A Dancer’s View: Analysis and Prevention of Common Dance Injuries

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“You are not obligated to complete the work, but neither are you free to abandon it.”
Abstract

The overwhelming majority of dancers’ face injuries throughout their careers. The effects of injuries can range from resting for two weeks to career ending. Many dancers, especially at the college level, lack accessible education on how to prevent their injuries. This research is being targeted at WOU dancers, hoping to give them easy access to injury prevention materials and exercises, while helping to minimize the financial burden of seeking professional help. Through detailed analyses of five major regions of the body, information on common dance injuries becomes clearer and easier to analyze. The analyses will include classification of major joints, ranges of motion, types of motion, and major contributing muscles. The major regions of the body will be classified as ankle/foot, leg/knee, hip/pelvis, spine, and shoulder/scapula. After examining the anatomical background, exercises to increase strength, flexibility and stability of the major contributing muscles will be developed. Given the vast number of possible injuries, the study has been delimited to include a sampling of common dance injuries that will allow this research to be applicable for many college-age dancers. A series of pictures and images will be created and distributed compiling all the researched exercises to provide accessible education and injury prevention resources to dancers.
Review of the Literature

The concept of injury prevention in dance is not uncommon and many dancers can devote ample amounts of time outside of the dance studio cross training and conditioning to supplement their dance technique training. Some professional companies and studios have gone as far to support a wellness screening program for their dancers that provides additional training and rehabilitation facilities. The dance community has taken great strides in protecting the body over furthering the art but still has far to go. Dance injuries are still a huge concern for participants and are a huge factor in the dancers’ short career and early retirement.

An important distinction to make is how dancers and more conventional athletes vary drastically physically and in their athletic forms. Both differences impact the way each group can approach injury prevention. Sports often hold a very high and enthusiastic fan base while dancers (performers, teachers, choreographers, etc.) experience a “lack of appreciation and respect by society at large for their extraordinarily physical and aesthetic craft” (Russell, 2013). Due to this, the very nature of dance as athletic artistry fosters a high degree of dedication in its participants. In contrast to most athletes who engage in daily practice sessions of comparatively short duration, dancers typically participate in technique
classes during most of the day, followed by rehearsals through the late afternoons and evenings. Weekends may be similarly filled. They feel an obligation to participate in and perfect their art and are credited by health care professionals for the “intense psyche these athletic artists possess” (Russell. 2013). Wainwright et al. concludes ballet dancers, specifically, exhibit a consuming passion for dance that makes a decision to stop dancing for injury or other reasons exceedingly difficult. Dancers also exhibit both a higher pain threshold and a higher pain tolerance than other athletes (Taget-Foxwell,1995) which seemingly plays a role in dancers’ minimalist reports of pain. In addition, Anderson and Hanrahan noted dancers tended to poorly distinguish between pain that is customary in dance performance and pain associated with injury. Pain is typically seen by dancers as an accompaniment of dance practice, and dancers are prone to “dance through” pain, even when doing so may be detrimental.

A majority of dance injury data exists for two genres: modern/contemporary dance and ballet. Moreover, the literature’s agreement of the term “injury” varies making consistency difficult. The majority of dancers considered an injury as something that stopped them from participating in dance or moving normally (Thomas et al., 2009). The prevalence of dance injury in previous research has been reported to be between 37.1% to 82% (Noh et al., 2005; Shah, Weiss, Camp; Burchette, 2012). Most often dancers sustain injury
affecting their ligaments (Ekegren et al., 2014) with muscle strains being the second most injured tissue in the dancers body (Echegoyen et al., 2010). Dance injuries can be categorized as ‘overuse’ or as ‘acute’. There are many additional factors such as age, gender, level, company-status, genre, reporting method, and touring-status that each play a part in teasing out certain dance injury rates (Caine et al., 2015). Injuries in dance are similar to injuries in sports in the sense that they are activity specific, emerging in patterns representative of the motion demands associated with the activity (Liederbach, 2007). Reynolds et al. found differences in injury frequency, with modern dancers having the highest injury frequency. Jazz and ballet dancers experienced an injury frequency pattern of distal to proximal joints, whereas modern dancers experienced a proximal to distal pattern. Lower extremity injuries were more common than upper extremity injuries across all dance types. Injury frequency and location cannot be generalized to all styles of dance but there are some common injury patterns across all 3 dance types noted above.

An investigation of ballet dancers suggested that inadequate physical training was a primary contributor to dance injuries. However, a 6-year follow-up of the same dancers revealed that, while they still were frequently injured, their increased age and dance workload did not result in more pain or injuries; rather, improved physical training facilities were identified as a helpful supplement to
their dance activity (Ramel et al., 1999). Furthermore, professional ballet dancers who participated in a fitness program apart from their dance technical training showed an increase in maximum oxygen uptake, as well as decreased psychological stress, in comparison to a control group of dancers who did not pursue a fitness program (Ramel et al., 1999).

