

The Prevalence of Severe Musculoskeletal Problems Among Male and Female Symphony Orchestra String Players

Susan E. Middlestadt, Ph.D., and Martin Fishbein, Ph.D.

Abstract

This paper examines the prevalence of severe music-related musculoskeletal problems among string players. It is a further analysis of the nationwide medical survey of musicians performing with the 48 ICSOM orchestras. The percentage of musicians reporting a musculoskeletal problem that they judged to be severe in terms of its effect on performance was found to differ significantly as a function of string instrument, gender, and musculoskeletal location, as well as of the interaction of these variables. Since different locations were found to be problematic for players of the different string instruments, there is clear evidence for occupational factors in the development of these problems. Furthermore, the gender differences in prevalence seen here and in previous research were found to depend on both string instrument and musculoskeletal location. For example, considering problems with fingers, hands, and wrists, there were no gender differences among violinists, but the percentage of violists and cellists reporting severe problems in these locations was significantly higher among females than males.

In the general population musculoskeletal disorders are common afflictions that significantly influence people's lives and their economic productivity. According to a number of health surveys,¹ musculoskeletal disorders are a leading source of chronic impairment, activity limitation, worker disability, time lost from work, and physician visits. Despite

the pervasiveness of musculoskeletal problems and their impact on individuals and on society as a whole, comparatively little is known about the epidemiology of these types of disorders. Perhaps because of the gradualness of onset, difficulty of diagnosis, and lack of fatal effect, relatively little research on musculoskeletal disorders has been conducted.

A growing concern with the special medical problems experienced by performing artists has begun to focus attention on these disorders. For example, a recent bibliography on the medical problems among instrumental musicians² lists over 200 citations from medical, musical, and popular literature. Of particular interest is a number of studies concerning various forms of musculoskeletal problems within different samples of musicians. The samples have ranged from high-level, professional musicians to music students and amateur musicians. These studies⁴⁻¹¹ show that musculoskeletal disorders among instrumental musicians occur with considerable frequency and that their effect on the musician's musical activities is serious. There is strong evidence that the presence of particular musculoskeletal problems depends upon the musician's instrument.⁶⁻¹¹ Furthermore, consistent with research on medical problems in the general population,^{1,12} compared to male musicians, female musicians are more likely to experience musculoskeletal problems.⁸⁻¹⁰

Recently, the International Conference of Symphony and Opera Musicians (ICSOM) sponsored a national survey of its members to obtain information about their medical

From the Department of Advertising (Dr. Middlestadt) and the Institute of Communications Research (Dr. Fishbein), University of Illinois at Urbana-Champaign, Urbana, Illinois. Address correspondence to Susan E. Middlestadt, Ph.D., Department of Advertising, University of Illinois at Urbana-Champaign, 810 S. Wright St., Urbana, IL 61801.

A version of this paper was presented at the Sixth Annual Symposium on Medical Problems of Musicians and Dancers, Aspen, Colorado, July 1988.

Funding for this research was provided by the International Conference of Symphony and Opera Musicians, the American Federation of Musicians, the Major Orchestra Managers Conference, and the University of Illinois Research Board.

There is strong evidence that the presence of particular musculoskeletal problems depends upon the musician's instrument.

problems. Preliminary findings from this survey also support the conclusion that the prevalence of medical problems among performing musicians is related to gender and type of instrument played. According to the initial report on the survey,³ fully 82% of the musicians performing with the 48 ICSOM orchestras reported at least one medical problem and 76% reported experiencing a problem that was severe in terms of its effect on their performance. Furthermore, the prevalence of medical problems was higher among females than among males and higher among string players than among other musicians. The present paper presents further analyses of these data; it focuses upon one set of problems within one group of symphony orchestra musicians. Specifically, this paper is concerned with "severe" musculoskeletal problems among those who play string instruments.

