoln and Guba 1985). In order to highlight different aspects of the research topic the informants were men and women of different age. They were teaching different groups of instruments and had varying degrees of musculoskeletal symptoms (Figure 1).

Papers IV and V

Sample III consisted of 18 string musicians of whom fifteen were violinists and two viola players and one played the cello. Twelve of the string musicians, six women and six men, of whom nine were
violin players, two viola players and a cello player, were invited to participate in the investigation of variability of the trapezius muscle activity pattern (Paper IV). All fifteen violinists in sample III were asked to participate in the Basic BAT intervention and all accepted. To make it possible for the working musicians to participate in the intervention program during work time, the training group was chosen among professional orchestra violinists at the same work place. To the reference group, violin teachers from municipal music schools and violin music students at higher-level education were invited. This resulted in a training group of five violinists and a reference group of ten violinists. In the training group there were two women and three men and in the reference group there were six women and four men. One woman in the reference group dropped out due to personal reasons, at the post training measurement. Thus a total of fourteen violinists completed the Basic BAT study (Paper V) (Figure 1).

Ethical approval

The Ethical Committee of the Faculty of Medicine at Umeå University approved of the studies (§16/99, §17/99, §18/99). Subjects in Paper I were given written information and subjects in Papers II to V were given written and oral information. All subjects included gave their consent.

Data collection methods

An overview of the data collection methods used in each study is presented in Table 3.

Table 3 Overview of data collection methods in Papers I–V

<table>
<thead>
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<td>Abduflex (arm position measurement)</td>
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<td>Interviews</td>
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<td>X</td>
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<td>Surface EMG (trapezius muscle activity)</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>
Questionnaire

A self-administered postal questionnaire used to assess musculoskeletal disorders, physical and psychosocial factors during work and leisure time and individual data, was sent to music teachers in 2000 (Paper I) and in 1988 and 1996 (Paper II). The basic premise was to use questions from validated and reliable questionnaires of work environment surveys. Items on main instrument played, playing habits, weekly amount of performing and practice time, physical exercise in leisure time, perceived general health, smoking habits and physical workload were added. Demographic data regarding sex, age, weight, height, Body Mass Index (BMI), employment, marital status, children and education was gathered. Two reminders were sent in connection with the questionnaires.

Musculoskeletal disorders

Musculoskeletal disorders were assessed by the Standardised Nordic Questionnaire (SNQ) (Kuorinka et al. 1987) (Papers I and II). In the SNQ, disorders were defined as pain and aches during the previous seven-day period and the preceding 12 months. All body regions were investigated and they were shown on a drawing. The response options were yes or no. The SNQ is widely used in epidemiological studies. It is recommended for screening of musculoskeletal disorders and evaluations of ergonomic workplace programs. Reliability and validity for the SNQ have been found to be acceptable (Kuorinka et al. 1987; Dickinson et al. 1992; Baron et al. 1996).

Physical work factors

Physical work factors have been proposed to influence neck-shoulder complaints in three dimensions: duration (time), level (amplitude) and frequency (repetitiveness) (Winkel and Mathiassen 1994). To our knowledge, no studies have been conducted taking into account these three dimensions when playing different instruments. Therefore, estimations were made in Paper I for each main instrument in each of the three dimensions. This procedure is described below and in Figure 2. The estimations were based on the self-administered questions and made by me and validated in collaboration with three music teachers and two health care professionals with experience in the field. Estimations of duration were based on the self-administered
questions concerning the total weekly playing time at work and during leisure time. Playing less than 15 hours per week was classified as low playing time (scored 1) and more than 15 hours per week as high playing time (scored 2). Estimations of level and frequency were made for each main instrument by evaluating the playing posture of the neck and shoulders and repetitive neck and shoulder movements. A dynamic playing posture was scored as 1, a medium playing posture was scored as 2 and an awkward or static playing posture was scored as 3. A low amount of repetitive movements was scored as 1, a medium amount was scored as 2 and a high amount of repetitiveness was scored as 3.

Manual materials handling was assessed according to how many times per day the main instrument and other equipment necessary for teaching, e.g. music stands, chairs, and amplifiers, were lifted and handled.

Psychosocial work factors

Psychosocial work factors were assessed using the demand-control-support questionnaire (Karasek 1979; Karasek and Theorell 1990) (Paper I-II). It provides measures of psychological demands and influence on the work situation and social support. The response options were yes often, yes sometimes, no seldom, and no almost never. The demand-control-support model is well proven and often used in epidemiological studies (Eriksson 1996; Theorell 2000). To the psychosocial variables a question was added on how many different school locations the music teacher was teaching at each week.

Individual factors

Perceived general health, smoking habits and physical exercise during leisure time were assessed using questions from the health survey questionnaire Västerbotten Intervention Programme (1985) (Paper I).
Figure 2 Definition of the physical workload variable. The variable is expressed as exposure on neck and shoulders in duration, level and frequency. For each music teacher the three dimensions were scored on a graded scale, with a total minimum score of three and a maximum of eight. The scoring was made from estimations for the main instrument for each music teacher.

Arm - position measurement

To register the flexion and abduction of the upper arms, an arm position analyser, the Abduflex, was used (Ericson et al. 1994) (Paper II). It is designed to record arm movements continuously for several hours without supervision. The Abduflex registers the angle between the upper arm and the vertical in seven 15° intervals (0-15° 15-30° 30-45°... > 90°) and time in each interval. The Abduflex has been evaluated in relation to a computer-based 3-D video analysing system (Mac Reflex, Qualisys, Sweden) and is considered to yield valid...
measurements (Wiktorin et al. 1995). The arm position measurements were performed at each violin teacher’s work place. The recording lasted one working day for each teacher. Breaks, usually lunch and one coffee break and transfers between schools were included. In order to get a representative working session, the physiotherapist and the participants together chose an ordinary working day from the schedule.

Interviews

The Grounded Theory approach

The aim of the qualitative study was to understand what music teachers in a municipal music school perceived to be important for their health and well being (Paper III). The data collection utilised thematised interviews based on an interview guide (Kvale 1996) covering three central themes: a) the interviewee’s health, including questions about what good or bad health meant to each teacher, and if they perceived themselves to have good health and how important it was in relation to work, b) strategies to achieve or maintain good health, including questions about how the teachers kept healthy and obstacles to staying healthy, c) teaching of and making of music, including questions about reasons for becoming a music teacher, goals of the work, how teaching and making music affected personal health and vice versa, and positive aspects of work.

For the qualitative study the Grounded Theory approach was adopted (Glaser and Strauss 1967). A central thought behind this method is that ideas and possible theories emerge and are grounded in empirical reality. With data as a base the interpretations are not only expressions of the researcher’s own ideas but are also valid for the interviewees’. Grounded Theory includes all the steps from formulation of the research question to sampling procedures, the data collection, the data analysis and finally the development of concepts and hypothesis or theories (Starrin et al. 1997). The interviews took between 1 and 1.5 hours and were conducted by myself. Each interview was audiotaped and transcribed. The transcripts were analysed in accordance with the Grounded Theory approach of constant comparison (Glaser and Strauss 1967; Starrin et al. 1997). The participants were invited to read the written material in order to make changes and to clarify the text.
The analysis of the text was performed in four stages. The first (open coding) involves reading the text line by line and paraphrasing what is said into different concepts. In stage two the text was read in order to get an overall picture and the open codes were collated into related categories. In stage three the categories were collated into intermediate categories, and in stage four into the core category. Figure 1 in Paper III provides an example of a Grounded Theory analysis from open codes to categories and the core category.

