Cross-training for Dancers:
Does Participation in Other Physical Activities Affect Rates of Dance Injury?

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ABSTRACT

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The author examined the relationship between physical activity history and injury records of 31 female dancers of various styles, ages 18-38, affiliated with a university department of kinesiology. Based on self-reported total hours of non-dance physical activities and total hours of dance participation, and the calculated amount of cross-training (CT) participants were broken into three groups: no-CT, low-CT, and high-CT. No significant differences were found between groups for the rate of injury, as determined by the number of injuries for every 1,000 hours of dance. When dancers were re-grouped based on their lifetime total hours of dance into a low-dance training group and a high-dance training group, a significant difference did emerge at the level of p<.05. With regards to cross-training, results suggested that participation in other physical activities did not reduce or increase rates of injury. The novel finding of the study was that the rates of dance injury were negatively correlated with dancers’ total hours of dance participation.
INTRODUCTION

Dance is a very particular art form that makes physical, as well as intellectual, emotional, and creative demands of its practitioners. Indeed, it requires years of careful physical training that must be continuous, or begun again from a less developed point due to deconditioning. For this reason, Koutedakis and Jamurtas (2004) referred to dancers as “performing athletes,” and Best (as cited in Nieminen, 1998, p. 55) called them participants in “aesthetic sport.” When discussing the physicality of dance, however, it is important to remember that dancers are fundamentally artists, with unique needs and motivations compared to participants in other aesthetic sports, such as figure skating and gymnastics. Popular awareness of the prevalence of injury among dancers has grown along with awareness of the physical demands of dance training. In particular, the potential of injury to end professional careers in dance has been widely acknowledged. What are often left out of the conversation are the daily nature of pain and injury among dancers, and the psychological toll that injury can take, even when it does not forcefully end dance participation (Mainwaring, Krasnow, & Kerr, 2001). This normalization of pain and injury among dancers has impeded efforts to determine the causes of dance injury, and make cultural shifts towards emphasizing injury prevention. In other words, the feeling that pain and injury are inevitable in dance has kept members of the dance community from asking how to best prevent and treat physical ailments (Krasnow, Kerr, & Mainwaring, 1994). Fortunately, successful interventions, such as the injury prevention and management program described by Bronner, Ojofeitimi, and Rose (2003), have demonstrated that the incidence of dance injury can be dramatically reduced, and that many dance injuries are, in fact, preventable.
The development of a field of medical care and scientific research dedicated to dancers has lagged dramatically behind the development of sports medicine, which focuses on conventional athletes (Krasnow & Chatfield, 1996). The past forty years, however, have seen the field generate a wealth of information related to these, and other aspects of dancer wellness. Though there has always been a focus on ballet, research has expanded to include a multitude of styles, including modern dance, hip hop, tap, ballroom, Irish dance, folk dance, and others (Hinacapié, Morton, & Cassidy, 2008; Krasnow & Kabbani, 1999). The highest rates of injury have been found in hip hop dancers, with one study reporting that dancers averaged 2.3-3.5 injuries per year in three distinct hip hop styles, and had a 237% annual incidence of injury overall (Ojofeitiimi, Bronner, & Woo, 2012). As the most frequently injured group, hip hop dancers are followed by ballet dancers in companies, who have been shown to have annual injury rates of up to 95% (Nilsson, Leanderson, Wykman, & Strender, 2001). Research has also revealed rates as high as, for example, 81% of modern dancers injured in a year of performing (Bronner et al., 2003), and 79.7% of a sample of professional Irish dancers reporting multiple past injuries (Noon, Hoch, McNamara, & Schimke, 2010).

Dance science researchers have borrowed many techniques from sports medicine to examine patterns of dance injury and determine risk factors, as well as strategies for supporting and rehabilitating injured dancers. Just as the body of research has diversified to examine many styles of dance, it has grown to include dancers in training schools and university programs, and revealed that impacts of injury are not limited advanced and professional dancers; dancers at all levels are affected (Chmelar, Fitt, Schultz, Ruling, & Zupan, 1987; Thomas & Tarr, 2009). Numerous studies have also shown that most dance
injuries are cumulative injuries that result from repetitive microtrauma rather than isolated incidents of macrotrauma (e.g. Leanderson et al., 2011; Nilsson et al., 2001). It is usually reported that the lower extremity is the most frequently injured area of the body in dancers, though it has been observed that the distribution of injuries varies with the style of dance. Chmelar et al. (1987) recorded injuries by seven specific body sites, and noted that both university-based and professional modern dancers had been most affected by back injuries, followed by knee injuries. Professional ballet dancers in the same study were most affected by most ankle and foot injuries (Chmelar et al., 1987). Ojofeitimi et al. (2012) found that the lower extremity was the most frequently injured area of the body of injuries in hip hop dancers, but the distribution of injury was different than in, for example, professional Irish dancers. Lower extremity injuries were most common in both studies, but accounted for only 52% of the hip hop dancers’ injuries, as compared with 75% of the injuries reported by the professional Irish dancers (Calahan & O’Sullivan, 2013; Ojofeitimi et al., 2012).