A study suggesting that decreased injury incidence in professional ballet dancers results from implementing physical training was performed by Allen et al. Over 3 years of prospective injury recording, male dancers’ injury prevalence dropped from 4.76 per 1,000 hours of dance exposure (technique classes, rehearsals, touring, performing, etc.) to 2.22 per 1,000 hours. Injury incidence for females declined from 4.14 to 1.81 per 1,000 hours in the same 3-year period. Based on their first year’s data, these researchers analyzed each dancer’s injury history and physical screening data and created an individualized conditioning routine and subsequently showed the value of such programs in reducing ballet injuries. As one possibility to limit the occurrence of injuries, physical regimens already popular with dancers should be encouraged and, while adhering to gradual, progressive overload, greater intensity and training volume across a general fitness program have shown great improvement of the overall health of participative dancers.
Core strength is an important factor in daily bodily movements and is a popular topic in musculoskeletal research. There are a variety of definitions among popular literature as to what core strength is which can be confusing to dancers. Despite this, there is a growing consensus among exercise science professionals that core stability is an important factor in every motor activity. It is highly important in dance and increased stability and strength can function in a vast variety of actions from maintaining low back health to preventing knee ligament injury. Wilson et al. determined that there is a clear relationship between trunk muscle activity and lower extremity movement and that a decrease in core stability may result in injury, while correct and appropriate training can result in reduced rates of back and lower extremity injury.

Whereas poor core stability has been identified as a risk factor for upper and lower extremity injury, inadequate neuromuscular control in the trunk has been specifically associated with increased athletic knee injuries in female dancers. In elite professional ballet dancers, weakness and lack of control of the multifidus muscles have been correlated with lower back pain. The trunk muscles appear to fire in anticipation of lower extremity muscle contraction; this suggests “the importance of optimal core function as the aesthetics of dance are intimately dependent on
precise control of both the trunk and extremities” (Zazulak et al., 2007). Therefore, attention to core stability and strength should be considered foundational to a dancer’s training with the caveat that, in light of Rickman et al. findings that research literature on this topic is relatively scant, further research on core function in dancers is needed. Even with the lack of published research, one could say that the potential benefits of core stability outweigh an unstable core with regard to safe movement practice.

Low levels of muscular strength and power also have been suggested as predictive of dance injuries. Specifically, thigh torque in a cohort of male and female ballet and contemporary dancers was correlated with severity of injury as measured in days lost from dancing (Koutedakis et al., (1997). Angioi et al. similarly found leg power measured by vertical jump height to be negatively correlated with days lost from dancing, showing that increased the time off of dancing contributes to the degree of leg power in an individual. In support of the need for physical training by dancers, a 6-week program of circuit and vibration training of contemporary dancers led to improvement in lower body muscular power, upper body muscular endurance, aerobic fitness, and aesthetic competence.

Ambegaonkar et al studied upper body muscular endurance in university modern dancers, finding no difference between dancers and non-dancers in spite of modern dance requiring more consistent work with the upper body than ballet,
especially in females. They surmised that their dancers’ lack of engagement in upper body physical training outside of dance classes, rehearsals, and performances was the primary contributor, thereby suggesting that participation in modern dance, in and of itself, does not lead to upper body muscular training effects.

In a sample of female professional ballet dancers compared to a control group, Koutedakis et al. reported significant improvements in quadriceps and hamstring torque, as well as improvement in thigh muscle fatigability during dance, as a result of 12 weeks of strength training for these muscles. The improvements were particularly noteworthy in dancers who were weaker at the beginning of the study. As the control group dancers did not exhibit strength increases, the authors suggested that “dance technical training alone is incapable of eliciting strength gains.” Undesirable increases in muscle bulk are a concern for many female dancers because of the importance of anatomical aesthetic contours in dance. However, importantly for females, the increases in thigh strength seen in this study occurred without a concomitant alteration of thigh circumference, a finding the researchers offer as an indicator that the aesthetic characteristics of the lower extremities can be preserved when female ballet dancers participate in weight training.
Hip and groin injuries accounted for 9.8% of all injuries reported in dancers. A review of the literature found a 17.7% hip/groin injury rate among all dancers studied, with individual studies ranging from 9.7% to 80% (Trentacosta et al., 2017) This assumes each injury reported occurred in a single dancer and no bilateral injuries were reported. If considering the risk “per hip” as opposed to “per dancer,” the injury rate per hip is 8.6% in the 4002 hips included in this study.

Prior studies show a 40% to 55% rate of musculoskeletal injury in professional ballet companies and 85% rate of musculoskeletal injury in dance students (Duthon et al., 2013) In looking at hip/groin injuries, Trentacosta et al. showed a 27.6% hip/groin injury rate was seen in the professional population versus a 14.1% hip/groin injury rate seen in the student population. This shows that in the hip region specifically, there is a higher prevalence of injuries in professional dancers versus students. This risk of injury is especially concerning for dancers as they grow older and increase their skill levels and overuse.

Swain et al. composed a literature review for documented lower back pain and lower back injuries. They observed a yearly average of 73% and lifetime average of 50% of dancers experience lower back pain. This is notably higher than the global averages for non dancers and olympic level athletes. There is a literature discrepancy about lower back injuries and they tend to be more general reported as lower back pain. Because of this, of the 73%, the lower back will only be
identified as the cause of time loss or medical attention for 11% of cases. The prevalence of lower back pain and percentage of all injuries located in the lower back appeared to increase with age and dance level. There was mixed information describing sex as a risk factor. Previously, it has been suggested that male dancers may be more vulnerable to pain and injury, due, in part, to the lifting demands required of men in ballet. While this still may be the case, both males and females from ballet and contemporary dance are exposed to a variety of physical factors beyond lifting that may increase risk of lower back pain and injuries.

