Dance Medicine: Strategies for the Prevention and Care of Injuries to Dancers

Independent Study Course 18.3.1

Epidemiology of Dance Injuries: Biopsychosocial Considerations in the Management of Dancer Health

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An Independent Study Course Designed for Individual Continuing Education
Dear Colleague,

I am pleased to welcome you to the monograph *Epidemiology of Dance Injuries: Biopsychosocial Considerations in the Management of Dancer Health* by Marijeanne Liederbach, PT, PhD, ATC, CSCS. This monograph is part of the Orthopaedic Section Independent Study Course series 18.3, titled *Dance Medicine: Strategies for the Prevention and Care of Injuries to Dancers*.

Marijeanne Liederbach is the director of research and education for the Harkness Center for Dance Injuries at the New York University Medical Center Hospital for Joint Diseases. Prior to her current appointment, Dr Liederbach headed the dance medicine services for The Joffrey Ballet for 10 years while also serving as supervisor of sports physical therapy at the Nicholas Institute of Sports Medicine and Athletic Trauma at Lenox Hill Hospital and instructor of kinesiology at Columbia University. She has a bachelor of arts degree in dance, a bachelor of science degree in health sciences, 2 master of science degrees, one in physical education and sports medicine and one in physical therapy, and a doctorate degree in biomechanics and ergonomics. Dr Liederbach is the owner of PT Plus P.C., a private physical therapy practice in the landmark City Center building in New York City.

Dr Liederbach has provided backstage therapy for hundreds of dancers, dance companies, and Broadway shows. She has also authored numerous papers and chapters, as well as lectured internationally on topics pertaining to the prevention and care of dance injuries. She is a member of the editorial review board of the *Journal of Dance Medicine and Science*, the DanceUSA task force on dancer health, the performing arts special interest group of the Orthopaedic Section within the American Physical Therapy Association, and a past member of the national advisory committee for the American Physical Therapy Association’s performing arts practice analysis. She is also an affiliate member of the American Orthopaedic Society for Sports Medicine, a founding member and former board member of the International Association for Dance Medicine, and current chair of its standard measures consensus initiative on screening, injury reporting, and measurement of function. Prior to her career in dance medicine, Dr Liederbach danced professionally for many years and worked as a choreographer. Her critically acclaimed work has been shown in Europe and throughout the United States.

In her monograph, Dr Liederbach describes the socioeconomic and psychological factors that influence the culture and occupational demands of dance and their impact on dance injury. Her perspective is not just as a researcher, but also as a professional dancer and lifelong teacher of dance. The author's blending of these backgrounds is a great benefit to clinicians who wish to effectively treat dance injury. Without understanding the culture of dance, one can only scratch the surface in terms of achieving clinical effectiveness in treating injuries in dance. Not only does Dr Liederbach evaluate ergonomic risk within the dance workplace, but she provides the reader with strategies for effective modification. She also discusses the value and limits of the screening process and its role in the broader context of prevention and intervention. Dr Liederbach also shares her knowledge of choosing the appropriate therapeutic techniques that can effectively restore function and minimize risk for reinjury.

The goal of this monograph is to shed light on how biopsychosocial factors influence best practice to prevent, diagnose, rehabilitate, and enhance the health and functional abilities of members of the dance community. I think Dr Liederbach has done just that! I am confident you will feel the same. My sincere thanks to Dr Liederbach for serving as author of 2 monographs in this course series and for mobilizing her professional colleagues to write for other monographs in the series.

Sincerely,

Christopher Hughes, PT, PhD, OCS, CSCS
Editor
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Epidemiology of Dance Injuries: Biopsychosocial Considerations in the Management of Dancer Health

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LEARNING OBJECTIVES

Upon completion of this monograph, the reader will be able to:
1. Identify biopsychosocial factors influencing injury occurrence among dancers and implement strategies to modify risk and prevent injury.
2. Recognize the value and limits of the screening process for dancers and understand how to utilize screening in a broader model of prevention and intervention.
3. Evaluate ergonomic risk within the dance workplace and create strategies for acceptable and effective modification.
4. Choose appropriate therapeutic techniques aimed at efficiently and effectively restoring function and minimizing risk for reinjury.

INTRODUCTION

“Dance is an artist’s job, not an athlete’s job.” This quote by an unidentified ballet coach from the Royal Ballet captures a sentiment fundamental to the understanding of why dance medicine has emerged as a subspecialty to orthopaedic and sports medicine. Dancers and athletes share a common requirement for extensive physical training that leads to the acquisition of highly specific and refined motor skill. Unlike athletes, however, dancers ultimately hone their physical prowess for the chief purpose of developing artistic expressivity, an ethereal quality without which a dancer’s physical virtuosity is incomplete. Dancers are trained to perfect their physical skills not for the sake of winning competitions, earning prize money, or scoring goals, but for the purpose of conveying dramatic intent. The reason this distinction is important for the reader to appreciate is because dancers, to this day, adhere strongly to a cultural perspective of training that is based in artistic rather than scientific traditions. Their work environments, therefore, do not incorporate modern principles of conditioning, leaving dancers relatively unprepared for stresses encountered during their career.

In the early 1980s, recognizing that dancers and dance as an art form were in crisis because of rampant injury problems, health care professionals and dance professionals interested in the health and well-being of dancers began to organize around the cause of health and safety promotion. Dance medicine formally emerged in the United States at that time when, for the first time, continuing medical education courses focusing on the unique health problems of dancers were offered by the Massachusetts General Children’s Hospital in Boston, the Nicholas Institute for Sports Medicine and Athletic Trauma at Lenox Hill Hospital in New York, and the American Dance Festival at Connecticut College and Duke University. Following these efforts, more organizations began to emerge and advance knowledge to the public about the special health needs of dancers and other performing artists; these organizations included the Performing Arts Medical Association, the International Association for Dance Medicine and Science, the Harkness Center for Dance Injuries, the Miller Healthcare Institute for Performing Artists, the DanceUSA Taskforce on Dancer Health, the Performing Arts Special Interest Groups of the American Physical Therapy Association, and the Performing Arts Work Group of the National Athletic Trainers Association.

EPIDEMIOLOGY OF INJURIES IN DANCE

Epidemiology is the study of disease frequency and of factors associated with the distribution and determinants of disease. In a dance medicine context, epidemiology is the methodology by which one measures the number, nature, and cause of dance injuries in order to determine risk associated with dance activity.

Risk

Risk is defined as the probability of an adverse outcome, and all dance activity creates some degree of risk (Figure 1). To be effective at reducing health risks and injury incidence among dancers, it is essential to first know the magnitude and nature of the dance injury problem and to have information about when, where, how, and to whom the injury occurred (Figure 2).

Prevalence

The prevalence of dance injuries is reported to be as high as 75% to 97%, suggesting that participation in dance activity is very risky. From a clinical point of view, however, prevalence values can be misleading with regard to actual activity risk because, while prevalence studies shed some light on the number of injuries present in a sample of dancers at a given point in time, they do not give us information about how many new injuries occur to dancers over a discrete period of time nor do they yield prospective, exposure-controlled data about factors associated with the injury onset.
Complicating matters, when reading the dance medicine literature one discovers that the definitions for injury have varied greatly and have included such methods as defining injury by dancer self-reports of subjective pain, by recall count of number of self-defined injuries over a career lifetime, and by retrospective chart reviews of medically documented impairments and disability reports. In this monograph, risk of dance activity will be compared with risk of sports activity from the point of view of prospective data using time lost from activity as the definition of injury, and the literature will be explored for high-level evidence about factors associated with risk for dance injury.

