Injuries and Injury Risk Factors Among Members of the United States Army Band

Joseph J. Knapik, ScD,*† Sarah B. Jones, MPH, Salima Darakjy, MPH, Keith G. Hauret, MSPH, Remington Nevin, MPH, MD, Tyson Grier, MS, and Bruce H. Jones, MPH, MD

Background *This project documented injuries in the professional musical performers of the US Army Band and used a multivariate approach to determine injury risk factors.*
Methods *Injuries were obtained from a medical surveillance database. Administrative records from the Band provided fitness test scores, physical characteristics, performing unit (Blues, Ceremonial, Chorale, Chorus, Concert, Strings), and functional group (strings, winds, keyboard, vocal, percussion, brass). A questionnaire completed by 95% of the Band (n = 205) included queries on practice time, physical activity, tobacco use, and medical care.*
Results *One or more injuries were diagnosed in 44 and 53% of Band members in the years 2004 and 2005, respectively. In univariate analysis, higher injury risk was associated with higher body mass index (BMI), less physical activity, prior injury, unit, functional group, and practice duration. In multivariate analysis, less self-rated physical activity, a prior injury, and functional group were independent risk factors.*
Conclusion *In the US Army Band, about half the performers had a medical visit for an injury in a 1-year period and injury risk was associated with identifiable factors.* Am. J. Ind. Med. 50:951–961, 2007. *© 2007 Wiley-Liss, Inc.*

KEY WORDS: physical activity; physical fitness; musician; vocalist; prior injury

INTRODUCTION

Like athletes, musical performers spend considerable time developing and improving particular physical skills. These performers repetitively use specific muscle groups for long periods of time and this long-term, recurrent use may increase injury risk. Surveys that have been conducted with professional musicians have indicated that the prevalence of musculoskeletal pain symptoms range from 50 to 80% [Fry, 1986; Middlestadt and Fishbein, 1989; Fjellman-Wiklund and Sundelin, 1998; Yeung et al., 1999; Davies and Mangion, 2002]. A few studies have also identified some factors that place professional musicians at risk of musculoskeletal disorders [Middlestadt and Fishbein, 1989; Yeung et al., 1999; Davies and Mangion, 2002]. Only one study has performed a multivariate analysis of professional performers by examining and analyzing multiple risk factors in a single investigation [Davies and Mangion, 2002].

The US Army Band is a unique group of professional musicians and vocalists. All members are soldiers in the US Army but are also highly skilled, full time musical performers. The band has six performing units including a Blues Jazz Ensemble, a Ceremonial unit, a Chorale, Chorus, Concert Band, and a Strings unit. The Band has a very demanding rehearsal and performance schedule and is active year round.

The purpose of the present project was to examine the professional performers in the US Army Band. Specifically,

US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland 21010

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†Research Physiologist.
*Correspondence to: Joseph J. Knapik, Directorate of Epidemiology and Disease Surveillance, 1570 Stark Road, US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD 21010. E-mail: joseph.knapik@apg.amedd.army.mil

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this article reports on the documented injuries, injury incidence, and examines multiple potential risk factors for injuries in this group of professionals.

METHODS

Questionnaires were distributed to all 217 performing members of the US Army Band with an explanation of the purposes of the project. The questionnaire was constructed based on a review of the literature and information from structured focus group interviews with 63 Band members. The 63 Band members were interviewed in 10 separate 2 hr sessions with four interviewers in each session. The interview involved perceived risk factors for pain, soreness, discomfort, and injuries related to practice and performance. A preliminary questionnaire was designed prior to the focus group and focus group members were asked to review and critique this preliminary questionnaire. The final questionnaire administered to the entire Band asked about (1) the frequency and duration of practice, rehearsal, and performance, (2) the frequency and duration of exercise and sport activities, (3) tobacco use, and (4) medical care. The questionnaire and project procedures were evaluated and approved by a review board.

Information obtained directly from Band administrative records included individual arrival dates at the Band, performing unit, primary musical instrument, physical characteristics (height and weight), and fitness test results. Fitness test results were obtained from the most recent Army Physical Fitness Test (APFT) given on a biannual basis to all military members. The APFT consisted of three events, the maximum number of push-ups completed in 2 min, the maximum number of sit-ups completed in 2 min, and a 2-mile run. For push-ups, an individual was required to lower his or her body in a generally straight line to a point where his or her upper arm was parallel to the ground, and then return to the starting point with elbows fully extended. For sit-ups, an individual bent his or her knees to a 90° angle, interlocked fingers behind the head, and a second person held the individual's ankles to keep the heels firmly on the ground. The individual raised the upper body to a vertical position so that the base of the neck was anterior to the base of the spine and then returned to the starting position. Run performance was measured as the time to complete the 2-mile distance. Weight and height were obtained during the APFT using a balance scale and stadiometer.

Additional demographic information was obtained from the Defense Manpower Data Center (DMDC) database. These data included date of birth, gender, educational status, marital status, and race.

