Athletes and the Arts — The Role of Sports Medicine in the Performing Arts

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Abstract

Performing artists are athletes. Like athletes, performing artists practice and/or perform most days with little off season, play through pain, "compete" in challenging environments, and risk career-threatening injury. Athletes and the Arts is a multiorganizational initiative linking the sport athlete and musician/performing artist communities. Performing artists of all ages and genre are an underserved population related to medical coverage, care, injury prevention, performance enhancement, and wellness. Sports medicine professionals are a valuable resource for filling this gap by applying existing knowledge of treating sport athletes (nutrition, injury prevention) while gaining a better understanding of performers' unique needs (hearing loss, focal dystonia) and environment. These applications can occur in the clinical setting and through developing organizational policies. By better understanding the needs of the performing arts population and applying existing concepts and knowledge, sports medicine professionals can expand their impact to a new patient base that desperately needs support.

Introduction

Performing artists are athletes. Just like sport athletes, they

- practice or perform almost every day.
- play through pain.
- compete in challenging environments.
- experience little "off season."
- face extreme competition.
- risk the temptation of substance abuse, and
- face real risk of career-threatening injury.

Comparing the work schedules of a professional performing artist and a professional baseball player highlights some of the similarities. Both perform/play in the evening (8 p.m. to 11 p.m. or later) with a schedule that may repeat for more than 150 games/performances a season. Their routine becomes habitual with disturbed eating and sleeping habits, sleeping late into the morning/early afternoon, skipping breakfast, or not eating at all.

In this scenario, the professional sport athlete has access to nutrition information to help them understand what and when to eat, medical support for injury prevention and rehab, film review to modify posture and mechanics, pitch counts to reduce the risk of overuse injuries, and a sport psychologist to help get out of a slump. However the performing artist (musicians, dancers, singers, conductors, actors, marching band — all ages from child to the elderly) has few if any of these resources yet many of the same needs. In addition, performers have unique needs that often are not addressed in the sport athlete, such as hearing loss.

Athletes and the Arts is an initiative focused on linking the sport athlete and musician/performing artist communities through collaborative exchange and application of wellness, training, and performance research and education. This program is committed to the belief that athletes exist throughout the performing arts community and that established training, wellness, and prevention research for sport athletes can benefit artists' general health and performance. Similarly, the athletic and general population can gain from principles primarily applied within the performing arts arena such as breath control, rhythm, and creativity (6).

A key component of this initiative is incenting performing artists to invest some time in personal wellness to supplement the commitment to their performance skill. The performing artist's body (like a sport athlete) is an essential instrument that is the foundation for performance. Musicians/performing artists should devote appropriate time to both

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practicing their voice, instrument, or craft and caring for their physical instrument — their body. Initiatives such as American College of Sports Medicine's Exercise is Medicine® (26,8) provide an evidence-based process to accomplish this while prolonging careers and enhancing performance.

This article will serve to educate sports medicine personnel on the issues and needs of performing artists. The sports medicine community has the general knowledge to address many of these issues, yet is often not aware of the need or nuances of working with this underserved population.

"Unique" Medical Issues for Performing Artists

Hearing loss

Noise-induced hearing loss (NIHL), a hearing loss that is a function of continuous or intermittent noise exposure and duration, continues to be one of the most prevalent occupational health conditions occurring across sectors including the military, manufacturing, and service industries. Occupational NIHL is always sensorineural, affects the cochlear hair cells in the inner ear, and initially is evidenced by a "notching" of the audiogram at frequencies of 3, 4, or 6 kHz with recovery at 8 kHz (49). Unlike age-related hearing loss, NIHL increases rapidly during the first years of exposure to daily sound levels that exceed the equivalent of 85 dB over an 8-h period with a 3-dB time/intensity exchange rate (12,13). This means for every 3-dB increase over 85 dB, the time exposure is halved to prevent NIHL. Sounds below threshold danger levels produce no risk, no matter how long the exposure time.

Recommended maximum daily exposure times (13) to sounds at or above 85 dB are as follows:

- 85 dB (vacuum cleaner, MP3 player at 1/3 volume) — 8 h
- 90 dB (blender, hair dryer) — 2 h
- 94 dB (MP3 player at 1/2 volume) — 1 h
- 100 dB (MP3 player at full volume, lawnmower) — 15 min
- 110 dB (rock concert, power tools) — 2 min
- 120 dB (jet planes at take-off) — without ear protection, sound damage is almost immediate

Because there are no known treatments or cures, prevention of occupational hearing loss is the basis for hearing conservation standards.