The shoulder is widely regarded as the least injured major body region. Historically, the majority of the shoulder movement is gestural. However, literature has shown an increasing number of shoulder injuries due to the high prevalence of modern and contemporary dance focuses professionally and collegiately. The inclusion of lifts, falls, and invented positions can place extreme torque and pressure on the shoulder girdle and upper body. Summer et al. found that majority of observed injuries involved the lower extremity (n = 31, 63.3%), and the majority of clinician sessions related to management of lower extremity injuries (n = 76, 66.1%); however, nine (17.7%) upper extremity injuries also occurred that required 19 (16.5%) clinician sessions. This shows an increase from previous data suggesting that upper body injuries account for a total of 2%-3% of all dance injuries. This increase is widely regarded due to the increase of “novelty”
choreography which can put much more strain on the upper extremity due to the emphasis placed on tricks (Summer et al., 2009).

The ankle is frequently injured in dance, accounting for up to 31% of dancers’ reported injuries (Luke et al., 2002). When foot injuries are included, the combined total accounts for up to 57% of all dance injuries (Liederbach et al., 2008). Overuse injuries tend to be more common than traumatic injuries and this is likely due to the repetitive nature of dance training coupled with the inability of the body’s tissues to withstand the demands imposed on them (Hincapie et al., 2008). In the ankle region, lateral sprains are the most common traumatic injury across all sports, including dance (Luke et al., 2002). Achilles tendinopathy and flexor hallucis longus tendinopathy (“dancer’s tendinopathy”) are frequently encountered overuse conditions. In the foot, spiral fracture of the fifth metatarsal shaft (“dancer’s fracture”) and bifurcate ligament sprain are two common traumatic injuries, while metatarsal stress fractures, Morton’s neuroma, and plantar fasciitis fall into the overuse category (Liederbach et al., 2008).

A barrier to dancers when it comes to treating injuries is how difficult it is to find the support they need in healthcare. Most dancers do not have access to specialized health care equivalent to their counterparts in traditional sports (Ojofeitimi, 2011; Ambegaonkar, 2009). Moreover, when they do approach the healthcare profession, the response they receive is often unconstructive or
discouraging. Russell et al. found that 80% of university dancers surveyed reported that they felt their health care providers did not understand dancers and 43% indicated that their health care providers gave unhelpful advice. The most common medical advice given, and abhorred by dancers, is “stop dancing” as a method to manage their injuries.

Wellness programs and dance screenings have become increasingly popular in well-funded collegiate dance departments and professional training schools (Cardinal et al., 2020). A medical student partnered with Garth Fagan Dance to develop a curriculum to teach principles of injury prevention specific to pre-professional and professional modern dancers. Quantitative assessments showed a significant increase in participant injury prevention knowledge after completion of the course (P < 0.0001) indicating a significant increase in knowledge acquisition. Participants’ concern that injury may end their careers showed no significant change after the course (P = 0.35). Injury prevention and dance-related injuries were reported the most often as useful topics while weight management was reported the least often as a useful topic. Qualitative evaluations showed that participants found a course on injury prevention valuable and desired a course of longer duration that includes a greater number of topics. These findings show that modern dancers perceive an educational course on injury
prevention as valuable and retain information presented in the course in the short-term (Fuhrmann et al., 2010).

There are important aspects to keep in mind when doing supplementary conditioning without professional supervision. It is vital to maintain a good warmup (pre-conditioning) and cool down (post-conditioning) routine. A good warm up includes dynamic and aerobic movements such as brisk walking, dynamic stretching, and safe joint mobility. Dynamic stretching is actively using muscles to reach full ranges of motion and avoiding sitting in a stretch for a designated period of time. The overall goal is to elevate heart rate and body temperature by starting with smaller movements and increasing ranges of motion throughout the warm up. A cool down should focus on the opposite by bringing heart rate closer to resting heart rate and utilizing more stationary stretching.

It is also important to start slowly with supplemental conditioning. The principle of gradual progressive overload is highly applicable here. It involves the gradual increase of stress placed on the body during exercise training that is beyond its current capabilities. This gradual increase in stress forces the body to continually try to adapt to the training program. For strength and flexibility exercises, start easier and gradually increase the level of difficulty. Focus first on form, with no added weights or resistance, to allow your body to adapt to the
exercises. After correct body alignment is achieved and maintained, slowly add weights, resistance, and repetitions as needed.

Definitions

This thesis will explore injuries related to the dancer’s body in depth. In order to do so without confusion, the following terms are defined and used consistently throughout the entirety of the thesis.

The cardinal planes of motion are important concepts to describe directionality of movement. There are three basic plans that divide the body and are used for anatomical description: the frontal, sagittal, and transverse planes. Each plane can be visualized to sub-divide the body into two parts. The frontal plane runs vertically and perpendicular to the eye line. This plane divides the body into a front and back. The sagittal plane also runs vertically and parallel with the eye line. Thus, this plane divides the body into a left side and a right side. The transverse plane runs horizontal and throughout the body. This plane cuts the body into an upper and lower half.