Incidence

Back in the 1970s, Dr. James Nicholas\textsuperscript{11} popularized an idea that dance is as physically tough as football and as mentally stressful as bullfighting. The aim of his expert opinion paper was to help sports medicine clinicians appreciate the different neuromuscular, environmental, and psychometric demands imposed on participants by various activities. By today’s standards of evidence,\textsuperscript{12} activities are now more objectively evaluated for risk using an injury rate equivalent scale, a 4-point classification system that evaluates the number of injuries occurring to groups of performers over 1000 units of exposure to their activity. With this system, injuries are counted when they fit a definition of having resulted in at least 1 day of missed participation from the activity beyond the day of the injury event itself.\textsuperscript{13} Within the injury rate equivalent system, an activity is considered low risk if the number of time-lost injuries that occur per 1000 units of exposure is between 0 and 2. As the number of time-lost injuries per 1000 exposure units goes up, so does the risk score. An activity that yields 2.1 to 4.0 time-lost injuries is considered low to moderate risk, compared to a moderate-risk to high-risk activity that would yield between 4.1 and 6.0 injuries per 1000 exposure, and a high-risk activity that would yield 6.1 or more injuries per 1000 exposures. Using this criteria, dance falls somewhere between level 1 (low risk)\textsuperscript{14,15} and level 2 (low to moderate risk)\textsuperscript{16} for injury risk, well behind football, which qualifies as a level 4 (high risk) activity.\textsuperscript{13,17}

Work-related Musculoskeletal Disorders

Work-related musculoskeletal disorders are defined by the United States Department of Labor as injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and intervertebral disks associated with exposure to risk factors in the workplace\textsuperscript{18} that result from repetitive tissue loading in combination with other physical, nonphysical, and nonoccupational risk factors.\textsuperscript{19} It is generally agreed that 65% of all dance injuries result from repetitive strain and 35% result from acute trauma,\textsuperscript{8,9,14,20–23} and that 95% to 98% are successfully treated with conservative care while 2% to 5% will require surgical intervention.\textsuperscript{6}

Injury Distribution by Anatomic Region

Injuries in dance are similar to injuries in sports in the sense that they are activity specific, emerging in patterns representative of the motion demands associated with the activity.\textsuperscript{6,24} Dance injuries occur most commonly in the lower extremities,\textsuperscript{8,16,21,22,25} especially to the foot and ankle region. Table 1 illustrates injury distribution by anatomic region as reported by different investigators. The foot and ankle region consistently emerged as the most common region of injury in every study. A different study\textsuperscript{16} that observed 4 distinct groups of dancers prospectively over a 5-year period for distribution of injury found similar results (Figure 3). In that study, foot and ankle injuries again emerged as the most common site of injury for each dance group. In Table 1 and in Figure 3, it can be further observed that relative to all injuries, ballet dancers reported injuries to the foot and ankle more often than do modern dancers, whereas modern dancers reported a higher incidence of injuries to the spine, hips, upper extremities, and knees than did ballet dancers.
Injury Distribution by Other Factors

**Sex**

No difference in injury frequency between men and women has been reported in the dance literature, but notable differences have been reported with regard to types of injuries by sex. For example, injuries to the foot and ankle have been reported to occur more often among women dancers compared to men dancers.\(^8\,14,22,23\) Men, on the other hand, have been reported to have a higher incidence of shoulder and back injuries compared with their women counterparts.\(^8,22\)

**Age and Skill**

When looking at injuries according to age and company rank, one study conducted on elite ballet dancers found that 21-year-olds to 25-year-olds had more injuries than both 17-year-old to 20-year-old dancers and 26-year-old to 35-year-old dancers.\(^26\) That same study reported that danc-

### Table 1. Distribution of Dance Injuries by Anatomic Location*

<table>
<thead>
<tr>
<th>Author and Year</th>
<th>Level and Style</th>
<th>Number of Injuries</th>
<th>Distribution (%)</th>
<th>Injury Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quirk 1984(^21)</td>
<td>Mixed level Ballet</td>
<td>2113</td>
<td>42.4% 17.3% 8.6% 8.5% 7.5%</td>
<td>foot and ankle knee hip low back leg</td>
</tr>
<tr>
<td>Liederbach 1985(^22)</td>
<td>Professional level Ballet</td>
<td>256</td>
<td>48.8% 18.4% 14.5% 7.4% 7.0% 3.9%</td>
<td>foot and ankle leg low back knee hip upper extremity</td>
</tr>
<tr>
<td>Solomon and Micheli 1986(^20)</td>
<td>Professional level Modern dance</td>
<td>229</td>
<td>26.6% 20.1% 15.3% 14.5% 11.3% 7.0%</td>
<td>foot and ankle knee low back upper extremity hip leg</td>
</tr>
<tr>
<td>Garrick and Requa 1993(^21)</td>
<td>Professional level Ballet</td>
<td>309</td>
<td>37.2% 23.0% 6.8%</td>
<td>foot and ankle low back knee</td>
</tr>
<tr>
<td>Liederbach et al 2008(^16)</td>
<td>Professional level Ballet</td>
<td>117</td>
<td>57% 12% 9% 6% 3%</td>
<td>foot and ankle spine hip knee upper extremity</td>
</tr>
<tr>
<td>Liederbach et al 2008(^16)</td>
<td>Mixed level Modern dance</td>
<td>175</td>
<td>47% 16% 11% 8% 8%</td>
<td>foot and ankle spine hip knee upper extremity</td>
</tr>
</tbody>
</table>

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Figure 3. Percent of time-lost injuries by anatomic region over 5 years among elite ballet and modern dancers.
ers in the corps de ballet rank had more injuries than apprentices, soloists, and principal dancers.\textsuperscript{26} Several studies have reported that injuries occurred more often among lesser skilled dancers when compared with elite dancers.\textsuperscript{14,15,27} and 2 studies have reported that injuries happen most often among adolescent dancers.\textsuperscript{28,29} One study found that injury severity among elite ballet dancers was positively correlated with increasing age and that incidence of stress fracture was highest among dancers who entered the profession at a later age.\textsuperscript{10}

**Exposure**

Kadel et al\textsuperscript{30} and Liederbach et al\textsuperscript{31} both found that exposure time among injured dancers was significantly higher than among uninjured dancers. Hamilton et al\textsuperscript{10} found that frequency of injuries and time disabled were functions of exposure.

