



**PASIG PERFORMING ARTS**  
SPECIAL INTEREST GROUP



**ORTHOPAEDIC SECTION**  
AMERICAN PHYSICAL THERAPY ASSOCIATION



**PASIG MONTHLY CITATION BLAST: No. 118**

**August 2016**

Dear Performing Arts SIG members:

**Upcoming Conferences!** We look forward to providing more programming at conferences in 2017. Upcoming events for the Orthopaedic Section is CSM 2017 on Feb 15-17 in San Antonio, TX. The 2017 annual conference will be San Diego Hyatt Regency mission bay April 20-22.

**Dance Fellowship Update!** The Description of Advanced Specialized Practice (DASP) for Performing Arts Physical Therapy was revalidated and approved by the ABPTRFE. This provides current practice guidelines for practitioners in the subspecialty field of Performing Arts Physical Therapy. It also provides the framework for competencies, skills, and attributes that a PT fellowship program should achieve for the subspecialty field. The ABPTRFE has already recognized one Performing Arts PT Fellowship program in development at Ohio State Sports Medicine. Several others are also in the early stages of planning and we hope for them to be developed soon. For questions please contact [Mariah.Nierman@osumc.edu](mailto:Mariah.Nierman@osumc.edu).

**USC Research Survey!** Please see the following research request from and help the researchers with their exciting dance injury screening tool research study:

We are a group of researchers from the University of Southern California, Division of Biokinesiology and Physical Therapy, working to develop a dance injury-screening tool. We would like to obtain the input of movement experts who work with individuals in the performing arts, or have been educated in the performing arts. Please take the time to watch a short video of a dancer performing a sauté de chat, and then complete the 10-minute survey.

You may watch the videos at the link as many times as you like. The results of the survey will be used to compile an observation form that will allow a physical therapist with basic physical therapy training and education, to study the kinematics of a specific dance movement, and be able to observe unique dancer-specific movement preferences that may eventually cause, or are currently causing, musculoskeletal impairments.

We thank you in advance for your input.

Link to videos:

<https://www.dropbox.com/sh/yxcg85znlhkyoqb/AAA2th0nVKELaoWmN7xk5F1Pa?dl=0>

Link to survey:

[https://uscdentistry.az1.qualtrics.com/SE/?SID=SV\\_0p4YPk6Ad8EAQ4d](https://uscdentistry.az1.qualtrics.com/SE/?SID=SV_0p4YPk6Ad8EAQ4d)

**Attention all PASIG Members!!** The PASIG Nomination Committee is looking for interested and qualified candidates interested in running for officer positions beginning 2017. There are 3 positions that will be up for election at the end of this year. These include: President (3 year term), Nominating committee member (3 year term), and Secretary (2 year term).

Job descriptions of each of these positions are available. If anyone is interested or would like to nominate someone for any of the positions, please e-mail Janice Ying ([JaniceYingDPT@gmail.com](mailto:JaniceYingDPT@gmail.com)).

**Looking for new committee members!** There is room for new committee members, and students are welcome to participate. Please refer to the list below for contact information.

Annette Karim, President	2014-2017	<a href="mailto:neoluvsonlyme@aol.com">neoluvsonlyme@aol.com</a>
Rosie Canizares, Vice President/Education Chair	2016-2019	<a href="mailto:Rcc4@duke.edu">Rcc4@duke.edu</a>
Janice Ying, Nominating Committee Chair	2016-2017	<a href="mailto:JaniceYingDPT@gmail.com">JaniceYingDPT@gmail.com</a>
Laura Reising, Research Chair	2016-2018	<a href="mailto:lbreising@gmail.com">lbreising@gmail.com</a>
Amanda Blackmon, Dancer Screen Chair	2016-2018	<a href="mailto:MandyDancePT@gmail.com">MandyDancePT@gmail.com</a>
Dawn Muci, Public Relations Chair	2016-2018	<a href="mailto:Dawnd76@hotmail.com">Dawnd76@hotmail.com</a>
Mariah Nierman, Fellowship Taskforce Chair	2016-2018	<a href="mailto:Mariah.Nierman@osumc.edu">Mariah.Nierman@osumc.edu</a>
Anna Saunders, Secretary/Student Scholarship Chair	2015-2017	<a href="mailto:annarosemary@gmail.com">annarosemary@gmail.com</a>
Andrea N. Lasner, Nominating Committee	2015-2018	<a href="mailto:alasner1@jhmi.edu">alasner1@jhmi.edu</a>
Jessica Fulton, Nominating Committee	2016-2019	<a href="mailto:jessicafultondpt@gmail.com">jessicafultondpt@gmail.com</a>
Laurel Abbruzzese, Fellowship Chair Asst.	2016-2018	<a href="mailto:La110@cumc.columbia.edu">La110@cumc.columbia.edu</a>
Elizabeth Chesarek, Membership Chair	2016-2018	<a href="mailto:echesarek@gmail.com">echesarek@gmail.com</a>

**Interested in a Performing Arts Fellowship? The American Board of Physical Therapy Residency and Fellowship Education (ABPTFRE) has approved the PASIG Description of Specialist Practice (DSP) for the Performing arts as an area of study.** We are now working with the ABPTFRE to turn the DSP into a Description of Fellowship Practice (DFP). We anticipate the DFP will be available online by June 2016. This means that sites can begin forming fellowships in dance medicine, music medicine, theater medicine, etc. The PASIG will provide the fellowship criteria for accreditation. We may have a meeting on creating a performing arts fellowship at CSM 2017 and/or the 2017 Orthopaedic Section annual meeting. Please contact Rosie Canizares, Mariah Nierman, and Laurel Abbruzzese if interested.