Musical behaviors in various occupational settings, including nightclubs, concert venues, and music schools, are capable of generating sound levels that exceed recommended exposure doses prescribed by the National Institute for Occupational Safety and Health (NIOSH) (15,34,61). In response, the Centers for Disease Control and Prevention (CDC) is calling for policies designed to protect musicians from excessive exposure to musical sounds produced during band, choir, and orchestra classes (12,13) because:

- 50% of musicians may have problems with hearing loss.
- Permanent NIHL is irreversible.
- Temporary NIHL is reversible with adequate rest and recovery (14–16).

Because these sounds are purposeful and desired, the current NIOSH standard may need to be modified in order to be effective when applied to a musical context. Music itself is not the issue; loudness and its duration are the concern. For a musician, hearing loss is usually a gradual process that initially affects a person's ability to hear very high-pitched sounds. Problems with pitch perception and tinnitus may accompany such initial-stage hearing loss, and these may be career ending. Even if debilitating problems do not occur initially, career activity becomes increasingly difficult and finally impossible as hearing loss proceeds to more advanced stages (47).

The music discipline is changing rapidly, and through new National Association of Schools of Music (NASM) health and safety accreditation standards (Ref. (46), discussed later in this article) and NASM/Performing Arts Medicine Association (PAMA) hearing health advisories (47), future music professionals now are being informed and trained to deal with these concerns. Concurrently music-specific dosimeter and exposure assessment strategies are demonstrating unprecedented gains toward an increased understanding of when and why certain musical behaviors are predictive of risk. For example, a typical practice session on the piano may elicit a sound meter reading of between 60 and 70 dB, similar in intensity to an average conversation (60 dB). There will be times when the music peaks and this level rises, but under normal practice conditions, these moments are not sustained over several hours. However certain instrumental sections such as brass, percussion, and woodwinds tend to produce higher sound levels. Sometimes these levels relate to the piece of music being performed and to notational requirements (*pianissimo, fortissimo*); other times, these levels are what naturally resonate from the instrument (14,47).

The sports medicine physician must understand that hearing risk levels are very difficult to manage in a music setting. Musical activities are always contextual and directly related to how music is taught, rehearsed, performed, and consumed. Just as sport injury prevention can be modified by the athlete, team coach, or athletic trainer, hearing loss prevention is driven by the education and conduct of the performer, teacher/conductor, and administrator. Ear protection has some benefit in protecting NIHL; however it may not be acceptable to all musicians, and more research is needed to optimizing this resource.

Health care professionals that treat performing artists should discuss NIHL and the appropriate sound exposure guidelines. Audiometric testing is essential for documenting and monitoring hearing — especially if done early and at times when early preventive intervention can be effective. This tracking should be a regular part of ongoing medical exams.

Focal dystonia

Focal or task-specific dystonia is defined as an abnormal movement disorder that develops when a person is attempting to perform a specific task such as playing piano or putting in golf. In the performing arts, focal dystonia is instrument related; artists that play strings or piano tend to develop dystonias of the hand (37), while those who play reed or brass tend to develop dystonias of the facial musculature. Singers can develop dystonias of the vocal cords, and drummers can develop dystonias of the upper extremities (39).

While this condition is often recognized in the performing artist, it is missed often in the sport athlete and often not included in the differential diagnosis. The subsequent treatment of the condition is ineffective since it is treated usually as an orthopedic disorder. The condition is most recognized in golf and is called *yips* (1,2). It is manifested primarily during putting as loss of the fine motor skills without an apparent cause. Some professional golfers have been forced to abandon competitive play because of the impairment in their ability to putt effectively.

The condition has been reported in a number of upper extremity-based sports in which highly trained competitors lose their ability to perform a highly skilled task for no apparent reason. It has been reported as a loss of throwing or batting ability in baseball and cricket, serving in tennis, shooting in basketball, rowing in crew, throwing in darts and Petanque, and shooting in pool and snooker (1).

It also is reported to occur in the lower extremity but less frequently, although the lower incidence may be a failure to recognize the condition. Reports have included the loss of accuracy in kicking while playing soccer or American football and in the ability to run in long-distance runners (38,42).

A variety of therapeutic options are available to treat the condition including medications, biofeedback, manipulative and movement therapies, relaxation techniques, stretching and strengthening programs, changes in equipment and technique, splinting, BoTox injections, and surgery. No single approach has proven to be statistically superior and so an integrated approach is often necessary to obtain an improved outcome.