Method

The results discussed in this paper are based on the ICSOM survey. A complete description of the methodology, the sample, and an overview of key results are available in *Senza Sordino*, an official ICSOM publication.³ Briefly, in May of 1986, the over 4000 musicians performing with the 48 symphony orchestras that constitute ICSOM were asked to complete a detailed medical survey. Completed questionnaires were returned by 2212 musicians from 47 of the 48 orchestras. As described in the initial overview article,³ the data from the 2212 respondents were mathematically balanced to make them representative of the total population of musicians performing on a regular basis with one or more of the 48 ICSOM orchestras. This report focuses on the 1378 respondents who play string instruments and represent the 2516 string musicians in the ICSOM orchestras.

The self-completion questionnaire asked for information about medical problems, treatments, diagnoses, and symptoms as well as demographic, health, and occupational characteristics. Of particular interest here, the musicians were given a numbered list of 59 medical problems. The list comprised 34 musculoskeletal locations (e.g., fingers on right hand, left wrist, right shoulder, right lower back) and 25 non-musculoskeletal problems (e.g., asthma, eye strain, stage fright). The musicians were first asked to "circle the numbers of ALL those problems they had experienced." They were then asked to indicate their most severe problems (up to four), with severe defined "from the point of view of its effects on your performance."

In interpreting the results described in this report, two points must be kept in mind. First, it must be remembered that the survey provides only a snapshot of the population

This report focuses on the 1378 respondents who play string instruments and represent the 2516 string musicians in the ICSOM orchestras.

of ICSOM musicians at one particular point in time. Thus, the data reflect prevalence (i.e., the percent of the population experiencing a problem), but not incidence (i.e., the likelihood of developing a medical problem). Musicians experiencing severe problems may find it necessary to leave their orchestras. Therefore, the data reported here may underestimate the incidence of medical problems.

Second, this report focuses on the problems perceived by the musicians as severely affecting their performance. The report is *not* based on the four most severe problems regardless of the effect on performance. Many musicians indicated problems when they were asked about *all* their problems but recognized them as minor or not musically related; they did not nominate them as severe, even though there was space left on the questionnaire to do so. For example, almost half of the musicians indicating only one severe problem (in terms of its effect on their performance) had one or more additional problems which they did not view as severe. Thus, to a large extent, minor problems with no effects on performance have not been included in the analyses.

Results

Prevalence of Musculoskeletal and Non-musculoskeletal Problems

Table 1 shows the prevalence of severe medical problems in all musicians (Column 1), by instrument group (Columns 2 through 5), and by gender (Columns 6 and 7). Chi-square tests of statistical significance were conducted to determine whether the percentage of the population reporting a problem differed by instrument group ($df = 3$) and/or by gender ($df = 1$). The table gives the results of these tests; an asterisk alongside the percentages in column 5 indicates a significant difference in prevalence as a function of instrument group and an asterisk alongside the percentages in column 7 indicates a significant difference by gender.

A statistically significant relationship between gender and prevalence is simple to interpret. Since there are only two categories, it means that males differ from females in the percentage reporting a problem. A significant finding by instrument group must be interpreted with more care since there are more than two categories of instrument group. A statistically significant relationship between prevalence and instrument group means that the percentages reporting a problem differ from one instrument to the next but it does not indicate exactly which groups are different. Furthermore, it is statistically inappropriate to conduct all possible pairwise comparisons of the four. Thus, if one finds a significant effect of instrument group, one must examine the pattern of percentages to determine how the groups differ.

As was described in the introduction and as shown on the bottom line of the table, considering the total population of ICSOM musicians, the prevalence of severe medical problems was related to both instrument group (marginally, $p < .10$) and gender ($p < .01$). Specifically,

TABLE 1. Prevalence of Severe Musculoskeletal and Non-musculoskeletal Problems Overall, by Instrument Group, and by Gender

	<i>By Instrument Group¹</i>					<i>By Gender²</i>	
	<i>Overall</i>	<i>String</i>	<i>Wood</i>	<i>Brass</i>	<i>Other</i>	<i>Male</i>	<i>Female</i>
	1	2	3	4	5	6	7
Musculoskeletal	58%	66%	48%	32%	60%**	52%	70%**
Non-musculoskeletal	50	46	57	65	46**	49	54*
Some type of severe problem	76	78	72	75	75 ^m	72	84**

¹Results of chi-square tests (df = 3) of prevalence by instrument group indicated next to percentages in column 5.