Each time a Band member reported to a clinic or hospital, the diagnosis for that visit was recorded as an International Classification of Diseases, version 9 (ICD-9) code in a database called the Standard Ambulatory Data Record (SADR). The Defense Medical Surveillance Activity provided ICD-9 codes from the SADR for all outpatient medical encounters occurring in calendar years 2004 and 2005. A specific group of ICD-9 codes was selected to define an injury case as described previously for the comprehensive injury index [Knapik et al., 2004]. The total number of injury visits was compiled for all Band members. New injury diagnoses in each year were determined by examining the first occurrence of a particular ICD-9 code. Note that this was a ''new'' injury diagnosis only in the sense that it was the first occurrence of that diagnosis within the year. Similar or identical ICD-9 codes within the same year were considered follow-up visits for the same problem. The cumulative incidence of injury was calculated as:

$$\Sigma \text{ Individuals with one or more injuries} / \text{total number of individuals} \times 100\%$$

The new injury diagnoses rate was calculated as:

$$\Sigma \text{ New injury diagnoses} / \Sigma \text{ total time at risk for all individuals} \times 100\%$$

Data Analysis

Body mass index (BMI) was calculated as weight/height^2 [Knapik et al., 1983]. Age was calculated from date of birth. Based on past literature, Band members were placed into six functional groups dependent on the instrument they played: brass, strings, woodwinds, percussion, keyboard, or vocal [Manchester, 1988; Middlestadt and Fishbein, 1989; Larsson et al., 1993; Morse et al., 2000].

Statistical Package for the Social Sciences (SPSS) version 13.0 was used for all analyses. Descriptive statistics were calculated for injuries, physical characteristics, and fitness variables. Logistic regression was used to examine the relationship between injuries and the various independent variables. The dependent variable in the regression analysis was injury in 2005. Independent variables in the regression analysis included physical characteristics, physical fitness variables, demographics, injury in 2004, and questionnaire responses. Univariate logistic regression was performed examining injury risk among various levels of each independent variable. Simple contrasts were used with a selected baseline level (risk defined as 1.00) for each categorical variable. Continuous variables (height, weight, BMI, push-ups, sit-ups, 2-mile run) were converted to categorical variables by establishing quartiles (four approximately equal groups) based on the distribution of the variable. Age was converted into six categories. Some adjacent ordinal questionnaire responses were combined to

increase the statistical power of the comparisons. Multivariate analysis was performed with a backward stepping logistic regression procedure using the Wald statistic and $P < 0.10$ to determine variable removal from the model. All independent variables with a univariate P-value ≤ 0.25 were included in the initial multivariate logistic regression [Hosmer and Lemeshow, 1989].

RESULTS

Of the 217 Band members, 205 returned questionnaires for a response rate of 95%. Table I shows descriptive data on age, height, weight, BMI, and APFT scores of the Band members. All three APFT scores were not available for all Band members so the sample sizes are shown in Table I. The average $\pm$ SD time as a member of the Band was 11.7 ± 8.0 years.

In 2004, there were 90 soldiers who had a total of 151 new injury diagnoses and 504 follow-up visits. In 2005, there were 108 soldiers who had a total of 152 new injury diagnoses and 439 follow-up visits. The overall cumulative incidence of injury was 43.9% in 2004 and 52.7% in 2005. The new injury diagnoses rate was 73.7 injuries/100 person-years in 2004 and 74.1 injuries/100 person-years in 2005.

Table II shows the new injury diagnoses by ICD-9 code groups. In 2004, the code groups with the largest number of cases were unspecified joint disorders (719 code group), other spinal disorders (723–724 code group), peripheral enthesopathies (726 code group), strains and sprains of the lower body (843–845 code group), and strains and sprains of the lower back (846–847 code group). In 2005, the ICD-9 code groupings with the largest number of cases were other spinal disorders (723–724 code group), strains and sprains of the lower body (843–845 code group), unspecified joint disorders (719 code group), and sprains and strains of the back (846–847 code group).

Table III shows the anatomic locations of the new injury diagnoses. In most cases, an anatomic location could be derived directly from the ICD-9 code (e.g., 727.05 tenosynovitis of the wrist and hands; 726.1 rotator cuff syndrome of the shoulder) but in some cases the location was implied (e.g., 724.2 lumbago; 354.0 carpal tunnel syndrome). Table III shows that the anatomic location with the largest number of new injury diagnoses was the back. Many of the back diagnoses were ''lumbago'' (724.2 code) or backache (724.5 code) accounting for 10 new injury diagnoses in 2004 and 18 in 2005. Of the new injury diagnoses for which there was a known location, upper body injuries accounted for 66% in 2004 and 58% in 2005.

Table IV shows the univariate associations between injuries and the various independent variables. Not all Band members responded to each question so sample sizes are shown. Band members were at higher injury risk if they had higher BMI, performed less strength training or physical activity, rated themselves as less physically active, or had been injured in the previous year. Among the factors relating to Band activities, performing unit, functional group, and practice duration were related to injury risk.

Table V shows the results of the backward stepping multivariate logistic regression. There were 202 Band members with complete data and 68% of them were correctly classified by the final model. Less self-rated physical activity, a prior injury in 2004 and functional group were independent risk factors for injuries.

DISCUSSION

This is the first investigation providing documented injury incidence in a group of full-time professional musical performers. The only previous studies on injury incidence involved music students [Manchester, 1988; Manchester and Flieder, 1991; Cayea and Manchester, 1998] and previous studies of professional musicians have involved self-reports of musculoskeletal pain syndromes [Fry, 1986; Hiner et al., 1987; Middlestadt and Fishbein, 1989; Blum and Ahlers, 1994; DeSmet et al., 1998; Fjellman-Wiklund and Sundelin, 1998; Yeung et al., 1999; Davies and Mangion, 2002]. The present project indicated that about half of all US