The key point when assessing both the sport and performing arts athlete is to include focal dystonia in the differential diagnosis when no other explanations for a sudden loss of skill can be identified. If needed, direct the patient to an appropriate facility that is able to treat the condition as early as possible after the diagnosis is made.

Similar Medical Issues for Performing Artists and Sport Athletes

Nutrition

Exercising or performing in a fasted state or going for long periods without eating, due to demanding practice and performance schedules, reduces the availability of energy and nutrients to active muscle and has been shown to impair performance (53). Research with sport athletes has shown that eating before exercise improves performance (44). Several sports nutrition guidelines can apply to performing artists to improve performance and reduce the risk of injury, such as follows:

- Fuel for performance; never show up for a performance in a fasted state. Artists should eat at least two meals before an evening performance as well as a small snack before performing.
- Pre-event meals should consist of mostly carbohydrate (*e.g.*, whole grains, pasta, rice, potatoes, energy bars, vegetables, and fruit), moderate protein, and low fat and be consumed 3 to 4 h prior to performance.
- The closer to the start of the performance, the smaller the meal should be.
- Stay hydrated. Performers are advised to drink 12 to 20 oz of water or a sports drink at least 2 to 3 h before a performance. This will optimize hydration and allow time for excretion of any excess fluid.

It is important to avoid overeating late at night by spreading meals throughout the day, a real challenge to performing artists. Baseball players ward off hunger during the game and are less hungry after a game by taking a few bites from a snack or energy bar between innings. Performing artists can do the same by eating small bites and drinking fluids between acts or during intermissions so as not to be as hungry late at night.

Postevent eating can impact fuel availability for the next day's performance. Similar to sport athletes who may compete in back-to-back games or in tournament play, performing artists often have little time to recover between performances. The window for optimal postexercise recovery spans several hours. The earlier food is ingested within this window, the faster energy stores are replenished. This is especially important for multiple performances per day or those who practice/perform every day. Postperformance nutrition tips include the following:

- Carbohydrate consumption within 30 min after a practice/performance replaces energy in the muscle and decreases recovery time compared to eating later.
- Protein should be added to a postevent recovery snack to support muscle repair and growth. Recent research suggests that consuming about 15 to 25 g of protein (51) is the maximum needed to stimulate muscle repair and growth.
- Protein should be ingested as part of a recovery snack or beverage as soon as possible after activity. Repeated feedings of protein throughout the day in the form of meals and snack can further support muscle building (32).
- Optimal rehydration postactivity includes consuming 1.5 times more fluid than was lost during the performance. Generally this means consuming three cups of fluid for each pound lost during the performance (58).

Adopting sports nutrition strategies for performing artists can improve practice tolerance and help with rapid recovery from performances. An important premise of these general recommendations is that the optimal mixture of nutrients to speed recovery from hard training and performance can be obtained by eating wholesome foods and beverages, provided correct choices are made regarding food type, amount, and timing (56).

Injury risk — musicians

Playing a musical instrument requires a complex combination of physical capabilities:

- Strength, coordination, and endurance for transporting and supporting large instruments (tubas, percussion, basses);
- Expert coordination and great endurance, especially for using small hand and forearm muscles repetitively at rapid rates, for extended periods, many days per week, and for many decades of a musical career;
- Respiratory and oral control (wind instruments) to move quantities of air for extended playing periods; also using

more than 20 orofacial muscles (the *embouchure*) to hold continually and control the mouthpiece or reed.

Studies have shown that playing an instrument can produce physical problems. More than 75% of orchestra instrumentalists will develop one or more musculoskeletal disorders from playing during their lifetimes, often beginning as early as the teen years (35,52). While many disorders are common to all instrumentalists, each class of instruments may produce certain specific, if not unique, associated problems. Most are related to overuse and misuse — physical demands of the combination of playing duration and intensity that exceed the body's capabilities to adapt, or playing-related technical problems (improper posture, excessive force, etc.).

Table 1 lists the most common types of physical disorders associated with playing certain groups of instruments or type of musical activity:

Table.

Most common physical disorders in musical instruments or activities.