Semi-structured interview

In the intervention study (Paper V) a semi-structured interview was performed individually with all subjects in the training group. This was made in order to evaluate their opinions of the training program, i.e., the length of the program, and if it was difficult to fit into the ordinary workday schedule. The subjects were also asked about their perceptions of such things as muscle tension, posture, breathing and tiredness during and between the training sessions.

Electromyography

Electromyography (EMG) was used in order to investigate variations in the muscle activity pattern bilaterally from the descending trapezius muscle. In this thesis a variation in the muscle activity pattern was defined as playing in shorter sequences at a varied number of amplitudes, in string musicians performing a piece of music (Papers IV and V). The surface EMG signal was detected by two silver-silver chloride electrodes (Medicotest, Ølstykke, Denmark), 6 mm in diameter, with a 20 mm centre-to-centre distance, placed over the muscle. The signal was recorded by a bipolar isolated amplifier (ISO-2104, Braintronics BV, Almere, the Netherlands). Signals from the EMG amplifier were acquired by a data acquisition processor (DAP 2400/6 Microstar Laboratories, Inc., Bellevue, WA, USA) running in parallel with a host personal computer equipped with MYSAS software for raw-data acquisition (Karlsson et al. 1994).

Protocol

The EMG recording was made with the subject seated in a standard chair, individually adjusted to provide the most comfortable support.
Subjects and Methods

Before the EMG measurement during playing, an arm flexion was performed. The subject was asked to hold one arm at a time straight at 90 degrees, in the sagittal plane, with the back of the hand turned upwards. A sling connected to a strain gauge dynamometer, measuring the exerted force, was attached to the wrist. No lateral bending of the body was allowed. The subject was instructed and encouraged to perform as much force as possible during a period of at least 3 seconds. The contraction with the highest force out of three trials was used as maximal voluntary contraction (MVC). A reference voluntary contraction (RVC) at 30% of MVC was then measured for left and right trapezius for each subject with simultaneous EMG registration. The EMG was normalised to the reference voluntary electrical activity (RVE) of the EMG obtained during RVC. It has been found that using RVC instead of MVC is more reliable for reducing the influence of strength, since the inter-individual differences in RVC are smaller than for MVC (Balogh et al. 1999). The subjects were then required to perform a classical piece of music lasting for seven minutes, during which EMG was recorded.

Exposure Variation Analysis

In order to quantify the EMG activity, an exposure variation analysis (EVA) was performed (Mathiassen and Winkel 1996). The pre-processed signal was averaged in consecutive intervals of 1/3 s and categorised according to length of uninterrupted intervals spent in specific amplitude levels. This resulted in a matrix where each element represented percent of time in a “period per amplitude category”. Plotting the EVA matrix resulted in a three-dimensional representation of EMG activity, where each column represented percent of total time spent in each level per period category.

Intervention

Basic Body Awareness Therapy training group

In the intervention study the violinists in the training group practiced a Basic BAT program designed and supervised by a physiotherapist specialised in the method (Paper V). The aim of the training program was to vary playing-related muscle activity and to better co-ordinate
work and rest phases during work by practising Basic BAT. The training period lasted for eight weeks, with sessions once a week, 90 minutes each session. The length of the training period was based on experience from how body awareness technique is practised at music universities. The training was included in the workday and was performed at the violinists’ work place where the Basic BAT was practised. All sessions started with a short warm up, followed by specific exercises and ended with a 15-minute verbal reflection and a summary of individual experiences. To avoid feelings of stress and competition during the training session none of the movements included practice with a violin. The program consisted of basic, simple movements to restore postural balance, grounding, coordination and to free the breathing (Roxendal 1985; Roxendal and Winberg 2002). The movements were performed in lying, sitting, standing and walking positions. The program also included special massage techniques performed by the subjects on each other during pair-wise exercises. Mental awareness was integrated during the whole training process, which means that turning the attention both to the doing of the exercises and to what was experienced in the movements was central.

Non-training group

A reference group of violinists did not perform any special training during the time the intervention took place (Paper V). They were asked to live as usual and not to change their ordinary physical activity habits.

Data handling and statistical analyses

The SPSS package (SPSS Inc., USA) for personal computer and MATLAB® were used for the statistical analysis. In all papers the statistical significant level was set at 0.05.

Descriptive methods

Means and standard deviations were used for background data in Papers I and II, IV and V and for the arm position measurement (Abduflex) in Paper II. Principal component analysis (PCA) was used
Subjects and Methods

in order to classify the EMG activity pattern of the EVA data on a group level (Papers IV and V). PCA involves a mathematical procedure that transforms a set of correlated response variables into a smaller set of uncorrelated variables called principal components (Johnson 1998). The first principal component accounts for as much of the variability in the data as possible and each succeeding component accounts for as much of the remaining variability as possible. By plotting the principal components that accounts for more than 80% of the variance, an overview is received, of how the subjects' data differ with respect to their EMG activity pattern.

Differences within and between groups

Chi-square analyses were used in order to analyse differences in the prevalence of WMSDs between men and women (Paper I). Longitudinal changes in prevalence of WMSDs in the eight-year period 1988-1996 were tested with McNemar's test (Paper II).

In Paper IV the intra-individual and the inter-individual variability of the PCA data based on the EVA were investigated by a multivariate analysis of variance, (ANOVA) using Hotelling's trace.

In paper V the EVA data from the Basic BAT training group and the reference group, were tested with a non-parametric test. The Mann-Whitney test was used to investigate differences, in mean, between the independent groups. The Wilcoxon signed-rank test was used to test if any changes, in mean, were significant for the training group before and after the training. The Wilcoxon signed-rank test was also used to test if changes in PCA shift, in mean, were significant for the training group before and after the training. PCA shifts were calculated as the Euclidean distances between two playing sessions.

Categorisation of variables

In Paper I, a dichotomised category was constructed for the outcome neck-shoulder disorders. In order to reduce the number of variables, indexes were constructed for the exposure of physical workload and psychosocial workload. Cronbach's alpha coefficient was used to test the reliability of each index (Nunally 1978). Coefficient values above 0.6 were considered to indicate a sufficient degree of internal
consistency of scales. For the index of the outcome neck-shoulder disorders the Cronbach’s alpha was 0.67. The Cronbach’s alpha for the physical workload index was 0.66 and for the psychological demand index it was 0.73. For decision latitude index it was 0.40 and for the social support index 0.84.