**Membership:** Current PASIG members, please remember to update your membership:

[https://www.orthopt.org/login.php?forward\\_url=/surveys/membership\\_directory.php](https://www.orthopt.org/login.php?forward_url=/surveys/membership_directory.php)

**Social Media:** For fun PT info and related performing artists info...

1) Facebook page: (closed) so, if you would like to be a part of the group, email me on Facebook: Dawn Doran and let me know you'd like to join.

2) follow PASIG on Twitter: @PT4PERFORMERS

**Call for case reports:** If you have a brief, clinically-focused case report on a performing arts PT patient, or a clinical commentary, please contact Annette Karim to submit your writing for the next Orthopaedic Physical Therapy Practice Magazine: [neoluvsonlyme@aol.com](mailto:neoluvsonlyme@aol.com)

**WE NEED MORE CONTRIBUTORS TO OUR MONTHLY CITATION BLASTS!!!!**

Past Monthly citation blasts are available, with citations and EndNote file, listed on the website:

[http://www.orthopt.org/content/special\\_interest\\_groups/performing\\_arts/citations\\_endnotes](http://www.orthopt.org/content/special_interest_groups/performing_arts/citations_endnotes)

**TOPICS THAT HAVE BEEN COVERED RECENTLY INCLUDE:**

*Plyometric Training in Dancers (Current)*

*HVLAT for Lower Extremity Conditions*

*Inguinal Disruption*

*Femoroacetabular Impingement*

*Hand and Wrist Conditions in Gymnasts*

*Factors in Optimal Turnout*

*Achilles Tendinopathy*

*Biomechanics and Posture in Musicians*

*Pilates*

*ACL Injuries in Dancers*

*Patellofemoral Pain and Dance*

*Neural Entrapments Found Among Musicians*  
*Stress Fractures of the Foot and Ankle*  
*Dry Needling*  
*Dynamic Warm Up and Stretching*  
*Platelet Rich Plasma Injections*  
*Back Pain in Dancers*

**If you are interested in contributing by writing a citation blast or joining the research committee, contact me at [lbreising@gmail.com](mailto:lbreising@gmail.com).**

Sincerely,

*Laura*

Laura Reising, PT, DPT, MS, OCS  
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**PASIG Research Committee members:**

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Sarah Edery-Altas, PT, DPT [SEderyAltas@kessler-rehab.com](mailto:SEderyAltas@kessler-rehab.com) (EndNote Organizer)

**PERFORMING ARTS CONTINUING EDUCATION, CONFERENCES, AND RESOURCES**

Musician Health Series, Janice Ying, PT, DPT, OCS  
Glendale Adventist Therapy and Wellness Center, Los Angeles area (Eagle Rock), CA  
<http://www.musicianshealthcorner.com/>  
Healthy Musician Series - Overuse

Orthopaedic Section Independent Study Course. *20.3 Physical Therapy for the Performing Artist.*

Monographs are available for:

- Figure Skating (J. Flug, J. Schneider, E. Greenberg),
  - Artistic Gymnastics (A. Hunter-Giordano, Pongetti-Angeletti, S. Voelker, TJ Manal),
- and
- Instrumentalist Musicians (J. Dommerholt, B. Collier).

Contact: Orthopaedic Section at: [www.orthopt.org](http://www.orthopt.org)

Orthopaedic Section-American Physical Therapy Association,  
Performing Arts SIG

[http://www.orthopt.org/content/special\\_interest\\_groups/performing\\_arts](http://www.orthopt.org/content/special_interest_groups/performing_arts)

Performing Arts Citations and Endnotes

[http://www.orthopt.org/content/special\\_interest\\_groups/performing\\_arts/citations\\_endnotes](http://www.orthopt.org/content/special_interest_groups/performing_arts/citations_endnotes)

ADAM Center

<http://www.adamcenter.net/>

Publications:

<http://www.adamcenter.net/#!vstc0=publications>

Conference abstracts:

<http://www.adamcenter.net/#!vstc0=conferences>

Dance USA

<http://www.danceusa.org/>

Research resources:

<http://www.danceusa.org/researchresources>

Professional Dancer Annual Post-Hire Health Screen:

<http://www.danceusa.org/dancerhealth>

Dancer Wellness Project

<http://www.dancerwellnessproject.com/>

Becoming an affiliate:

<http://www.dancerwellnessproject.com/Information/BecomeAffiliate.aspx>

Harkness Center for Dance Injuries, Hospital for Joint Diseases

<http://hjd.med.nyu.edu/harkness/>

Continuing education:

<http://hjd.med.nyu.edu/harkness/education/healthcare-professionals/continuing-education-courses-cme-and-ceu>

Resource papers:

<http://hjd.med.nyu.edu/harkness/dance-medicine-resources/resource-papers-and-forms>

Links:

<http://hjd.med.nyu.edu/harkness/dance-medicine-resources/links>

Informative list of common dance injuries:

<http://hjd.med.nyu.edu/harkness/patients/common-dance-injuries>

Research publications:

<http://hjd.med.nyu.edu/harkness/research/research-publications>

International Association for Dance Medicine and Science (IADMS)

<http://www.iadms.org/>

Resource papers:

<http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=186>

Links:

<http://www.iadms.org/displaycommon.cfm?an=5>

Medicine, arts medicine, and arts education organization links:

<http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=5>

Publications:

<http://www.iadms.org/displaycommon.cfm?an=3>

Performing Arts Medicine Association (PAMA)

<http://www.artsmed.org/>

<http://www.artsmed.org/symposium.html>

Interactive bibliography site:

<http://www.artsmed.org/bibliography.html>

Related links:

<http://www.artsmed.org/relatedlinks.html>

Member publications:

<http://artsmed.org/publications.html>

***(Educators, researchers, and clinicians, please continue to email your conference and continuing education information to include in future blasts.***

## **Plyometric Training in Dance**

It has been reported that dancers have a decreased risk for ACL injury compared to other female athletes who may fatigue sooner (Liederbach et al). Despite this information, a dancer's fitness parameters are on par with healthy albeit sedentary adults and according to the literature, dance training lacks general fitness and explosive power training which we also now know may lead to a reduced risk of injury. Other athletic populations have enhanced sport-performance by incorporating plyometric and strength training; dance, in all forms, has been slow to introduce the same type of supplemental exercise training. Traditional dance training has avoided fitness and power training; most likely because it is widely believed that these types of training will change anthropomorphic measurements of the dancer's body and decrease the aesthetic line that is so sought after in dance performance. Another concern when incorporating plyometrics into a dancer's training regimen is that plyometric training often emphasizes jumping from a position with the trunk flexed, for biomechanically correct alignment. Jumping with the trunk flexed is not specific to dance technique, which emphasizes an upright trunk during take off and landing. It was found that the ground reaction forces from landing with an upright trunk might contribute to increased risk of patellar tendinopathy. The articles below have concluded that plyometric training was shown to improve and decrease risk of injury for dance specific jumps, indicating generalizability with plyometric training. Moderate evidence indicates that supplementary strength training interventions via traditional resistance training,

whole-body vibration methods and plyometric-training interventions may increase certain dance-performance measures such as jump height and general aesthetic facility without changing anthropometric measures. Additional articles on different jumping methods between sports and dance were included for comparison and critical thought.

Sarah Edery-Altas, PT, DPT , Kessler Rehabilitation Center, West Orange, NJ  
Jennifer Stoskus, PT, DPT, Kessler Rehabilitation Center, Hackensack, NJ

**Angioi M, Metsios G, Twitchett EA, Koutedakis Y, Wyon M. Effects of supplemental training on fitness and aesthetic competence parameters in contemporary dance: a randomised controlled trial. *Med Probl Perform Art.* 2012;27(1):3-8.**

Within aesthetic sports such as figure skating and rhythmic gymnastics, physical fitness has been shown to have positive benefits on performance outcomes. Presently the link between physical fitness and aesthetic contemporary dance performance has not been demonstrated within an intervention study. In this study, 24 females engaged in contemporary dance (age  $27 \pm 5.9$  yrs; height  $165.3 \pm 4.8$  cm; weight  $59.2 \pm 7.6$  kg) were recruited and randomly assigned to either an exercise ( $n = 12$ ) or a control group ( $n = 12$ ). Three dancers withdrew during the study. The intervention group completed a 6-week conditioning programme comprising two 1-hr sessions of circuit and vibration training per week. The circuit training focused on local muscular endurance and aerobic conditioning and vibration training protocol concentrated on power. Repeated measures ANOVA revealed significant increases for the conditioning group in lower body muscular power (11%), upper body muscular endurance (22%), aerobic fitness (11%), and aesthetic competence (12%) ( $p < 0.05$ ). The control group reported decreases in all the fitness parameters with the exception of aerobic fitness as well as a decrease in aesthetic competence (7%). A 6-week circuit and vibration training programme, which supplemented normal dance commitments, revealed significant increases in selected fitness components and a concomitant increase in aesthetic competence in contemporary professional and student dancers.