²Results of chi-square tests (df = 1) of prevalence by gender indicated next to percentages in column 7.

^mp < .10 *p < .05 **p < .01

severe medical problems were more prevalent among string players than among woodwind, brass, or other musicians (i.e., keyboard, harp, tympani, and percussion). In addition, severe medical problems were more prevalent among women than among men.

More importantly, Table 1 also shows the findings separately for musculoskeletal and non-musculoskeletal problems. It can be seen from columns 2 through 5 that the higher prevalence of severe medical problems among string players is confined to musculoskeletal problems. Fully 66% of string players reported experiencing a severe musculoskeletal problem. This percentage is much higher than that among players of woodwind (48%) and brass (32%) instruments but only slightly higher than that among players of other instruments (60%). In contrast, string players have the lowest prevalence of non-musculoskeletal problems (46%). This percentage is lower than that found among woodwind (57%) and brass (65%) players and is the same as that found among players of other instruments.

It is clear from columns 6 and 7 in Table 1 that the gender difference in prevalence of medical problems is more pronounced for the musculoskeletal problems than for the non-musculoskeletal problems. Compared to 52% among the male musicians performing with the 48 ICSOM orchestras, a significantly larger percentage of female musicians (70%) reported at least one musculoskeletal problem that was severe in terms of its impact on their performance. By contrast, when severe non-musculoskeletal problems are considered, the prevalence is only slightly (albeit significantly) higher among females (54%) than among males (49%).

Given this higher prevalence of musculoskeletal problems among string players and among female musicians, a detailed examination of the prevalence of musculoskeletal problems among string players with special attention to gender differences is in order.

Prevalence by 21 Musculoskeletal Locations

Table 2 presents the prevalence of severe musculoskeletal problems at each of 21 musculoskeletal locations. Since few musicians indicated severe problems with respect to the lower body locations (e.g., left ankle, right knee, left hip), these locations were combined. Column 1 presents the per-

centages reporting a problem among all string musicians, columns 2 through 5 present these figures for musicians playing each of the string instruments, and columns 6 and 7 present the prevalence rates for male and female string players, respectively. The results of the chi-square significance test for instrument (df = 3) are presented alongside the percentages in column 5, and those for gender (df = 1) are next to the percentages in column 7.

Using the proportion reporting a severe problem as the dependent variable, a repeated measures multivariate analysis of variance was conducted with two between-subjects factors: gender (male and female) and string instrument (violin, viola, and cello); and two within subjects factors: location (fingers, hands, wrist, forearm, elbow, shoulder, neck, upper back, middle back, and lower back) and side (right and left). These analyses revealed statistically significant effects of gender ($F[1,1177] = 22.79, p < .001$), location ($F[9,1169] = 23.94, p < .001$), side ($F[1,1177] = 3.21, p < .10$), location by side ($F[9,1169] = 12.26, p < .001$), gender by location by side ($F[9,1169] = 2.20, p < .05$), and gender by string by location ($F[18,2240] = 1.72, p < .05$). The latter effect is key in that it implies that the gender differences are not overall effects but depend on both string instrument and musculoskeletal location.

Prevalence at each location over all string players. From column 1 in Table 2, it is clear that the shoulder, neck, and lower back are particularly problematic locations among string players. More specifically, 16% of string players reported a severe problem with the right shoulder and 14% with the left shoulder; 14% listed a problem with each side of the neck; 14% indicated a severe problem with the right lower back and 12% with the left lower back.