TABLE I. Physical Characteristics and Fitness Variables

	Men		Women		Men and women	
	N	Mean $\pm$ SD	N	Mean $\pm$ SD	N	Mean $\pm$ SD
Age (years)	159	39.8 ± 7.7	46	38.3 ± 8.4	205	39.4 ± 7.8
Height (cm)	159	179.3 ± 6.4	46	164.3 ± 6.6	205	175.9 ± 8.9
Weight (kg)	159	85.1 ± 11.4	46	61.3 ± 8.3	205	79.8 ± 14.7
BMI (kg/m^2)	159	26.4 ± 2.8	46	22.7 ± 2.6	205	25.6 ± 3.2
Push ups (reps)	147	48 ± 14	39	27 ± 11	186	43 ± 16
Sit-ups (reps)	152	54 ± 14	42	59 ± 17	194	55 ± 15
Two-mile run (min)	126	16.2 ± 1.4	35	18.6 ± 1.8	161	16.7 ± 1.8

TABLE II. New Injury Diagnoses

	2004		2005	
ICD-9 code groups	**N**	**Proportion (%)**	**N**	**Proportion (%)**
354–355 neuritis	9	6.0	4	2.6
715–716 osteoarthritis	2	1.3	4	2.6
717–718 internal derangement of joints	5	3.3	3	2.0
719 unspecified joint disorders	20	13.2	17	11.2
721 spondylosis	2	1.3	0	0.0
722 intervertebral disk disorders	7	4.6	6	3.9
723–724 other spinal disorders	16	10.6	26	17.1
726 peripheral enthesopathies	14	9.3	7	4.6
727 other disorders of synovium, tendon, and bursa	4	2.6	2	1.3
728 disorders of muscle, ligament, fascia	6	4.0	8	5.3
729 other soft tissue disorders	7	4.6	4	2.6
733 other bone, joint disorders	2	1.3	4	2.6
736 acquired deformities of limbs	8	5.3	9	5.9
739 nonallopathic lesions	5	3.3	0	0.0
805–818 upper body fracture	1	0.7	2	1.3
820–829 lower body fracture	0	0.0	3	2.0
835–837 lower body dislocation	1	0.7	1	0.7
840–842 sprains/strains upper body	5	3.3	5	3.3
843–845 strains/sprains lower body	11	7.3	19	12.5
846–847 strains/sprains back	12	7.9	10	6.6
848 strains/sprains other	1	0.7	3	2.0
870–897 open wounds	7	4.6	6	3.9
910–919 abrasions	3	2.0	4	2.6
920–924 contusions	2	1.3	3	2.0
959 unspecified injuries	1	0.7	2	1.3

Army Band members experienced injuries in each of the 2 years examined. Most of these injuries occurred in the upper body, especially the back, but lower body injuries were also prevalent. Risk factors for injuries included higher BMI, less physical activity, previous injury, performing unit, functional group, and practice duration. When considered in a multivariate model, lower physical activity, prior injury, and functional group were independent injury risk factors.

In previous studies, musicians have reported musculoskeletal symptoms at multiple anatomic sites. Most studies report the fingers, hands, and wrist as the region with the highest symptoms prevalence ranging from 13 to 63% of those sampled [Hochberg et al., 1983; Caldron et al., 1986; Fry, 1986, 1987; Revak, 1989; Larsson et al., 1993; DeSmet et al., 1998; Blackie et al., 1999; Shields and Dockrell, 2000; Pak and Chesky, 2001; Sadeghi et al., 2004]. Other affected areas include the neck, shoulders, arms, and back [Caldron et al., 1986; Fry, 1986, 1987; Hiner et al., 1987; Middlestadt and Fishbein, 1989; Revak, 1989; Larsson et al., 1993; Fjellman-Wiklund and Sundelin, 1998; Blackie et al., 1999; Shields and Dockrell, 2000; Ackerman and Adams, 2003]. Studies that include the lower body find that only 2–9% of musicians report symptoms in this area [Caldron et al., 1986; Middlestadt and Fishbein, 1989; Larsson et al., 1993; Fjellman-Wiklund and Sundelin, 1998; Ackerman and Adams, 2003]. Contrary to these data, we found only about 9% of injuries involved the wrist and hands while 34% to 42% of injury medical visits involved the lower body. Part of this difference many be due to the methodology and outcome definitions (musculoskeletal symptoms by questionnaire versus diagnoses by a medical care provider). Also, the studies cited above involve students, teachers, or professional musicians who are likely to be seated most of the time. Many Army Band members perform on their feet, especially if they are in the chorale, chorus, ceremonial, or string ensembles. One study [Harman, 1993] involving the Baltimore Colts marching band found that the proportion of musicians reporting musculoskeletal symptoms (primarily pain and stiffness) in the upper extremities, lower extremities, and lumbar region was 36, 22, and 41%, respectively. The proportional distribution of these anatomic locations was somewhat similar to that of the present study despite methodological differences.

TABLE III. Anatomical Distribution of New Injury Diagnoses

		2004		2005	
Anatomical area	**Anatomical location**	**N**	**Proportion (%)**	**N**	**Proportion (%)**
Upper body	Head/face	4	2.6	0	0.0
	Neck	13	8.6	8	5.3
	Chest	1	0.7	2	1.3
	Shoulder	12	7.9	11	7.2
	Forearm	4	2.6	4	2.6
	Elbow	6	4.0	3	2.0
	Wrist	8	5.3	4	2.6
	Hand	2	1.3	8	5.3
	Hand and wrist	3	2.0	0	0.0
	Fingers	2	1.3	1	0.7
	Back	29	19.2	34	22.3
Lower body	Pelvis and thigh	6	4.0	8	5.3
	Knee	12	7.9	13	8.6
	Calf/shin	13	8.6	12	7.9
	Ankle	4	2.6	5	3.3
	Foot	8	5.3	14	9.2
	Ankle and foot	10	6.6	16	10.5
	Toe	2	1.3	1	0.7
Unspecified		12	7.9	8	5.3