**Angioi M, Metsios GS, Koutedakis Y, Wyon MA. Fitness in contemporary dance: a systematic review. *Int J Sports Med.* 2009;30(7):475-84.**

It has been suggested that dancers are less fit compared to other athletes. However, the majority of studies make their arguments based on data deriving mainly from ballet. Therefore, the aim of the current review was to investigate: a) aerobic and anaerobic fitness, muscular strength and body composition characteristics in contemporary dancers of different levels, and b) whether supplementary exercise interventions, in addition to normal dance training, further improves contemporary dance performance. Three databases (Medline, Cochrane and the Cumulative Index to Nursing & Allied Health research database) were searched to identify publications regarding the main fitness components of contemporary professional and student dancers. At a professional level, it appears that contemporary dancers demonstrate higher maximal oxygen uptake and higher scores in muscular endurance than ballet dancers. However, contemporary dance students are equally fit compared to their ballet counterparts and their body composition is also very similar. Only two studies have investigated the effects of supplementary exercise training on aspects of dance performance. Further research is needed in order to confirm preliminary data, which suggest that the implementation of additional fitness training is beneficial for contemporary dance students to achieve a better performance outcome.

**Brown A, Wells T, Schade ML, Patricia FC. Effects of plyometric training versus traditional weight training on strength, power, and aesthetic jumping ability in female collegiate dancers. *J Dance Med Sci.* 2007;11(2).**

While the benefits of traditional strength training for dancers has been examined, no such investigation has been performed for plyometric training. Therefore, the purpose of this study was to compare the effects of plyometric training and traditional weight training on aesthetic jumping ability, lower-body strength, and power in collegiate dancers. Eighteen female dancers who were enrolled in a minimum of one intermediate or advanced ballet or modern class at Skidmore College volunteered to participate in the study. Twelve subjects were randomly assigned to a plyometric (n = 6) or traditional weight training (n = 6) group. The remaining six subjects served as a self-selected control group. The plyometric group performed 3 sets of 8 repetitions of 4 different lower-body plyometric exercises twice a week. The weight training group performed 3 sets of 6 to 8 repetitions of 4 lower-body isotonic exercises twice a week. The control group refrained from all forms of strength training. Each subject maintained



her normal dance classes throughout the six week intervention. All subjects were tested prior to and following the six-week training period. Testing consisted of assessments of jumping skill and lower-body strength and power. Strength was assessed via 3 one-repetition maximum tests: leg press, leg curl, and leg extension. Power was assessed with a Wingate anaerobic power test and vertical jump height tests. Aesthetic jumping ability was assessed via an evaluation by dance faculty at Skidmore College on ballon, jump height, ability to point the feet in the air, and overall jumping ability. There were no differences in the descriptive measures of jumping ability, strength or power among the groups at the start of the study. The plyometric group significantly increased leg press strength (37%), standing vertical jump height (8.3%), and aesthetic jump height (14%). The weight training group significantly increased leg press strength (32%), leg curl strength (23%), mean anaerobic power (6%), aesthetic jump height (22%), and aesthetic ability to point the feet in the air (20%). No significant changes were seen in the control group. The results of this study indicate that either plyometric training or traditional lower-body weight training can be useful in improving variables applicable to dance. This study also supports the notion that short-term dance training alone may not be sufficient to elicit improvements in these variables.

**Feitzer AL, Chang YJ, Kulig K. Dancers with patellar tendinopathy exhibit higher vertical and braking ground reaction forces during landing. *J Sports Sci.* 2012;30(11): 1157-63.**

Dancers are exposed to the effects of repetitive jumping and leaping as are other athletes that tend to develop patellar tendinopathy. Greater vertical ground reaction forces occur during landing from a dance leap than during takeoff and during other common athletic activities. The purposes of this study were: (1) to compare the landing ground reaction force profiles of participants with and without clinically diagnosed patellar tendinopathy, and (2) to determine the strength of the relationship between landing angle, and braking impulse. Eighteen elite pre-professional dancers (12 healthy, 6 with patellar tendinopathy; both groups 50% male) performed sauts de chat for kinetic and kinematic analysis. Dancers with patellar tendinopathy demonstrated greater peak vertical ground reaction force and impulse (36% and 15% greater, respectively). Dancers with patellar tendinopathy demonstrated greater peak braking ground reaction force and impulse (82% and 126% greater, respectively). Landing angle explained 67% of the braking impulse. Dancers with patellar tendinopathy exhibited greater vertical and braking impulses than healthy dancers. Braking impulse was strongly correlated with landing angle. While there was no difference between groups in

landing angle, dancers with patellar tendinopathy exhibited greater braking impulse than their non-tendinopathic counterparts, even at similar landing angles.

**Girard J, Koenig K, Village D. The effect of strength and plyometric training on functional dance performance in elite ballet and modern dancers. *Phys Ther.* 2015;20(4):233-240.**

**BACKGROUND:** Ballet and modern dance are both art forms that require technique, artistry, grace and precision. Both dance forms require a degree of strength and muscular endurance for optimal performance. It is not known what value strength or plyometric training may have on functional dance performance.

**OBJECTIVE:** To systematically review the effects of strength and/or plyometric training on functional dance performance in elite ballet and modern dancers. **Methods:** A systematic review of literature indexed in the following databases: Medline, CINAHL, Sports-Discus, Physiotherapy Evidence Database (PEDro) and PubMed was conducted. The quality of the studies was graded using the PEDro Scale.