**Personal factors**

Three studies have reported that approximately 10% of individual dancers in the group of dancers studied were more prone to injuries than all of the other dancers in that same group for reasons unrelated to age, skill, company rank, or exposure.\textsuperscript{8,15,21}

**When do injuries happen?**

Four studies in the dance literature have reported that injuries occurred more often during performance seasons when dancers were engaged in work-related physical activity for approximately 4 more hours per day when compared with other times of the year, such as during rehearsal and layoff periods.\textsuperscript{8,16,21,32} Three studies found the greatest incidence of injuries occurred during rehearsal periods when new work was being learned and participation in repetitive activity was at its highest.\textsuperscript{15,23,33} In the sports medicine literature, Hootman et al\textsuperscript{34} evaluated 182,000 injury reports from 17 different men’s and women’s sports over a 5-year period and found that the vast majority of sports injuries occurred during games in the competitive season versus during practice in the preseason or postseason periods, with the exception of gymnastics. Gymnasts, by contrast, got injured 3 times more often during the preseason practice phases than during competition seasons due to either a relatively decreased status of physical conditioning or to fatigue from increased training intensity and duration associated with practice schedules.\textsuperscript{17}

**Time Lost From Injuries**

In professional ballet, 90% of lost days are due to foot and ankle injuries,\textsuperscript{9} and ankle sprain injuries are the second most common reason for most days lost from work in dancers in general.\textsuperscript{15} The number of days lost from work because of injury ranges from 7 to 28 among professional dancers,\textsuperscript{9,14,17,22} whereas 82% of students injured in ballet class had an average length of disability of 54 days.\textsuperscript{27}

**Cost of Injuries**

The human and economic costs of injuries are great. In health care outlay costs, average out-of-pocket expenses have been estimated to be between $1300 and $3000 per minor injury and in excess of $10,000 per major injury.\textsuperscript{8,21}

**ETIOLOGY**

To date, attempts to understand the root causes of dance injuries have largely concentrated on the physical aspects of dance as an activity and on the physical vulnerabilities of dancers as participants. But even when physical deficiencies are established prior to participation, their correspondence with later injury is very low.\textsuperscript{36,37} Relatively few studies in dance have examined the influence of environmental and psychosocial risk factors on injury occurrence. It may be that dancers’ psychological attributes and social influences play a significant role in the occurrence of injury and on the progression and outcome of work-related musculoskeletal disorders. Studies from other areas in medicine have shown that psychosocial factors are at least as important, and often more important, than physical factors in determining health.\textsuperscript{38} The purpose of this monograph is to consider the health of dancers from a biopsychosocial perspective.

**Cause**

Understanding the cause of injury is central to advancing knowledge, particularly regarding prediction and prevention.\textsuperscript{39} Dance injuries result from a complex interplay between human (intrinsic) risk factors and environment (extrinsic) risk factors (Figure 4).\textsuperscript{39–45} Risk factors are defined as those entities that contribute to the cause of injury. They need not be, and often are not, direct causes of injury; instead, they are markers for particular conditions, which, by virtue of association with other determinants

![Figure 4. Injuries result from a complex interplay between intrinsic and extrinsic variables.](image-url)
of the same condition, may be confounded as a causal factor.\textsuperscript{39,46} Risk factors should be seen as hypotheses until they have been substantiated as defensible injury predictors through correlational or experimental research.\textsuperscript{39,45}

Intrinsic factors that can influence injury occurrence include: age, sex, general and mental health, prior injury history, fitness level, body mass index, body alignment, morphology, limb dominance, muscular flexibility, joint range of motion, joint laxity, muscular strength, muscular balance, and muscular reaction time. Environmental factors in the dance workplace to which dancers are exposed that potentially impact health include: floor construction and incline, ambient temperature, noise and light, live music tempo, costume and set design, level of performance, level of skill, preparation of the facility to handle emergencies, employer policies regarding breaks, hydration, stretching, time-loss discipline, conditioning practices and body weight regulations, and shoe type and shoe-surface interface. Situational variables also come into play in the form of workplace attitudes, peer pressure, and support structures, as illustrated by a stress-strain-capacity model (Figure 5).\textsuperscript{40,45} The stress-strain-capacity model considers athlete behavior along with other intrinsic and environmental factors in injury occurrence. It views the participant as “an active manipulator of stress by whom the amount of strain evoked by participation in the activity can be altered, thereby influencing the capacity to perform in various situations, and also influencing the risk to sustain an injury.”\textsuperscript{45}

### Risk Factors in Dance

As noted in the opening paragraph of this monograph, dance training is dictated by artistic traditions, not scientific principles. As such, traditional dance training does not universally incorporate modern conditioning methodologies that might better prepare dancers for the metabolic and tissue-specific stresses and strains they encounter during rehearsal and performance.\textsuperscript{47} Factors associated with the etiology of common dance injuries can be condensed into 3 broad categories: occupational demands, movement demands, and training oversights.\textsuperscript{48}

### Occupational Demands of Dance

Dancers, like other athletes, are subjected to circumstances that require above average strength, flexibility, coordination, and concentration. Further, they are often subjected to rigorous aesthetic demands, such as the maintenance of thinness and the need for exquisite motor control at end-range postures on precarious bases of support. Added to these occupational demands, there is little professional or financial security available to those pursuing a career in dance.

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Figure 5. Stress-strain-capacity model of injury cause modified for dance. Reprinted with permission from *Sports Medicine*.\textsuperscript{45} Copyright 1992, Wolter Kluwer Health.
dance, often making access to health care difficult. Many dancers have little or no health insurance. 59,60 Only 11% of dance groups in New York City provide health coverage for their dancers, and only 21% carry workers’ compensation insurance. 51 These conditions, plus the fact that dance, unlike sports, knows no regular seasons, place a tremendous psychological burden on the performer. 6

**Selection of Dancers**

Dancers are typically selected for artistically pleasing qualities manifested, in part, by certain physical and psychological tendencies. Elite dancers, similar to elite athletes, represent the top of a broad-based field of competitive students 27,52 who have survived an inherent selectivity for the body type and personality able to adapt well to the aesthetic, psychological, and physical training stresses along the way. The selection of dancers is highly subjective, based not on measures of time or distance but on emotional and aesthetic attributes, 53–56 and tends to be intensely discriminating. In national ballet schools, only 5% of the children who begin their training at the age of 8 graduate 9 years later. 57 Of approximately 20,000 dance students auditioning annually for company-affiliated schools, only 10% will be chosen for the school, with only 0.1% making it to the stage. 52 Data from profiling studies do indeed indicate a typical somatotype. In general, the typical dance archetype is described by low body weight and fat, long and slender legs, high-arched feet, and a general predisposition for arthritic tendencies. 56–58 Forty-eight elite women dance students (average 14.9 years of age) were followed at the School of American Ballet to distinguish the physiologic tendencies. Elite dancers, similar to elite athletes, know no regular seasons, place a tremendous psychological burden on the performer. 6

Like elite athletics, among whom discriminate analysts separate somatotypes by sport played, 59 a homogenous morphology is evident at the level of the professional dancer. Some have speculated that dancers who make it to the elite level do so by virtue of a Darwin-like “survival of the fittest” mechanism, such that their particular set of anatomic attributes 27,60 allows them to perform successfully without experiencing debilitating injury. 53,61

**Physical Tendencies**

**Mobility**

Dancers tend to be hypermobile and selectively hyperflexible. 20,58,60,62–64 While these are aesthetic assets in that they permit the accomplishment of the extreme ranges of motion needed in many styles of dance, these attributes may increase the risk for injury. Chronically overstretched muscles and tendons show decrements in the muscle spindle output and reflex force characteristics. 65–67 In addition, hypermobile dancers perform poorly on tests of proprioception, 68 suggesting that changes in neural elements associated with the changes in tissue length, which may adversely affect motor skills. 69 Anterior cruciate ligament injuries, for example, have been linked to altered muscle recruitment patterns associated with a long amortization phase in the stretch reflex response. 70,71

**Selective muscle tightness and weakness**

Screening data from tests performed at the Harkness Center for Dance Injuries on 800 healthy, uninjured adult advanced (college or professional) dancers from various dance forms revealed that 76% tested positive for calf tightness and 63% tested positive on Thomas tests for hip flexor tightness. In that same population of dancers, 68% failed tests for normal muscular endurance of the plantarflexors; 50% failed tests for functional quadriceps control (maintenance of lower extremity alignment during bench stepping); and 38% failed supine double-leg lowering tests for abdominal strength and trunk stability. Past studies corroborate the finding that dancers lack strength in certain muscle groups. 58,72–75 Dance is an intense, highly repetitive, high-impact activity. Muscular strength and endurance are important in joint and postural stability, shock absorption, motor control, and performance stamina. Relative imbalances and deficits in strength pose significant risks for injury.