Two other locations worth noting are the left hand and the fingers on the left hand. With respect to each of these locations, 12% of string players reported musculoskeletal problems that were severe enough to affect their performance. Interestingly, in contrast to most of the locations, there is distinct right-left asymmetry with respect to the fingers and the hands. That is, at these two locations, severe musculoskeletal problems are significantly more prevalent on the left side (the side that fingers the strings) than on the right side (the side that controls the bow).

Prevalence at each location by string instrument. From columns 2 through 5, it can be seen that, over all mus-

TABLE 2. Percentage of String Musicians Indicating Severe Musculoskeletal Problem Overall, by Instrument, and by Gender

		By Instrument ¹					By Gender ²	
		Overall	Violin	Viola	Cello	Bass	Male	Female
		1	2	3	4	5	6	7
Sample size		1378	695	250	241	192	776	602
All Locations		66%	65%	69%	70%	65%	62%	72%**
By location:								
Fingers	Right	4	4	5	6	3	4	5
	Left	12	10	11	16	12	11	13
Hand	Right	6	6	5	7	5	5	7 ^m
	Left	12	13	12	12	11	11	14 ^m
Wrist	Right	7	6	6	8	7	6	7
	Left	7	5	12	7	7*	5	10**
Forearm	Right	5	5	6	3	4	4	6
	Left	6	6	7	6	5	5	7
Elbow	Right	7	7	8	9	5	6	8
	Left	5	4	5	5	6	4	5
Shoulder	Right	16	16	16	16	14	14	18
	Left	14	15	18	11	8**	11	18**
Neck	Right	14	15	17	14	10	12	18**
	Left	14	16	16	11	6**	11	18**
Upper Back	Right	11	11	15	10	5**	8	15**
	Left	10	10	13	8	4**	8	11
Middle Back	Right	5	5	6	5	5	4	6
	Left	5	5	6	5	3	4	6 ^m
Lower Back	Right	14	13	11	14	22**	15	13
	Left	12	10	10	12	18**	12	12
Lower Body		3	2	3	4	6 ^m	3	3

¹Results of chi-square tests (df = 3) of prevalence by string instrument indicated next to percentages in column 5.

²Results of chi-square tests (df = 1) of prevalence by gender indicated next to percentages in column 7.

^mp < .10 *p < .05 **p < .01

culoskeletal locations, cellists (70%) and violists (69%) are slightly, but not significantly, more likely to experience at least one severe musculoskeletal problem than are violinists (65%) or bassists (65%). In contrast to these relatively small differences, large differences due to string instrument are found when the 21 separate locations are examined. As indicated by the asterisks in the table next to the percentages in column 5, the differences are statistically significant ($p < .05$) for seven of the locations and are marginally significant ($p < .10$) for one additional location.

From the bottom of the table, it can be seen that the percentage of musicians reporting severe problems in the lower back was significantly higher among bass players than among players of the other string instruments. And, although only marginally significant, a higher percentage of bassists indicated severe medical problems in lower body locations. In fact, these three locations, lower body and right and left lower back, were the only ones for which bass players had a higher prevalence of severe musculoskeletal problems than did other string musicians.

Problems in the middle back are relatively uncommon among string players and their prevalence does not seem to depend upon the string instrument that one plays. In contrast, the prevalence of upper back, neck, and shoulder problems varied significantly depending upon the instrument. At both sides of the upper back, the prevalence is lowest among bass players, highest among violists and in-

termediate among violinists and cellists. Considering the left neck, the percentage of musicians indicating a severe problem is again lowest among bassists and highest among viola players. Not surprisingly, the prevalence of left neck problems among violinists is almost as high as it is among viola players. Although not as extreme, the pattern of results for the right neck is similar to that for the left neck. At the left shoulder, prevalence is again higher among violists and violinists than among cellists and bassists. In contrast, with respect to the right shoulder, a relatively high percentage of string musicians report serious problems and the prevalence of this problem does not vary with the particular string instrument. It appears that the bowing activity shared by all four types of string players places them equally at risk with respect to problems at the right shoulder.

