

- and Earnings. Washington, DC: Bureau of Labor Statistics; 1981-1990:28-37 (issue no. 1 for each).
6. *Standard Industrial Classification Manual*. Washington, DC: Office of Management and Budget; 1987.
 7. US Dept of Commerce. *County Business Patterns* [state files and public use data tapes]. Washington, DC: Bureau of the Census; 1980-1988.
 8. US Dept of Commerce. *1982 Census of Agriculture* [state files and public use data tapes]. Washington, DC: Bureau of the Census; 1984.
 9. Stout NA, Bell CA. Effectiveness of source documents for identifying fatal occupational injuries: a synthesis of studies. *Am J Public Health*. 1991;81:725-728.
 10. National Center for Health Statistics. *Health, United States, 1992*. Hyattsville, Md: US Public Health Service; 1993. DHHS publication PHS 93-1232.
 11. Thomas JL. CPTED: a response to occupational violent crime. *Professional Safety*. June 1992;27-31.
 12. Crow WJ, Erickson RJ, Scott L. Set your sights on preventing retail violence. *Secur Manage*. September 1987.
 13. *Study of Safety and Security Requirements for "At-Risk Businesses."* Tallahassee, Fla: Office of the Attorney General, Dept of Legal Affairs; 1991.
 14. Windau J, Toscano G. *Workplace Homicides in 1992*. Washington, DC: US Dept of Labor, Bureau of Labor Statistics; 1994.
 15. Hammet M, Powell KE, O'Carroll PW, Clanton ST. Homicide surveillance—United States, 1979-1988. *MMWR Morb Mortal Wkly Rep*. 1992;41(SS-3):1-32.
 16. Fleming A, ed. *Fatality Facts 1990*. Arlington, Va: Insurance Institute for Highway Safety; 1990.

A Survey of Injuries among Broadway Performers

ABSTRACT

To obtain more information about injuries of Broadway performers, 313 performers appearing in 23 Broadway companies were surveyed. The percentage of performers injured was 55.5%, with a mean of 1.08 injuries per performer. Lower extremity injuries were the most common. Sixty-two percent of performers believed that their injuries were preventable. As this study reports factors that significantly increase the risk of injury for dancers and actors, it may help to heighten concern with reducing the incidence of injuries to professional performers, theatrical students, and nonprofessionals worldwide. (*Am J Public Health*. 1996;86:77-80)

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Introduction

To the audience, a Broadway production appears to be a perfectly fine-tuned exercise of precision performed eight times a week and always starting on time. However, the demands and pressures of performing on this level take their toll on actors, dancers, and singers on the Broadway stage, who frequently sustain a variety of injuries. Although surveys of injuries to professional theatrical and ballet dancers¹⁻³ and theatrical dance students⁴ have been made, little information is available about injuries to Broadway dancers and actors. To better understand the prevalence and risk factors for theatrical injuries, we conducted a survey of performers in Broadway productions and touring companies.

Methods

Sampling

With the cooperation of the staff and members of Actors' Equity Association, performers in all Broadway productions current as of February 1993, including 10 productions in New York City and 13 on tour throughout the United States, were surveyed (Table 1). The productions were predominantly musicals with varying amounts of choreography and a few dramas.

The survey was administered by the stage manager of each company, who called a cast meeting on various dates in February 1993 without announcing the

topic. An attached letter from the senior business representative of Actors' Equity Association introduced and endorsed the survey. After the questionnaires were completed by all performers who attended the company meeting, they were mailed by the stage managers to Actors' Equity Association's main office and then forwarded to the investigators. The total number of respondents was 313.

Sources of Error and Bias

Retrospective surveys present potential problems with the accuracy of the respondents' recollections. For performers, however, memories of injuries are likely to be particularly vivid since their livelihood is at stake. The assurance of confidentiality and anonymity may have also encouraged candor in this survey. Because performers who were disabled at the time of the survey were not included, the injury rate may actually be higher than described. Anecdotal information suggests that the overall number of such performers was low.