In addition to the particular demands of each style of dance, there are many factors that create and exacerbate the risk of dance injury. Luke et al. (2002) categorized risk factors as either “intrinsic,” meaning that they are characteristics of the dancer, or “extrinsic,” meaning that they are aspects of the dancer’s situation or environment. The effort to mitigate these factors and reduce the incidence of dance injury, which has been central to dance science research, has addressed both intrinsic and extrinsic risks. It is, therefore, a multi-branched effort that attempts to examine every aspect of dance training, as well as characteristics of dancers’ physiologies and lifestyles. Most notably, branches of the injury prevention effort have been concerned with nutrition, the biomechanics of
dance movements, dance pedagogy, footwear, successful rehabilitation from injury, psychological support, and general fitness.

To promote fitness in dancers, suggestions have been made for the content of technique class, for the frequency and duration of training sessions, and for dance-specific conditioning. These were reviewed by Rafferty (2010), who summarized the conclusion of many dance scientists that it would not be possible for technique classes to address all of dancers’ fitness needs, or even to include the conditioning and alignment work that could help prevent injury. Systems designed with this goal in mind, however, have increasingly been adopted by dancers, and by organizations including university programs, dance schools, and companies. In a large study of modern and contemporary dancers in the United Kingdom, 94% of participants reported that they had experience with at least one type of somatic or body work technique (Thomas & Tarr, 2009). It was noted, however, that this experience was most common among the professional dancers in the sample. It was also observed that yoga and Pilates, which are not actually conditioning programs designed for dancers, though they share some similarities with dance, were by far the most commonly used. These observations suggest that, even among dancers who are willing and able to supplement their dance training, conditioning systems designed specifically for dancers are not the most frequently utilized. They also imply that professional dancers are most likely to supplement their dance training. It is possible that conditioning systems for dancers are following in the footsteps of medical care for dancers, which was observed by Krasnow (2005) to be most readily available to dancers in large companies and dance schools, but difficult to access for the many dancers in smaller organizations and independent studios. The alternative to dance-
specific conditioning, participation in other physical activities, or cross-training, remains curiously unexplored in dance, in spite of the reality that it might increase dancers’ fitness and contribute to injury prevention.
REVIEW OF THE LITERATURE

Fitness for Dancers

Arguably the most controversial branch of the dance wellness and injury prevention effort is that of exercise – of supplementing dance training with conditioning and other physical activity to increase fitness. The investigation into the effects of supplementary training for dancers was inspired, in part, by revelations about dancers’ relatively low levels of physical fitness. Koutedakis and Jamurtas (2004) defined fitness as “the individuals’ ability to meet the demands of a specific physical task” (p.652). The “task” of dance, however, is complicated, as it is what Best called an “aesthetic sport,” rather than a purposive sport, in which goals and task accomplishment are clearly defined (as cited by Nieminen, 1998, p.55). To further complicate the issue, the “task” of dance varies depending on the style of dance, on individual’s skill level, and choreography. Accordingly, it is difficult to determine standards of fitness for dancers. What is possible is to test measures of general physiological fitness – such as maximal oxygen uptake, muscular endurance, and anaerobic capacity – and to selectively assess strength and stability in different areas of the body. These assessments allow comparisons to be made among groups of dancers, and among dancers, other athletes, and their sedentary peers. groups of dancers to one another, and to sedentary and/or non-dance individuals. More importantly, they allow us to search for relationships between various aspects of fitness and indicators of vulnerability to injury, such as rates of injury, and injury severity.

Compared to other athletes, dancers have generally been found to have low levels of cardiorespiratory, or aerobic, fitness, as measured by VO\textsubscript{2max} (Angioi, Metsios, Koutedakis, & Wyon, 2009; Koutedakis & Jamurtas, 2004). This is surprising, given that even beginning level dancers often spend more than four hours each week dancing, while
more advanced dancers spend over 16 hours per week, on average (Chatfield, 1990). It has been found, however, that most theatrical dances (such as ballet, jazz, and modern) are intermittent activities that typically do not involve strenuous effort for the lengths of time that are necessary to promote cardiovascular adaptation (Koutedakis & Jamurtas, 2004). It should be noted that this is not the case for types of folk dance such as the Swedish “hambo,” which has been shown to make high demands on the cardiovascular system that do have the potential to cause aerobic adaptation (Wigaeus & Kilbom, 1980).

In their review of research examining the aerobic capacities of ballet dancers, Twitchett, Koutedakis, and Wyon (2009) found that average maximum oxygen uptake (VO$_{2}$max) ranged from 40.9 in one sample to 50.22 ± 12.6. In a study with modern dancers, Koutedakis et al. (2007) assigned students to either a control group or an exercise group before a three-month intervention program. Baseline VO$_{2}$max scores for the groups were 49.2 (±5.5) and 50.7(±7.5). Bronner et al. (2003) suggested that modern dancers might have greater aerobic fitness than ballet dancers due to greater and more sustained demands on the cardiovascular system in modern choreography and training. In a study that did not measure VO$_{2}$max directly, but used heart rate to estimate oxygen consumption, there were no significant differences between female ballet and modern dance students in a university’s company (Bemben, Green, Philpot, & White, 2004). The estimations of VO$_{2}$max produced by Bemben et al. (2004) were very close to the low end of the range determined by Twitchett et al. (2009), and the overall finding that the dancers had lower levels of aerobic fitness than elite athletes in the same age group, but an average level for non-athletes in the age group, was consistent with related studies (Koutedakis et al., 1996).
Koutedakis and Jamurtas (2004) suggested that all dancers require a large reserve of power for bursts of activity, and muscular endurance, in addition to cardiorespiratory endurance. In an early study of dancers’ anaerobic fitness, Chmelar, Schultz, & Ruhling (as cited by Angioi et al., 2009, p. 479-480) found that maximum levels of blood lactate were lower in professional ballet dancers than professional contemporary dancers, and university dancers studying either ballet or contemporary dance. Chatfield et al. (1990) used isokinetic dynamometry to test muscular endurance, strength, and power in ankle and knee actions, as well as a Wingate test, and found that dancers performed similarly to non-athlete, non-dancer peers. They reasoned that the modern dance classes attended by dancers in this sample were not challenging enough to promote anaerobic adaptation. These results in line with the findings of another early study of anaerobic capacity in dancers that measured and compared the anaerobic demands of technique class, and performance in professional ballet dancers using analysis of blood lactate concentration. Schantz and Åstrand (1984) found that demands of performance greatly exceeded those of training sessions, as represented by concentrations of blood lactate that averaged 3mM during class and reached 11mM on stage.