Similar to the findings with respect to severe middle back problems, players of all four string instruments appear to have relatively few elbow, forearm or wrist problems. The one notable exception to this is the relatively high prevalence of left wrist problems among violists. Considering the hands and fingers, it can be seen that prevalence does not vary significantly as a function of the string instrument one plays, although the prevalence of problems with the left fingers is slightly higher among cellists than among players of the other three string instruments. Finally, it is worth noting that the right-left asymmetry for the hand and fingers described above with respect to all string mu-

sicians appears when the findings are examined separately by string instrument. That is, violinists, violists, cellists, and bassists alike report experiencing more severe problems with the left (string) hand and fingers than with the right (bow) hand and fingers.

Most of the above findings are consistent with expectations concerning some of the more obvious differences in the physical activities associated with playing each instrument. As such, they provide rather strong evidence for the operation of an occupational component in the etiology of severe musculoskeletal problems among symphony orchestra musicians. Equally important, these "anticipated" findings give credence to the less obvious results, and these latter findings point to more subtle musculoskeletal consequences of playing different string instruments.

Prevalence at each location by gender. The gender difference in prevalence of severe musculoskeletal problems shown in Table 1 for all ICSOM musicians is also seen when only the string players are considered. At the top of columns 6 and 7 in Table 2, it is clear that the percentage of string players reporting at least one severe musculoskeletal problem is significantly higher among female (72%) than among male (62%) string players. When the 21 locations are considered, there are statistically significant ($p < .05$) gender differences at five locations and marginal differences ($p < .10$) at three more. Specifically, the prevalence of severe problems was higher for females at the left wrist, left shoulder, right and left neck, and right upper back. The prevalence was marginally higher among women compared to men with respect to both hands and the left middle back.

Prevalence at each location jointly by string instrument and gender. It is well known that the distribution of male and female musicians in an orchestra varies within as well as between instrument groups. Within the ICSOM orchestras, females constitute 41% of all string players; 8% of brass players, 30% of woodwind players, and 28% of the musicians playing instruments in the other group (i.e., keyboard, harp, percussion, and tympani). And, within the string players, females constitute 50% of the violinists, 43% of the violists, 39% of the cellists, and 9.5% of the bass players. Note that the percentage of players who are female decreases with the size of the string instrument, which makes it difficult to determine whether gender or instrument is the source of the findings in Table 2. For example, is the higher prevalence of left shoulder problems among violin and viola players (in contrast to cello and bass players) due to differences in the way the instruments are played? Or are these differences just a reflection of the fact that there are more women among the violin and viola players (than among the cello and bass players) and that women have more left shoulder problems than men? In order to clarify this issue, a joint consideration of gender and string instrument is necessary.

Table 3 shows the prevalence of severe musculoskeletal problems jointly by instrument and gender. For each of the 21 locations and within each of the string instruments, a

chi-square test ($df = 1$) was conducted comparing males to females in percentage reporting a problem. The results of these tests of statistical significance are presented alongside the female percentages within each string instrument.

As indicated at the top of the table, there are almost 700 violinists in the sample compared to approximately 250 violists and 250 cellists. With respect to each of these three instruments, there are sufficient numbers of male and female musicians to provide valid estimates of prevalence rates. However, the large difference in sample size between the violinists and both the violists and cellists means that the significance tests comparing gender are more powerful and more likely to yield significant results among violinists. Thus, care must be taken in comparing the number of significant gender effects across the particular string instruments. Finally, with respect to the bassists, there is a sufficient number of male, but not of female, musicians to provide valid estimates of prevalence rates. Although the percentages for female bass players are presented for comparison purposes, it must be recognized that they are based on only 22 respondents. Therefore, when examining the findings for the bass players, both the prevalence rates among females and the significance tests comparing males to females must be interpreted with extreme caution.