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TABLE 1—Productions Surveyed and Demographics of Broadway and Tour Performers

Production	No. Respondents	Mean Weeks in Production	Mean Physical Demands ^a	Mean Injuries per Performer	% Injured during Production	Size of Rake, in./ft ^b	Choreography in Show ^b
On Broadway							
Cats	22	146.4	4.32	1.81	72.7	1.00	3
Conversations with My Father	06	48.8	1.67	0.17	16.7	3.25	0
Crazy for You	14	56.8	3.07	1.64	85.7	0.00	3
Falsettos	10	26.6	2.90	1.20	60.0	0.00	1
Guys and Dolls	26	39.9	3.31	1.08	57.7	0.75	3
Jelly's Last Jam	07	36.1	4.00	1.00	57.1	0.00	3
Les Misérables	26	94.5	4.19	1.23	69.2	0.50	1
Miss Saigon	17	58.0	2.29	2.24	88.2	1.00	2
Phantom of the Opera	30	120.6	2.83	1.13	63.3	0.00	1
Will Rogers' Follies	12	44.8	2.33	1.33	41.7	0.00	2
Broadway totals	170	78.6	3.24	1.36	66.5	0.55	1.9
On tour							
Breaking Legs	03	39.0	2.00	0.00	0.0	0.00	0
Camelot	17	19.8	1.47	0.35	23.5	0.00	1
Cats IV	08	89.9	4.63	2.00	75.0	1.00	3
A Chorus Line	17	23.9	3.47	0.59	35.5	0.00	3
Evita	11	12.1	3.82	0.64	45.5	0.00	2
Guys and Dolls	09	19.8	2.78	0.56	44.0	0.75	3
Jesus Christ Superstar	15	09.3	3.60	1.13	60.0	1.00	2
Les Misérables	07	45.1	3.71	1.57	71.4	0.50	1
Lost in Yonkers	04	19.3	1.00	0.00	0.0	0.00	1
Phantom of the Opera	09	11.8	2.89	1.22	77.8	0.00	1
The Secret Garden	20	33.9	1.80	0.30	25.0	0.00	0
Will Rogers' Follies	20	16.9	2.50	0.65	45.0	0.00	2
The World Goes Round	03	21.3	4.33	1.67	66.7	0.00	1
Tour totals	143	25.0	2.85	0.75	42.4	0.34	1.9
Survey totals	313	54.0	3.05	1.08	55.5	0.49	1.9

^a"Mean physical demands" is a self-rating ranged from 1 (least) to 5 (most).

^bThese data were provided by Actors' Equity Association. "Choreography in show" ranged from 0 (none) to 3 (heavy).

TABLE 2—Demographics of Broadway Performers Surveyed

	Women (n = 149)		Men (n = 168)	
	Dancers (n = 89)	Actors (n = 60)	Dancers (n = 77)	Actors (n = 91)
Age, y	28.0 ± 5.5	35.1 ± 9.8	32.2 ± 8.4	37.7 ± 11.6
Age began instruction	8.5 ± 5.4	14.1 ± 6.3	15.9 ± 6.6	15.7 ± 6.6
Duration as professional, y	9.5 ± 6.0	14.6 ± 8.8	11.0 ± 8.9	16.3 ± 11.0
Height, m	1.64 ± .08	1.63 ± .08	1.77 ± .09	1.76 ± .11
Weight, kg	53.5 ± 6.4	58.4 ± 9.3	74.5 ± 9.6	77.8 ± 16.8
Body mass index (kg/m ²)	20.0 ± 2.3	22.0 ± 3.4	23.8 ± 1.9	25.0 ± 3.6
Total no. injuries as performer	3.0 ± 2.2	1.6 ± 1.6	2.3 ± 2.0	1.8 ± 1.6
Injuries in current production	1.4 ± 1.3	.9 ± 1.2	1.1 ± 1.4	.9 ± 1.1
Total missed time owing to injuries, wk	9.8 ± 21.3	1.8 ± 4.4	5.5 ± 11.9	3.2 ± 16.6
Time missed owing to current production injuries, wk	.9 ± 2.7	.4 ± 1.7	.4 ± 1.0	.5 ± 1.7
Currently weight trains, %	37.1	...	68.8	...
Currently in dance classes, %	39.3	...	31.2	...
Warms up before performing, %	92.1	...	89.6	...
Currently exercises, %	...	88.5	...	84.6