**Thinness and low energy expenditure**

In the sports medicine literature, dance is considered a “thinness sport.” 66 and women ballet and modern dancers tend to be, on average, only 75% and 88% of expected body weight, respectively. 77,78 The most technically talented dancer may not be accepted into a ballet company because of body size. 77 Aberrant nutritional patterns in dancers are associated with stress fractures before the development of bone density changes, suggesting that the quality of bone may be affected before clinical changes are seen. 36 Malnutrition is suspected to be common among dancers because dance is not a calorie-expensive movement activity. 23,26 As a result, chronic dieting to restrict calorie consumption as a strategy for maintaining low body weight is common among dancers. 77,86 Inadequate energy intake and nutritional imbalance are factors known to increase injury and illness risk. The actual risk for injuries associated with the female athlete triad syndrome 26,87,88 (the relationship between amenorrhea, disordered eating, and osteoporosis) is difficult to quantify, 87 but clinicians should be aware that amenorrhea has been linked to decreased estrogen, a condition that is linked to the pathogenesis of osteoporosis. 20,81,89

Menstrual abnormalities are well-documented among dancers and may be related, at least in part, to nutritional deprivation. Among dancers, there is little knowledge about basic principles of nutrition and there is a high degree of food faddism. 69 There is a moderate incidence of anorexia nervosa and bulimia among dancers, 53,82 but there is far more disordered eating, a phrase coined by the Women’s Task Force of the American College of Sports Medicine 24 to describe chronic restrictive and sometimes ritualistic, compulsive eating patterns. This is a condition the physical therapist should be aware of because of its potential effect...
on the dancer's ability to fully recover from injury. Dancers have reported regularly consuming as little as 1000 to 1800 kilocalories per day, in some cases since the age of 12, despite age-related or growth factor demands of physical development and despite several hours of dancing per day.77,83,89,90

One important factor for the clinician to understand from the discussion is that dancers are often driven more by how they look than by how they are functioning during performance. Some dancers have an extreme fear of fat and they may under-eat or become exercise dependent to control their weight,11 a situation that can cascade into central fatigue, muscle failure, and injury.

Psychosocial Tendencies

Psychosocial factors in dance are complex and can contribute to occurrence, progression, and outcome of injuries.91-94 The biopsychosocial model was first described by Engel95 in 1977, with the purpose of looking beyond mind and body factors to also include the role of society on illness behaviors. Engel95 concluded that any injury must be viewed from a multidimensional perspective that takes into consideration not only biological factors, but also psychological and social factors, since physical injuries are interpreted cognitively and perceived emotionally. Waddell96 later theorized that the cognitive belief one has of an injury in turn impacts mood and pain behavior, making the perception of symptoms variable. One dancer may experience an injury as more or less severe than another dancer with the exact same injury according to the belief held about the injury and the emotional meaning associated with that belief.

Personality

Personality traits associated with the drive necessary to achieve elite levels of physical skill in ballet have also been associated with the occurrence of injuries. Ballet dancers with the greatest number of total injuries throughout their careers, regardless of sex, were found to be significantly more enterprising than those with fewer injuries, and ballet dancers with stress fractures and other overuse injuries were those with the personality type of overachiever.10

Perception of self

Personality type alone, however, can rarely predict who will potentially become injured.18 A state of psychological distress, for example, can influence injury outcome. Theories given to explain the relationship between stressful life events and injuries include attention disruption of the cognitive level96 and increased muscular tension and reduced motor coordination on the somatic level.97

Negative affective states, such as depression and anxiety, have been shown to be important components of work-related injury etiology.18 Patterson et al92 studied 46 professional ballet dancers prospectively over an 8-month period to determine injury vulnerability factors of a psychosocial nature. They measured positive and negative stressful life events within the context of individual perceptions of social support (defined as “the subjective belief that there exist sources of support, help, and caring within one’s social network”) and found that recently experienced stressful life events were unrelated to injuries for all the dancers, but that negative life events were significant predictors of subsequent injuries for those dancers who reported low levels of social support.

Performance anxiety, or stage fright, has also been associated with injury in dancers. Performance anxiety, reported to occur in more than 40% of dancers,99 is defined as an internal conflict between one's need to publicly display his or her artistry coexistent with an often profound fear of proving inadequate and suffering public humiliation and rejection.99 As a cognitive event, performance anxiety is accompanied by somatic responses, including elevated cardiovascular and neuroendocrine activity.100 Smith et al101,102 measured trait anxiety in dancers in relation to injury and found that 61% of 46 professional ballet dancer injuries were predicted by a combination of cognitive and somatic anxiety subindicators, including heightened physical arousal, loss of focus, and worrying.

Other-oriented perfectionism is a common theme among professional dancers,103 as is self-surveillance. The dancer's sense of self is primarily formed as a result of the perception of how others see the dancer, wherein the dancer develops a role identity instead of a self-identity.104 In a review of 500 injury reports submitted by 644 dancers over a 2-year period, subjective reports of fatigue, body dissatisfaction, drive for thinness, bulimic tendencies, and perfectionism were significantly higher among injured dancers compared with uninjured dancers.105 Adam et al106 found that absenteeism in dance was related to stress and negative mood state such as depression, fatigue, confusion, and anger.

Dance training stimulates the externalization of goals, which can lead to self-destructive behaviors by placing emphasis on achievement of superior ability, daily personal best, fear of failure, inability to accept personal mistakes, and unrelenting threats to self-esteem. A consistent emphasis on a performance-oriented climate in dance with constant body judgment has been associated with development of maladaptive dispositions in many young dancers.104 The external reality of the profession had an adverse influence on dancers' relationship with self and their future-directedness such that 43% of dancers surveyed in a university dance program had symptoms of depression. These dancers expressed frequent feelings of hopelessness and uncertainty about their future, doubts about success, lack of time in life to accomplish what they want, and being unlucky. While there was no statistical relationship in that study between number of hours training per day and overall mood state, the students dancing more hours per day were measurably more sad. Among those students, lack of social support and feelings of loneliness resulted in a longer period of
recovery following injury. This finding corroborates work by Mainwarig et al., who found a strong correlation between psychological stress and injury duration.

**Perception of work**

There is much evidence to indicate that workplace stress has a great influence on health. Since injuries in dance occur at work, or are believed to be the result of work, the cognitive, affective, behavioral, and social elements of those injuries are inextricably related to the workplace. Byhring and Bo found that 61% of dancers believed that factors related to training (e.g., insufficient preparation before rehearsal and performance periods) caused their injuries. In addition, the authors found dancers felt their daily ballet technique class did not prepare them for the modern dance repertoire they were subsequently exposed to in rehearsal and they felt that injuries would occur less often if they were better prepared mentally and physically for their work. Among those same dancers, 78% experienced negative stress at work on a regular basis and 64% felt they had no influence on decisions about their working conditions. van Mechelen reminds us that injury risk factors include appreciation of the participant's attitude about risk and subsequent risk-taking behavior as well as the participant's perception about ability for, and barriers to, success.