Instrument Type/ Musical Activity	Common Disorders
Keyboards (9)	Hand/forearm muscle strain, RT > LT
Upper strings (violin, viola) (36,37)	Hand/forearm muscle strain, LT > RT
Lower strings (cello, bass) (36,37)	Hand and spinal muscular strains
Guitars (27)	Hand/forearm muscle strain, LT > RT
Clarinet, oboe, flute (21,54)	Thumb strain from supporting instrument
Bassoon (22)	LT thumb strain and basal joint arthritis
Brasses (17,54)	Embouchure problems including dystonia
Percussion (55)	Wrist strain, shoulder disorders
Drum corps (7)	Multiple issues ranging from heat illness to stress fractures
Conductors	Shoulder disorders

Suggestions for evaluation and prevention strategies include the following:

- Medical history should include information on length and duration of playing, practice habits, and times, outside life stressors/activities, and if possible, relation of symptoms to specific musical activity.
- It is important to observe the patient while holding and playing the instrument in addition to the routine exam. Problems often will be obvious only by this method. For keyboard musicians, find a convenient venue to watch the patient play.
- Musicians' jargon/terminology is often different from that of sport athletes. Attempt to learn it, and if some terms are unfamiliar, ask for an explanation or demonstration on the instrument.
- Familiarity with the anatomy and function of the hand intrinsic muscles helps greatly when evaluating instrumentalists. They use these muscles vigorously and continuously when playing, often developing hand pain.
- Large, rapid increases in practicing/performing times may increase risk of injury. If practice duration or intensity must increase, do it gradually, and decrease either component if painful symptoms occur.
- Musicians frequently play with excessive muscle tension, even in those body areas not needed to play the instrument. This is a common cause of painful symptoms and often can be observed by watching the patient play. Discuss the possibility of consciously relaxing muscles not directly needed to make music.
- Musicians ideally should have a 5-min break away from their instrument every half hour, to rest heavily used muscles and also refocus mentally. This recommendation pertains more to practice times than to performances.

Injury risk — dance

The art of dance, particularly ballet, is one of the most physically demanding on the musculoskeletal system. Most literature and medical treatments focus on professional classical ballet and professional modern dance probably because of the high injury rate of 67% to 95% per year and approximate average of 1.7 to 6.7 injuries per dancer per contract year (3,10,57,59). Overuse injuries remain the most common type that occurs with the highest incidence in the foot and ankles followed by the hip, lumbar/thoracic/cervical spine, and then knee/leg (3,10,31,57,59). Psychosocial stress also has an adverse effect on the dancer physically and contributes to a higher injury rate. Dancers who undergo psychosocial stress-related interventions have less physical injuries and increased recovery from injuries (30,41). Dancers also face nutritional challenges to maintain lean body physiques and optimal performance (24), and the challenges of the female athlete triad as seen in women sport athletes are well documented in professional ballet dancers (23).

Injury prevention has focused on educating the performer, teachers, and staff to modify activity levels to allow for adequate rest and recovery time for the dancer's body. There is limited published medical literature that documents the differences in injury and medical cost reductions of these interventions (59). Injury prevention also has focused on proper dance technique, footwear, and dance floors. There is limited evidence of any effect on injury prevention with dance footwear (28), but proper dance floors do play a significant role in injury prevention (60). As a part of a clinical assessment, clinicians should evaluate floor conditions, number of hours danced per week, high-impact recreational activities, and psychological stressors. Proper dance technique also is important and should be demonstrated to the health care professional. Key aspects to monitor include overpronation of the feet, no forced turn-out, no hyperflexion of toes in stance, no hyperextending the back (sway back), no tucking under pelvis, keep heels on the floor in plié, and keep the knee over the second toe in plié (43).

Practice and Performance in Perspective

Training

In most sports, there are objective measures that can be used to show individual improvement. These include variables measured by time (speed, agility, pitch velocity) or distance (jump height, long jump, javelin throw). Pre- and posttraining measures of these variables can indicate improvement. Even team sports have a metric — the final score.

Defining improvement in performing arts is more subjective (similar to sports like gymnastics and diving). The audience or critics become the judges. The element of creativity is even more pronounced in the arts and even harder to define. Yet performing artists spend countless hours practicing to get better; a "better" that may not be able to be measured objectively.

In addition, the work of Ericsson *et al.* (25) on training patterns of elite musicians has set the standard for many young aspiring performers in musical, athletic, and academic arenas. These researchers report that 10,000 h of "deliberate practice," training focused on improvement as opposed to enjoyment, is the threshold that distinguishes good from expert-level performers.

So what is the optimal number of hours to practice? At what point do additional hours of practice hurt rather than help performance?