Note. Plus-minus values are means ± SD.

Statistical Analysis and Variable Selection

The survey instruments consisted of items designed to determine risk factors related to theatrical injuries. They were pretested by a physician and behavioral scientists with input from staff members, a choreographer, and performers enrolled in Actors' Equity Association. For the analysis, logistic regression was used to generate odds ratios for potential risk factors. The outcome for all analyses was whether performers responded affirmatively to the question, "Have you sustained any injuries over the course of the [current] production?" The definition of injury was based on the self-reporting of the performers and included minor as well as more severe injuries.

All variables that predicted injury with even moderate probability of significance ($P < .25$) were further explored through logistic regression modeling. This is the recommended criterion for first

variable selection before the further refinement of multivariate factors through logistic regression procedures.⁵ A stepwise prediction procedure employing the variables that met the initial criteria was used for each group (SPSS Logistic Regression: Backward-LR).⁶ These selected models were further expanded by the forced inclusion of the three covariates implemented in the prior risk factor analysis: number of weeks with the current production, number of performances with the current production, and number of minutes on stage per performance.

Results

Characteristics of the Study Population

Tables 1 and 2 summarize the demographic characteristics of the performers. Dancers and actors, respectively, sustained 5.1 and 3.0 injuries per 1000 performances and 8.4 and 2.8 injuries per 1000 hours performing on stage. For dancers and actors, respectively, 37.0% and 28.8% of injuries resulted in at least one missed performance, and 62.1% of dancers and 62.2% of actors believed that their injuries were preventable.

Risk Factors for Injury

The initial risk factor analysis identified various factors that influence the risk of injury for dancers and actors (Table 3). Final unconditional multiple logistic models included five predictor variables in each model for dancers ($\chi^2 [df = 8] = 44.4$, $P < .0001$) and actors ($\chi^2 [df = 8] = 40.1$, $P < .0001$). More than 75% of the dancers were correctly classified within each predicted group of those injured or not injured. For dancers, the adjusted odds ratios for the model variables were as follows: being female, 2.4 (95% confidence interval [CI] = 1.1, 5.2); being a professional longer, 3.8 (95% CI = 1.4, 10.50); having previously missed performing because of injury, 2.5 (95% CI = 1.2, 5.3); encountering high physical demands in their roles, 3.0 (95% CI = 1.1, 8.0); and performing on a raked stage, 3.0 (95% CI = 1.2, 7.6).

In the multivariate model, more than 73% of the actors were correctly classified within each predicted group of those injured or not injured (overall correct classification was 74.3%). For actors, the adjusted odds ratios for the model variables were as follows: having greater body mass, 2.7 (95% CI = 1.1, 6.6); having begun instruction later, 2.4 (95% CI = 1.0,