**Dancers' Cultural Context and Perception of Health Care Providers**

**Role models**

Ninety-three percent of dance teachers became teachers because of injury. Furthermore, most dance injuries among dance teachers go untreated because the teachers report being too busy to go to the doctor or being unable to go because of lack of insurance or ability to afford the visit. Many successful teachers in dance are persons who survived the rigors of dance without disabling injury and who, thus, believe that their way of training is superior (e.g., “tough it out;” “dance through the pain and leave your troubles at the studio door”). In addition, many dancers of a generation ago who sought medical care for injuries, before concepts of relative rest were common, were given the then-gold standard advice to stop dancing, which was an unacceptable option to them. While this was appropriate medical advice for the times, a directive such as this only made dancers more leery of medical advice altogether; thus, that generation of dancers, proud about having accomplished a career without stopping for pain and without the benefits of sports medicine services, believe that doctors don’t understand them and that their way of managing aches and pains is superlative to all others.

**Avoidance of mainstream health care**

On top of the ubiquitous insurance barriers, dancers avoid contact with health care professionals for other reasons. For some, there is a strong feeling that they are not understood by doctors. As described by Krasnow and associates: “A dancer is someone who trains daily for 10 years or more, investing time, money and energy with the foreknowledge that gainful employment is questionable, and that even success guarantees little, in fact a good chance of living at the poverty level. Dancers have different values and priorities from persons in mainstream career cultures. In the same study, the authors reported that only 20% of injured dancers pursued a physician visit for care of their injuries, citing reasons such as lack of money, lack of time, and a feeling that the physicians would view their problems as more incidental than they actually were.

An understanding of the psychosocial culture within which professional dancers rise is crucial to working with them successfully in a health care context. The vocational calling to dance is so overwhelming that a dancer's body becomes her identity; because of this, injury is experienced as a profound crisis for the dancer. Quoting Hamilton: “As any professional athlete who depends on the maintenance of the body, the dancer becomes very conscious of injury. Like the racehorse, the dancer's life depends entirely on their physical condition, so psychologically they display great insecurity with regard to aches and pains. Every affliction, no matter how minor, becomes a catastrophic accident with thoughts of 'what if I can't dance' flashing through their minds.” Clinicians may, thus, view the dancer as obsessive and unreasonable.

Macchi and Crossman found that more than half of dancers who saw physicians felt the doctors were impersonal and did not give them information about their injuries. As a result, the dancers did not comply with the medical advice given. Scialom et al also found that 80% of dancers did not comply with recommended health behavior changes in their work or lifestyle habits, even though 83% of them had resolved past injury problems after seeking help from a health care practitioner. Scialom et al reported that, although dancers investigated the cause of injury with a health care professional, they themselves could not later explain its occurrence or any details about the medical evaluation. Furthermore, those same dancers were willing to change their exposure to dance for the short term to pursue medical treatment, but they were not willing to change their technique or training habits or strategies in the long term, even if a physician spent a lot of time educating them as to reasons for such adaptations during their clinical visits. The treating physicians felt they were communicating very clearly with dancers and their teachers about specific diagnoses and treatments, whereas the dancers felt they were not asked anything specific about their work.

**Movement Demands of Dance**

Hamilton has noted that even dancers who are perfectly conditioned, technically well-trained, and psychologically prepared for the rigors of a life in dance will experience injuries, simply due to the nature of the movement demands. For example, each day in class dancers will perform approximately 200 jumps, some of which impose forces as high as 12 times body weight on the performer.
Each full relevé (heel rise) a dancer does onto the tips of the toes loads the ankle and first metatarsophalangeal joints with forces equivalent to 10 to 12 times body weight. Of course, not all dancers are equally prepared for stresses associated with the dance workplace and, thus, enter the activity with variable levels of neuromuscular conditioning and joint structures that will influence the arthrogenomics of their training. Pathomechanics is the study of the origin of injury, a discipline within which one attempts to explain how and why a particular injury occurs. Knowledge of pathomechanics is important for the dance medicine physical therapist to effectively manage and prevent injuries. Some movement demands in dance suspected to be associated with injury are reviewed below.

Posture and alignment

In classical ballet, there are 5 basic stance postures, known as 1st through 5th position, from which all movement tasks are executed. In these stance positions as well as during all leg gesture and movement tasks, maximal external rotation of the lower extremities, known among the dancers as “turnout,” is expected at all times except during unusual choreographic applications. The amount of turnout considered ideal is 90° per limb. Since femoral neck anteversion angles in dancers are similar to age-matched, non-dance trained individuals in the general population, dancers must borrow movement from the spine, pelvis, and lower extremity segments to achieve turnout in stance. It is theorized that dancers friction-couple their feet with the floor to achieve full turnout, a behavior that may produce joint motion and muscle imbalance from plastic changes to tissues surrounding various joints.

Base of support

The feet do not always serve as the body’s base of support in dance. Many dance forms rely on the knees, buttocks, spine, neck, upper extremities, or head to serve as a transitory base of support, presenting a whole new class of injury risks. Dancers are sometimes asked to try one of these interesting postures without any special instructions, safety precautions, preconditioning exercises, or warm-up activity and then often repeat the maneuver over and over again.

Balance and proprioception

During preparticipation screenings held at the Harkness Center for Dance Injuries, 40% of dancers routinely fail the Romberg static balance tests. Dancers rely on a keen sense of balance to sustain extremely small bases of support for extended periods of time, as well as to move rapidly and expansively between spatial postures, often shifting direction, timing, and level multiple times within just 1 movement phrase. Balance is governed by postural control systems, including: (1) the vestibular apparatus, which provides information about body accelerations and orientation in an inertial frame of reference; (2) the visual system, which provides information about the environment and about the orientation and movement of the body; and (3) the proprioceptive system (muscle, joint, and cutaneous receptors), which provides information about the state of the effector system and the environment. Balance deficits place the dancer at increased risk for trauma because of the associated alterations in neuromuscular feedback.

Movement Demands on the Spine, Pelvis, and Hip

The majority of back injuries, like most other dance injuries, can be attributed to repetitive movement stress. In dance, repetitive microtraumas occur from asymmetrical loading of articular and soft tissue structures during end-range movements that level and unlevel the pelvis as the center of gravity is shifting. Sacroiliac dysfunction is the most common lumbosacral pathology in professional classical dancers and is a result of the forces inherent in the extreme movement demands and the ligamentous laxity possessed by most elite dancers. The aesthetic nature of classical dance requires the trunk to be stable during large movements of the lower limbs, which may result in functional hypermobility of the pelvis. Many dancers are able to assume extreme hip and lumbar spine hyperextensions, creating a great deal of spinal rotation in opposition to the stance limb. The attempt to accommodate these ranges of motion may lead to excessive vertebral rotation, hypermobility at the lumbosacral and sacroiliac joints, or sometimes spondyloysis. The incidence of spondyloysis and spondylolilosis in dancers (12% to 17%) resembles that of elite gymnasts and is higher than the general population (6%).

Lower extremity muscle imbalance is considered both a cause and an effect of lumbar spine and pelvic injury. Dancers frequently complain of clicks, pops, and snaps around the hip, which are most often associated with a tight iliotibial band, as well as long and weak iliopsoas accompanied by weak gluteal muscles. Intra-articular causes of snapping hip symptoms include synovial chondromatosis, loose bodies, osteochondritis dissecans, osteocartilaginous exostosis, labral tear, or inverted labrum. A full monograph has been devoted to the topic of hip injuries in dance.