The sport athlete world provides some guidance:

- At the college level, National Collegiate Athletic Association (NCAA) sport athletes may participate in no more than 20 h of practice a week, with 1 $d \cdot wk^{-1}$ completely off. These rules are in place to allow student-athletes time to be students, but also for health and safety reasons. At the same NCAA institutions with performing arts programs, many music and dance students are practicing 6 $h \cdot d^{-1}$.
- Olympic sport athletes have a 4-year training schedule that, at a cursory level, consists of gradual foundation work, incremental aerobic training, technique work, and tapering to peak for 2 wk during the Olympic Games. Recovery during training and subsequent to performance is an important component of this cycle. This cycle and the concept of recovery often is not considered in performing arts.
- Baseball pitchers of all ages are monitored for pitch counts (40). As they rise in level of competitiveness, the pitch counts increase gradually as their physical development and training increases. Individuals at risk or returning from an injury may be monitored more closely. "Play" counts rarely exist in the performing arts world.
- Many sport athletes cross-train to maintain aerobic fitness while minimizing the mental and physical stress associated with their principal sport. Soccer players play basketball, swimmers do running workouts, and vice versa.

Many of these findings from the world of sport can be applied to performing artists to optimize their talent and longevity. When counseling a performing artist, consider the following:

- The ability to identify and objectively measure improvement in each aspect of the performing arts is essential in order to better understand the type and volume of practice necessary to optimize performance. Understand their ultimate goal and how long and how intense (per week) they are working to achieve it.
- At some point, the number of practice hours may hurt rather than help. Consider focused practice segments with different goals in each session. Rote repetition for extended periods has not proven successful in the athletic world.
- Large acute increases in the time spent physically practicing/performing may increase risk of injury. If the volume or intensity of practice must increase, do it gradually.
- Cross-train — employ a mental or physical activity that allows the body to focus on something different. Emphasize rest and recovery when possible.
- Introduce the concept of Exercise is Medicine®. Help them understand how much their instrument weighs and the strength needed to hold it during long stretches of practice, how many repetitive strokes they take a day, and how much their posture is dependent on core strength. Prescribe 30 to 45 min of current practice time for separate complementary physical activity. Encourage them to invest in overall fitness to enhance their skill and longevity.

Overuse/burnout in children

Youth in today's culture are driven to train early and extensively. Traditional models of what is called "early sampling" (trying various sports throughout one's early years and ultimately choosing a preferred sport in late adolescence) are now challenged by models of early specialization (20), an exclusive focus on one performance entity.

Early specialization and extensive training creates well-documented risks as reported in the youth sports literature. Since the publication of Ericsson *et al.* (25) on elite performance, various experts caution that early specialization leads to overuse injury, burnout, stress, and less enjoyment, particularly in sports (4,11,18–20). While some researchers note that early specialization programs are critical in more individualistic sports (*e.g.*, tennis, gymnastics), others caution that young athletes are ill-equipped physically, socially, and psychologically to handle the rigors of intense training and make informed decisions about their training path (50). The daily training demands in addition to academic and other social activities can exhaust children. Sleep specialists recommend that adolescents sleep up to 9 h per evening (29). Yet, under this intensive training regimen, such rest is virtually impossible unless other critical aspects of a young adolescent's life are sacrificed.

Extreme training in time and intensity can tax the young athlete and result in various physical damages to tissue, growth capacity, including growth plate damage, as well as other injuries such as tendinitis, apophysitis, or stress fractures (4). In response, experts recommend training limits for young athletes. The AAP's Council on Sports Medicine and Fitness (4) recommends that children participate in various activities during their youth, limiting training and playing to no more than 6 $d \cdot wk^{-1}$ with at least 1 to 2 d off from organized play each week.

The young performing artist faces many of these same challenges, but the specific research for this population is scarce. It is essential for medical personnel to consider the learning from youth sport research when evaluating these performing artists to minimize the risk of physical and mental overuse in this population.

Policy

Organizational policy and guidelines have the potential to enhance education and, when needed, behavior modification. Sports medicine guidelines from the NCAA (*e.g.*, preparticipation physical exams (48) or Position Stands from the American College of Sports Medicine (*e.g.*, participation in extreme environments (5) have been successful in enhancing health and safety. The same opportunities exist in the performing arts community (33,45), and medical professionals have an opportunity to influence content. The National Association of Schools of Music (NASM) Health and Safety Standard provides such an example,

NASM is an association of approximately 644 schools of music, primarily at the collegiate level. It is the national accrediting agency for music and music-related disciplines. NASM uses national standards that characterize basic requirements and conditions for the study of music. The standards have a definitive impact on curriculum and subsequent knowledge base of students educated by these institutions. They directly influence the knowledge and skill base of teaching professionals that eventually touch the lives of countless children, teenagers, and young adults throughout the United States. However, until recently, there were no standards specific to health and safety.