Body movements have standardized language that correlates with the cardinal planes of motion. Each movement at a synovial joint results from the contraction or relaxation of the muscles that are attached to the bones on either side of the articulation. The type of movement that can be produced at a synovial
joint is determined by its structural type. Movement types are generally paired, with one being the opposite of the other. Body movements are always described in relation to the anatomical position of the body: upright stance, with upper limbs to the side of the body and palms facing forward. Flexion and extension are movements in the sagittal plane and involve anterior (forward) and posterior (backward) movements. Examples of these would be a forward fold and cambre back, flexion and extension of the spine respectively. Lateral flexion is specific to the neck and the spine and is movement in the frontal plane and involves the head or body bending or tilting from side to side. Abduction and adduction are movements that are made by the limbs, hands, and fingers and occur along the frontal plane. Raising the arm from bras ba directly to second position and a developpe a la seconde are examples of abduction of the arm and the leg. Reversing each action would be an example of adduction of the arm and the leg. Circumduction is a term used to describe a combination of flexion, extension, abduction, and adduction. Both the shoulder and hip sockets are examples of joints that experience circumduction. The anatomical definition can be whittled down for the purpose of this thesis, external rotation is synonymous with turn out and internal rotation is synonymous with turn in.

The foot and ankle is a unique region under explorations. For the purposes of this thesis, there are two sets of terms that will be used only for this region.
Dorsiflexion (or dorsal flexion) and plantar flexion occur at the ankle joint. Because of the perpendicular nature of the foot, the general terms of flexion and extension cannot apply here. Lifting the foot so that the top of the foot is reaching toward the leg, also termed flexing the foot, is dorsiflexion. Lifting the heel of the foot, releve, and pointing the toes downward is plantar flexion. Inversion and eversion are also foot and ankle specific actions. Inversion is the turning of the foot to angle the bottom of the foot toward the midline of the body, while eversion turns the bottom of the foot away from the midline. Inversion can be described as rolling towards the outside region of the foot, while eversion is rolling in the inside region of the foot.

The scapula also has very specific terms for movement due to its unique structure and function. Elevation is raising the scapula directly upward, like shrugging the shoulders, and depression is the opposite by drawing the scapula directly downward. Abduction of the scapula is pulling the two scapula away from each other, like when the shoulders are rounded or hunched forward. Scapular adduction is pulling the scapula across the rib cage and towards each other, like pinching your shoulder blades together and opening your chest. Upward and downward rotation can also occur at the scapula region and is mainly involved to assist shoulder and arm abduction and adduction.
Injury Prevalence

A dancer’s body is their instrument. It facilitates movement, learning, training, healing, and performance. Many people might consider dance a mere form of artistic expression. Among the activities in the wide realm of sports, dance is not often listed as one. However, any dancer could explain the amount of physical prowess that is incorporated in dance. Dancers are clearly athletes due to the degree of physical capabilities required to perform at a high level. The standard complement of athletic attributes – muscular strength and endurance, anaerobic and aerobic energy utilization, speed, agility, coordination, motor control, and psychological readiness – are all essential for dance performance (Russell, 2013). Because of the high physical demands placed upon dancers, injury is an inevitable result. While throughout the literature review, there are varying definitions of injury, for the purpose of this research an injury is something that prevents a dancer from participating in their art or moving in a normal way, relative to the dancer. Previous research has shown that about 80% of dancers develop a documented injury. Previous research suggests that 37.1% to 82% of dancers experience one or multiple injuries in a dance career (Noh et al., 2005; Shah, Weiss, & Burchette, 2012). Most often dancers sustain injury affecting their ligaments (Echegoyen et al., 2010; Ekegren et al., 2014; Ojofeitimi &
Bronner, 2011) with muscle strains being the second most injured tissue in the dancer’s body (Echegoyen et al., 2010). Injuries in dance are similar to injuries in sports in the sense that they are activity specific, emerging in patterns representative of the motion demands associated with the activity. Another main reason for injury is muscle imbalances throughout the body (Clippinger, 2016). Dance injuries can often go unreported or misreported so it can be easy to surmise that almost every dancer has faced an acute or chronic injury throughout their career (Caine et al., 2015). Previous research suggests that a general reason for many injuries is muscle imbalances in the body and overuse by repetitive movements. There are many additional factors such as age, gender, level, company-status, genre, reporting method, and touring-status that each play a part in teasing out certain dance injury rates (Caine et al., 2015). Injuries in dance are similar to injuries in sports in the sense that they are activity specific, emerging in patterns representative of the motion demands associated with the activity (Liederbach, 2007). For example, modern dancers will more commonly have injuries concentrated at proximal joints such as the spine, hips shoulders with injury rates decline in more distal joints such as ankles, knees, and neck. Ballet dancers have been reported to see the reverse phenomena with injuries increase from distal to proximal joints (Reynolds, 2013). These injury patterns are attributed to the different physical demands of specific dance forms. The
flexibility extremes, often required of dancers can be problematic and leave
dancers vulnerable to injuries. Overstretched muscles and tendons are not capable
of maximal force production. This can cause dancers to not be able to complete
choreography as necessary. Too much flexibility, called hypermobility, can
contribute to joint instability. In addition, hypermobility decreases proprioception,
or awareness of the body in space, which could cause injury. Because injury is so
prevalent among dancers, injury prevention and rehabilitation are not new
practices. Many prevention and rehabilitation programs for dancers are costly and
found at larger, more affluent universities. This thesis seeks to provide easily
accessible and free information about injury prevention that is specific to common
dance injuries and will give ways to help prevent the detailed injuries through
supplemental muscular conditioning.