Both performing unit and functional group were risk factors for injuries, although only functional group was an independent injury risk factor. The keyboard players had the highest injury risk but the small sample size and wide confidence intervals of the odds ratios suggests caution in interpretation. Other studies [Manchester, 1988; Manchester and Flieder, 1991; Zaza, 1992] have demonstrated high risk for keyboard players. This may be related to the forces required to strike the keys on some instruments and the wide finger abduction necessary to play some chords. The strings unit and the string functional group also had high risk in consonance with other studies involving both univariate [Fry, 1986, 1987; Lockwood, 1988; Manchester, 1988; Middlestadt and Fishbein, 1989; Larsson et al., 1993; Cayea and Manchester, 1998; Zetterberg et al., 1998; Morse et al., 2000] and multivariate [Zaza and Farewell, 1997; Davies and Mangion, 2002] analysis. Others [Zaza and Farewell, 1997] have hypothesized that the higher injury rate for string players may be related to the positions required to play these instruments. Instruments like the violin, viola, cello, and double bass require the musician to hold the upper arms in shoulder abduction for extended times. Long periods of shoulder abduction have been shown to increase the incidence of discomfort and musculoskeletal problems [Chaffin, 1973; Corlett et al., 1979; Bjelle et al., 1981]. In addition, it has been reported that string players tend to start at an earlier age than other instrumentalists and require more time to master the instrument. This long exposure time may contribute to long-term problems [Davies and Mangion, 2002]. String players tend to play more notes during performances, require more movements on their instruments [Fry, 1986; Brandfonbrener, 1994], and tend to practice longer [Zaza, 1992] than players of other instruments. Factors such as these may contribute to problems for stringed instrument players.

The hypothesis was tested that some functional groups in the US Army Band tended to routinely rehearse, practice, and perform for longer durations than other performers. Reported days per week of practice, rehearsal, and performance were multiplied by the midrange value of practice durations from the questionnaires. Results are in Table VI. String players had the greatest amount of time per week but it was only about 1 hr/week longer, on average, than the keyboard and brass players. The string, keyboard, and brass performer's times were 5 to 9 hr/week longer than the percussion, wind, and vocal performers. For all functional groups in the Band, the average range of estimated practice, rehearsal, and performance times (17 to 26 hr/week) was similar to that reported by other professional performers [Hiner et al., 1987; Yeung et al., 1999].

Low self-reported physical activity on three questionnaire items was associated with injury risk. Only the response to the question asking for a global self-assessment of physical activity [Washburn et al., 1987] was an independent injury

TABLE IV. Proportion Injured and Univariate Logistic Regression Results for Independent Variables

					Logistic Regression	
Variable grouping	**Variable**	**Level of Variable**	**N**	**Proportion Injured (%)**	**Odds ratio (95% CI)**	***P*-value (from Wald statistic)**
Physical characteristics	Gender	Men	159	52.2	1.00	Reference
		Women	46	54.3	1.09 (0.56–2.11)	0.80
	Age	22.0–30.0 years	23	43.5	1.00	Reference
		30.1–35.0 years	44	59.1	1.88 (0.68–5.21)	0.23
		35.1–40.0 years	36	44.4	1.04 (0.36–2.99)	0.94
		40.1–45.0 years	37	56.8	1.71 (0.60–4.88)	0.32
		45.1–50.0 years	35	60.0	1.95 (0.67–5.66)	0.22
		>50.0 years	30	46.2	1.11 (0.36–3.44)	0.85
	Height	150–167 cm	45	57.8	1.52 (0.69–3.34)	0.30
		168–175 cm	52	46.2	0.95 (0.45–2.02)	0.90
		176–180 cm	51	60.8	1.72 (0.81–3.70)	0.16
		181–193 cm	57	47.4	1.00	Reference
	Weight	45–71 kg	52	53.8	1.00	Reference
		72–80 kg	51	45.1	0.70 (0.32–1.53)	0.38
		81–90 kg	52	55.8	1.08 (0.50–2.34)	0.84
		91–120 kg	50	56.0	1.09 (0.50–2.38)	0.83
	Body mass index	17.1–23.6 kg/m^2	52	46.2	1.00	Reference
		23.7–25.5 kg/m^2	54	46.3	1.01 (0.47–2.16)	0.99
		25.6–27.3 kg/m^2	50	56.0	1.49 (0.68–2.24)	0.18
		27.4–36.9 kg/m^2	49	65.3	2.31 (1.07–2.61)	0.03
Physical fitness	Push-ups	13–35 repetitions	40	57.5	1.68 (0.72–3.92)	0.24
		36–40 repetitions	52	51.1	1.29 (0.57–2.91)	0.54
		41–51 repetitions	47	48.1	1.15 (0.52–2.53)	0.74
		52–132 repetitions	47	44.7	1.00	Reference
	Sit-ups	30–43 repetitions	49	55.1	1.09 (0.49–2.40)	0.84
		44–51 repetitions	49	57.1	1.18 (0.53–2.62)	0.69
		52–66 repetitions	47	40.4	0.60 (0.27–1.35)	0.22
		67–111 repetitions	49	53.1	1.00	Reference
	2-mile run	12.0–15.4 min	39	46.2	1.00	Reference
		15.5–16.4 min	39	43.6	0.90 (0.37–2.20)	0.82
		16.5–17.8 min	46	50.0	1.17 (0.50–2.74)	0.72
		17.9–22.8 min	36	52.8	1.30 (0.52–3.23)	0.55
Demographics	Educational status[a]	High school/some college	27	59.3	1.22 (0.51–2.92)	0.65
		Bachelor's degree	75	49.3	0.81 (0.44–1.51)	0.52
		Master's degree or higher	92	54.3	1.00	Reference
	Martial status[a]	Single	35	57.1	1.00	Reference
		Married	147	53.7	0.87 (0.41–1,83)	0.72
		Other	16	43.8	0.58 (0.18–1.92)	0.38
	Race[a]	White	178	51.7	1.00	Reference
		Black	16	50.0	0.94 (0.34–2.60)	0.90
		Other	7	71.4	2.34 (0.44–12.36)	0.32
Lifestyle characteristics	Aerobic training	0–1 days/week	15	66.7	1.59 (0.49–5.124)	0.44
		2–3 days/week	120	49.2	0.77 (0.43–1.39)	0.38
		4–7 days/week	70	55.7	1.00	Reference