*Risks Associated with Low Fitness*

In and of themselves, low levels of anaerobic and aerobic fitness are not problematic. What is dangerous to dancers is that the tasks of dance performance and, increasingly, of choreography, have outpaced the demands of training, leaving dancers unfit for the tasks at hand, and vulnerable to injury (Rafferty, 2010). The situation described above, in which performance initiates an accumulation of blood lactate that the dancer has not been prepared for by technique class, can result in dancers experiencing
diminished coordination and balance on stage (Balda
dri & Guidetti, 2001; Twitchett et al. 2009). Though
the issue is complicated, and it is very difficult to establish the causes of
dance injury, dancers’ self-reports have echoed the observation that fatigue might create
injury-proneness. Of the hip hop dancers surveyed by Ojofeitimi et al. (2012), 57%
indicated that fatigue had been a factor in causing the injuries they had sustained in the
past 12 months. A similar proportion (55.4%) of the professional Irish dancers studied by
Calahan and O’Sullivan (2013) also reported that fatigue had been a cause of injury in
their careers.

Correspondingly, fatigue has been acknowledged as a risk factor for injury in
dance science literature, though the exact mechanisms of the relationship are still
somewhat controversial (Rafferty, 2010). In a pivotal article about the physiological
manifestations of burnout in dancers, Koutedakis (2000) wrote about imbalances between
time spent training, and time spent resting and recovering from training sessions. He
argued that such imbalances might actually negate the potential benefits of that training,
and lead to burnout as dancers feel that they are unable to perform optimally. Increased
injury proneness was listed as a symptom of burnout, as were conditions that can lead to
injury indirectly, such as loss of concentration, degradation of technique, and loss of
maximal voluntary muscle contraction (Koutedakis, 2000). Fatigue was presented as
both a cause of burnout, and a symptom of burnout. Lower levels of physical fitness,
Koutedakis (2000) argued, require athletes or dancers to exert themselves more to
accomplish the same task. Therefore, between two dancers facing the same demands
from choreography and training schedules, the one who has cultivated less aerobic or
anaerobic fitness might be plagued by burnout, while the other might successfully avoid
burnout and the associated risk of injury. While it might seem counter-intuitive that increased training more might save a dancer from over-training and developing burnout, it is critical to consider an emerging body of literature that suggests that many dancers are over-trained, and may benefit from taking more rest time between and during dance activities (Batson, 2007).

Two final aspects of the fitness of dancers that have been shown to elevate risks of injury are inadequate muscular strength, and strength imbalances. Koutedakis, Khaloula, Pacy, Murphy, and Dunbar (1997) made one of the first inquiries into the relationships between muscular strength and dance injury. By testing the thigh-power outputs of professional ballet and modern dancers (20 male, 22 female) who had endured at least one injury to the lower back, pelvis, or lower extremity in the prior year, and gathering data about the severity of those injuries, they were able to examine the relationship between thigh strength and injury severity in the professional dancers. A clear trend in the raw data suggested that dancers with greater thigh strength had less severe injuries. Conversely, dancers with weaker thighs had more severe injuries, and lost more time from dance due to injury. Unfortunately, no significant main effects were found for thigh force outputs on the rate or severity of dance injury (Koutedakis, et al., 1997). Nevertheless, authors recommended supplementary strength training for dancers as a potential protection against dance injury, or against some degree of injury severity. In a previous, similar study, Koutedakis, Pacy, Sharp, and Dick (1996) tested the theory that an imbalance between the strength of dancers’ quadriceps and hamstrings would be responsible for the severity of lower back injuries, due to the relationship shared by this strength ratio and lumbo-pelvic rhythm. There was no statistical analysis comparing the
means of the strength ratio and the number of days off due to injury. There was, however, a trend showing that larger differences between the force outputs of the quadriceps and hamstrings, due to underdevelopment of the hamstrings compared to the quadriceps, were associated with greater injury severity. Though injury proneness is not necessarily related to the quality of dance performance, it is interesting that muscular power in the lower extremity, which was associated with diminished injury severity in these two studies, was found to be one of two main predictors of aesthetic competence by Angioi, Metsios, Twitchett, Koutedakis, & Wyon (2009).