In the physical workload index, the lifting variable, the psychosocial indexes and number of teaching locations, the subjects were categorised as exposed or non-exposed using the median value as a cut off. Exercising regularly less than once a week was categorised as exposed and exercising more was categorised as non-exposed. Perceived poor health (the answer “worse health” when compared to others of the same age) was categorised as exposed. Perceived good health (the answer “better or same health”) was categorised as non-exposed. Main instrument was divided into instrument subgroups and all subgroups were examined as a categorical variable. The keyboardists were used as the reference group in accordance with an earlier study by Zaza and Farewell (1997).

Initially univariate analyses were performed to find important risk factors. These are reported with crude odds ratios (OR) with a 95% confidence interval (95% CI). Finally, multivariate analyses were performed using multiple logistic regression modelling in order to obtain estimates of the odds ratio (OR), with a 95% confidence interval for the outcome of neck-shoulder disorders and the independent variables. All analyses were performed separately for women and men. The variables age, education, working hours per week, length of employment and smoking were controlled for as confounders. Since the variable age was influencing the model, it was adjusted for in the final model. The interactions between all the variables in the multiple logistic regression models were systematically examined with an additive model (Rothman 1986).
Out of the 208 music teachers who answered the questionnaire (72%), in 2000, 171 (82%) had experienced WMSDs during the preceding 12 months. The highest prevalence was found in the neck (59%), the shoulders (55%) and the lower back (45%), (Table 4). Female teachers reported significantly more symptoms than male teachers in the neck (p=0.02), the shoulders (p=0.02), the upper back (p<0.001). The same musculoskeletal regions showed the highest prevalence during the previous seven-day period (Table 4). Neck and shoulder symptoms during the previous seven-day period occurred in 46% of the women and in 38% of the men.

The prevalence of WMSDs from 1988 to 1996, in 36 music teachers, showed in general that the complaints increased over the eight-year period. In the first survey in 1988, 29 teachers (80%) reported WMSDs and in the second survey in 1996, 33 teachers (92%). WMSDs occurred most often in shoulders (39-56%), low back (50-56%) and neck (39-44%). There were no significant differences between 1988 and 1996 for shoulder pain (p=0.17), low back (p=0.75) or neck pain (p=0.77). The highest 12-month prevalence of WMSDs in the women involved neck, shoulders and low back pain; and in the men, shoulders and low back pain. There were nine more cases of neck and shoulder pain and three more cases of low back pain reported over the eight-year period. No difference was significant. The violin teachers complained mostly of shoulder, neck

### Table 4 The prevalence of musculoskeletal pain and aches (%) in the total music teacher group (n=208) and comparisons between women (n=88) and men (n=120)

<table>
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<th>Musculoskeletal region</th>
<th>12-month prevalence</th>
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<tr>
<td></td>
<td>Total (%)</td>
<td>Women (%)</td>
</tr>
<tr>
<td>Neck</td>
<td>59</td>
<td>67</td>
</tr>
<tr>
<td>Shoulders</td>
<td>55</td>
<td>63</td>
</tr>
<tr>
<td>Elbows</td>
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<td>20</td>
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<td>Lower back</td>
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<tr>
<td>Hips</td>
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</tbody>
</table>

The prevalence of WMSDs from 1988 to 1996, in 36 music teachers, showed in general that the complaints increased over the eight-year period. In the first survey in 1988, 29 teachers (80%) reported WMSDs and in the second survey in 1996, 33 teachers (92%). WMSDs occurred most often in shoulders (39-56%), low back (50-56%) and neck (39-44%). There were no significant differences between 1988 and 1996 for shoulder pain (p=0.17), low back (p=0.75) or neck pain (p=0.77). The highest 12-month prevalence of WMSDs in the women involved neck, shoulders and low back pain; and in the men, shoulders and low back pain. There were nine more cases of neck and shoulder pain and three more cases of low back pain reported over the eight-year period. No difference was significant. The violin teachers complained mostly of shoulder, neck
and low back pain. The brass teachers reported low back and neck complaints. Piano teachers had low back problems. In the group of other instrumental teachers there were shoulder, neck and low back complaints.

**Work factors and neck–shoulder disorders - Paper I**

The most important factors significantly associated with neck and shoulder disorders for women, after adjusting for age, were *high psychological demands* (OR 6.0) and *teaching at many schools* (more than four per week) (OR 4.8) (Table 5). Among men, *lifting* (OR 8.7), *playing the guitar* (OR 6.0) and *low social support* (OR 3.1) were the strongest factors significantly associated with neck-shoulder symptoms (Table 6). No other variables were found to be significantly associated with neck-shoulder disorders. In the univariate analysis for women, significant associations were found for the variables *perceived health* (worse than others) (OR 3.6) and *physical exercise* (once a week or less) (OR 3.3). In the multivariate analyses the associations were lost.

Table 5 The percent of the exposed female music teachers, odds ratios (OR) with a 95 % confidence interval (95 % CI), and estimated odds ratios (OR) in a multiple logistic regression analysis, for neck-shoulder disorders

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exposed (%)</th>
<th>Univariate analysis</th>
<th>Multiple logistic regression analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical activity during leisure time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once a week or less</td>
<td>69</td>
<td>3.3 1.1-9.6</td>
<td>4.3 0.9-20.6</td>
</tr>
<tr>
<td>Perceived health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The general health worse compared to others</td>
<td>20</td>
<td>3.6 1.1-13.8</td>
<td>7.0 0.8-63.8</td>
</tr>
<tr>
<td>High physical work load</td>
<td>32</td>
<td>2.1 0.8-5.8</td>
<td>0.8 0.2-3.5</td>
</tr>
<tr>
<td>Lifting instruments (&gt; 6 times per day)</td>
<td>43</td>
<td>1.2 0.4-3.8</td>
<td>1.8 0.4-8.4</td>
</tr>
<tr>
<td>The guitar as the main instrument</td>
<td>8</td>
<td>4.4 0.4-2.3</td>
<td>4.1 0.2-71.5</td>
</tr>
<tr>
<td>High psychological demands</td>
<td>45</td>
<td>1.5 0.6-3.8</td>
<td>6.0 1.1-32.4</td>
</tr>
<tr>
<td>Low authority over decision</td>
<td>41</td>
<td>1.2 0.5-3.1</td>
<td>1.0 0.2-4.0</td>
</tr>
<tr>
<td>Low social support</td>
<td>55</td>
<td>1.3 0.5-3.1</td>
<td>0.4 0.1-2.2</td>
</tr>
<tr>
<td>Teaching at 5-12 schools / week</td>
<td>45</td>
<td>2.7 1.1-6.8</td>
<td>4.8 1.0-24.4</td>
</tr>
</tbody>
</table>
Table 6 The percent of the exposed male music teachers, odds ratios (OR) with a 95 % confidence interval (95 % CI), and estimated odds ratios (OR) in a multiple logistic regression analysis, for neck-shoulder disorders