TABLE IV. (*Continued*)

					Logistic Regression	
Variable grouping	**Variable**	**Level of Variable**	**N**	**Proportion Injured (%)**	**Odds ratio (95% CI)**	***P*-value (from Wald statistic)**
	Strength training	0–1 days/week	57	57.9	2.02 (0.90–4.55)	0.09
		2–3 days/week	106	54.7	1.78 (0.86–3.67)	0.12
		4–7 days/week	42	40.5	1.00	Reference
	Sports activity	0–1 days/week	154	53.9	1.17 (0.48–2.86)	0.73
		2–3 days/week	29	48.3	0.93 (0.31–2.83)	0.90
		4–7 days/week	22	50.0	1.00	Reference
	Other physical activity	0–1 days/week	55	63.6	2.36 (1.09–5.09)	0.03
		2–3 days/week	93	50.5	1.38 (0.70–2.71)	0.35
		4–7 days/week	54	42.6	1.00	Reference
	Self-rated physical activity	Much to somewhat more active	134	52.2	1.00	Reference
		About the same	50	42.0	0.66 (0.34–1.28)	0.22
		Somewhat to much less active	18	83.3	4.57 (1.27–16.53)	0.02
	Cigarette smoking	Never	176	44.8	1.00	Reference
		Quit	18	51.7	1.34 (0.35–5.15)	0.67
		Smoker	9	61.1	1.96 (0.39–9.93)	0.41
Medical factors	Injury in 2004	No	115	41.7	1.00	Reference
		Yes	90	66.7	2.79 (1.57–4.96)	<0.01
	Satisfaction with medical care	Completely to reasonably satisfied	131	50.4	1.00	Reference
		Borderline	45	55.6	1.23 (0.62–2.43)	0.55
		Moderately to extremely unsatisfied	25	56.0	1.25 (0.53–2.96)	0.61
Band activities	Unit	Strings	20	80.0	6.07 (1.83–20.14)	<0.01
		Chorale	11	72.7	4.05 (0.99–16.64)	0.05
		Blues	17	70.6	3.64 (1.15–11.52)	0.03
		Chorus	27	59.3	2.21 (0.90–5.48)	0.09
		Ceremonial	68	46.8	1.33 (0.67–2.68)	0.42
		Concert	68	39.7	1.00	Reference
	Functional group	Winds	38	23.7	1.00	Reference
		Keyboard	5	80.0	12.88 (1.27–130.55)	0.03
		Strings	32	75.0	9.67 (3.23–28.90)	<0.01
		Percussion	16	62.5	5.37 (1.53–18.90)	0.01
		Vocal	26	61.5	5.16 (1.74–15.30)	<0.01
		Brass	88	51.1	3.37 (1.43–7.94)	<0.01
	Time in band	1.0–4.7 years	50	54.4	1.22 (0.56–2.67)	0.62
		4.8–9.6 years	50	54.4	1.22 (0.56–2.67)	0.62
		9.7–16.5 years	50	54.4	1.22 (0.56–2.67)	0.62
		16.6–33.9 years	51	49.0	1.00	Reference
	Practice, rehearsal, and performance frequency	2–5 days/week	67	49.3	1.00	Reference
		6 days/week	76	56.6	1.34 (0.69–2.60)	0.38
		7 days/week	62	51.6	1.10 (0.55–2.19)	0.79

(*Continued*)

TABLE IV. (*Continued*)

					Logistic Regression	
Variable grouping	**Variable**	**Level of Variable**	**N**	**Proportion Injured (%)**	**Odds ratio (95% CI)**	***P*-value (from Wald statistic)**
	Practice, rehearsal, and performance duration	≤60 min/day	50	62.1	1.00	Reference
		61–90 min/day	45	40.0	0.41 (0.18–0.93)	0.03
		91–120 min/day	57	47.4	0.55 (0.25–1.19)	0.13
		>120 min/day	52	59.6	0.91 (0.52–2.01)	0.52

[a]Does not include unknowns. In all cases, unknowns had little effect on *P*-values.

risk factor, possibly because of collinearity among the activity questions. Prior studies have indicated low levels of previous physical activity are associated with higher current injury risk [Jones et al., 1993; Shaffer et al., 1999; Knapik et al., 2001; Rauh et al., 2006b]. Physical activity of the proper intensity, frequency, and duration can increase aerobic fitness, bone strength, muscle strength, and general health and can reduce body fat [ACSM, 1998; Blair et al., 2001; Kell et al., 2001; Ross and Janssen, 2001; Kohrt et al., 2004]. These factors may assist in reducing susceptibility to injury [Knapik et al., 2006a]. Studies among music students and professional musicians have indicated that lower physical activity increases the risk of musculoskeletal pain symptoms [Roach et al., 1994; Yeung et al., 1999]. With regard to the specific types of physical training that might be most beneficial, one study found that resistance training programs that emphasized the upper body and that improved either muscle strength or muscular endurance resulted in reduced musculoskeletal symptoms in music students [Ackerman et al., 2002].