The Athletic Dancer

The question of where dancers fall on the spectrum of athletes has been a
long discussion. In reality, there is a high amount of crossover between the
definitions of athlete and dancer and it is important to note the similarities and
differences between the two. While both need to have good strength, flexibility,
stamina, and coordination, the requirements for dance are more specific based on
the style of dance. For example, a ballet dancer requires more balance and foot
strength while a break dancer requires more shoulder and leg strength. This specificity is one reason why dancers need detailed and specific cross training. Like athletes, dancers prefer not to take time off from rehearsals and performances, even when they are injured. This may be due to expectations, denial of injuries, or a competitive personality. This can lead to ignoring the body’s signals and not seeking necessary medical attention. Wainwright et al. concludes ballet dancers, specifically, exhibit a consuming passion for dance that makes a decision to stop dancing for injury or other reasons exceedingly difficult. Dancers also exhibit both a higher pain threshold and a higher pain tolerance than other athletes (Taget-Foxwell, 1995) which seemingly plays a role in dancers’ minimalist reports of pain and somewhat skewed injury report data. Another reason dancers may avoid seeking medical attention is the fear of being held from dancing. Dance intersects both artistic and athletic abilities. While dancers are subject to some of the same physical demands as athletes, they are also faced with unique challenges. Some physical characteristics of dancers could increase the risk for injury. For example, dancers require good, and sometimes considered extreme, flexibility to achieve required positions and movements.

An important distinction to make is the difference between dancers and more traditional sports athletes. The largest differences, in regards to this research, pertain to the actual physical differences and athletic form differences, both of
which impact the approach of injury prevention. Traditional dance training is
typically dictated by artistic traditions rather than scientific principles that shape
athletic training. Dance is a year-round activity without set seasons like other
sports. Thus, dancers are not given sufficient rest periods to allow for proper
muscle recovery, tissue growth, and nutritional replenishment. Athletes generally
take part in daily practice sessions of comparatively short duration; dancers
typically participate in technique classes during most of the day, followed by
rehearsals through the late afternoons and evenings. Weekends may be similarly
filled (Russel, 2013). In addition, the techniques performed in classes do not
always reflect the movement demands expected in performances. Choreographers
often seek to push the boundaries of movement under the assumption that the
dancer will succeed. This puts additional pressure on the dancer to practice outside
of class and continue to decrease the rest time that is required for general wellness.
Dancers can experience a “lack of appreciation and respect by society at large for
their extraordinarily physical and aesthetic craft” (Russell, 2013). This is much
different than the high following sports have in society. This athletic artistry
fosters a high degree of dedication in its participants. They feel an obligation to
participate in and perfect their art and are credited by health care professionals for
the “intense psyche these athletic artists possess” (Russell. 2013).
Normalization of Pain

Dancers are notorious for forcing themselves to keep dancing regardless of the ramifications. While some level of pain is simply part of being a dancer, most dancers have the ability to differentiate between "good pain" and "bad pain."

"Good pain" may best be reframed as "sensation," sometimes of mild soreness or when your body is pushed to the point of tension (like when you're stretching).

"Bad pain" might prevent you from executing technique normally, or it might be less obvious. Anderson and Hanrahan noted dancers tended to poorly distinguish between pain that is customary in dance performance and pain associated with injury. Pain is typically seen by dancers as an accompaniment of dance practice, and dancers are prone to “dance through” pain, even when doing so may be detrimental. "If you have tweaks and twinges, you're going to test that and see how far you can go” is what Leigh Schanfein, MS of biomechanics and past dancer, says about dancers and pain. Significant issues arise when dancers don't always stop when they know those tweaks and twinges get worse. Pushing through can lead to injury; at the very least, it can keep dancers from performing at their full potential. Aspects of dance culture normalize pain and injury by young dancers being encouraged to “dance through” the pain. Some people may place the completion or success of a performance at a higher priority than the health of an
individual performer (Anderson et al., 2008). Brooke Siem, a former dancer who now writes about mental health, says she knew she was different from her non-dancer friends in part because of her reaction to pain—with a quip of "pain is pain, no big thing." The competitive nature of dance made her want to "beat everyone at everything, even in how much pain I could bear." The intense peer-to-peer competition influences dancers, especially younger dancers, to continue and disregard pain as a signal of impending injury (Wainwright, 2005).