**Conditioning Interventions**

Dancers are famously resistant to doing exercise that increases strength. This is especially true of female ballet dancers, and is grounded in three myths. The first of these myths is that building strength necessarily involves muscle hypertrophy, or, “bulking.” The second is that building strength will decrease flexibility. The third is that all of dancers’ available time should be dedicated to technique training. These myths were first examined by Fitt (1981), who put an experimental group of dancers through a six-week conditioning program. The conditioning protocol was not described in detail, except as having been based on the overload principle. Pre- and post-tests were performed of isometric strength in seven positions, circumference of nine body parts, range of motion in 15 joint actions, cardiovascular endurance, and dance technique, as evaluated by instructors. The results demonstrated the effectiveness of the six-week conditioning program in increasing strength and endurance, as well as range of motion in 10/15 joint actions, without causing significant increases in the size of any measured body parts. The control group, which continued normal dance training during the six
weeks of the study, did not have significant increases in strength, endurance, or range of motion. Almost a decade later, the same assumptions that were examined by Fitt (1981) persisted in ballet dancers, and were re-examined. Stalder, Noble, and Wilkinson (1990) performed a study with 14 female ballet dancers at a university, half of whom were assigned to an experimental group that completed a nine-week resistance training program. Like Fitt (1982), Stalder et al. (1990) measured isometric strength, flexibility, limb circumference, and muscular endurance, and evaluated dance performance. Additionally, they measured anaerobic capacity. Results were very similar; researchers saw strength gains, and improvements in flexibility, muscular endurance, anaerobic power, and the evaluated dance sequence without any accompanying increase in limb circumference (Stalder et al., 1990).

In the interest of preventing injury, as well as enhancing the quality and efficiency of dance movement, a number of systems have been developed to supplement dance training. Krasnow, Chatfield, Barr, Jenson, and Dufek (1997) categorized these as either concerned primarily with alignment and neuromuscular patterning, or with exercising to improve fitness. There is no question that dance-specific conditioning programs would be ideal for supplementing dance training, or that it would benefit dancers most to be individually assessed, and provided with tailored programs that were designed with their needs as dancers in mind. What such programs would look like would vary on the physiology of an individual dancer, and the dancer’s personal and artistic goals. Unfortunately, there is also no question that we are far from realizing this goal. There are dance organizations that model incorporation of dance science into the training and care of dancers, including examinations of fitness and injury proneness. One such
organization is the Australian National Ballet, which has created an injury management and prevention program that includes the collaboration of physiotherapists, a body conditioning specialist, and a rehabilitation facilitator in caring for the dancers (The Australian Ballet, 2007). This care includes screening dancers for characteristics of their anatomy, technique, or injury history that may elevate their risks of injury, and subsequently designing individual programs to reduce that risk. Other ballet and modern companies are definitely going down this same path, and dancers at universities – where much of dance science research is generated – also have a good chance of finding responsible, scientifically up-to-date training, along with availability of conditioning classes that are designed for dance students. Outside of professional and educational settings, however, dance-specific conditioning will be difficult for many dancers to find. For those who can find it, such classes might require time and money that they may not have, or may not be willing to spare. Lai et al., (2008) observed that shortages of time and money have prevented many dancers from seeking medical care. Furthermore, surveys will dancers revealed that long-term compliance with injury treatment protocol was poor, and young dancers were unlikely to ask instructors for help in modifying technique to avoid future injury. Given that dancers are so reluctant to modify behavior in order to rehabilitate or avoid re-occurrence once they have been injured, it seems unlikely that they will make such changes in order to prevent future injury, when the threat of injury is still abstract.
Cross-training

Koutedakis et al. (2007) speculated that the fitness gains such as those brought on by the 12-week exercise intervention in their study could result in dancers suffering fewer injuries over time. There were, however, no inquiries into the prevalence of injury among participants. Bronner et al. (2003) took the opposite approach, in that they were very specific about changes in injury patterns during a three year intervention program with the Alvin Ailey modern dance company, but not specific about cross-training or supplemental exercise. Researchers defined injury as any musculoskeletal issue that led to money being spent on medical attention by either the dancer or the company. These injuries were categorized, based on amount of dance time lost, as mild, moderate, or severe. They were also categorized as overuse injuries (the products of repeated microtrauma over a long period of time) and trauma injuries (injuries that occurred suddenly in a single incident of macrotrauma). Researchers gathered data about injury prevalence and patterns of injury for two years before establishing an injury management program in order to use a repeated measures design, rather than create a control group that could miss potential benefits of the intervention. The intervention was a full-scale injury prevention and management program that included “primary prevention,” to minimize injury risk, and “secondary prevention” for responding to injury. Primary prevention included cross-training. Unfortunately, however, authors did not include many details about the cross-training, such as amount of time spent, percentage of dancers participating, or proportions of dancers engaged in disparate types of cross-training. Dancers who did cross-train were not compared to dancers who did not. Authors did state, however, that “increasing numbers of dancers incorporated cross-training...
training programs into their regimens,” (p.372) such as aerobic training, working to correct strength imbalances, and working on technique through floor barre, yoga, Pilates, or other activities (Bronner at al., 2003). It was reported that, from the first year of observation to the third year of the intervention, incidence of overuse injuries and trauma injuries both decreased, from 74% to 10%, and from 24% to 5%, respectively.