Movement Demands on the Knee and Leg

The knee is exposed to considerable stress in dance. Dancers perform approximately 200 jumps per class, usually with some transverse plane rotation for the lower limb provided by the tibiofemoral joint. Patellofemoral syndromes are common in dance and are thought to be related to the high frequency of eccentric loading secondary to the repetitive landings from jumps. A full monograph has been devoted to the topic of knee injuries in dance.

Movement Demands on the Ankle and Foot

A full monograph has been devoted to the topic of foot and ankle injuries in dance, but a few key issues will be discussed here. Two of the regularly practiced ankle movements in dance, relevé and plié, are associated with
a number of orthopaedic problems. During relevé en pointe, the dancer rises to the tips of her metatarsal phalanges, bearing full body weight there while performing movement tasks. Forces at the foot and ankle are estimated to be 10 to 12 times body weight, comparable to that of a runner doing a 6-minute mile.133

In the position of relevé, the dancer experiences less anatomic stability at the talocrural joint, resulting in increased activity of the peroneal muscles.145,146 Further, winging, or relevé with eversion (a stylistic embellishment on the formal relevé position), is a behavior commonly practiced by dancers that markedly increases the pressure at the first metatarsophalangeal joint. This elective foot posture also places the first ray in a mechanical disadvantage, requiring the flexor hallucis longus and other supporting soft tissues to overcome inordinate tensile forces and encounter greater resistance to flexion of the digits.147 If the flexor hallucis longus tendon (referred to as the dancer’s Achilles heel)145 becomes inflamed, it may progress to partial rupture. Erosion of this tendon within its osseofibrous tunnel (known as stenosing tenosynovitis) can result in a condition commonly referred to as trigger toe.118,141,145,148,149

Dancers spend a substantial portion of their work time in relevé, which often results in a short and strong gastrocnemius-soleus complex and accompanying loss of active dorsiflexion.58,73,130 As a result of this training adaptation, functional equinus is common. The pathomechanics underlying equinus include adaptation for dorsiflexion at the midtarsal joint region, thereby extending pronation and exposing the dancer to excessive pressure and tensile forces on the medial column of the foot. This motor behavior can lead to increased compression forces at the lateral cuboid, since prolonged pronation allows for an unlocked forefoot near the toe-off phase of gait where the angles of pull of the anterior tibialis and peroneal longus muscles are less optimal in their relationship to the first ray, thereby preventing the foot from assuming its most effective position as a stable and rigid lever for propulsion.151,152

Related to the position of plié, men dancers have been shown to develop anterior ankle impingement problems more frequently than women dancers. Its occurrence has been associated with years of high-impact landing from large jumps into the demi-plié position where anterior articular margins of the tibia impinge on the talus and bone spurs develop. Anterior ankle impingement is also associated with eccentric weakness of the calf.142 Ballet dancers, when compared with soccer and football players, have been found to possess similar levels of calf strength but significantly weaker dorsiflexors both alone and in relation to the plantarflexors and overall ankle strength.153

Shoes

Unlike athletes who wear shoes specially designed to absorb shock and stabilize foot and ankle joints, dancers wear only thin slippers, toe shoes, flat-soled leather shoes, or no shoe at all. The emphasis of classical dance footwear is on style and tradition. Traditional dance disciplines employ shoes that have undergone little or no modification for generations despite the vastly improved materials available.116 Indeed, the major construction materials of the ballet toe shoe are burlap, wheat paste, satin, cardboard, hard rubber, and leather.116 Albers et al142 found that pointe shoes, compared with barefooted walking, increased peak plantar pressure in dancers when doing functional movement due to a reduction in the amount of plantar surface contact area they could establish with the ground. The authors concluded that ballet shoes provide some stability but no absorption or attenuation of ground reaction forces.

Training Oversights in the Traditional Dance Setting

Perhaps the most important category of etiologic factors associated with dance injuries is training oversights. Four of the major principles of kinesiological science155 are neglected or poorly incorporated into dance settings. Because they are so important to the prevention of dance injury, each will be addressed separately. These principles are: periodization, specificity, overload training, and overtraining.

The principle of periodization

The principle of periodization is concerned with the timing and intensity of training exposures. This principle asserts that sufficient time must be allowed between workouts for tissue growth, nutritional replenishment, and biochemical resynthesis to occur, while exposures to work overloads are gradually increased in order that optimal physiological development and fitness be achieved.155 One problem inherent in traditional dance settings is that regulated periodization of training and performance exposures is lacking. Typically, dance company schedules are not as seasonally predictable as organized sports schedules. Hence, adequate rest cycles and safe, step-up phasing of performance stress loads are not reliably incorporated, thus placing the dancer at increased risk for repetitive stress and fatigue injuries.

The greatest number of injuries per year are reported during the end of the day and the end of performance seasons when dancers became most vulnerable to fatigue.10,116,157 Fatigue has been demonstrated to have adverse effects on neuromuscular control, coordination, reflex activity, and muscular power.65,158–160 Previous reports161–163 have implicated muscle fatigue as the origin of tibial stress fractures. Stress fractures are a common injury in ballet dancers.164,165

The principle of specificity

The principle of specificity refers to the phenomenon wherein a specific demand made on the body results in a specific response by the body.155 The principle states that in order for a particular movement skill to be achieved, that skill must be trained by imposition of exactly similar motions, intensities, and durations to that of the goal movement.166 For example, if a dancer wants to become proficient at a particular type of jump, she should practice that jump in a constructive, progressive, and exacting manner until the ultimate level is achieved.
Traditional dance settings typically lack specificity when it comes to crossover of movement vocabulary from the technique classroom to the choreographic application in the rehearsal and performance setting, as well as in metabolic pathway training in classroom versus stage performance.\textsuperscript{12,72,79,167–169} Motor patterns, muscular contraction demands, and cardiopulmonary demands vary between the classroom and stage.\textsuperscript{167,168,170} Classroom technique training remains relatively constant while the choreographic application is ever-evolving in its creative departure from baseline technique. An unspoken and ungrounded assumption that dancers are ready to handle these differences permeates most dance environments, again leaving the dancer vulnerable to otherwise avoidable injuries. For example, dance training in the classroom does not specifically precondition for the demands of lifting; hence, the dancers who are required to execute lifts are at risk for traumatic overload injuries. In 3 British ballet companies, one third of all back injuries suffered by the men were attributed to the demands of lifting.\textsuperscript{171}

The principle of overload training
The overload principle states: “Beneficial human performance adaptations occur in response to demands applied to the body at levels beyond a certain threshold value, but within the limits of tolerance and safety.”\textsuperscript{155(p259)} The limits of tolerance and safety are often exceeded in dance, particularly when a student increases from 3 to 5 classes per week during the school year to 3 to 5 classes per day in a summer-intensive program. Another example where the limits of tolerance and safety are violated would be similar to the situation described above under specificity, where the shift from classroom movement to studio or stage movement is progressed without proper overload step-up training for safe mechanical and physiological management of the performance stresses. If too great a stress is imposed over a very short time period, the body will be unable to adapt and there will be a decrement in performance, possibly resulting in injury.

Thought of from the opposite side of the same coin, the overload principle also asserts: “Low-level demands, to which the body has already adapted, are not sufficient to induce a further training adaptation.”\textsuperscript{155} Once a dancer has reached an advanced level of technique, the demands of the classroom training remain relatively steady, failing to further advance fitness beyond the tasks of the classroom itself. While the repeated practice of technique during class work is very beneficial to both motor learning and motor control, it is inadequate training for the physiologic capacities of strength, power, and endurance required by the more demanding aspects of performance.