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exposed (%)</th>
<th>Univariate analysis</th>
<th>Multiple logistic regression analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical activity during leisure time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once a week or less</td>
<td>70</td>
<td>0.5</td>
<td>0.2-1.3</td>
</tr>
<tr>
<td>Perceived health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The general health worse compared to others</td>
<td>11</td>
<td>1.3</td>
<td>0.4-4.0</td>
</tr>
<tr>
<td>High physical work load</td>
<td>31</td>
<td>1.0</td>
<td>0.4-2.2</td>
</tr>
<tr>
<td>Lifting instruments (&gt; 6 times per day)</td>
<td>54</td>
<td>4.2</td>
<td>1.6-10.7</td>
</tr>
<tr>
<td>The guitar as the main instrument</td>
<td>22</td>
<td>3.2</td>
<td>1.2-8.1</td>
</tr>
<tr>
<td>High psychological demands</td>
<td>37</td>
<td>1.0</td>
<td>0.5-2.2</td>
</tr>
<tr>
<td>Low authority over decision</td>
<td>47</td>
<td>0.6</td>
<td>0.3-1.4</td>
</tr>
<tr>
<td>Low social support</td>
<td>50</td>
<td>1.8</td>
<td>0.8-3.8</td>
</tr>
<tr>
<td>Teaching at 5-12 schools / week</td>
<td>53</td>
<td>0.6</td>
<td>0.3-1.2</td>
</tr>
</tbody>
</table>

Arm - position measurement – Paper II

Arm positions measured with the Abduflex showed that the total mean percentage time with the right arm elevated >30° was 22.8% (range 15.4-36.2%), which was approximately two hours of the working day. The total mean percentage time with the left arm elevated >30° was 11.9% (range 3.5–16.2 %), approximately one hour of the working day. The total mean frequency for the right arm was 5731 elevations (± 2945) and for the left arm 2556 (± 379) elevations. The mean recording time for the group was 9h 5 min of which breaks and transfers between schools was 1hr 45 min ± 30 min.

Perceived health and work - Paper III

The interviews with the music teachers resulted in the categories found in Figure 3 representing the strategy code-family (Starrin et al. 1997). The work contained positive and negative elements influencing health and well being. This was, expressed in the core category Replenishing and using up energy, a conceptual model of the
process experienced as influencing health (Figure 3). Work comprised an interaction between creativity in the music and in meeting students and colleagues (Playing together), which supplied energy while at the same time using up energy in relationship to organisational goals (Goal setting), which were perceived to be stressful and frustrating. The ability to modify work and life situations (Modify) was found to be important to perceived good health as well as the role identification, as a musician or as a pedagogue (Music as goal or means). Experiences of how interviewees felt both physically and mentally are found in Bodily reactions. Quotations from the interviews with the music teachers’ on different themes are given in Paper III.

Figure 3 Model of the process music teachers perceived to be important for health and well being

All the teachers experienced their work as demanding—many of these demands self-imposed. The teachers were highly motivated and they wanted to be enthusiastic in order to give their students their all in the short periods they were teaching. The demands imposed by work were often connected to political decisions and financial preconditions and consumed energy.
Playing together with colleagues, students and other musicians was for everyone the most positive force in the work and gave energy. Some music teachers described themselves as primarily teachers with an interest for working with children and youngsters. We have chosen to refer to this as “the pedagogue”. They enjoyed the interaction between music and teaching. Their teaching goal was to provide students with a good foundation for music and for life in general. Other teachers emphasised the importance of music in their work and described themselves as positive musical models. We have chosen to refer to this as “the musician”. Their teaching goal was to transfer knowledge music and develop skills in playing, which was more of an end in itself than a means to an end.

All teachers emphasised the importance of keeping active and fit in order to feel good. Everyone said they felt well, were in good health, gave it high priority but at the same time they experienced physical and mental reactions that consumed a lot of energy. The pedagogue dealt with the demands through structuring work, finding flexible solutions such as lowering personal goals. The pedagogue tried to find a balance between activities and rest. They perceived that they were able to influence the work situation. The musician dealt with demands through physical exercise, relaxation, sleep and socialising with family and friends. The musician overlooked the pedagogic tools and had difficulties modifying the work situation, which was perceived as frustrating.

Variability of the trapezius muscle activity - Paper IV

The intra-individual trapezius muscle activity patterns were similar between the first and the second playing session meaning that each string musician repeated his/her trapezius muscle activity pattern in a similar way at the two playing sessions. No significant intra-individual differences in the two sessions were found for the left trapezius for either period distribution (p=0.18), or amplitude levels (p=0.34), or for the right trapezius either for the period distribution (p=0.92), or amplitude levels (p=0.22). However, there was substantial variability in the muscle activity pattern between string players and between the left and the right trapezius.
The EVA data showed that period times generally were longer for the left trapezius muscle than for the right trapezius, ranging from mainly short periods lower than 1 s to period times lasting longer than 15 s (left trapezius) or 7 s (right trapezius). Among the violin and viola players, the left trapezius was generally exposed to amplitude levels lower than 50% RVE. The right trapezius was generally exposed to moderate amplitude levels between 10-23 and 23-50% RVE. The EVA pattern from one violinist is illustrated in Figure 4. The violinist played at a low load in long periods on the left trapezius while the EMG activity of the right trapezius was more varied, i.e., was distributed over a greater amount of period-amplitude categories. The EVA patterns at the second playing session were similar to the first session, except that the pattern for the right trapezius was transferred to higher amplitude levels.

Figure 4 Exposure variation analyses (EVA), expressed in duration of time (s) and amplitude (% RVE), for the left and the right trapezius muscle recording from a violinist during two playing sessions. At the first playing session (#1), the left trapezius muscle showed long periods over 7 s (a) and at the second playing session (#2) periods of 1-3 s and 3-7 s dominated (c). The right trapezius muscle showed periods up to 15 s at the first playing session (b) and periods of 1-3 s dominated in the second session (d). Amplitude levels of the left trapezius muscle were shifted from 3-10 % RVE at the first playing session (a) to 10-23 % RVE at the second (c). Amplitude levels for the right trapezius muscle were shifted from 23-50 % RVE at the first playing session (b) towards 50-103 % RVE at the second (d)
Results

Basic Body Awareness Therapy intervention – Paper V

No significant differences were found in the variability of the trapezius muscle activity pattern between the Basic BAT training group and the reference group, before the intervention (left trapezius, p=0.4, right trapezius, p=0.2) or after the intervention (left trapezius, p=0.9, right trapezius, p=0.7). There was no significant difference found in the training group before or after the training period (left trapezius, p=0.4, right trapezius, p=0.7). However, the trapezius muscle activity patterns differed from individual to individual (Figures 5 and 6). No significant group differences in shift were found, either in amplitude (left trapezius, p=0.06, right trapezius, p=0.52) or in period (left trapezius, p=0.08, right trapezius, p=0.61). The Basic BAT training group perceived positive changes in breathing, muscular tension, postural control and concentration, mainly during practise sessions.