**Accessible Education and Medical Attention**

Communicating with health-care professionals and dealing with health concerns can be challenging for anyone. This interaction can pose specific challenges for many dancers, who may hesitate to seek help for their health concerns, fearing the counsel they receive will lack an understanding of their lives and practice. Familiar advice, such as “Don’t do that movement” or “You’ll have to take time off” and “A few visits to the massage therapist will help,” can seem frustrating to a dancer who lacks the necessary time and funds to comply. Russell et al. found many university dancers reported that they felt their health care providers did not understand dancers and indicated that their health care providers gave unhelpful advice. The most common medical advice given, and abhorred by dancers, is “stop dancing” as a method to manage their injuries. While this advice is sound under certain injury circumstances that require complete rest (e.g., a tibial
stress fracture), dancers loathe receiving it as a carelessly offered panacea and often cannot adhere to it due to the regular rehearsal schedule and limited off season. Dance as a profession does not commonly provide job stability. Practitioners who fail to acknowledge this reality can leave a dancer feeling stressed and unsatisfied with an appointment. The reality is that independent dance artists may lose contracts if they take time off or cease to do movements that are essential to a piece of choreography. Furthermore, these dancers are unlikely to receive paid sick leave or be able to afford the services of allied health professionals. Even a dancer with a contract that does provide paid leave for illness, injury or personal reasons may hesitate to take time off for fear of losing a valued role. In such cases, a well-meaning sick note or requisition can feel unhelpful, and seemingly practical counsel may go unheeded by the dancer. Most dancers do not have access to specialized health care equivalent to their counterparts in traditional sports (Ojofeitimi, 2011; Ambegaonkar, 2009). Wellness programs and dance screenings have become increasingly popular in well-funded collegiate dance departments and professional training schools (Cardinal et al., 2020). These programs offer dancers with highly specialized practitioners who aim to help provide care without being a barrier to a dancer’s career. However, most professional dance companies and colleges cannot afford to keep a consistent wellness program of high caliber.
Shoulder and Scapula

The upper extremity is the first region upon analysis. For this, focus will be on the shoulder girdle and the upper arm. Due to the highly linked nature of the shoulder and the upper arm, they are usually viewed as a single functional unit referred to as the shoulder complex. The shoulder complex is characterized to have great mobility which is necessary in the “everyday life” movements such as reaching or raising the arm. As with almost any functional design, flexibility and mobility come at a cost: stability and strength.

The shoulder complex is composed of three main bone structures that link together to form two main joints. The bone structures are the clavicles (collar bones), scapulae, and humerus. The clavicle joins with the scapula on its respective side to form the acromioclavicular joint which is stabilized by ligaments and the scapula is jointed to the humerus via the glenohumeral joint (shoulder joint). The paired range of motions of these joints and the actions of the scapulae allow for the circumduction and large range of motion of the shoulder complex. Scapulohumeral rhythm is coordinated movement of the scapula and humerus. Without scapular movement, the arms could only be raised about 90-100 degrees. Much of dance movement requires a range of motion beyond that, and this rhythm
is necessary to keep in mind when looking to stabilize and strengthen the shoulder complex.

In traditional styles of dance, ballet, early modern, and early jazz, the upper arms are generally used for aesthetic reasons and are mainly gestural. Arm movements traditionally aid in balance and proper spinal positions for dance to give the dancer a specific and posed look. Arms are often viewed as lightly and effortlessly placed to give the entire movement of the body a look of ease. Another use of the arms in more traditional dance styles is to help portray a story or specific emotion via pantomime or the way tension can easily be seen in the shoulders of a dancer. There was a significant amount of partnering in these dance styles, usually with the male dancer lifting a female dancer. As dance evolved and choreographers pushed more limits of the human body, the shoulder complex became more vulnerable to injury. Movements typically viewed in contemporary and postmodern dances are intense partnering and weight sharing and inversions. Even still with the added movement and stress being applied to the shoulder complex, it tends to be the least abused region of a dancer’s body. Because of this, there is very little emphasis in typical dance training that focuses on the upper body and arm. This leaves a shoulder unit, already lacking in stability and strength, extremely vulnerable when dancers rush into learning new choreography with lifts and inversions that they have done no strength training for.
A common injury found in dancers is rotator cuff tendonitis (Clippinger, 2016). This involves chronic overuse of rotator cuff muscles. This results in inflammation and irritation of the tendons responsible for aiding shoulder movement, specifically rotation. Commonly reported symptoms are pain when raising or lowering arm, overhead movements, clicking noise when moving the shoulder, and overall loss of strength and mobility of the joint. Repetitive, fast motions using the full range of motion can contribute to rotator cuff injuries. These can be found in all dance forms, in some aspect, but are very notable in African dance.

Another frequently observed injury is subacromial impingement syndrome. This refers to the impingement or pinching of the soft tissue between the head of the humerus and the coracoacromial arch. The coracoacromial arch, composed of distinct aspects of the scapula and a ligament, forms a protective barrier over the humerus to protect soft tissue from damage. When the arm is raised to the side and rotated inward, the space between the humerus and the coracoacromial arch is decreased significantly, around 50%, and leave the area highly subject to impingement. Indications for this injury is pain in the shoulder occurring specifically when lifting the arm overhead. Pain is normally the most severe in the classic arc of pain which has a range between 60 and 120 degrees of arm abduction. This can also be accompanied with abnormal and excessive elevation
of the scapula. An example where this is found in dance can be when ballroom
dancers assume a closed position, a common partnering position.