TABLE 3—Analysis of Risk Factors for Injury in the Current Productions^a

Risk Factors	Dancers (n = 166)		Actors (n = 152)	
	Adjusted OR	95% CI	Adjusted OR	95% CI
Demographic variables				
Female	1.6	0.8, 3.1	0.7	0.3, 1.4
Age				
Older	0.7	0.3, 1.5	0.9	0.4, 1.4
Younger	1.2	0.6, 2.4	0.6	0.3, 1.5
Height				
Taller	0.8	0.4, 1.8	1.2	0.5, 2.8
Shorter	0.9	0.4, 2.1	0.8	0.3, 1.9
Weight				
Greater	0.7	0.3, 1.4 ^b	2.3	1.0, 5.0 ^c
Lesser	1.2	0.6, 2.6	0.5	0.2, 1.2
Body mass				
Greater	0.9	0.4, 1.9	2.4	1.1, 5.3
Lesser	1.1	0.5, 2.4	1.0	0.5, 1.9
Career variables				
Age began instruction				
Later	0.8	0.4, 1.7 ^b	2.0	0.9, 4.4
Earlier	1.7	0.8, 3.6	1.1	0.5, 2.4
Duration as professional				
Longer	2.3	0.9, 5.6	0.9	0.6, 1.4
Shorter	0.3	0.3, 1.5	0.7	0.3, 1.5
Previously injured	2.0	1.0, 4.0	1.0	0.5, 2.0
Previously missed performing due to injury	2.4	1.2, 4.7	1.2	0.5, 2.9
Training/preparation				
Currently weight trains (exercises)	0.6	0.3, 1.2 ^b	0.5	0.2, 1.3
Currently in dance classes	1.6	0.8, 3.2
Warms up before performing	3.4	1.0, 11.1 ^c
Production features				
Physical demands of their role				
Greater	3.7	1.6, 8.8	2.6	1.1, 6.2
Lesser	0.6	0.3, 1.2	0.7	0.3, 1.5
The extent of choreography in the show				
Greater	1.3	0.6, 2.7	1.0	0.4, 2.4
Lesser	0.5	0.2, 1.1	0.2	0.1, 0.6
Performed on a raked stage	3.0	1.4, 6.2	1.1	0.6, 2.4

Note. OR = odds ratio; CI = confidence interval.

^aResults were calculated with single predictor models by using SPSS Logistic Regression,⁶ controlling for the number of performances with that production, the number of weeks with that production, and the number of minutes on stage per show. Of the total sample, 103 dancers and 74 actors were injured during their current production. All dichotomous risk factors were coded using the partial method. The continuous risk factors were coded into two additional binary variables reflecting the two extreme quartiles of risk factors' distributions in reference to the remaining distribution of that risk factor. For the variables representing demographic and career characteristics, these quartiles were developed within the gender-specific norm of each performer type.

^bPairwise interactions with the sex of the performer were examined for all for variables except the production features (which did not demonstrate gender differences). Of those variables evaluated, these significantly interacted with the sex of that performer type in predicting injury ($P < .05$).

^cThis value reached its bounds because of rounding and was statistically significant ($P < .05$).

5.8; significantly different from 1.0); currently exercising, 0.4 (95% CI = 0.2, 1.2); encountering high physical demands in their roles, 3.0 (95% CI = 1.2, 8.5); and

having a lesser amount of choreography, 0.2 (95% CI = 0.1, 0.6).

For the dancers, an additional 1.9 injuries per 1000 performances can be

attributed to the self-reported high physical demands of their roles, accounting for 31.7% of the injuries to those with high physical demands and 9.2% of the injuries to all dancers. Dancers who performed on raked stages had an additional 1.6 injuries per 1000 performances, representing 28.0% of the injuries to those who dance on raked stages and 11.2% of the injuries to all dancers.

For actors, greater body mass was associated with an additional 0.6 injuries per 1000 performances, representing 18.2% of the injuries to those with greater body mass and 4.9% of the injuries to all actors. An additional 0.7 injuries per 1000 performances can be attributed to not exercising, accounting for 21.6% of the injuries to those not exercising and 3.1% of the injuries to all actors. High physical demands of the role were associated with 0.3 additional injuries per 1000 performances, representing 11.0% of the injuries to this group and 3.3% of the injuries to all actors.