In June 2010, NASM and the Performing Arts Medicine Association (PAMA) agreed to cooperate and lead in the development of studies and projects focused on the health and wellness of musicians. The agreement enabled the knowledge, skills, and contextual understandings of medical doctors and music administrators to be combined and coordinated at a new and more formal level. As a part of this effort, a new Health and Safety Standard was added to the NASM Handbook in November 2011 that reads in part:

Students enrolled in music unit programs and faculty and staff with employment status in the music unit must be provided basic information about the maintenance of health and safety within the contexts of practice, performance, teaching, and listening.

General topics include, but are not limited to, basic information regarding the maintenance of hearing, vocal, and musculoskeletal health and injury prevention. They also include instruction on the use, proper handling, and operation of potentially dangerous materials, equipment, and technology as applicable to specific program offerings or experiences Decisions regarding topic areas and breadth and depth are made by the institution, and normally are correlated with the nature, content, and requirements of specific areas of specialization or specific courses of study (46).

Because the specifics of identifying and addressing these issues are an institutional prerogative, there is a great opportunity for medical professionals to collaborate with their local schools of music through this health and safety standard to develop specific health and safety guidelines. Collectively this effort can enhance the wellness of 100,000 music students annually and the future generations they touch. The topics addressed earlier in this article should be priority educational items to develop with local institutions.

Conclusion

Performing artists of all ages and genre are an underserved population related to medical coverage, care, injury prevention, and wellness. Sports medicine health professionals can be a valuable resource for filling this gap by applying their existing knowledge of treating sport athletes while gaining a better understanding of the performer's unique needs and environment. By integrating the science of sport and Exercise is Medicine® concepts into the performing arts population, sports medicine professionals can expand their impact to an entirely new patient base that desperately needs their help.

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References

1. Adler CH. Sports-related task-specific dystonia: the yips. In: Stacy M, editor. *Neurology Handbook of Dystonia, Second Edition*. London: Informa Healthcare; 2012. p. 209–17.
2. Alder CH, Crews D, Kahol K, *et al*. Are the yips a task-specific dystonia or "golfers cramp"? *Mov. Disord*. 2011; 26:1993–6.
3. Allen N, Nevill A, Brooks J, *et al*. Ballet injuries: injury incidence and severity over 1 year. *J. Orthop. Sports Phys. Ther.* 2012; 42:781–90.
4. American Academy of Pediatrics Committee on Sports Medicine and Fitness. Intensive training and sports specialization in young athletes. *Pediatrics*. 2000; 106:154–7.
5. American College of Sports Medicine Position Stand. Exertional heat illness during training and competition. *Med. Sci. Sports Exerc*. 2007; 39:556–72.
6. Athletes and the Arts Web site [Internet]. Denver (CO). Athletes and the Arts. Available from: http://www.athletesandthearts.com.
7. Bischof RO. Drum and bugle corps: medical problems and issues. *Med. Probl. Perform. Art*. 1994; 9:131–6.
8. Blair SN, Sallis RE, Hutber A, Archer E. Exercise therapy — the public health message. *Scand. J. Med. Sci. Sports*. 2012; 22:e24–8.
9. Bragge P, Bialocerkowski A, McMeeken J. Musculoskeletal injuries in elite pianists: prevalence and associated risk factors. *Aust. J. Mus. Educ*. 2008; 1:18–31.
10. Bronner S, Ojofeitimi S, Rose D. Injuries in a modern dance company: effect of comprehensive management on injury incidence and time loss. *Am. J. Sports Med*. 2003; 31:365–9.
11. Butcher J, Lindner KJ, Johns DP. Withdrawal from competitive youth sport: a retrospective ten-year study. *J. Sport Behav*. 2002; 25:145–63.
12. Centers for Disease Control and Prevention Web site [Internet]- Noise induced hearing loss — Promoting hearing health among youth; [cited 2013 July 15]. Available from: http://www.cdc.gov/HealthyYouth/noise/index.htm.
13. Centers for Disease Control and Prevention Web site [Internet]. Noise and Hearing Loss Prevention Facts and Statistics; [cited 2013 Aug 1]. Available from: http://www.cdc.gov/niosh/topics/noise/stats.html.
14. Chesky K. Schools of music and conservatories and hearing loss prevention. *Int. J. Audiol*. 2011; 50:S32–7.
15. Chesky K. Measurement and prediction of sound exposure levels by University wind bands. *Med. Probl. Perform. Art*. 2010; 25:29–34.
16. Chesky K. Preventing noise-induced hearing loss. *Mus. Ed. J*. 2008; 94:36–42.
17. Chesky K, Devroop K, Ford J III. Medical problems of brass instrumentalists: prevalence rates for trumpet, trombone, French horn, and low brass. *Med. Probl. Perform. Art*. 2002; 17:93–8.
18. Côté J. The influence of the family in the development of talent in sport. *Sport Psychol*. 1999; 13:395–417.