The principle of overtraining
The overtraining principle states that an individual ceases to adapt positively to training stress when it is imposed in a sustained, long-term, and highly intense manner. Dancers are at risk for developing overtraining syndrome. Overtraining syndrome is defined as an unexpected drop in performance that cannot be attributed to illness or injury. This condition is most likely to occur when they are required to execute frequent performances, when they undertake consistent training that is monotonous and lacks sufficient rest periods, when they consume a poor diet, and when they are exposed regularly to psychosocial stressors including work or school conflicts. Poor coping abilities can exacerbate the problem.\textsuperscript{5,32,172–176}

The lack of proper rest cycling and formal periodization to load build-up, as well as the lack of cardiovascular endurance training inherent in dance training, its anaerobic nature, and the common practice of chronic calorie restriction for maintenance of low body weight, places the dancer at an increased risk for fatigue injuries.\textsuperscript{87} The adverse effects of fatigue on neuromuscular and psychometric performance are well-known,\textsuperscript{177–182} and fatigue has been associated with injury in several dance studies.\textsuperscript{16,30,32,105}

Summary
Considered together, the principles of periodization, specificity, overload training, and overtraining characterize exposure to dance, in which a spectrum of effects come together in a correlative, dose-response relationship.\textsuperscript{183} Injury risk relative to the dose-response curve varies for each person given the same exposure.\textsuperscript{184} In a defined group of dancers, measuring the number of injuries that occur relative to exposure is the best way to determine if the injuries are related to the general activity risk of dance per unit time or to other factors such as unique intrinsic attributes of a given dancer or to particular features in the environment. It is for these reasons that a standardized measure of exposure is so important in an overall sequence-of-prevention strategy, which will be discussed next.

STRATEGIES FOR EFFECTIVE INTERVENTION
Prevention
Injury is something that every dancer seeks to avoid, and prevention is an element of health provision that is not only ideal from the point of view of the dancer and the health care provider, but also from the young dancer’s family and the dance organization as the preferred and most cost-effective method of providing health care.\textsuperscript{185} The most basic expression of risk is incidence, and the most basic expression of prevention is a decrease in incidence. Indeed, primary prevention is defined as a reduction of injury incidence.\textsuperscript{186} Measures of incidence alone, however, cannot reveal much about an individual dancer’s chance for injury.

Being precise about which individuals in a group are at particular risk of injury at any given time is extremely difficult.\textsuperscript{187–189} In an article by Chmeler, Kevin McKenzie, the Artistic Director of the American Ballet Theatre, so wisely observed: “Some dancers are ‘workhorses’ while others are ‘racehorses.’ The former have an inherent ability to withstand great stresses and repeated performances, while the latter are able to perform spectacularly but need more rest between periods of elevated physical stress.”\textsuperscript{190(p134)} Difficulty with prediction, and thus prevention, arises because, as discussed in the sections above, dance injuries result
from a complex interaction between many different intrinsic and extrinsic variables.\textsuperscript{39,41–44,64,187,189}

What complicates the identification and quantification of risk is that, in many situations, risk factors interact. Meeuwisse\textsuperscript{39} proposed a model that accommodates a multifactorial assessment of causation in athletic injuries. In that model, intrinsic factors are viewed as factors that predispose an athlete or dancer to react in a specific manner to an injury situation; then, once the athlete or dancer is predisposed, extrinsic, or enabling, factors may facilitate manifestation of injury (Figure 6).\textsuperscript{39}

The heterogeneity of predisposing and outcome factors often render a correlation between risk and cause statistically and clinically insignificant.\textsuperscript{187} So, while certain intrinsic and extrinsic factors may render the dancer susceptible to injury, they are often not enough to trigger an injury occurrence. Rather, a constellation of factors sum or interact in such a way as to make the dancer vulnerable for an injury event (Figure 4).\textsuperscript{39}

**Best Practice**

*Best practice* in dance medicine and science is defined as behavior that furthers the profession’s capability to prevent, diagnose, rehabilitate, and enhance the health and functional abilities of members of the dance community.\textsuperscript{191} How, then, should the dance medicine profession best advance its aims to be effective in reducing risk and injury occurrence and avoid repeating anew efforts of the past that have not achieved optimal success? If the understanding of dance injury epidemiology is to advance, a multifactorial approach must be taken when assessing etiology or causation. Multifactorial analyses can yield a more complete understanding of injury causality and lead to the advancement of a scientific basis for the development of specific treatment and prevention guidelines.\textsuperscript{192}

**Screening and Injury Reporting**

Despite enormous challenges posed by cause-determination research, it is plausible, with time and careful observation, to quantify risks for dancers with some certainty by measuring the proportion of injured persons relative to the at-risk population and comparing exposure to the activity in both the injured and uninjured members of the group. This is done in industry and sport by systematic reporting of injury. Injury reporting, also referred to as injury surveillance, is an ongoing collection, analysis, and interpretation of data related to occupational exposures in a work environment and to adverse health outcomes associated with exposure to work.\textsuperscript{5,193} One well-accepted way to use injury surveillance data effectively is to employ a sequence-of-prevention model.\textsuperscript{194} Such a model evaluates preparticipation screening data in the context of a broader longitudinal health care system that addresses the biopsychosocial aspects\textsuperscript{38} of the dancer’s life relative to an ongoing and iterative injury-reporting analysis (Figure 7).

This process allows practitioners to observe injury occurrence not only relative to measured intrinsic attributes of dancers, but also relative to the complex interplay between those variables and environmental elements in the dance workplace, all tempered by the dancers’ understanding of their role and responsibilities with respect to the health care process and the variable nature of dancer state versus trait depending upon situational factors at any given time.

Figure 7 illustrates an iterative process that begins at step 1 with identification of the magnitude of injury rates by standardized and reliable methods,\textsuperscript{5} followed in step 2 by identification of the factors and mechanisms that play a role in the injury-illness events. Once that information is collected, step 3 is to introduce measurable interventions that are likely to counter the variables identified in the process.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{diagram.png}
\caption{Multifactorial model of injury etiology modified for dance. Reprinted with permission from *Clinical Journal of Sports Medicine*.\textsuperscript{39} Copyright 1994, Wolter Kluwer Health.}
\end{figure}
On-site Care

It is also known from the literature that establishing on-site health care at dance schools and companies is an effective way to reduce injury incidence and medical costs. These programs ensure dancers privacy while also providing them with timely and affordable access to qualified health care practitioners, functionspecific tests and measures, and progression protocols that consider all aspects of their occupational demands (Tables 2 to 4).

When working on-site, it is important for the therapist to remember that dancers are often training up to 10 hours per day, and this training volume must be accounted for when developing rehabilitation protocols. Often this workload is performed while also restricting calories. In addition, as discussed in a prior section of this monograph, it is important for therapists to be cognizant that injuries frequently produce feelings of depression. Values such as perfectionism and daily personal bests are ingrained in the dancer. Relative rest and time out from some activities to restore function progressively is anathema to their sense of professional responsibility as well as to the maintenance of their identity and self-worth. Injured dancers report being fearful of harsh judgment from peers (eg, being perceived as unreliable, weak, or lazy). They are also fearful of the loss of performance opportunities, and thus hide their pain or deny their injury at its initial onset. Forty-eight percent of professionals continue to work injured because they are fearful to seek medical attention. Forty-four percent report feeling hopeless, anxious, angry, and frustrated and 35% present with frank clinical depression, 100% of whom have suicidal thoughts.