Discussion

This is the first survey of injuries to Broadway performers, and its results may be useful for the growing number of physicians who practice performing arts medicine.⁷ The survey reveals an extensive level of injuries to dancers and actors in Broadway productions and touring companies, with 55% of all performers surveyed sustaining at least one injury and 1.08 mean injuries per performer.

For dancers, the most frequent sites of injuries were the lower extremities (52%), back (22%), and neck (12%). The most common lower extremity injuries involved the knee (29%), ankle (25%), foot (20%), hip (12%), and calf (6%). These findings are consistent with prior reports of injuries to theatrical dance students and professionals^{1,4} and professional ballet dancers³ in the United States, as well as to professional dancers

of classical ballet and modern dance in the United Kingdom.²

For actors, the most frequent sites of injuries reported were the lower extremities (38%), lower back (15%), and vocal cords (17%). Surveys of injuries of actors have not been previously reported. The majority of injuries for both groups have a reported diagnosis of sprain/strain.

A number of variables influence the likelihood of injury for dancers. Female dancers are more likely to sustain injuries than male dancers. The reason is not certain but wearing high-heel shoes may contribute. Based upon initial analysis, dancers who warm up before performances and attend dance classes are more likely to be injured; however, dancers with more physically demanding roles are more likely to warm up and attend dance classes. In subsequent risk factor modeling, these factors are no longer significant, and the physical demands of a role become an even more powerful predictor of injury. Having spent a greater number of years as a professional and having missed performances increase the risk of injury, probably reflecting the influences of older age and prior injuries.

Various environmental causes of dance injury have been cited previously based on anecdotal evidence; these causes include cold ambient temperatures, poorly constructed dance floors, the surface of the dance floor, and raked stages.⁸ Cold ambient temperatures are occasionally a problem onstage and backstage in theaters on Broadway and around the country. Although not formally assessed as a risk factor, theatrical "smoke" or "fog" is commonly cited by performers in this survey as being hazardous and resulting in voice problems. For Broadway productions and touring companies, specifications for dance floors placed over a structural slab or framing are used. A raked stage is a stage that is angled down toward the audience to improve the view. The degree of angle varies from a dropoff

of 0.5 in./ft to 3.25 in./ft in the productions surveyed. Our data demonstrate that raked stages are a significant risk factor for injuries to dancers as they can lead to increased injuries because of the dancers' accommodating shift backwards in their center of gravity.⁸

Performers, directors, choreographers, producers, and set designers should be concerned with reducing the incidence of injuries and should attempt to minimize risk factors. For example, since highly raked stages are significantly associated with a greater frequency of injuries, set designers might question whether this risk is justified by somewhat improved audience viewing. The results of this study may also be applicable to the evaluation and prevention of injuries to the many theatrical students and nonprofessionals worldwide. □

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References

1. Washington EL. Musculoskeletal injuries in theatrical dancers: site, frequency, and severity. *Am J Sports Med.* 1978;6:75-98.
2. Bowling A. Injuries to dancers: prevalence, treatment, and perceptions of causes. *Br Med J.* 1989;298:731-734.
3. Solomon R, Micheli LJ, Solomon J, Kelley T. The "cost" of injuries in a professional ballet company: anatomy of a season. *Med Probl Perform Art.* 1995;10:3-10.
4. Rovere GD, Webb LX, Gristina AG, Vogel JM. Musculoskeletal injuries in theatrical dance students. *Am J Sports Med.* 1983;11:195-198.
5. Hosmer DW, Lemeshow S. *Applied Logistic Regression.* New York, NY: John Wiley and Sons; 1989.
6. *SPSS for Windows: Advanced Statistics, Release 6.0.* Chicago, Ill: SPSS Inc; 1993.
7. Ostwald PF, Baron BC, Byl NM, Wilson FR. Performing arts medicine. *West J Med.* 1994;160:48-52.
8. Howse J, Hancock S. Causes and complications of dance injuries. In: *Dance Technique and Injury Prevention.* London, England: A & C Black; 1992:73-77.