The principal component analyses (PCA) were made on the marginal period distribution (time) and the marginal amplitude distribution. The PC plots can be divided into four quadrants, Q1-Q4, describing which periods and amplitude levels that dominated a subject’s pattern, extending from short (Q1) to long (Q4) periods (Figure 5) and from low (Q1) to high (Q4) amplitude levels (Figure 6). Generally, the load on the left trapezius was more static (longer period times) on a lower load (lower amplitude levels) than on the right trapezius. Period times varied from very short to very long with the main duration in the range 1-15 s (left trapezius) and 1-7 s (right trapezius) (Figure 5). Amplitude levels also varied, even though most of the subjects showed low or moderate amplitude levels mainly in the range 3-23% RVE (left trapezius) and 3-50% RVE (right trapezius) (Figure 6).
Results

Figure 5 Principal component analyses (PCA) of the period distribution for the left (a) and the right (b) trapezius muscle for the total group of violinists. The graphs are divided into four quadrants, Q1-Q4, describing which period lengths that dominate the subject’s activity pattern. The period times, in seconds, that are dominant for subjects in the quadrant are written in parentheses (Q1 = short periods – Q4 = long periods). In the figure above r = reference group, t = training group, A-l = each violinist, 1 = first playing session, 2 = second playing session.
Figure 6  Principal component analyses (PCA) of the amplitude distribution for the left (a) and the right (b) trapezius muscle for the total group of violinists. The graphs are divided into four quadrants, Q1-Q4, describing which amplitude levels that dominate the subject’s activity pattern (Q1=low amplitude levels – Q4=high amplitude levels). Amplitude levels (% RVE) that are dominant for subjects in the quadrant are written in parentheses. In the figure above r = reference group, t = training group, A-I = each violinist, 1 = first playing session, 2 = second playing session
DISCUSSION

Methodological considerations

Study design

In this thesis a study design based on a quantitative as well as a qualitative approach was used. Combinations of quantitative and qualitative approaches can present a holistic picture that gives a deeper understanding of how people experience and deal with problems. The quantitative and qualitative combination maximise the strengths of the methods, which is especially interesting when studying the complexity of factors that influence health and illness (Morgan 1998). A qualitative approach is further recommended in a field where little knowledge is at hand. Since questions of health and illness in musicians in many ways are unclear, undefined, and often of a complex nature, (Zaza et al. 1998) a combined quantitative and qualitative approach seemed feasible to use. Further, it is important to widen the perspective — from not only preventing ill health but to highlighting the actual process that support people’s lives. For this reason a salutogenic health perspective was adopted (Antonovsky 1987). This involves trying to capture the particular “protective factors” that are positive to health. The salutogenic perspective was adopted in Paper III although we did not use the sense of coherence questionnaire since few studies have demonstrated the real relevance of Antonovsky’s theory to working life (Eriksson 1996). The positive health perspective was also highlighted in Paper V, in the choice of Basic BAT as an intervention. Basic BAT has been described as a method primarily aimed at discovering creativity and activating health resources in the body as a whole (Roxendal 1985; Roxendal and Winberg 2002).

Participation rate and dropouts

The participation rate in the cross-sectional study (Paper I) was about 70%. This figure may be considered somewhat low, although the dropouts presumably did not affect the results. An analysis of the dropout group showed that they did not differ from the respondent group in regard to sex, age, length of employment and main
instrument played, so the study does demonstrate important associations. Somewhat low participation rates have also been found in other studies of musicians' playing-related risk factors (Zaza and Farewell 1997; Miller et al. 2002). A possible explanation for this is that musicians may see disorders and pain as signs of weaknesses; they are trained to compete and might find it difficult to reveal their health problems. A low interest in work environment and health issues, or a high priority for artistic and aesthetic matters could also be alternative explanations. In Paper II, 36 music teachers from the original study group of 62 music teachers were investigated. In the dropout group, 21 music teachers had left the municipal music school in question and were not possible to follow further. A study design including an investigation of that group could have revealed more certain information on WMSDs and also information on why they had left their jobs. In Paper V a total of 14 violinists participated, five in the training group and nine in the reference group, which could be considered a small sample. In the planning of the intervention study more participants were invited to both groups but for practical reasons they were not able to participate.

External validity

The cross-sectional studies (Paper I and II) were conducted among all music teachers at municipal music schools in the two northernmost counties in Sweden. The samples were probably reasonably representative of music teachers in Scandinavia since the music teaching in this area is fairly similar to the rest of the area. The results may therefore be valid for music teachers in Scandinavia. The results from the qualitative study (Paper III) are considered to be valid for music teachers working in similar contexts as the informants of our study. Results from the EMG study (Paper IV) may be valid for string players in general. However conclusions cannot be drawn to sting players with serious aches and pains since the musicians in our study were all able to work and functioned very well in daily life.

Exposure

In Paper I all the analyses were performed separately for women and men. It has been suggested that this is a better strategy than using gender as a confounder when analysing data since more information
is gained and important relationships can be found (Messing and Kilbom 1998a; Fredriksson 2000; Theorell 2000). A cross-sectional design was used in Paper I and II which could have introduced recall bias. Music teachers with WMSDs may have been more likely to report exposure in an attempt to explain or understand the symptoms while music teachers without WMSDs were less likely to remember an exposure because of less meaning or importance of the symptoms to them (Greenberg et al. 1996). A possible limitation of the study concerns the assessment of the physical work exposure. Questionnaire data on physical exposure may be useful, even though interviews or direct measurements are preferable (Hagberg et al. 1995). Since no “golden standard” exists for assessing the musicians’ physical workload, estimations were based on the dimensions duration (time), level (amplitude) and frequency (repetitiveness) (Winkel and Mathiassen 1994). The evaluations were made for each music teacher when playing his/her main instrument and the physical workload was categorised as high, medium or low. This method has not been used in studies on other groups of workers or musicians and therefore needs to be further developed and tested for validity and reliability. Cronbach’s alpha coefficient was used in Paper I to test the reliability of different indexes. The psychosocial index for authority over decisions showed a coefficient value of 0.40, which indicates a low degree of internal consistency for a scale (Nunally 1978). It could be argued that the index should have been excluded, but it was considered to be an important aspect of the total work environment and was thus kept in the final multivariate modelling.

Trustworthiness

To increase the trustworthiness in Paper III, different techniques were utilised, proposed by Lincoln and Guba (1985). The credibility was partly increased by using triangulation in investigators to code the interviews independently and using mutual comparison and a negotiated outcome. Reference group checking was used to increase reliability. The material was presented to music teachers at different music schools and further discussed how relevant the results were to other music teachers. The prolonged engagement was represented in the study by my in-depth knowledge of the music school’s activity and that a number of the informants knew me, which possibly created a trusting environment in which they were prepared to be open.
possible danger is that the informants said certain things, which they thought that I wanted to hear as a professional, for example if, and how much they exercised. The other two investigators did not know the informants and in this way represent the outsider perspective. We were all "professional strangers" in the sense that we were not practising musicians. All interviews were taped and transcribed. In order to highlight the informants’ own words and not our own, the material was taken back to the informants to check if they agreed with our transcription (member check).

EMG measurements

The EMG measurements (Papers IV and V) were made on the trapezius muscle bilaterally, based on the fact that the trapezius muscle is active in violin playing (Philipson et al. 1990; Berque and Gray 2002), and it seems to be more vulnerable to muscle tension and pain than other neck and shoulder muscles (Vasseljen et al. 2001). A study design with EMG measurements of other muscles important to violin playing could have shown if there were differences in the muscle activity pattern of other shoulder muscles as well.