Acromioclavicular sprains are also prevalent dance injuries. This involves
injury to the ligaments around the acromioclavicular joint. Mild forms of this
injury can be a simple overstretching of ligaments whereas more severe form can
result in tearing the acromioclavicular ligaments and surrounding ligaments. This
can also be accompanied with the dislocation of the clavicle in the most severe
cases. This injury most notably occurs when falling to the ground and hitting the
shoulder upon impact. Falling and rolling are huge culprits of this injury in
dancers.

Shoulder dislocations are also among the most common dance injuries.
Anatomically, due to its design to provide mobility, it is the most frequently
dislocated joint in the human body (Ludewig et al., 2011). This injury typically
occurs when the arm is abducted or externally rotated and the shoulder hits the
ground with heavy impact. Again, dance forms that use heavy floor work or falling
are making the dancers susceptible to shoulder dislocations. When approaching
floorwork, the arms are often used to support and cushion the rest of the bodies’
fall to the ground. Often, this requires the arm to be in the vulnerable position,
abducted or rotated.
Ambegaonkar et al studied upper body muscular endurance in university modern dancers and found no difference between dancers and non-dancers in spite of modern dance requiring more consistent work with the upper body than ballet, especially in females. They surmised that their dancers’ lack of engagement in upper body physical training outside of dance classes, rehearsals, and performances was the primary contributor, thereby suggesting that participation in modern dance, in and of itself, does not lead to upper body muscular training effects. Additionally, dance technique classes typically do not integrate exercises to develop upper body strength with the same vigor as those to develop lower body strength. Thus, dancers would need to seek outside training to develop the musculature to safely execute dance forms (Clippinger, 2016). Dancers can lower risks of upper body extremity injury by developing adequate and balanced strength and developing and maintaining adequate flexibility (Clippinger, 2016). The following exercises will focus on protecting the shoulder complex from injury by targeting major muscle groups for strength, flexibility and stabilization.

<table>
<thead>
<tr>
<th>Exercise Name</th>
<th>Muscle Group(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front arm raise</td>
<td>Shoulder Flexors</td>
<td>Stand with your feet hip-width apart. Hold a weight (dumbbell) in your hand with your arm hanging at your side. Slowly raise the weighted arm to shoulder height and slowly lower</td>
</tr>
</tbody>
</table>
back to start position. This can also be done with an elastic band, anchored by feet, instead of weight. For beginners, do not use heavy weights or resistance and focus on maintaining good form in the exercise movement.

<table>
<thead>
<tr>
<th>Exercise</th>
<th>MusclesTargeted</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral arm raise</td>
<td>Shoulder Abductors and scapular upward rotators</td>
<td>Place an elastic band under your feet (standing) and hold the end of the band with each hand. Focus on engaging your back by visualizing drawing your scapula towards each other. Raise your arms from your hips sideways to shoulder height and return to starting position. For beginners, do not use heavy weights or resistance and focus on maintaining good form in the exercise movement.</td>
</tr>
<tr>
<td>Serratus Push Ups</td>
<td>Scapular abductors/protractors</td>
<td>Can be done in a push up position on the floor or against the wall depending on current strength level. Begin in a push up position. Keeping the elbows straight, press against the floor/wall so that the shoulder blades protract (move to the side and the around the upper back), then slowly return to push up position. Now squeeze shoulder blades together, allowing the chest to come forward slightly. Focus on engaging the core to protect the lower back. Return to the neutral spine.</td>
</tr>
<tr>
<td>Standing Row</td>
<td>Shoulder extensors and scapular adductors</td>
<td>Loop the elastic band around a stationary object (door knob on the opposite side of a closed door) at a hip height. Stand holding the band with your arms forward and slowly pull your elbow straight back behind you. Return slowly to the starting position.</td>
</tr>
</tbody>
</table>
This can also be done sitting with legs stretched out in front anchoring the elastic band around your feet. Begin with low resistance and build up to using higher resistance bands.

<table>
<thead>
<tr>
<th>Exercise Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Across the chest</td>
<td>Shoulder abductors and scapular adductors/retractors</td>
<td>Bring your arm across your chest using the opposite arm to support. Hold the position up to 1 minute return to neutral position.</td>
</tr>
<tr>
<td>Wall stretch</td>
<td>Shoulder adductors and horizontal adductors</td>
<td>Stand with your side facing the wall and your palm on the wall. Slowly turn away from the wall, opening the chest, while keeping the shoulder blade down. Hold the position up to 1 minute return to neutral position</td>
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</tr>
<tr>
<td>Chest expansion</td>
<td>Shoulder flexors</td>
<td>Hold an elastic band behind your back with both hands. Broaden the chest and allow arms to raise and shoulder blades to move towards each other. Hold for up to 30 seconds.</td>
</tr>
<tr>
<td>Pendulum</td>
<td>Rear shoulder muscles</td>
<td>Lean forward using a surface (counter or table) for support. Let the working arm hang freely at your side. Gently swing your arm forward and back and return to the starting position. Repeat with side to side swing and circular motions.</td>
</tr>
</tbody>
</table>

**Spine**

The spine is the central unit of the body. Various dance forms place great stress on the spine. Movement of the spine helps dance become dynamic and the
The strength of spinal muscles help support upper and lower body movements. It is separated in five basic regions: cervical, thoracic, lumber, sacrum, and coccyx. The regions of focus will be the cervical (neck), thoracic (mid back), and lumbar (lower back) regions as they provide the spine with the majority of its motion and are susceptible to many injuries. Each of these spinal regions are composed of a variable number of vertebrae with slight alterations in structure to allow for different ranges of motion and support for each region. There are seven cervical vertebrae and are stacked to allow for flexion, extension, lateral flexion, and rotation. The thoracic region consists of 12 larger vertebrae. Due to its connections to the ribcage, the region has limited flexion and extension; however, most of the rotation viewed in the spine is due to thoracic vertebrae. The lumbar region has 5 vertebrae, with the last one connecting to the sacrum. This region has limited rotation and significant flexion, extension, and lateral flexion.