High BMI increased the likelihood of injury in consonance with many other studies employing military [Reynolds et al., 1994; Darakjy et al., 2003; Hauret et al., 2003; Knapik et al., 2006b,c] and civilian [Macera et al., 1989a,b; Spaine and Bollen, 1996; Werner, 1999; Engkvist et al., 2000; Anton et al., 2002] samples. There is contradictory data on the influence of BMI on musculoskeletal symptoms in musicians. Roach et al. [1994] found no association between BMI and musculoskeletal symptoms but surveyed a young student population where it might have been difficult to get a broad BMI range that might have allowed easier identification of risk differences, if present. In multivariate analysis, Zaza and Farewell [1997] found higher BMI to be a significant risk factor for musculoskeletal symptoms. They used a much more diverse population of students and professional musicians which may have had a broader range of BMIs. Likewise, the population in the present project had a wide span of BMI values with about 95% of the sample ranging between 19.3 and 31.9 kg/m^2 (based on standard deviation).

Prior injury in 2004 was independently associated with injury in 2005. Studies in athletes [Marti et al., 1988; Macera et al., 1989b; Walters et al., 1989; Knowles et al., 2006; Rauh et al., 2006b], industrial workers [Forde et al., 2005], and

TABLE V. Multivariate Logistic Regression Results

Variable	**Level of variable**	**N**	**Logistic regression odds ratio (95% CI)**	***P*-value (Wald statistic from logistic regression)**
Self-rated physical activity	Much to somewhat more active	134	1.00	Reference
	About the same	50	0.60 (0.29–1.26)	0.18
	Somewhat to much less active	18	3.36 (0.86–13.10)	0.08
Functional group	Winds	38	1.00	Reference
	Strings	32	11.60 (3.63–37.01)	<0.01
	Keyboard	5	14.17 (1.18–170.29)	0.04
	Vocal	26	4.97 (1.59–15.5)	<0.01
	Percussion	16	4.55 (1.20–17.27)	0.03
	Brass	85	2.88 (1.17–7.10)	0.03
Injury in 2004	No	114	1.00	Reference
	Yes	88	2.82 (1.49–5.34)	<0.01

TABLE VI. Calculated Weekly Performance, Practice, and Rehearsal Time by Functional Group

Functional group	N	Mean ± SD (hr/week)
Strings	31	26.3 ± 9.3
Keyboard	6	25.3 ± 13.2
Brass	87	25.3 ± 11.4
Winds	38	19.9 ± 8.8
Percussion	16	19.8 ± 11.7
Vocal	26	17.1 ±6.0

military groups [Knapik et al., 2000; Schneider et al., 2000] have reported that prior injuries were associated with current injuries, especially if the injury had occurred in the preceding year [Marti et al., 1988; Macera et al., 1989b; Walters et al., 1989; Rauh et al., 2006b]. Many injuries may be chronic or recurrent, possibly accounting for at least part of this relationship. An analysis was performed of Band soldiers who had prior injuries in 2004 to examine this possibility. The criterion for a chronic or recurrent injury was an identical or similar diagnosis (ICD-9 code) in both 2004 and 2005. A ''similar'' diagnosis could involve (1) an anatomical location with a diagnosis in 1 year with an implied anatomical location and a similar diagnosis in another year (e.g., degenerated lumbar disc and lumbago), (2) a similar diagnosis in both years (e.g., fasciitis, unspecified, and plantar fasciitis), or (3) an anatomic location with an injury in 1 year and possible ''carry over'' effects into the next year implied by the same anatomical location (e.g., ruptured tendon, foot and arthralgia, foot). There were 90 Band members with a prior injury in 2004. Of these, 51 had a similar or identical diagnosis in both years. Thus, 57% (51/90) of Band members appeared to have injuries in 2005 that might be considered similar or identical to those seen in 2004.

In summary, this project determined that about half of all members of the US Army Band experienced an injury in a 1-year period. Most of these injuries were in the upper body (especially the back) but there were also a large number of lower body injuries. Specific risk factors for these activities were identified and these included higher BMI, less physical activity, previous injury, unit, functional group, and practice duration. These data and information from the literature suggest that increasing physical activity (especially resistance exercise) and reducing BMI may assist in reducing injuries, although this suggestion should be tested in future intervention studies.

REFERENCES

Ackerman BJ, Adams R. 2003. Physical characteristics and pain patterns of skilled violinists. Med Probl Perform Art 18:65–71.

Ackerman BJ, Adams R, Marchall E. 2002. Strength or endurance training for undergraduate music majors at a university? Med Probl Perform Art 17:33–41.

American College of Sports Medicine. 1998. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 30:975–991.

Anton D, Rodsecrance J, Merlino L, Cook T. 2002. Prevalence of musculoskeletal symptoms and carpal tunnel syndrome among dental hygienists. Am J Ind Med 42:248–257.

Bjelle A, Hagberg M, Michaelson G. 1981. Occupational and individual factors in acute shoulder-neck disorders among industrial workers. Br J Ind Med 38:356–363.

Blackie H, Stone R, Tiernan A. 1999. An investigation of injury prevention among university piano students. Med Probl Perform Art 14:141–149.