Note first that over all locations, and for each of the four string instruments, the percent of females reporting at least one severe problem is higher than the percent of males. These differences, however, are only statistically significant with respect to violinists and violists. More important are the findings by specific location. Here it becomes clear that, rather than being an across-the-board finding, the higher prevalence of severe musculoskeletal problems among females depends on both the particular string instrument the musician plays and the musculoskeletal location.

First, consider the findings for the left hand and wrist. For these two locations, the prevalence among females is equal to that among males for the smallest string instrument, the violin. This is not the case, however, for musicians who play the viola or the cello, two larger string instruments. Here, the prevalence among females is higher than among males. The prevalence is marginally higher in the case of problems with the left hand among violists and significantly higher for problems of the left wrist among violists and for problems of the left hand and wrist among cellists. Although not as extreme, a similar pattern is seen with respect to the right hand and wrist. That is, there are no gender differences among violinists, but among violists and cellists the prevalence of severe musculoskeletal problems in the right hand and wrist is higher among females than among males. Thus, as the size of the string instrument increases from violin to viola to cello, so does the vulnerability of women (in comparison to men) with respect to severe musculoskeletal problems at the hand and wrist. Unfortunately, there are too few women bassists in the sample to reach firm conclusions about whether these patterns continue as one moves to the largest of the string instruments.

TABLE 3. Percentage of String Musicians Indicating Severe Musculoskeletal Problem By Instrument and Gender¹

	Violin		Viola		Cello		Bass	
	M	F	M	F	M	F	M	F
Sample size	330	365	134	116	142	99	170	22
All locations	59%	71%**	63%	77%*	67%	74%	64%	73%
By location								
Fingers								
Right	4	4	5	6	7	4	2	9
Left	10	11	10	12	14	19	11	23
Hand								
Right	5	6	4	6	4	11 ^m	5	5
Left	13	13	9	17 ^m	8	18*	11	14
Wrist								
Right	7	6	3	10*	6	11	7	4
Left	4	7	6	19**	3	13**	6	9
Forearm								
Right	4	6	5	8	4	3	4	4
Left	5	7	6	8	6	5	4	14
Elbow								
Right	6	8	8	7	7	12	5	4
Left	3	5	5	6	7	3	5	14
Shoulder								
Right	15	17	11	22*	15	16	15	4
Left	12	18*	14	23	10	11	7	18
Neck								
Right	12	18*	15	20	14	14	10	9
Left	12	20**	15	17	11	12	5	9
Upper Back								
Right	8	14**	12	19	8	13	5	9
Left	11	10	11	16	7	10	4	9
Middle Back								
Right	4	6	6	6	6	7	5	4
Left	4	6	5	7	4	7	3	4
Lower Back								
Right	12	14	13	9	13	16	24	9
Left	9	12	10	9	10	15	19	9
Lower Body								
Right	2	3	3	3	3	5	6	4

¹Results of chi-square tests (df = 1) comparing males to females within each instrument indicated next to percentages in columns 2, 4, 6, and 8.
^mp < .10 *p < .05 **p < .01

As the size of the string instrument increases from violin to viola to cello, so does the vulnerability of women with respect to severe musculoskeletal problems at the hand and wrist.

A very different interaction of gender and instrument occurs with respect to the prevalence of severe musculoskeletal problems in the shoulders, neck, and upper back. Here the gender differences are difficult to summarize; first, because they are complicated, and second, because of the differential sensitivity of the statistical tests due to the larger sample size among the violinists described above. One thing is clear, however: there are practically no gender differences at these locations among cellists, whereas there are substantial gender differences among violinists and violists. Among the violinists, a significantly higher percentage of women than men reported severe problems in the left shoulder, both sides of the neck, and the right upper back. Among violists, the prevalence of problems at both shoulders and, to a lesser extent, at the right neck and both sides of the upper back, was higher among females than among males.