**RESULTS:** Eight studies satisfied the eligibility criteria and were included in this review. The studies' population age range was 19–27 years. Methodological scores based on the PEDro scale were 4 to 6 out of 10. All of the included studies (100%) scored 4 out of 10 or higher on the PEDro scale. Strength training resulted in significant improvements in jump height (P<0.05) and enhanced aesthetic performance measures (P<0.05). Plyometric training was found to enhance both vertical and subjective jump height (P<0.05). Strength or plyometric interventions did not impact lower extremity anthropometric measures such as thigh and calf girth.

**CONCLUSION:** Moderate evidence indicates that supplementary strength training interventions via traditional resistance training or whole-body vibration methods and plyometric training interventions may increase certain dance-performance measures such as jump height and general aesthetic facility without changing certain anthropomorphic measures in elite ballet and modern dancers.

**Hunnicut J, Elder C, Dawes J, Elder A. The effects of a plyometric training program on jump performance in collegiate figure skaters: a pilot study. *Int J Exerc Sci.* 2016;9(2):175-186.**

**ABSTRACT:** Plyometric training has been implemented to increase jump height in a variety of sports, but its effects have not been researched in figure skating. The purpose of this study was to determine the effects of a plyometric training program on on-ice and off-ice jump performance. Six collegiate figure skaters ( $19.8 \pm 1.2$

years; 164.7±4.9 cm; 60.3±11.6 kg) completed a six-week sport-specific plyometric training program, consisting of low to moderate intensity plyometric exercises, while eight collegiate figure skaters (21.1±3.9 years; 162.6±6.0 cm; 60.4±6.1 kg) served as the control group. Significant increases were found for vertical jump height, standing long jump distance, ( $F = 31.0, p < 0.001$ ), and flight time ( $F = 11.6, p = 0.007$ ). No significant differences were found for self-reported jump evaluation ( $p = 0.101$ ). Six weeks of plyometric training improved both on-ice and off-ice jump performance in collegiate figure skaters, while short-term skating training alone resulted in decreases. These results indicate that figure skaters could participate in off-ice plyometric training.

**Koutedakis Y, Jamurtas A. The dancer as a performing athlete: physiological considerations. *Sports Med.* 2004;34(10):651-61.**

The physical demands placed on dancers from current choreography and performance schedules make their physiology and fitness just as important as skill development. However, even at the height of their professional careers, dancers' aerobic power, muscular strength, muscular balance, bone and joint integrity are the 'Achilles heels' of the dance-only selection and training system. This partly reflects the unfounded view, shared by sections of the dance world, that any exercise training that is not directly related to dance would diminish dancers' aesthetic appearances. Given that performing dance itself elicits only limited stimuli for positive fitness adaptations, it is not surprising that professional dancers often demonstrate values similar to those obtained from healthy sedentary individuals of comparable age in key fitness-related parameters. In contrast, recent data on male and female dancers revealed that supplementary exercise training can lead to improvements of such fitness parameters and reduce incidents of dance injuries, without interfering with key artistic and aesthetic requirements. It seems, however, that strict selection and training regimens have succeeded in transforming dance to an activity practised by individuals who have selectively developed different flexibility characteristics compared with athletes. Bodyweight targets are normally met by low energy intakes, with female dance students and professional ballerinas reported to consume below 70% and 80% of the recommended daily allowance of energy intake, respectively, while the female athlete 'triad' of disordered eating, amenorrhoea and osteoporosis is now well recognised and is seen just as commonly in dancers. An awareness of these factors will assist dancers and their teachers to improve training techniques, to employ effective injury prevention strategies and to determine better physical conditioning. However, any change in the traditional training regimes must be approached cautiously to ensure that the aesthetic content of the

dance is not affected by new training techniques. Since physiological aspects of performing dance have been viewed primarily in the context of ballet, further scientific research on all forms of dance is required.

**Kulig, K, Fietzer, AL, Popovich, JM. Jr. Ground reaction forces and knee mechanics in the weight acceptance phase of a dance leap take-off and landing." *J Sports Sci.* 2011;29(2):125-31.**

Aesthetic constraints allow dancers fewer technique modifications than other athletes to negotiate the demands of leaping. We examined vertical ground reaction force and knee mechanics during a saut de chat performed by healthy dancers. It was hypothesized that vertical ground reaction force during landing would exceed that of take-off, resulting in greater knee extensor moments and greater knee angular stiffness. Twelve dancers (six males, six females; age 18.9 +/- 1.2 years, mass 59.2 +/- 9.5 kg, height 1.68 +/- 0.08 m, dance training 8.9 +/- 5.1 years) with no history of low back pain or lower extremity pathology participated in the study. Saut de chat data were captured using an eight-camera Vicon system and AMTI force platforms. Peak ground reaction force was 26% greater during the landing phase, but did not result in increased peak knee extensor moments. Taking into account the 67% greater knee angular displacement during landing, this resulted in less knee angular stiffness during landing. In conclusion, landing was accomplished with less knee angular stiffness despite the greater peak ground reaction force. A link between decreased joint angular stiffness and increased soft tissue injury risk has been proposed elsewhere; therefore, landing from a saut de chat may be more injurious to the knee soft tissue than take-off.