In the Basic BAT intervention (Paper V) a total of 14 violinists participated, five in the training group and nine in the reference group. Studies assessing upper trapezius EMG amplitudes have in general been conducted on groups rarely exceeding 15 subjects (Mathiassen et al. 2002). Common-size ergonomic intervention studies with small groups run a great risk of not having insufficient statistical power. Low power occurs when exposure variability between and within subjects is large as compared to the expected exposure differences between groups. Mathiassen et al. (2002) have presented a general strategy when planning for comparative EMG studies for considering power issues. The results of exposure variability in this thesis (Paper IV) showed no differences in variability within subjects, which could be regarded as positive in relation to statistical power. Variability between subjects was substantial and could have affected the result in a negative way. Thus, larger groups of string musicians need to be studied to allow for more accurate conclusions.
Main findings

Work related musculoskeletal disorders

Work related musculoskeletal disorders especially in the neck, shoulders and back are common in music teachers as well as in other professional musicians. The female music teachers experienced more symptoms than the male music teachers both during the previous 12 months and the preceding seven-day period. This is in agreement with many other studies on professional musicians and in general working populations (Zaza and Farewell 1997; Sataloff et al. 1998, Zetterberg et al. 1998; Liljeholm Johansson and Theorell 2001; De Zwart et al. 2001). The 12 months prevalence of neck and upper extremity disorders in this thesis was high compared to the Swedish population (Statistics Sweden 2002a; 2002b). When compared with other groups of teachers, the prevalence of shoulder disorders was higher for female music teachers (Statistics Sweden 2002b). In our study neck, shoulder and lower back disorders were common and tended to be of long duration and to increase over the years, which is supported by Fredriksson and colleagues (1999) who showed a trend towards an increase of disorders in all body parts, measured during a 10-year period.

Exposure and music playing and teaching

Neck and shoulder disorders were associated with both physical and psychosocial work factors, with different risk association patterns in men and women, which is in agreement with studies in the Swedish general population (Messing and Kilbom 1998a; Fredriksson et al. 2000; Fredriksson et al. 2002). In general there is more evidence for the effects of physical work factors on the development of neck and shoulder disorders than for non-physical/psychosocial work factors (Sluiter et al. 2000). However, psychosocial work factors play an important role in the development of WMSD. The etiology behind this is not clearly understood and different explanation models have been proposed (Karasek and Theorell 1990; Bongers et al. 1993; Hagberg et al. 1995; Brandfonbrener 1998).
Discussion

Physical work factors

In this thesis the physical exposure was considered from the dimensions duration (time), level (amplitude) and frequency (repetitiveness) (Winkel and Mathiassen 1994). Working postures, force and repetitive movements related to duration and frequency could increase the risk of WMSDs of the upper extremity (Sluiter et al. 2000). In musicians the playing posture, the effort needed to support the static load of the instrument, repetitive depression of keys or strings, and the force of the airflow through the instrument are all factors relevant for developing WMSDs (Brandfonbrener and Kjelland 2002). Although playing may be considered as “light” work, musicians perform highly skilled and coordinated repetitive motions at very high speed, which requires precision. Such patterns of repetitive muscle activity have been found to be important with regard to contracting WMSDs (Dommerholt et al. 1998). The total playing time for the musicians in our studies varied from about 15-25 hours per week for music teachers and 30 hours per week for professional musicians. Violin teachers spent approximately a quarter of the working day with arms elevated 30-90°, with the right arm subjected to more repetitive work than the left. Evidence indicates that the amount of time spent practising and the intensity of the playing could increase the risk of WMSDs in musicians (Brandfonbrener and Kjelland 2002). Taking breaks have been shown to prevent injury (Zaza 1998b). It has been suggested that practice sessions be limited to a maximum of 45 minutes with a break of no less than 10 minutes to allow the muscles to relax (Dommerholt et al. 1998).

Lifting instruments and other equipment during teaching, was a risk factor for neck and shoulder disorders for men but not for women. Musicians often move their instrument (frequently a bulky and heavy one) and other music equipment from one place to another (Sataloff et al. 1998). Music teachers often load and transport instruments between classes and rearrange chairs, instruments, and other equipment in the classroom. Manual handling as a work task is common in working life (Hagberg et al. 1995; Sataloff et al. 1998; Buckle and Devereux 1999). It is regarded as a complex task requiring strength, endurance, balance, and experience. Studies on manual handling have usually found that men lift more than women in working life and under experimental conditions, as well as during
leisure time (Kjellberg 1998). Men often handle heavier loads, while women do lighter, more repetitive lifting (Messing and Kilbom 1998b). It seems plausible that manual material handling, which causes high loads on the neck and shoulders, could cause disorders (Hagberg et al. 1995).

Playing the guitar was associated with neck and shoulder disorders for male music teachers but not for female teachers which also has been found in a study in university music students (Cayea and Manchester 1998). It must be taken into consideration that there were few female guitar teachers in our study. The choices of main instrument may differ between female and male musicians (Brändström and Wiklund 1995). The guitar has been found to be an instrument more often played by men than by women (Zaza 1998a). Certain instruments are found to be risk factors mainly for upper extremity disorders in studies among different kinds of musicians. Most studies have shown that violin, viola, and keyboard players develop more musculoskeletal problems than other instrumentalists (Zaza 1998a). The reasons for this are not entirely clear, but factors such as extreme postures while playing, repetitive arm and finger movements, and required force have been proposed as explanations for other occupational groups (Hagberg et al. 1995; Buckle and Devereux 1999; Sluiter et al. 2000).

Though the guitar constitutes one “music family”, there are differences between playing classical guitar, electric guitar, and electric bass, but each instrument may affect the association with neck and shoulder disorders (Sataloff et al. 1998). The fact that the guitar is a plucked instrument could contribute to the disorders (Cayea and Manchester 1998). The classical guitar is played with many rapid and repetitive movements requiring precision. The electric guitar is played with slower motions but with more force. Playing the electric bass guitar requires great effort to depress strings with the left hand and to pluck, pull or bend the strings with the right hand, while supporting the instrument’s considerable weight. These instruments are mostly played standing up and supported by a neck strap, which may also cause neck problems (Sataloff et al. 1998).

Psychosocial work factors

High mental demands and teaching at a number of different schools, which may be perceived as demanding, were of importance with regard to neck and shoulder disorders for female music teachers but
Discussion

not for male teachers. In our qualitative study, music teachers reported their work environment to be demanding. However, many of the demands seemed to be self-imposed and perceived in a positive light. The teachers had set high goals for themselves and they were very motivated in their work. This may have its origin in early days of music education and that the music teachers have become used to competing, performing and achieving results. The demands imposed by work were often connected to political decisions and financial preconditions. A conflict existed between, on the one hand, the goals for the music school set by politicians and, on the other hand, the limited resources available to school management and music teachers to fulfil those goals. Since the required resources were not forthcoming teachers were forced to take on more students within existing time frames. This meant less time for each individual student, which was experienced as lack of time and involved teaching at more schools within the catchment area. The conflict was experienced as extremely frustrating and stressful by the teachers. Some evidence has been found for a positive relationship between high quantitative work demands and neck and shoulder pain (Ariëns et al. 2001). Liljeholm Johansson and Theorell (1999; 2001) found that orchestral musicians perceive there to be high demands on the quality of their work and a social pressure on them to be good musicians, which may lead to more stress and tension in its turn increasing the risk of developing WMSDs. Theorell et al. (1993) have shown that the higher the mental demands the higher the pain threshold. Subjects with a high pain threshold may not obey bodily warning signals which could lead to an increased risk of developing WMSDs.