In comparing violinists to violists, two gender differences at the shoulder and neck locations are worth noting. First, at the right shoulder there are no gender differences among violinists but substantial ones among violists. Second, at the left neck there are no gender differences among violists but substantial ones among violinists. Unlike gender differences with respect to the hand and wrist, these rather unexpected findings cannot be attributed to the greater size or weight of the viola. Finding an explanation for these differences is an important and necessary step toward understanding the etiology of problems string musicians experience at these locations.

Although the small number female bass players prevents one from reaching any definitive conclusions, the data do suggest a pattern of gender differences among bass players which is very different from the pattern of gender differences that occur with respect to the other string instruments. While severe musculoskeletal problems in the fingers of the left hand, the left forearm, the left elbow, and the left shoulder are more prevalent among female than among male bassists, the prevalence of severe lower back problems is much higher among male than among female bassists.

Discussion

Before discussing the implications of the findings reported here, it would be useful to compare them with previous

research. Unfortunately, detailed comparisons are quite difficult for a number of reasons. First, the reports of many studies do not provide sufficiently detailed information about the population of musicians being considered to allow the computation of comparable prevalence estimates (e.g., Fry¹¹). In addition, investigators use different definitions of problems (e.g., overuse as determined by examination vs. self-reported severe musculoskeletal problem). Finally, studies often report data based on noncomparable instrument groupings (e.g., non-wind instrumentalists vs. string players).

Despite these limitations, a number of the general results reported here are consistent with previous work. First, it was found here that 66% of string players and 60% of players of other instruments (keyboard, harp, tympani, and percussion) reported at least one severe musculoskeletal problem. Caldron et al.⁸ found that 59% of a sample of non-wind instrumentalists reported a musically related injury. Given the difference in populations and in response rate, these two prevalence estimates are remarkably similar. Second, the higher percentage of musculoskeletal problems among female musicians found here replicates findings in a number of studies⁸⁻¹⁰ as does the greater vulnerability of string musicians to musculoskeletal problems.^{9,10} Third, the higher prevalence of problems in the left finger, hand, and wrist (compared to the right) has been seen in a number of other studies in the literature, including studies of general populations of musicians^{9,11} as well as studies of presenting populations.^{6,7} Finally, similar to the findings of this study, Fry¹¹ reports gender differences which seem to be a function of the particular string instrument the musician plays.

It is important to recognize, however, that the findings reported here go beyond those conducted in previous work. While these results are not projectable to the entire universe of string players in the United States, they do describe the prevalence of severe musculoskeletal problems in a major population of high-level professional instrumental musicians. And, given the high response rate, they represent this population quite well. Furthermore, although they are based on self-reports of problems rather than upon physical examination, these data provide important insights into, and allow statistical tests of, a large number of relationships among variables based on individual differences, occupational variables, and the prevalence of medical problems. This ability to test relationships and to project data to known populations should be contrasted to other research methods that provide more detailed clinical information but that are often based on small convenience samples (e.g., patients) whose relationship to a total population is unknown.

Summary

The data presented here provide strong evidence for statistically significant differences in the prevalence of severe musculoskeletal problems as a function of musculoskeletal location, the string instrument the musician plays, and gender. While many of these differences are main effects

(e.g., the prevalence of neck problems is higher than the prevalence of wrist problems; the prevalence of problems among women is higher than that among men), in most cases location, instrument, and gender interact. Thus, it is often necessary to take two or three of the variables into consideration to account for differences in prevalence. For example, considering problems with the left hand, there are no gender differences among violinists and significant gender differences among cellists; whereas, considering problems with the left neck, there are no gender differences among cellists and significant gender differences among violinists.

At a theoretical level, the findings provide a number of insights into the etiology of musculoskeletal problems among symphony orchestra musicians. Obviously, there is clear evidence for the role of occupational factors in the development of severe musculoskeletal problems. Not surprisingly, the different physical movements associated with playing different instruments seem to lead to problems at different musculoskeletal locations. The data point to a number of potential problem locations for players of different string instruments. Moreover, depending upon both the instrument and the musculoskeletal location in question, these problems may be more likely to be experienced by female rather than male string players. Medical personnel, educators, and musicians should all be aware of the musculoskeletal problems to which string players are vulnerable. This information should be useful not only in the early identification and treatment of these problems, but it should also guide the development of proper techniques to prevent their onset.