Calahan and O’Sullivan (2013) conducted a study with professional Irish dancers that examined injury patterns in a sample of 111 dancers with an average of 7.5 years of professional Irish dance experience. Injuries were defined as any physical insult that caused at least one day or rehearsal or performance to be missed, and severity was judged based in the total amount of time lost from dance. Interestingly, authors accounted for the reality that dancers often dance in spite of injury by asking separate questions about how often respondents danced in pain. The Irish dancers revealed injury patterns that were similar to those seen in ballet and modern dancers in that overuse injuries were the most common type, and the lower extremity was the most often injured area of the body. Questions about cross training yielded information that 74.7% of dancers engaged in some form of cross-training, such as aerobic training, Pilates, and stretch classes. There was not a significant relationship between cross-training and injury, which seems to contradict the implications of the two studies discussed above. It is important to note, however, that types of cross-training were diverse; only 25.3% of participants engaged in aerobic activities, and injury profiles of this group were not compared with the other cross-trained dancers. Another 24.1% of participants (roughly a third of the cross-trained group) engaged in stretch classes. It is possible that the distinct types of cross-training would have distinct impacts on rates of injury, and distribution of injury. Applicability of the information generated by the injury
profiles of the Irish dancers to other types of dancers is compromised, too, by the high rates of engagement with injury management practices such as massage and physiotherapy in this sample of professional Irish dancers, which far exceeded those in most ballet communities (Calahan & O’Sullivan, 2013).
METHODS

Participants

Participants were 31 female dancers affiliated with a university department of kinesiology who were enrolled in a larger institutional review board-approved study. Criteria for participation included either a dancing role in a pre-professional concert that was performed in a 500 seat auditorium, or other professional dance experience coupled with department affiliation. Dancers who met these criteria included undergraduate and graduate students, instructors of university-level dance courses, and other community members. Participants ranged from 18 to 38 years of age; there were no restrictions based on age, type of dance training, race, or ethnicity. Participants completed an informed consent form, biographical screening questionnaires, and questionnaires detailing physical activity history and injury history. This study used data from two self-report instruments.

Instruments

The Entry Questionnaire. This questionnaire gathered background data on participants, and included categorical, Likert, and narrative variables. The Physical Activity History section was used for this questionnaire, in addition to demographic information. The physical activity history section is narrative; participants were asked to list their recreational and competitive physical activities both pre- and post-puberty, and give details including age started participation, age stopped (if applicable), total years participation, weeks of participation per year, sessions per week, and minutes per session.

Questionnaire Regarding your Health. This questionnaire has a similar format to the Entry Questionnaire and combines categorical, Likert, and narrative items. The
Orthopedic Injury History portion of this questionnaire was used. Participants were asked to indicate whether or not they had experienced injuries or pain, by circling yes or no, in nine areas of the body (see table 1), and to indicate what types of problems they had had either by circling ailments in a list next to the area name, or describing the problem on a provided blank line. At the end of the section, participants were asked to give the dates and details of their injuries, and whether each injury was resolved or ongoing. An additional item asked whether participants had ever missed a week or more of dance training or rehearsal due to injury, and, if yes, to list the relevant injuries.

Protocol

Participants who performed in the university-based concert were told about the larger study when assembled for a rehearsal. They completed the consent form and a packet of research measures, including the two questionnaires used for this study, in or nearby the studio either before or after dancing. Participants affiliated with the department of kinesiology who volunteered for the study but did not perform in the same concert either completed these materials in an exercise physiology lab, or were allowed to take the materials home and return them to a researcher at a later date.

All participants signed an agreement that allowed researchers to contact them by phone or email for further information. Of the 31 participants, 11 were contacted and asked to clarify information in their narrative responses, or to provide answers to questions that had been left blank.

Analysis

IBM SPSS Statistics Software 22.0 was used for all statistical calculations. Descriptive statistics ($M \pm SD$) were used to examine the entire sample, and then to create
groups for further analysis. Total time in minutes of dance activity and total time in minutes of other physical activity were calculated, and synthesized into a single variable: hours cross-training per 1,000 dance-hours. Each participant’s total time in minutes of dance activity and total number of injuries were used to calculate their rate of injury, as injuries/1,000 dance-hours. The rate of injuries that resulted in a week or more of time lost from dance was also calculated, as time loss injuries (TL-injuries) per 1,000 dance-hours.

Because nine participants (29%) had no cross-training at all, they were placed into a no-CT group. The remaining participants were assigned to low-CT and high-CT groups, based on a median split. Separately, participants were divided into high and low dance training groups based on a median split. One-way ANOVA was used to identify significant differences among the rates of injury in the cross-training groups, and between the rates of injury in the dance training groups. The same tests were repeated to examine effects of cross-training and total hours of dance training on rates of TL-injury.

Finally, a linear regression analysis was used to examine whether hours of cross-training or hours of dance training could be used to predict the variance in rates of injury, as expressed by injuries/1,000 dance-hours and TL-injuries/1,000 dance-hours.
RESULTS

Descriptive Statistics

At the time of the study, dancer participants were ages 18-38 ($M=23$). Two reported dance and other physical activity history prior to the current time period, making the ages at time of dance participation 18-34 ($m=22.7$). Participants used 23 different labels for their dance activities including, most frequently, the non-specific label “dance.” Specific styles that were named included ballet, jazz, lyrical, hip hop, Indian, Armenian, modern, and ballroom (list 1). The reported lifetime hours of dance participation ranged from 364 to 21,050 ($M=6111.11$, $SD=5250.78$). Dancers named 24 physical activities in which they had participated that were unrelated to dance (list 2) and reported a mean of 1348.67 hours of such activities ($SD=2410.63$).