Decision latitude was found to be sufficient for both male and female teachers in our study, and thus it was not found to be a risk factor. Negative aspects of authority over decisions, according to Karasek and Theorell (1990), were found, but also positive aspects. The teachers had sufficient control over what to teach the students and how to do it. The teachers also had influence over their own schedules. They worked long days but this may be in order to get longer periods of leisure time. To some extent there were some opportunities for learning new things at work. On the other hand, the work was monotonous, teaching a new individual or a small group of students every 40 minutes for a whole working day. The teachers perceived that the work required skill and creativity. Creating music with others was found to be the most positive and important factor in
work. In some situations of group creativity a kind of peak experience was experienced, often described as flow (Csikszentmiháliy 1990). This peak experience has been found to be one of the reasons for becoming an artist (Roland 1997). It is so enjoyable in itself that it becomes intrinsically rewarding. The experience is created under conditions, which often match those for making music in a group.

The importance of role identity and influence over one’s own work situation with regard to good health has been pointed out in our qualitative study. Music teachers with a more pedagogical focus found energy in the interaction between music and teaching. They felt that they could influence their working situation and as a result were less frustrated and more content in their work. Over time this can lead to perceived better health. Focusing on “protective factors” that are positive to health has been labelled as a salutogenic perspective (Antonovsky 1987). Antonovsky (1987) based his theory of “sense of coherence” on ideas about mechanisms of resistance. According to his theory individuals with a strong “sense of coherence” have optimal resistance resources for dealing with stress. This implies they have a whole battery of actions to choose from when deciding how to deal with a situation and perceive the environment as comprehensible, manageable and meaningful. The concept stress is defined as a state when demands caused by strain exceed the individual’s capacity to meet those demands. Constant repetition of actions creates positive experience from which we learn how to deal with difficult situations. Similar ideas are found in Karasek and Theorell’s model (1990), which describes the interaction between stress and work. For music teachers who had music itself as the focal point, the interaction between music and teaching was not so clear. They experienced frustration and dissatisfaction with both the choice of profession and the work situation and some had considered changing profession. Similar findings have been reported from studies of Swedish students studying to be music teachers. Teachers who are fascinated by the aesthetics in music often lack something in their work as music teachers (Bouij 1998). A study of Austrian music teachers established that a music teacher should feel a vocation for the teacher role rather than for the musician role if he wants to cope with school requirements (Mark 1998). There are many more frustrated people among the musically motivated teachers than among primarily pedagogically motivated teachers. Studies on music teachers’ socialisation have found that music teacher education is characterised
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by the giving of a double role — the teacher's and the musician's (Roberts 1991; Brändström and Wiklund 1995; Bouij 1998; Bladh 2002).

In a review Bongers and colleagues (1993) concluded that there is an association between a combination of a number of mental work demands or high work demands and low decision latitude, and neck and shoulder disorders. Further, they pointed out that demand variables such as time pressure, monotonous work, poor work content and a perceived high workload are also related to neck and shoulder symptoms. A study on the occupations most at risk in Sweden showed that both female and male teachers were exposed to considerable demands, but to some extent they had more influence on their working conditions compared to other occupations (Statistics Sweden 1997). This is especially true of female secondary school teachers and female teachers in arts study programs, who perceived major demands at work, which supports our findings. Male teachers of arts study programs were found to have high demands and low decision latitude, a combination that was not found in our study.

Low social support was of importance to neck and shoulder disorders for male music teachers but not for female teachers. A review has shown that the influence of social support at work on health is not consistent (Bongers et al. 1993). Some of the studies did find positive associations between low social support from colleagues and superiors and WMSDs, but others observed no effect. Social support has been found to differ between men and women in some studies, but is consistent in others (Zetterberg et al. 1998; Kjellberg 1998). A possible explanation concerning differences in perceptions of social support and demands between male and female teachers may be found in the process of becoming a music teacher. In the music teacher profession, interest in these matters seems to start early when training at a university music school (Bouij 1998). Prior to studying at a university music school, 80% of the music teacher students have already experience in different occupations. Bouij (1998) found that female music teacher students tend to have had more experience of occupations where social contact is central, e.g. teaching, child care, or health care, while male music teachers have worked in industrial and transport occupations. During teacher-related training, the female music teachers are more likely to develop teaching and the interactive skills needed in the profession since they seem to have more interest
in such issues. Male students develop their music skills built on performance and demands. This has also been confirmed in a recent study among music teacher students (Bladh 2002). This process continues to develop after being qualified as a music teacher (Bouij 1998; Bladh 2002) and may lead to perceptions such as in this study. Male music teachers, being used to demands, may perceive their work demands as acceptable, while female music teachers have developed their social skills and thus can handle the social support at work in a better way. Contrary to the results in this thesis, a previous study on musicians showed that low social support was a risk factor for female music students and having high demands at work was a risk factor for male music students (Zetterberg et al. 1998).

To repeat and to practice

The EMG trapezius muscle activity patterns were similar between two playing session indicating that each musician repeated his/her muscular activity pattern in a similar way. However, there was substantial variability in the muscle activity pattern between string players and between the left and the right trapezius which was also indicated by the results from the arm-position measurements. Our findings are supported by studies on movement analyses of the bowing arm in string musicians that gave reproducible results on repeated testing and demonstrated clear differences between players (Tulchinsky and Riolo 1994; Turner-Stokes and Reid 1999). Among violinists and violists, studies have revealed a considerable inter-individual variability in the trapezius muscle activity, with an even larger variation when playing a more difficult music piece as opposed to an easy one (Philipson et al. 1990; Berque and Gray 2002). The ability to repeat the playing technique during a musical performance has been studied in trumpet players by measuring biomechanical forces. The results indicated that each subject played with the same maximum forces and maintained a similar trumpet angle at two test conditions though there was variability in the mean forces between trumpet players (Devroop and Chesky 2002).

The factors that determine the individual repeated movement pattern may be explained by concepts of motor control and motor learning, including integration of muscular, neurological and psychological aspects (Shumway-Cook and Woollacott 2001). Starting to play an
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 instrument at an early age leads to many years of daily practice and refining a good playing technique. It has been estimated that by the age of 21 the best music performers have spent over 10,000 hours practising their instrument (Ericsson et al. 1993). As a consequence of daily practice, the nervous system is modified to cope with extraordinary challenges and requirements of performance leading to reorganisation in neural structure - plasticity. The changes take place in certain sensory and motor systems and in their interface (Pascuale-Leone 2001). The somatosensory cortices of string players were compared to non-musicians (Pantev et al. 2001). Musicians had enlarged representation in their brain cortex representing the fingers that are intensively used in string playing. The cortical change was greater in musicians who had begun playing their instrument before the age of seven. Hence, transfer of the playing technique from the teacher to the student, and the massive hours of practising, developed the person into a skilled string musician. From this point of view it seems plausible that each string musician could repeat his or her own trapezius muscle activity pattern from the first playing session to the second one.