Blair SN, Cheng Y, Holder S. 2001. Is physical activity or physical fitness more important in defining health benefits? Med Sci Sports Exerc 33:S379–S399.

Blum J, Ahlers J. 1994. Ergonomic considerations in violists' left shoulder pain. Med Probl Perform Art 9:25–29.

Brandfonbrener AG. 1994. Joint laxity: Help or hindrance? Med Probl Perform Art 9:1–2.

Caldron PH, Calabrese DO, Clough JD, Lederman RJ, Williams G, Leatherman J. 1986. A survey of musculoskeletal problems encountered in high level musicians. Med Probl Perform Art 1:137–139.

Cayea D, Manchester RA. 1998. Instrument-specific rates of upper-extremity injuries in music students. Med Probl Perform Art 13:19–25.

Chaffin DB. 1973. Localized muscle fatigue-definition and measurement. J Occup Med 15:346–354.

Corlett EN, Madeley SJ, Manenica I. 1979. Posture targeting: A technique for recording working postures. Ergonomics 22:357–366.

Darakjy S, Hauret KG, Canada SE, Knapik JJ, Wells J, Hodebecke EL, Kenyon M, Marin RE, Bullock SH. 2003. Injuries and injury risk factors among armor battalion soldiers at Ft Riley, Kansas. Med Sci Sports Exerc 35:S278.

Davies J, Mangion S. 2002. Predictors of pain and other musculoskeletal symptoms among professional instrumental musicians: Elucidating specific effects. Med Probl Perform Art 17:155–165.

DeSmet L, Ghyselen H, Lysens R. 1998. Incidence of overuse syndromes in the upper limbs in young pianists and its correlation with hand size, hypermobility, and playing habits. Ann Chir Main 17:309–313.

Engkvist IL, Hjelm EW, Hagberg M, Menckel E, Ekenvall L. 2000. Risk indicators for reported over-exertion back injuries among female nursing personnel. Epidemiology 11:519–522.

Fjellman-Wiklund A, Sundelin G. 1998. Musculoskeletal discomfort of music teachers: An eight year perspective and psychosocial work factors. Int J Occup Environ Health 4:89–98.

Forde MS, Punnett L, Wegman DH. 2005. Prevalence of musculoskeletal symptoms in union ironworkers. J Occup Environ Hyg 2:203–212.

Fry JH. 1986. Overuse syndrome of the upper limb in musicians. Med J Aust 144:182–185.

Fry JJ. 1987. Prevalence of overuse (injury) syndrome in Australian music schools. Br J Ind Med 44:35–40.

Harman SE. 1993. Medical problems of marching musicians. Med Probl Perform Art 8:132–135.

Hauret KG, Darakjy S, Canada S, Knapik JJ. 2003. Injury incidence and risk factors for male military police (Army). Med Sci Sports Exerc 35: S279.

Hiner SL, Brandt KD, Katz BP, French RN, Beczkiewicz TJ. 1987. Performance-related medical problems among premier violinists. Med Probl Perform Art 2:67–71.

Hochberg FH, Leffert RD, Heller MD, Merriman L. 1983. Hand difficulties among musicians. JAMA 249:1869–1872.

Hosmer DW, Lemeshow S. 1989. Applied Logistic Regression. New York: John Wiley & Sons.

Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN. 1993. Epidemiology of injuries associated with physical training among young men in the Army. Med Sci Sports Exerc 25:197–203.

Kell RT, Bell G, Quinney A. 2001. Musculoskeletal fitness, health outcomes and quality of life. Sports Med 31:863–873.

Knapik JJ, Burse RL, Vogel JA. 1983. Height, weight, percent body fat and indices of adiposity for young men and women entering the U.S. Army. Aviat Space Environ Med 54:223–231.

Knapik JJ, McCollam R, Canham-Chervak M, Arnold S, Hoedebecke EL, DuVernoy TS. 2000. A second investigation of injuries among officers attending the US Army War College, Academic Year 2000. Technical Report No 29-HE-2682-00, Aberdeen Proving Ground: US Army Center for Health Promotion and Preventive Medicine.

Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, Jones BH. 2001. Risk factors for training-related injuries among men and women in Basic Combat Training. Med Sci Sports Exerc 33:946–954.

Knapik JJ, Darakjy S, Scott S, Hauret KG, Canada S, Marin R, Palkoska F, VanCamp S, Piskator E, Rieger W, Jones BH. 2004. Evaluation of two Army fitness programs: The TRADOC Standardized Physical Training Program for Basic Combat Training and the Fitness Assessment Program. Technical Report No 12-HF-5772B-04, Aberdeen Proving Ground, MD: US Army Center for Health Promotion and Preventive Medicine.

Knapik JJ, Darakjy S, Hauret KG, Canada S, Scott S, Rieger W, Marin R, Jones BH. 2006a. Increasing the physical fitness of low fit recruits prior to Basic Combat Training: An evaluation of fitness, injuries and training outcomes. Mil Med 171:45–54.

Knapik JJ, Jones SB, Darakjy S, Hauret KG, Bullock S, Canada S, Morrison S, Hoedebecke E, Sharp MA, Burrell L, Jones BH. 2006b. Injuries among Army wheel vehicle mechanics. Technical Report No 12-MA-7193A-06, Aberdeen Proving Ground MD: Army Center for Health Promotion and Preventive Medicine.

Knapik JJ, Jones SB, Sharp MA, Darakjy S, Hauret KG, Burrell L, Goddard D, Nevin R, Jones BH. 2006c. A prospective study of injuries and injury risk factors among United States Army wheel vehicle mechanics. Technical Report No 12-MA-7193B-06, Aberdeen Proving Ground MD: US Army Center for Health Promotion and Preventive Medicine.