**Liederbach M, Hagins M, Gamboa JM, Welsh Tm. Assessing and Reporting Dancer Capacities, Risk Factors, and Injuries: Recommendations from the IADMS Standard Measures Consensus Initiative. *J Dance Med Sci.* 2012;16(4):139-53.**

This technical report of the Standard Measures Consensus Initiative of the International Association for Dance Medicine and Science (IADMS) describes the results of the committee's multi-year effort to synthesize information regarding the tests and measures used in dance-related research, protocols for reporting injuries, and appropriate use of available technologies to aid in standardizing such matters. Specific recommendations are presented, with accompanying rationales, to facilitate consensus among members of the dance medicine and science community. An Executive Summary of this Technical Report, which contains implementation strategies and appendices, should soon be available on the IADMS website.

**Liederbach M, Kremenec IJ, Orishimo KF, Pappas E, Hagins M.  
Comparison of landing biomechanics between male and female dancers  
and athletes, part 2: Influence of fatigue and implications for anterior  
cruciate ligament injury. *Am J Sports Med.* 2014;42(5):1089-95**

**BACKGROUND:** Fatigue is strongly linked to an increased risk of injuries, including anterior cruciate ligament (ACL) ruptures. Part 1 of this study identified differences in the biomechanics of landing from a jump between dancers and team athletes, particularly female athletes, which may explain the epidemiological differences in ACL injuries between dancers and team athletes and the lack of a sex disparity within dancers. However, it is not known if these biomechanical variables change differently between team athletes and dancers in the face of fatigue.

**PURPOSE/ HYPOTHESIS:** The purpose of this study was to compare dancers' and team athletes' resistance to fatigue and its effect on the biomechanics of single-legged drop landings. The primary hypotheses were that dancers may be more resistant than team athletes to the onset of fatigue and/or may have different biomechanical responses than athletes in landing tasks once fatigue has been achieved.

**STUDY DESIGN:** Controlled laboratory study.

**METHODS:** Kinematics and kinetics were recorded as 40 elite modern and ballet dancers (20 men and 20 women) and 40 team sport athletes (20 men and 20 women; National Collegiate Athletic Association Division I-III) performed single-legged drop landings from a 30-cm platform before and after a fatigue protocol consisting of step-ups and vertical jumps. Unfatigued and fatigued joint kinematics and kinetics were compared between groups and sexes with multivariate analyses of variance, followed by pairwise t tests as appropriate.

**RESULTS:** Dancers took longer ( $P = .023$ ) than team athletes to reach a similar state of fatigue. Multiple kinetic (eg, increased peak knee valgus moment;  $P < .001$ ) and kinematic (eg, increased lateral and forward trunk flexion;  $P < .001$  and  $P = .002$ , respectively) parameters of landing changed with fatigue, such that both fatigued dancers and athletes landed with mechanics that were more at risk for ACL injuries as compared with before fatigue.

**CONCLUSION:** Dancers took significantly longer to reach fatigue than team athletes. Female athletes consistently exhibited landing patterns associated with a risk for ACL injuries when compared with the other 3 groups. Fatigue changed landing mechanics similarly in both dancers and athletes, such that all groups landed with worse alignment after being fatigued.

**CLINICAL RELEVANCE:** Dancers are more resistant to lower extremity fatigue than athletes, and this may partially explain the lower incidence of ACL injuries in both male and female dancers compared

to team athletes. The extensive training in landing technique and daily practice that dancers undergo from a young age may be responsible for the higher levels of endurance.

**Orishimo KF, Kremenic IJ, Pappas E, Hagins M, Liederbach M. Comparison of landing biomechanics between male and female professional dancers. *Am J Sports Med.* 2009;37(11):2187-93.**

The incidence of anterior cruciate ligament injuries among dancers is much lower than that among team sport athletes and no clear gender disparity has been reported in the dance population. Although numerous studies have observed differences in lower extremity landing biomechanics between male and female athletes, there is currently little research examining the landing biomechanics of male and female dancers. Comparing landing biomechanics within this population may help explain the lower overall anterior cruciate ligament injury rates and the lack of gender disparity.

**Orishimo, KF, Liederbach M, Kremenic IJ, Hagins M, Pappas E. Comparison of landing biomechanics between male and female dancers and athletes, part 1: Influence of sex on risk of anterior cruciate ligament injury. *Am J Sports Med.* 2014;42(5):1082-8.**

**BACKGROUND:** The incidence of anterior cruciate ligament (ACL) injuries among dancers is much lower than among team sport athletes, and no clear disparity between sexes has been reported in the dance population. Although numerous studies have observed differences in landing biomechanics of the lower extremity between male and female team sport athletes, there is currently little research examining the landing biomechanics of male and female dancers and none comparing athletes to dancers. Comparing the landing biomechanics within these populations may help explain the lower overall ACL injury rates and lack of sex disparity.