**LIST 1:** Dance activities

- Armenian dance
- Ballet
- Ballet Folklorico
- Ballroom dance
- Baton
- Belly dancing
- Cheerleading
- Classical stretch
- Contemporary dance
- Dance
- Dance team
- Folk dance
- Hip-hop
- Hula
- Indian dance
- Jazz dance
- Lyrical dance
- Modern dance
- Pilates
- Rhythmic gymnastics
- Samba
- Street dance
- Yoga

**LIST 2:** Other physical activities

- Archery
- Badminton
- Basketball
- Bicycling
- Bicycle touring
- Boomerang
- Cardio
- Cross-training
- Golf
- Gymnastics
- Hiking
- Karate
- Pole vaulting
- Rock climbing
- Running
- Snowboarding
- Soccer
- Softball
- Swimming
- Tennis
- Track & field
- Volleyball
- Walking
- Weight training
A high rate of 90.3% of dancers \((n=28)\) reported at least one injury. The range of total number of injuries recorded per subject was 1-12 \((m=4.06\) injuries). Exactly 50% of participants \((n=14)\) did not follow questionnaire instructions to provide the dates and details of each injury. When the causes of injuries were given, injuries that were not related to dance participation were excluded from the participant’s injury count.

Only 41.9% \((n=13)\) of participants reported losing one week of time from dance due to injury. Of these dancers, six (46.15%) had only one such injury; four recorded two such injuries. Only two dancers reported three TL-injuries. No participant recorded more than three separate injuries that resulted in a week or more of time loss. The proportion of participants who reported past injury in the nine areas of the body highlighted by the Questionnaire Regarding Your Health is reported in table 1.

**TABLE 1: Injury Frequency**

<table>
<thead>
<tr>
<th>Area of Injury</th>
<th>Participants reported (n)</th>
<th>Portion of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankle/foot</td>
<td>19</td>
<td>61.30%</td>
</tr>
<tr>
<td>Knee</td>
<td>18</td>
<td>51.80%</td>
</tr>
<tr>
<td>Hip/pelvis</td>
<td>15</td>
<td>48.40%</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>13</td>
<td>41.90%</td>
</tr>
<tr>
<td>Elbow/wrist/hand</td>
<td>13</td>
<td>41.90%</td>
</tr>
<tr>
<td>Lower leg/shin</td>
<td>10</td>
<td>32.30%</td>
</tr>
<tr>
<td>Cervical/thoracic spine</td>
<td>9</td>
<td>29%</td>
</tr>
<tr>
<td>Shoulder</td>
<td>9</td>
<td>29%</td>
</tr>
<tr>
<td>Thigh</td>
<td>7</td>
<td>22.60%</td>
</tr>
<tr>
<td>None</td>
<td>3</td>
<td>10.33%</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>90.32%</td>
</tr>
</tbody>
</table>

Notes: Total refers to the total number of participants who had been injured.

*Calculations*

As is consistent with the literature and recommended by a systematic review (Hincapié et al., 2008), rates of injury were reported as injuries per 1,000 hours of dance. The mean calculated number of injuries for each 1,000 hours dance was 1.13 \((SD=1.25,\)
range=0-5.49). Participants’ total numbers of hours participating in non-dance physical activities were also calculated in a ratio with 1,000 hours of dance participation. Because the questionnaire pertained to lifetime histories of injury, lifetime totals of dance and non-dance participation hours were examined as well. In order to isolate the effects of participation in non-dance activities on rates of injury, activities that were very similar to dance, such as rhythmic gymnastics and cheerleading, were included in the total dance hours, as were activities that could qualify as dance-specific conditioning, such as yoga, Pilates, and stretch classes.

**TABLE 2: Descriptive Statistics for Cross-training Groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total N=31</th>
<th>No cross-training n=9</th>
<th>Low cross-training n=11</th>
<th>High cross-training n=11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age range</td>
<td>18-34</td>
<td>18-24</td>
<td>19-34</td>
<td>18-32</td>
</tr>
<tr>
<td>Total dance hrs. range</td>
<td>6111.81 (5250.78)</td>
<td>3578.67 (2008.35)</td>
<td>8401.42 (7198.63)</td>
<td>5894.76 (4008.91)</td>
</tr>
<tr>
<td>Total other PA hrs. range</td>
<td>0-10,028</td>
<td>0-0</td>
<td>52-426.38</td>
<td>420-10,028</td>
</tr>
<tr>
<td>Other PA hrs./1,000 hrs. dance range</td>
<td>0-1145.65</td>
<td>0-0</td>
<td>9.88-111.11</td>
<td>167.95-1145.65</td>
</tr>
<tr>
<td>Injuries/1,000 hrs. dance range</td>
<td>0-5.49</td>
<td>0-5.49</td>
<td>.23-.427</td>
<td>2.27</td>
</tr>
<tr>
<td>Time loss injuries/1,000 hrs. dance range</td>
<td>.12 (.23)</td>
<td>0.02 (0.07)</td>
<td>0.07 (0.09)</td>
<td>0.26 (0.34)*†</td>
</tr>
</tbody>
</table>