19. Côté J, Baker J, Abernethy B. Practice and play in the development of sport expertise. In: Tenenbaum REG, editors. *Handbook of Sport Psychology.* Hoboken (NJ): Wiley; 2007. p. 184–202.

20. Côté J, Lidor R, Hackfort D. ISSP position stand: to sample or to specialize? Seven postulates about youth sport activities that lead to continued participation and elite performance. *Int. J. Sport Exerc. Psychol.* 2009; 9:7–17.

21. Dawson WJ. Common problems of wind instrumentalists. *Med. Probl. Perform. Art.* 1997; 2:107–11.

22. Dawson WJ. Bassoonists' medical problems — current state of knowledge. *Med. Probl. Perform. Art.* 2012; 27:107–12.

23. Doyle-Lucas AF, Akers JD, Davy BM. Energetic efficiency, menstrual irregularity, and bone mineral density in elite professional female ballet dancers. *J. Dance Med. Sci.* 2010; 14:146–54.

24. Doyle-Lucas AF, Davy BM. Development and evaluation of an educational intervention program fro pre-professional adolescent ballet dancers: nutrition for optimal performance. *J. Dance Med. Sci.* 2011; 16:65–75.

25. Ericsson KA, Krampe RT, Tesch-Romer C. The role of deliberate practice in the acquisition of expert performance. *Psychol. Rev.* 1993; 100:363–406.

26. Exercise is Medicine Web site [Internet]. Indianapolis (IN): American College of Sports Medicine; [cited 2013 Jul 30]. Available from: http://www.exerciseismedicine.org.

27. Fjellmann-Wiklund A, Chesky K. Musculoskeletal and general health problems of acoustic guitar, electric guitar, electric bass, and banjo players. *Med. Probl. Perform. Art.* 2006; 21:169–76.

28. Fong Yan A, Hiller C, Smith R, *et al*. Effect of footwear on dancers: a systemic review. *J. Dance Med. Sci.* 2011; 15:86–92.

29. Foster R. Adolescence: a time of vulnerability and opportunity. *NY Acad. Sci. Mag.* 2003;2–5.

30. Hamilton LH, Hamilton WG. Occupational stress in classical ballet dancers: the impact in different cultures. *Med. Probl. Perform. Art.* 1994; 9:35–8.

31. Hincapie CA, Morton EJ, Cassidy JD. Musculoskeletal injuries and pain in dancers: a systematic review. *Arch. Phys. Med. Rehabil.* 2008; 89:1819–29.

32. Howarth KR, Moreau NA, Phillips SM, Gibala MJ. Coingestion of protein with carbohydrate during recovery from endurance exercise stimulates skeletal muscle protein synthesis in humans. *J. Appl. Physiol.* 2009; 106:1394–1402.

33. International Association for Dance Medicine and Science Web site [Internet]. Resources for Teachers; [cited 2013 Aug 1]. Available from: http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=242.

34. Jansen EJ, Helleman HW, Dreschler WA, de Laat JA. Noise induced hearing loss and other hearing complaints among musicians of symphony orchestras. *Int. Arch. Occup. Environ. Health.* 2009; 82:153–64.

35. Leaver R, Harris EC, Palmer KT. Musculoskeletal pain in elite professional musicians from British symphony orchestras. *Occup. Med. (Oxford).* 2011; 61:549–55.

36. Lederman RJ. Medical problems of violinists and violin makers. *J. Violin Soc. Am.* 1990; 10:21–45.

37. Lederman RJ. Primary bowing tremor: a task-specific movement disorder of string instrumentalists. *Med. Probl. Perform. Art.* 2012; 27:219–23.

38. Leveille LA, Clement DB. Case Report: action induced focal dystonia in long distance runners. *Clin. J. Sport Med.* 2008; 18:467–8.

39. Lim V, Altenmuller E. Musicians cramp: instrumental and gender differences. *Med. Probl. Perform. Art.* 2003; 18:21–7.

40. Little League International Baseball and Softball Web site [Internet]. Pitch Count Regulations: Protecting Young Pitchers' Arms; [cited 2013 July 29]. Available from: 17701.0485http://www.littleleague.org/assets/old_assets/media/pitch_count_publication_2008.pdf

41. Mainwaring L, Kerr G, Krasnow D. Psychological Correlated of Dance Injuries. *Med. Probl. Perform. Art.* 1993; 8:3–6.