Depression is characterized by feelings of sadness, emptiness, and tearfulness that last for most of the day, as well as a loss of interest or pleasure that lasts for at least 2 weeks. A dancer suffering from depression might experience the following symptoms:

- Significant changes in appetite resulting in weight gain or loss.
- Insomnia or hypersomnia.
- Psychomotor agitation.
- Fatigue or loss of energy.
- Feelings of worthlessness or excessive or inappropriate guilt (increased self-criticism).
- Diminished ability to think or concentrate; indecisiveness.
- Thoughts of death or suicide that are recurrent.

On-site care will be most successful when it incorporates a regional interdependent examination approach and a biopsychosocial perspective, addressing affective and cognitive elements into the determination of prognosis and encouraging a sense of self-efficacy as well as accomplishment of neuromuscular control and restoration of occupational-specific musculoskeletal function.

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1. Extent of injury-illness measured with standardized injury-reporting system
2. Factors or mechanisms related to injury-illness occurrence are identified
3. Implementation of measurable interventions targeted to reduce associated risk factors
4. Outcomes measured

### Table 2. 4-Stage Progressive Rehabilitation Protocol*

<table>
<thead>
<tr>
<th>Rehabilitation Stage</th>
<th>Clinical Goals</th>
<th>Studio Goals</th>
</tr>
</thead>
</table>
| Stage 1: restricted  | - Reduce swelling and pain  
- Active rest  
- Evaluate kinetic chain for dysfunction  
- Aerobic conditioning | - Restrict tissue loading  
- Somatics and mental practice  
- Take floor exercise class or pool class |
| Stage 2: restoration | - Restore range of motion and strength  
- Progress aerobic conditioning  
- Begin functional weight bearing and basic skills | - Permit limited movement with restricted tissue loading (eg, padding, taping)  
- Concentrate on alignment and stability  
- Take beginner level dance class |
| Stage 3: reacquisition | - Progress strength to supernormal levels  
- Bilateral → unilateral weight bearing  
- Eyes open → eyes closed  
- Slow → fast movement exercise | - Return to original level class  
- Progress from 1 class per day to more, as tolerated  
- Limit number of jumps and rehearsals |
| Stage 4: refinement | - Build confidence, carriage, and control  
- Complicate skills  
- Progress cardiovascular drills  
- Increase speed and loads  
- Progress dynamic balance  
- Increase repetitions | - Unrestricted dance movement  
- Prescribed warm-up  
- Implementation of injury management and prevention techniques learned in rehabilitation  
- Understanding of nutritional needs discussed during rehabilitation |

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### Table 3. Functional Progressions for Dance*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Basic Level</th>
<th>Progressed Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement patterns</td>
<td>- Pedestrian stance and gait</td>
<td>- Ballet stances and skills</td>
</tr>
</tbody>
</table>
| Cardiovascular  | - 20 to 40 minutes, 4 times per week  
- Target heart rate | - 40 minutes, 4 times per week  
- Alternate aerobic with anaerobic bouts of ratio 2-minute maximum heart rate |
| Strength        | - Wide, parallel base  
- Proximal resistance keeping trunk in sagittal plane | - Sagittally restricted turned-out base  
- Digital resistance  
- Moving trunk and upper extremities  
- Head and eye focus throughout frontal and transverse planes |
| Exercise tempos | - Slower                                                  | - Faster                                                                                                                                     |
| Mechanical loads | - Lighter                                                 | - Heavier                                                                                                                                   |
| Balance         | - Two legs  
- Grounded base of support (eg, plié)                     | - Single leg  
- Narrow base of support (eg, relevé)                                                                          |
| Surface         | - Stable floor                                           | - Trampoline, sand, mattress, moving treadmill                                                                                                 |
| Vision          | - Eyes open  
- Comfortable light level                                  | - Eyes closed  
- Dim or very bright light level                                                                                      |
| Jumping         | - Low height, low repetitions  
- 2 feet                                                      | - High height, moderate repetitions  
- 1 foot                                                                                                                   |
| Concentration   | - Perform simple verbal recall while performing balance task on stable floor surface | - Perform complex verbal recall while executing balance tasks on unstable surface; reverse                                                |

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Table 4. Selected Functional Tests in Dance*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Example of Task</th>
<th>Score Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>- Romberg-type test</td>
<td>- Time</td>
</tr>
<tr>
<td>Agility</td>
<td>- Direction-oriented, dance-specific reaction time drills</td>
<td>- Number of successful completions with time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>limitations imposed</td>
</tr>
<tr>
<td>Concentration</td>
<td>- Movement task with changing instructions in chaotic environment</td>
<td>- Number of successful completions with sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and space distractions imposed</td>
</tr>
<tr>
<td>Proprioception</td>
<td>- Balance tests: changing lights and surface</td>
<td>- Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Goniometric accuracy: joint angle replication</td>
</tr>
<tr>
<td>Trunk strength and endurance</td>
<td>- Pike sit-ups with mobile upper extremities</td>
<td>- Number of repetitions without fatigue-induced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>movement errors</td>
</tr>
<tr>
<td>Trunk power</td>
<td>- Transfer of lower extremity weight</td>
<td>- Number of stable transfers completed</td>
</tr>
<tr>
<td></td>
<td>- Efficiency of lower extremity placement following change in body level or</td>
<td>- Number of successful foot placements with</td>
</tr>
<tr>
<td></td>
<td>directional facing</td>
<td>time-dependent level or direction changes</td>
</tr>
<tr>
<td>Lower extremity strength</td>
<td>- Unilateral limb wall sits</td>
<td>- Time</td>
</tr>
<tr>
<td>Lower extremity power</td>
<td>- Unilateral sauté jumps</td>
<td>- Height and/or number of repetitions without</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fatigue-induced movement errors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Horizontal distance</td>
</tr>
</tbody>
</table>

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1. Prevalence of injury in dance is reported to be:
   a. 50% to 70%.
   b. 75% to 97%.
   c. 10% to 20%.
   d. 25% to 38%.

2. Dance is considered to be a:
   a. high-risk activity.
   b. low-risk activity.
   c. low-risk to moderate-risk activity.
   d. moderate-risk to high-risk activity.

3. The average cost of a minor dance injury is estimated to be:
   a. between $4500 and $6000.
   b. between $1300 and $3000.
   c. between $2800 and $4500.
   d. $10,000.

4. Injuries in dance are most common in the:
   a. foot and ankle of lesser skilled dancers.
   b. hip of amenorrheic dancers.
   c. knee of older dancers.
   d. spine of women dancers.

5. Injuries in dance can be predicted what percentage of the time by trait anxiety?
   a. 97%.
   b. 61%.
   c. 25%.
   d. 2%.

6. In the 1970s, dance was considered to be as dangerous as:
   a. fencing and rowing.
   b. football and bull fighting.
   c. soccer and basketball.
   d. volleyball and baseball.

7. Which injury results in the second most common reason for time lost from work as a dancer?
   a. Achilles tendonitis.
   b. ankle sprain.
   c. anterior cruciate ligament sprain.
   d. low back pain.

8. Women ballet dancers average what percentage of expected body weight?
   a. 88%.
   b. 58%.
   c. 95%.
   d. 75%.

9. What percentage of university dancers report symptoms of depression?
   a. 43%.
   b. 90%.
   c. 72%.
   d. 28%.

10. What percentage of dancers make it to the professional stage?
    a. 1%.
    b. 10%.
    c. 0.1%.
    d. 0.01%.
ANSWERS

1. b  2. c  3. b  4. a  5. b  6. b  7. b  8. d  9. a  10. c