**HYPOTHESIS:** The purpose was to compare the effects of sex and group (dancer vs team sport athlete) on single-legged drop-landing biomechanics. The primary hypothesis was that female dancers would perform a drop-landing task without demonstrating typical sex-related risk factors associated with ACL injuries. A secondary hypothesis was that female team sport athletes would display typical ACL risk factors during the same task.

**STUDY DESIGN:** Controlled laboratory study.

**METHODS:** Kinematics and kinetics were recorded as 40 elite modern and ballet dancers (20 men and 20 women) and 40 team sport athletes (20 men and 20 women) performed single-legged drop landings from a 30-cm platform. Joint kinematics and kinetics were compared between groups and sexes with a group-by-sex

multivariate analysis of variance (MANOVA) followed by pairwise t tests.

**RESULTS:** Dancers of both sexes and male team sport athletes landed similarly in terms of frontal-plane knee alignment, whereas female team sport athletes landed with a significantly greater peak knee valgus ( $P = .007$ ). Female dancers were found to have a lower hip adduction torque than those of the other 3 groups ( $P = .003$ ). Dancers (male and female) exhibited a lower trunk side flexion ( $P = .002$ ) and lower trunk forward flexion ( $P = .032$ ) compared with team sport athletes.

**CONCLUSION:** In executing a 30-cm drop landing, female team sport athletes displayed a greater knee valgus than did the other 3 groups. Dancers exhibited better trunk stability than did athletes.

**CLINICAL RELEVANCE:** These biomechanical findings may provide insight into the cause of the epidemiological differences in ACL injuries between dancers and athletes and the lack of a sex disparity within dancers.

**Ravn S, Voigt M, Simonsen EB, Alkjar T, Bojsen-Moller F, Klausen K. Choice of jumping strategy in two standard jumps, squat and countermovement jump – effect of training background or inherited preference? *Scand J Med Sci Sports*. 1999;9(4):201-8.**

Six male subjects, three professional ballet dancers and three elite volleyball players, performed maximal vertical jumps from 1) a static preparatory position (squat jump), 2) starting with a countermovement (countermovement jump) and 3) a specific jump for ballet and for volleyball, respectively. The jumps were recorded on highspeed film (500 Hz) combined with registration of ground reaction forces, and net joint moments were calculated by inverse dynamics. The purpose was to investigate the choice of strategy in two standard jumps, squat jump and countermovement jump. The volleyball jump was performed with a sequential strategy and the ballet jump was performed with a simultaneous strategy. In the two standard jumps, the choice of strategy was individual and not related to training background. This was additionally confirmed in a test of seven ballet dancers and seven volleyball players.

**Sozbir K, Sozbir SA, Kutlu A, Karli U. Effects of plyometrics on anaerobic performance of collegiate female contemporary dancers. *Int J Sports Stud*. 2014;4(11):1329-35.**

The purpose of this study was to investigate the effects plyometrics on vertical jump and peak anaerobic power in collegiate female contemporary dancers. Twenty seven contemporary modern dancers were randomly assigned as plyometric training group (n: 14, age:

20.14 ± 0.95 year, stature: 161.21 ± 3.42 cm, body mass: 57.76 ± 4.39 kg) and control group (n:13, age: 20.15 ± 0.99 yr, stature: 162.46 ± 3.78 cm, body mass: 58.52 ± 3.11 kg). The experimental group participated to plyometric training program 2 times per week for 6 weeks and the control group did not perform any plyometrics. All participants continued their routine contemporary dance work outs, during the study. Countermovement jump test was used to determine the vertical jump (VJ) height and to calculate peak anaerobic power (PAP). The independent sample t-test was used to identify the differences between two groups and paired t-test was used to identify the differences between the pre and post-tests for the dependent variables. Statistical significance for all tests was accepted at an alpha level of  $p < 0.05$ . Significant improvements were found in VJ height and PAP from pre-test to post-test in plyometric group ( $p < 0.1$ ). The percentage of change in VJ and PAP from pre-test to post-test was significantly greater in plyometric group compared to control group ( $p < 0.01$ ). As a conclusion, this study suggests that plyometric training can be useful in improving variables applicable to dance in collegiate female contemporary dancers. This study also supports the notion that contemporary dance training alone may not be sufficient to elicit improvements in VJ and PAP.

**Twitchett E, Brodrick A, Nevill AM, Koutedakis Y, Angioi M, Wyon M. Does physical fitness affect injury occurrence and time loss due to injury in elite vocational ballet students? *J Dance Med Sci.* 2010;14(1):26-31.**

Most ballet dancers will suffer at least one injury a year. There are numerous causes of injury in dance, and while many investigators have documented risk factors such as anatomical characteristics, past medical history, menstrual history, dance experience, length of dance training, fatigue, and stress, risk factors related to body characteristics and nutrient intake, levels of conditioning, or physical fitness parameters have only recently received the same amount of attention. The aim of the present study was, therefore, to investigate correlations between ballet injury and body fat percentage, active and passive flexibility, lower limb power, upper body and core endurance, and aerobic capacity. Low levels of aerobic fitness were significantly associated with many of the injuries sustained over a 15-week period ( $r = .590$ ,  $p = 0.034$ ), and body fat percentage was significantly associated with the length of time a dancer was forced to modify activity due to injury ( $r = -.614$ ,  $p = 0.026$ ). This information may be of benefit to dancers, teachers, physical therapists and physicians in dance schools and companies when formulating strategies to prevent injury.