42. McClinton S, Heiderscheit B. Diagnosis of primary task-specific lower extremity dystonia in a runner. *J. Orthop. Sports Phys. Ther.* 2012; 42:688–97.

43. Miller CM. Dance medicine: current concepts. *Phys. Med. Rehabil. Clin. N. Am.* 2006; 17:803–11.

44. Moseley L, Lancaster GI, Jeukendrup AE. Effects of timing of pre-exercise ingestion of carbohydrate on subsequent metabolism and cycling performance. *Eur. J. Appl. Physiol.* 2003; 88:453–8.

45. Music Teachers National Association (MTNA) Web site [Internet]. Wellness Statement; [cited 2013 July 20]. Available from: https://members.mtna.org/leadership/WellnessStatement.pdf; adopted July 2007.

46. National Association of Schools of Music (NASM) 2012–13 Handbook. Health and Safety Standard. National Association of Schools of Music 11250 Roger Bacon Drive, Suite 21, Reston, Virginia 20190-5248 Pub Jan 24, 2013 http://nasm.arts-accredit.org, p 67.

47. National Association of Schools of Music (NASM) Web site [Internet]. NASM-PAMA Advisory for Hearing Loss: Basic Information on Hearing Health, Information and Recommendations for Faculty and Staff in Schools of Music; [cited 2013 July 29]. Available from: http://nasm.arts-accredit.org/index.jsp?page=NASM-PAMA_Hearing_Health, November 2011.

48. National Collegiate Athletic Association (NCAA) Sports Medicine Handbook, Medical Evaluations, Immunizations and Records. The National Collegiate Athletic Association, P.O. Box 6222 Indianapolis, Indiana 46206-6222 Twenty-second edition July 2011. www.NCAA.org, p. 8–10.

49. National Hearing Conservation Association Web site [Internet]. Westminster (CO): National Hearing Conservation Association; [cited 2013 Aug 1]. Available from: http://www.hearingconservation.org/displaycommon.cfm?an=12.

50. Patel DR, Pratt HD, Greydanus DE. Pediatric neurodevelopment and sports participation: when are children ready to play sports. *Pediatr. Clin. North Am.* 2002; 49:505–31.

51. Phillip SM, Van Loon LJC. Dietary protein for athletes: from requirements to optimum adaptation. *J. Sports Sci.* 2011; 29:S29–S38.

52. Ranelli S, Smith A, Straker L. Playing-related musculoskeletal problems in child instrumentalists: the influence of gender, age, and instrument exposure. *Int. J. Mus. Educ.* 2011; 29:28–44.

53. Rodriguez NR, DiMarco NM, Langley S. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: nutrition and athletic performance. *J. Am. Diet Assoc.* 2009; 109:509–27.

54. Rodriguez-Lozano FJ, Sáez-Yuguero MR, Bermejo-Fenol A. Orofacial problems in musicians: a review of the literature. *Med. Probl. Perform. Art.* 2011; 28:150–6.

55. Sandell C, Frykman M, Chesky K, Fjellman-Wicklund A. Playing-related musculoskeletal disorders and stress-related health problems among percussionists. *Med. Probl. Perform. Art.* 2009; 24:175–80.

56. Sports, Cardiovascular, and Wellness Nutrition (SCAN) Web site [Internet]. Performing Arts Nutrition Fact Sheets (created 2011); [cited 2013 July 29]. Available from: http://www.scandpg.org/sports-nutrition/athletes-in-the-arts-fact-sheets/

57. Shah S, Weiss DS, Burchette RJ. Injuries in professional modern dancers: incidence, risk factors, and management. *J. Dance Med. Sci.* 2012; 16:17–25.

58. Shirreffs SM Taylor AJ, Leiper JP, Maughan RJ. Post-exercise rehydration in man: effects of volume consumed and drink sodium content. *Med. Sci. Sports Exerc.* 1996; 28:1260–71.

59. Solomon R, Solomon J, Micheli LJ, McGray E, Jr. The cost of injuries in a professional ballet company: a five year study. *Med. Probl. Perform. Art.* 1999; 14:164–9.

60. Wanke EM, Mill H, Wanke A, *et al*. Dances floors as injury risk: analysis and evaluation of acute injuries caused by dance floors in professional dance with regard to preventative aspects. *Med. Probl. Perform. Art.* 2012; 27: 137–42.

61. Zhao F, Manchaiah VK, French D, Price SM. Music exposure and hearing disorders: an overview. *Int. J. Audiol.* 2010; 49:54–64.