Note: Value are reported as Mean(SD). *A significant effect of cross-training was found on the rate of injuries that resulted in time lost from dance (time loss injuries). Fisher's Least Significant Difference (LSD) post-hoc test was used, and showed that the mean rate of time loss injuries in the no-CT group differed significantly from the rate of time loss injury in the high-CT group at the level of p<.05. †A significant difference in the rate of time loss injury was also found between the low-CT group and high-CT group, at the level of p<.05.
Of the 31 participants, 29% (n=9) indicated that they had no history of participation in non-dance physical activities. These formed the no-CT group. The participants who had cross-training were divided into low-CT and high-CT group, using a median split (mdn=111.11). See table 2 for descriptive statistics of these groups. Separately, participants were divided into low-dance training and high-dance training groups using a median split (mdn=4680). For descriptive statistics of these two groups, see table 3.

| TABLE 3: Descriptive Statistics for Dance Training Groups |
|---------------------------------|-----------------|-----------------|
| Variable                        | Total           | Low training    | High training   |
|                                 | N=31            | n=15            | n=16            |
| Age (range)                     | 22.77 (3.89)    | 23.4 (4.21)     | 22.19 (3.60)    |
| Total Dance Hrs. (range)        | 6111.18 (5271.8)| 2457.86 (1203.83)| 9537.39 (5283.98)|
| Injuries/1,000 hrs. dance (range)| 1.13 (1.25)    | 1.63 (1.57)     | .66 (.59)*      |
| Time loss injuries/1,000 hrs. dance (range) | .12 (.23) | .17 (.32) | 0.08 (.11) |

Note: Values are reported as Mean(SD). *A significant effect of lifetime hours of dance training on the rate of dance injury at the p<.05 level.

Analysis of Variance

A one-way ANOVA was used to test for differences in rates of injury among the no-CT, low-CT, and high-CT groups. Differences in rates of injury were not found to be statistically significant, F(2,28)=.45, p>.05. A second ANOVA was run to assess differences in rates of TL-injuries among the same three groups of participants. A significant main effect for cross-training was found, F(2,28)=3.57, p<.05, where cross-
training was associated with a greater number of injuries that resulted in time lost from dance.

A third ANOVA was run to determine whether the rates of dance injury were related to total amounts of dance training, comparing dancers in the low-dance training and high-dance training groups. The high-training group had a lower average rate of injury (see table 3). Between group differences were significant for injuries/1,000 dance-hours, $F(2,29)=5.27, p<.05$. There was no significant main effect found for the rate of TL-injuries, $F(2,29)=1.03, p>.05$.

**Regression Analysis**

A regression analysis was used to examine whether total amounts of dance training, or the ratio of cross-training to dance could be used to predict the number of injuries/1,000 dance-hours. Consistent with the results of the ANOVA, cross-training did not significantly predict any variance in the rate of injury, ($R^2=0, F(1,29)=.979, p>.05$). Total hours of dance training, on the other hand, were found to explain 14.2% of the variance in rate of injury with a negative association, $F(1,28)=3.48, p<.05$.

Cross-training ratios (hours CT/1,000 dance-hours) and amounts of dance training were also examined in a regression analysis for their potential to predict variance in rates of time loss injury. It was found that cross-training explained 32.5% of the variance in rates of time loss injury, $F(2,28)=8.23, p<.05$, with an adjusted $R^2=.325$. Unlike the general rate of injury, the rate of time loss injury could not be predicted significantly by amounts of dance training.
DISCUSSION

Summary

Because it is clear that supplemental exercise can offer many benefits to dancers, and because non-dance activities may be more accessible than dance-specific conditioning, the relationship between cross-training (participation in non-dance physical activities) and dance injury warrants examination. Though injury prevention may not be the only potential benefit of cross-training, injury is a critical issue in the dance community regardless of dance style.

The results gathered from the Entry Questionnaire and Questionnaire Regarding Your Health revealed no significant relationship between cross-training and dance injury. There was, however, a trend in the raw data that echoed the hypothesis; the high-CT group did, in fact, have the lowest rate of injury, followed by the low-CT group. The group of dancers with no cross-training had the highest rate of injury. Though the results were not statistically significant, they suggest that this avenue of inquiry should be pursued with a larger sample. In terms of statistical significance, it is important that the results showed no relationship between cross-training and increased rates of dance injury. In this way, the results suggested that any stigma against non-dance physical activities, as far as direct and indirect causes of injury are concerned, is unwarranted.

This was a novel study in that it examined the effects of general cross-training on rates of injury in a diverse group of dancers. The conclusions were, however, consistent with findings in a sample of 178 professional Irish dancers, 74.7% of whom cross-trained, and among whom cross-training and injury were not significantly related (Calahan & O’Sullivan, 2013). In a study with a modern dance company, cross-training
was anecdotally related to a dramatic decrease in workers’ compensation cases (Bronner et al., 2003). Data from the present study did not contradict, or support, that anecdotal connection, except with the statistically insignificant trend.

It was interesting to find that cross-training was significantly associated with time loss from dance due to injury, in spite of its non-relationship with injuries generally. The stark difference between the number of total injuries and the number of injuries that resulted in time lost from dance was consistent with literature concerning dancers’ reluctance to acknowledge injuries, rest, seek medical attention, and follow medical advice (Lai, Krasnow, & Thomas, 2008). Though authors including Bronner and Browstein (1997) and Calahan and O’Sullivan (2013) have used time loss as criteria for injury, this measure may warrant further examination. It is telling that Calahan and O’Sullivan (2013) created a separate item in the questionnaire that asked dancers whether they ever danced in pain. These authors, along with Ojofeitimi et al. (2012), also used time loss as an indicator of injury severity, but categorized injuries that resulted in up to one week of time loss as mild injuries.