**Twitchett E, Nevill A, Angioi M, Koutedakis Y, Wyon, M. Development, validity, and reliability of a ballet-specific aerobic fitness test. *J Dance Med Sci.* 2011;15(3):23-7.**

The aim of this study was to develop and assess the reliability and validity of a multi-stage, ballet-specific aerobic fitness test to be used in a dance studio setting. The test consists of five stages, each four minutes long, that increase in intensity. It uses classical ballet movement of an intermediate-level of difficulty, thus emphasizing physiological demand rather than skill. The demand of each stage was determined by calculating the mean oxygen uptake during its final minute using a portable gas analyser. After an initial familiarization period, eight female subjects performed the test twice within seven days. The results showed significant differences in oxygen consumption between stages ( $p < 0.001$ ), but not between trials. Pearson correlation co-efficients produced a very good linear relationship between trials ( $r = 0.998$ ,  $p < 0.001$ ). Bland-Altman reliability analysis revealed the 95% limits of agreement to be  $\pm 6.2$  ml.kg<sup>-1</sup>.min<sup>-1</sup>, showing good agreement between trials. The oxygen uptake in our subjects equated positively to previous estimates for class and performance, confirming validity. It was concluded that the test is suitable for use among classical ballet dancers, with many possible applications.

**Twitchett EA, Angioi M, Koutedakis Y, Wyon M. Do increases in selected fitness parameters affect the aesthetic aspects of classical ballet performance? *Med Probl Perform Art.* 2011;26(1):35-8.**

Research has indicated that classical ballet dancers tend to have lower fitness levels and increased injury rates compared to other athletes with similar workloads. The aim of the current study was to examine the effects of a specifically tailored fitness training programme on the incidence of injury and the aesthetic quality of performance of classical ballet dancers compared to a control group. Proficiency in performance was evaluated at the beginning and end of the intervention period for both groups through a 4-min dance sequence using previously ratified marking criteria. The intervention group ( $n = 8$ ) partook in a weekly 1-hr training session that included aerobic interval training, circuit training, and whole body vibration. All dancers' performance proficiency scores increased from pre-intervention testing to post-intervention. The intervention group's overall performance scores demonstrated a significantly greater increase ( $p = 0.03$ ) than the equivalent for the control group. It was concluded that supplementary fitness training has a positive effect on aspects related to aesthetic dance performance as studied herein; further research is recommended on a larger and more varied sample.

Practical applications from this study suggest that supplemental training should be part of a ballet dancer's regime, and minimal intervention time is required to have observable effects.

**Twitchett, EA, Koutedakis Y, Wyon MA. Physiological fitness and professional classical ballet performance: a brief review. *J Strength Cond Res.* 2009;23(9):2732-40.**

Most ballet dancers will suffer at least one injury a year. There are numerous causes of injury in dance, and while many investigators have documented risk factors such as anatomical characteristics, past medical history, menstrual history, dance experience, length of dance training, fatigue, and stress, risk factors related to body characteristics and nutrient intake, levels of conditioning, or physical fitness parameters have only recently received the same amount of attention. The aim of the present study was, therefore, to investigate correlations between ballet injury and body fat percentage, active and passive flexibility, lower limb power, upper body and core endurance, and aerobic capacity. Low levels of aerobic fitness were significantly associated with many of the injuries sustained over a 15-week period ( $r=.590$ ,  $p=0.034$ ), and body fat percentage was significantly associated with the length of time a dancer was forced to modify activity due to injury ( $r=-.614$ ,  $p=0.026$ ). This information may be of benefit to dancers, teachers, physical therapists and physicians in dance schools and companies when formulating strategies to prevent injury.

**Wyon M, Guinan D, Hawkey A. Whole-body vibration training increases vertical jump height in a dance population. *Jour Strength and Cond Res.* 2010;24(3): 866.**

Whole-body vibration (WBV) training has gained popularity with the strength and conditioning environment. Previous research reported improvements in strength and power after WBV interventions in untrained individuals with hypertrophical development of the muscles, suggesting that the improvements are because of neuromuscular adaptations. The present intervention study recruited moderately trained individuals that have jumping as integral to their training. Participants were randomly allocated to an intervention or control group. The intervention group was exposed to WBV at 35 Hz for 5 minutes twice a week, whereas the control group was exposed to similar isometric contraction stress. Results indicated that after a 6-week intervention, vertical jump height increased significantly ( $p > 0.05$ ) in the intervention than in the control group. The study concluded that WBV was able to maintain vertical jump height with very little intervention time (10 minutes a week) and therefore should

be considered as an intervention form for maintaining jump performance.