Beyond its descriptive utility, the finding that gender differences in prevalence rates occur only in certain locations for players of particular string instruments is also of theoretical importance. This finding brings into question several of the possible explanations that are often given in an attempt to account for the higher prevalence of both reported and observed medical problems among females than among males. For example, since the higher prevalence of severe musculoskeletal problems among women is *not* an across-the-board finding, but one that depends on both string instrument and musculoskeletal location, one can no longer explain the higher prevalence rates among women by suggesting that women are more at risk because of social and cultural factors, such as career difficulties or problems integrating their professional and family lives. Similarly, one can no longer attribute the higher prevalence rates in women primarily to their greater willingness to admit to medical problems, their greater sensitivity with respect to body discomforts, or their greater readiness to take medical action.

Clearly, there is a strong physical component to the increased prevalence among female string players compared to males. A close consideration of where (at which locations for which string instruments) gender differences exist and where they are absent may indicate what it is about the instrument, the technique, and/or the musician that con-

tributes to the development of a medical problem. For example, the findings of increased gender differences in problems with the hand and wrist as the size of the string instrument increases from the violin to the viola to the cello suggests that the musician's strength may be a contributing factor. Or, as suggested by a reviewer, the differences in stretch or reach due to the differences in hand size may account for this pattern of gender differences in prevalence. As a second example, the tentative finding of a higher prevalence of lower back problems among male compared to female bass players (in contrast to a lack of gender differences in lower back problems among the other three types of string musicians) could point to an aspect of technique or posture that makes male bassists vulnerable to problems at this location. And, as a third example, what is it about the violin chin rest in relation to the violinist's left neck (in contrast to that of the violist) that leads to a gender difference in prevalence among violinists but not among violists? Although these data cannot provide definitive answers to these etiologic questions, they can provide useful information necessary to further our understanding, treatment, and prevention of musculoskeletal disorders.

References

1. Kelsey J: *Epidemiology of Musculoskeletal Disorders*. New York, Oxford University Press, 1982.
2. Harman SE: Bibliography of occupational diseases of instrumental musicians. *Med Probl Perform Art* 2:155-162, 1987.
3. Fishbein M, Middlestadt SE, et al: Medical problems among ICSSOM musicians: Overview of a national survey. *Senza Sordino* 25:1-8, 1987. Reprinted in *Med Probl Perform Art* 3:1-8, 1988.
4. Hochberg FH, Leffert RD, et al: Hand difficulties among musicians. *JAMA* 249:1869-1872, 1983.
5. Lederman RJ and Calabrese LH: Overuse syndromes in instrumentalists. *Med Probl Perform Art* 1:7-11, 1986.
6. Knishkowsky MD, Lederman RJ: Instrumental musicians with upper extremity disorders: A follow-up study. *Med Probl Perform Art* 1:85-89, 1986.
7. Newmark J, Hockberg FH: "Doctor, it hurts when I play": Painful disorders among instrumental musicians. *Med Probl Perform Art* 2:93-97, 1987.
8. Caldron PH, Calabrese LH, et al: A survey of musculoskeletal problems encountered in high-level musicians. *Med Probl Perform Art* 1:136-139, 1986.
9. Manchester RA: The incidence of hand problems in music students. *Med Probl Perform Art* 3:15-22, 1988.
10. Fry HJH: Incidence of overuse syndrome in the symphony orchestra. *Med Probl Perform Art* 1:51-55, 1986.
11. Fry HJH: Patterns of over-use seen in 658 affected instrumental musicians. *Int J Music Educ* 11:3-16, 1988.
12. Verbrugge LM: Gender and health: An update on hypotheses and evidence. *J. Health Soc Beh* 26:156-182, 1985.