Knowles SB, Marshall SW, Bowling JM, Loomis D, Millikan R, Yang J, Weaver NL, Kalsbeek W, Miller FO. 2006. A prospective study of injury incidence among North Carolina high school athletes. Am J Epidemiol 29:1209–1221.

Kohrt M, Bloomfield SA, Little KD, Nelson ME, Yingling VR. 2004. Physical activity and bone health. Position stand of the American College of Sports Medicine. Med Sci Sports Exerc 36:1985–1996.

Larsson LG, Baum J, Mudholkar GS, Kollia GD. 1993. Nature and impact of musculoskeletal problems in a population of musicians. Med Probl Perform Art 8:73–76.

Lockwood AH. 1988. Medical problems in secondary school-aged musicians. Med Probl Perform Art 3:129–132.

Macera CA, Jackson KL, Hagenmaier GW, Kronenfeld JJ, Kohl HW, Blair SN. 1989a. Age, physical activity, physical fitness, body composition and incidence of orthopeadic problems. Res Q 60:225–233.

Macera CA, Pate RR, Powell KE, Jackson KL, Kendrick JS, Craven TE. 1989b. Predicting lower-extremity injuries among habitual runners. Arch Intern Med 49:2565–2568.

Manchester RA. 1988. The incidence of hand problems in music students. Med Probl Perform Art 3:15–18.

Manchester RA, Flieder D. 1991. Further observations on the epidemiology of hand injuries in music students. Med Probl Perform Art 6:11–14.

Marti B, Vader JP, Minder CE, Abelin T. 1988. On the epidemiology of running injuries. The 1984 Bern Grand-Prix study. Am J Sports Med 16:285–294.

Middlestadt SE, Fishbein M. 1989. The prevalence of severe musculoskeletal problems among male and female symphony orchestra string players. Med Probl Perform Art 4:41–48.

Morse T, Ro J, Cherniack M, Pelletier SR. 2000. A pilot population study of musculoskeletal disorders in musicians. Med Probl Perform Art 15:81–85.

Pak CH, Chesky K. 2001. Prevalence of hand, finger, and wrist musculoskeletal problems in keyboard instrumentalists. Med Probl Perform Art 16:17–23.

Rauh MJ, Koepsell TD, Rivara FP, Margherita AJ, Rice SG. 2006a. Epidemiology of musculoskeletal injuries among high school cross-country runners. Am J Epidemiol 163:151–159.

Rauh MJ, Macera CA, Trone DW, Shaffer RA, Brodine SK. 2006b. Epidemiology of stress fractures and lower extremity overuse injuries in female recruits. Med Sci Sports Exerc 38:1571–1577.

Revak JM. 1989. Incidence of upper extremity discomfort among piano students. Am J Occup Ther 43:149–154.

Reynolds KL, Heckel HA, Witt CE, Martin JW, Pollard JA, Knapik JJ, Jones BH. 1994. Cigarette smoking, physical fitness, and injuries in infantry soldiers. Am J Prev Med 10:145–150.

Roach KE, Martinez MA, Anderson N. 1994. Musculoskeletal pain in student instrumentalists: A comparison with the general student population. Med Probl Perform Art 9:125–130.

Ross R, Janssen I. 2001. Physical activity, total and regional obesity: Dose-response considerations. Med Sci Sports Exerc 33:S521–S527.

Sadeghi S, Kazemi B, Shooshatari SMJ, Bidari A, Jafari P. 2004. A high prevalence of cumulative trauma disorders in Iranian instrumentalists. BMC Musculoskelet Disord 5:1–5.

Schneider GA, Bigelow C, Amoroso PJ. 2000. Evaluating risk of re-injury among 1214 Army Airborne soldiers using a stratified survival model. Am J Prev Med 18 (Suppl 3):156–163.

Shaffer RA, Brodine SK, Almeida SA, Williams KM, Ronaghy S. 1999. Use of simple measures of physical activity to predict stress fractures in young men undergoing a rigorous physical training program. Am J Epidemiol 149:236–242.

Shields N, Dockrell S. 2000. The prevalence of injuries among pianists in music schools in Ireland. Med Probl Perform Art 15:155–160.

Spaine LA, Bollen SR. 1996. ''The bigger they come''. The relationship between body mass index and severity of ankle fractures. Injury 27: 687–689.

Walters SD, Hart LE, McIntosh JM, Sutton JR. 1989. The Ontario cohort study of running-related injuries. Arch Intern Med 149:2561–2564.

Washburn RA, Adams LL, Haile GT. 1987. Physical activity assessment for epidemiological research: The utility of two simplified approaches. Prev Med 16:636–646.

Werner U. 1999. Ejection associated injuries within the German Air Force from 1981–1997. Aviat Space Environ Med 70:1230–1234.

Yeung EW, Chan W, Pan F, Sau P, Tsui M, Yu B, Zaza C. 1999. A survey of playing-related musculoskeletal problems among professional orchestral musicians in Hong Kong. Med Probl Perform Art 14:43–47.

Zaza C. 1992. Playing-related health problems at a Canadian music school. Med Probl Perform Art 7:48–51.

Zaza C, Farewell VT. 1997. Musicians' playing-related musculoskeletal disorders: An examination of risk factors. Am J Ind Med 32:292–300.

Zetterberg C, Backlund H, Karlsson J, Werner H, Olsson L. 1998. Musculoskeletal problems among male and female music students. Med Probl Perform Art 13:160–166.