To teach and to practice

Concepts of motor learning and motor control (Shumway-Cook and Woollacott 2001) and the results of short-term interventions also emphasise how important it is that music teachers teach their students a proper playing technique during the early stages of education since the playing technique seems hard to influence once it is established (Medoff 1999; Brandfonbrener and Kjelland 2002). Preventive measures from the start establish efficient performance techniques and postural habits, a positive attitude and a healthy lifestyle. To teach the student how to play with an optimal playing technique is a primary goal for the music teacher (Kaladjev 2000). It is of vital importance that the music teacher integrates the playing and practice into the teaching process as well as the knowledge into his/her own body (Bouij 1998). By doing this the music teacher can both make ergonomically correct decisions and be an influential role model for children and young people in the learning process. What the teacher actually does during lessons has a more profound influence upon the student’s practice than what the teacher actually says (Barry and Hallam 2002). Brandfonbrener (1998) emphasises that there is
opportunity for the music teacher to influence, positively or negatively, the musical development and life of a young musician. She further argues that there are many things to consider when selecting a music teacher. Therefore it should be a joint process including the teacher, the music student and also the parents. Questions concerning the music teacher’s musical competence are vital, but questions of communication, teaching style and mutually compatible goals are equally important. Later when the playing technique has been established, musicians might benefit more from practising proper warming up before playing, taking regular breaks to recover, and establishing good working techniques in activities other than playing an instrument (Spaulding 1988).

Prevention of musculoskeletal disorders in musicians

Preventions for music teachers should be targeted at the organisation, the team and the individual music teacher. At the organisation level, teaching at fewer schools with lessons spread over the whole week could lower stress and muscle tension. Working in smaller teams of teachers with work planning and development of “pedagogical tools” could increase collaboration and support between teachers and give less repetitive work for each teacher. On the group level principles of occupational medicine regarding ergonomics and adaptive equipment should be followed. Good working premises including chairs ergonomically designed for different instrumental groups, access to technical aids for playing, carrying and loading instruments as well as proper lighting and sound levels are of equal importance (Dommerholt et al. 1998). For each music teacher, practice habits such as proper warming up before playing, taking regular breaks to recover, stretching and cooling down are vital. The total practice time, good working techniques in activities other than playing, and an individual adaption of the musical instrument should also be considered.

Furthermore, education in body awareness techniques could help the music teachers listen to their bodily warning signals so they know when it is best to stop playing, rest and relax. The intervention in our study with Basic BAT was chosen because the use of special body-oriented techniques in practice sessions has been recommended as prevention for WMSDs in musicians (Spaulding 1988;
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Brandfonbrener and Kjelland 2002) and because one of the most common techniques practised by Swedish music university students is the Basic BAT. The practice is often short-term and in many cases occasional and irregular. In our study no differences in the trapezius muscle activity were found between a group of violinists practising Basic BAT and a non-training group. However, the Basic BAT group perceived positive changes in breathing, muscular tension, postural control and concentration mainly during practice sessions. The eight-week training period of Basic BAT may be long enough for the violinists to experience positive bodily awareness but not long enough to change the EMG muscle activity pattern. If the goal, in healthy subjects, is to change the EMG muscle activity pattern during playing, the musicians would probably benefit from a longer training period, which also was suggested by the subjects in the Basic BAT training group in the evaluation of this intervention. If the goal is to treat a musician with chronic pain due to incorrect playing posture and playing technique, the Basic BAT training has to be regular and over several months up to a year (Roxendal and Winberg 2002).

Implications

It is most important to take up a discussion concerning the health problems of musicians and music teachers and to put musicians’ health problems “on the agenda”. Information about musicians’ WMSDs and the consequences of the problem should be discussed with the musicians themselves, employers, health care professionals, educators at the music universities, and researchers interested in the field. The health maintenance and care of musicians and music teachers needs to become more consistent, effective and founded on research.

An important task for music teacher education is to establish the power of pedagogy and of a good physical and psychosocial work environment for the students, not only in order to become a skilled teacher but also to maintain good health. Good health is a precondition for playing well on a musical instrument. When the body works in harmony with the musical instrument a oneness is created which facilitates music playing. It is therefore important in the teaching to highlight the positive factors in playing music, which can affect the health and well being of the students, our future musicians.
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It is vital that the music teachers instruct their students in a proper playing technique since it seems hard to change once it has been established. Good postures and playing techniques have to be learned while playing the instrument but might also be highlighted, regularly over the years, in training modalities such as Basic BAT or other methods used in physiotherapy in order to increase the awareness of bodily warning signals.

Prevention programs for musicians at all levels should be long-term, preferably over several years, on a regular basis and integrated into ordinary work tasks. For musicians at all levels of performance proper education in ergonomics, the importance of work organisation and a good physical and psychosocial work environment are crucial in order to prevent WMSDs.

Future research in the field of music medicine

Homogenous classification systems of clinical diagnosis and exposure in music work are needed and the concepts and definitions should be investigated in accordance with occupational medicine research of other groups of workers.

The health problems of musicians are under-recognised and under-researched (Zaza 1998a). Much research is needed, especially prospective, longitudinal studies in school music students and adolescent music students to illuminate the natural history and development of WMSDs, the causation of the disorders and to identify those who are at risk for developing WMSDs. As gender seems to influence WMSDs in musicians, a gender perspective could be introduced into the studies.

In order to prevent WMSDs in musicians, multifactorial intervention programs should be documented and the effect of the programs should be evaluated preferably in randomised and controlled trials.
GENERAL CONCLUSIONS

• Work related musculoskeletal disorders (WMSDs) were common in music teachers. The disorders tended to be of long duration and to increase over the years. Female music teachers reported more symptoms in neck, shoulders and upper back than male music teachers.

• Neck and shoulder disorders were associated with both physical and psychosocial work factors with different risk association patterns between female and male music teachers.

• A process of replenishing and using up energy was important for music teachers' health. Creativity in the music and playing together with others were experienced as sources of energy. The goals of the organisation were experienced as stressful and used up energy. Whether the music teacher work was regarded as pedagogical or musical could affect the perception of health and the strategies for dealing with the strains of work.

• Violin, viola and cello players could repeat their trapezius muscular activity pattern in two playing sessions. There was considerable variability in the muscle activity pattern between cello, violin and viola players and between individual violin players. The EVA method using EMG may be used to analyse individual muscle activity patterns when performing a musical work task and to evaluate intervention studies.

• An intervention with Basic BAT training during a short-term period did not affect the trapezius muscle activity pattern in violinists. However, the training was perceived as positive for breathing, muscular tension, postural control and concentration during practice sessions.
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