It is, of course, possible that the injuries of the cross-trained dancers were simply more severe than those of the not-cross-trained dancers. This seems unlikely, however, given that injuries listed by dancers who reported that they had never missed a week of dance participation due to injury included a torn meniscus, and a torn adductor muscle. It is interesting to speculate that time loss may increase with cross-training for other reasons. One possible reason is cultural: that, perhaps, dancers with other athletic identifications are more likely to take time off when injured because they have experience with athletic communities that have different normative behaviors related to
injury. Another is that dancers who do other activities are more willing to take time off from dance simply because they already engage in other activities, and time away from dance is not necessarily inactive time, during which time they would be anxious about deconditioning.

The final revelation of the data was that actual rates of injury were negatively correlated with the total numbers of dance training. The average rate of injury in the sample (1.4/1,000 dance-hours) fell within the range of .18/1,000 dance-hours to 4.7/1,000 dance-hours, which was identified by Hincapié et al. (2008) in their systematic review of dance injury studies. The large range of total hours spent in dance training among participants allowed for a comparison between dancers who had more training, and those with less training; groups were created using a median split of lifetime 4,201 dance-hours. The average number of injuries in the high and low training groups (.68/1,000 dance-hours and 1.57/1,000 dance-hours, respectively) also fell within the range observed by Hincapié et al. (2008). Furthermore, the current results illustrate a point that has been made in other studies, that dance injury affects dancers at all levels (Chmelar et al., 1987; Encarnacion, Meyers, Ryan, & Pease, 2000).

The low training group had a significantly higher rate of injury. This might seem counter-intuitive given the prevalence of cumulative injuries, which involve microtrauma that accumulates over time. It appears, however, that such injuries often begin affecting dancers early in their training. Additionally, this data agrees with the assessment of Bronner et al. (2003) that one risk factor for injury is a sudden increase in amounts of training. Those increases do, obviously, occur when someone starts dancing. As training progresses, injuries are more common in those dancers who train less and have
accumulated less experience, perhaps due to greater potential to make dramatic increases in their training volume. For example, a dancer who already takes class every day will be very hard pressed to double her training volume, while a dancer who trains twice a week is likely to sharply increase her volume by choosing to take class four times a week, or by maintaining a technique class schedule and entering a rehearsal process. In the study that involved the first and second Alvin Ailey companies, a higher rate of injury was actually found in the junior company (Bronner et al., 2003). These authors speculated that rapid increases in training and performance volume were associated with injuries, as the dancers in the second company had less experience, and were struggling to adjust to the demands of a professional company.

Limitations of the Current Study

The primary limitation of this study is that it was based on self-report, and it was necessary to assume that participants would be able to accurately recall their history with injury and physical activity, and that they would honestly report their activity and injury history. Additionally, the instruments used were not designed for this study, and may not have provided critical information relevant to this research question in adequate detail due to wording and formatting of the questionnaire. Exactly 50% of the participants who had been injured (n=14) did not follow the direction to give dates and details of each injury. For this reason, it was often unclear whether all of the injuries listed were actually dance-related. While injuries were removed from each participant’s total if the causes were specified and unrelated to dance, it is possible that the number of dance-related injuries was over-stated. One participant who responded “yes” to the question of whether
she had ever missed a week of dance activities often failed to specify which injuries had caused the time loss, and thus did not indicate how many such injuries she had sustained.

Finally, this study faced many of the same obstacles that have plagued other investigations regarding dance injury. Injury was not actually defined by the questionnaire, and thus was left open to the interpretation of the dancers. As pain is normalized in dance communities, it is impossible to know whether dancers would recognize, for example, pain that does not inhibit dancing as the symptom of an injury.

**Strengths of the Current Study**

The greatest strength of the study was the diversity among participants. This allowed a look at dancers in university programs without narrowing the implication to dancers of a specific style. Diversity in age and experience allowed for the comparison of dancers with high and low levels of training, which is unusual for such a study.

Another strength was the study’s examination of cross-training, generally, which is still very rare in dance science literature. As most dancers have opportunities to participate in non-dance physical activities throughout their lives (from walking on their own, to playing with organized sports teams) it is important to determine whether such activities have any impacts on dancer health and well-being.

**Implications**

As injury is a great concern for all dancers, the finding that cross-training does not impact rates of dance injury is important. Though every physical activity will involve a certain amount of risk, there are many reasons that dancers may desire to cross-train. This study suggests that dancers do not need to avoid other physical activities for fear of increasing their injury proneness during dance.
Directions for Further Research

Due to the limitations described above, as well as the small sample size, this study should be considered preliminary. Two-thirds the university-affiliated female dancers in the sample had backgrounds in cross-training. Though this high proportion may not be found among university students who actually major in dance, or in dance schools, the proportion is high enough to suggest that effects of cross-training on dancers health and well-being should be examined in future research. As this study revealed a huge range of non-dance activities, it will be important in future research to distinguish between different types of cross-training, as was done in the study with professional Irish dancers (though relationships between types of activities and injury were not examined in that study). Specifically, it would be interesting to see whether aerobic activities – those with promote adaptation of the cardiovascular system – provide and protection from dance injury. Another potential area of research is the chronological relationship between dance activities and others, and whether any benefits of cross-training are dependent on concurrent engagement, or whether a history of other physical activity can at all predict rates of dance injury.
REFERENCES