The spine naturally has curvature, due to the shape and interaction of the individual vertebrae. These curves also play an important role in balance and shock absorption. Ideal spinal alignment is necessary to understand and maintain for a healthy spine. Neutral spinal alignment, when viewed from the front, consists of the spine being in straight line with the skull being centered over the pelvis with the head, shoulders and pelvis being level. Viewed from the side (sagittal alignment), there should be lordotic curves (c-shaped curves) in the
cervical and lumbar spine and kyphotic curves (reversed C-shaped curves) in the thoracic spine and sacrum (Pal et al., 1998). One major issue in dancers is incorrect spinal alignment which can be a large contributing factor in spinal injuries.

Dance requires major movement of the spine causing the spine to sustain weight loading, high compression forces, forceful twisting, and repetitive flexion and extension (Clippinger, 2016). The intensity of dance demands makes it understandable why back injuries are very prevalent and often require substantial time off in order to recover. One such repetitive movement is extreme hyperextension (cambré back). As aforementioned, the lumbar region of the spine will bear the majority of the stress from extension and can result in many different lower back injuries. In order to help the body sustain the repetitive hyperextension, substantial core strength, upper back strength, and upper back flexibility is needed. In dance, the spine also undergoes copious amounts of spinal flexion (contracting the spine). In spinal flexion, the stability of the spine is greatly decreased and must rely heavily on more passive structures such as ligaments, intervertebral discs, and surrounding muscles. Partnering can also cause a huge strain on the spine. Ideally, all dance lifts would allow the lifter to reduce risk to the spine by lifting their partner vertically, emphasizing using the legs and trunk for power. However, complex partnering rarely follows these ideal guidelines and additional cross training for core and back strength are needed to protect dancers' bodies.
One of the common injuries that dancers can face is a lumbosacral strain which is caused by over stretching the muscle or ligaments responsible for extending the spine, localized to the lower back. Over stretching can be a direct result of excessive movement including flexion, extension, and rotation of the spine. For dancers, movements that fall into those categories could be cross lateral movement, circular port de bras, or other dance moves that twist the spine excessively. Partnering can also be a factor for this injury, especially with complicated lifts. Indications of this injury can be generalized pain in the lower back, muscle stiffness, or muscle spasms.

Another injury common to dancers is spondylolysis. This usually occurs in younger dancers and is classified as a stress fracture in the pars interarticularis. Vertebrae have two main points of connection to the vertebrae above and below in the vertebral column. The primary one, and the most commonly thought of, is connection of vertebral bodies which are cushioned by intervertebral discs. The secondary connection is the par interarticularis; it is the connection of the spinous processes, a perpendicular and posterior protrusion, of adjoining vertebrae. This is the weakest region of the vertebrae which is why spondylolysis can occur. This has a high prevalence in dancers, gymnasts, and figure skaters due to the high amounts of repetitive hyperextension required to perform each sport. Some studies show that there is a slightly higher prevalence for spondylolysis in male dancers.
because it also is aggravated by large overhead lifts, especially those where the bulk of the partners weight is behind the lifter. This causes the lift to compensate for the backwards weight by arching the back into slight hyperextension (Eck et al., 2004). Symptoms of spondylolysis are lower back pain, specifically when on one leg, for example an arabesque. General lower back pain can also be accompanied with spine tenderness (directly on spine, not surrounding muscles), sciatica (shooting pain from spine down to the leg, and hamstring tightness (Gottschlich, 2011). A very similar injury, with similar symptoms with regards to this research, to spondylosis is spondylolisthesis where there is actual slipping of vertebrae due to spondylolysis.

Facet syndrome is also similar to spondylolysis but would normally be found in older, post teen dancers. The mechanism of the injury is the same as spondylolysis with damage to the pars interarticularis. With this damage, the facet joints of the spine become inflamed and may undergo degenerative processes (Clippinger, 2016). Lumbar facet sprain can present as back pain with spinal tenderness and occasionally radiating pain to the groin and the back of the leg, but it does not extend past the knee. Pain is exacerbated by jumping, hyperextension and abduction positions, especially if accompanied by forced turnout and by "overturning" during second position (Gottschlich, 2011).
Disc herniation is also a common injury in dancers. It was typically an injury mostly prevalent with dancers in their thirties or forties but a study by Kjaer et al. found an increasing prevalence of this injury in younger dancers. The intervertebral disc is composed of an inner ring named the nucleus pulposus and an outer ring of annulus fibrosus, which is innervated richly with pain fibers (Marieb et al., 2019). The main job of the disc is to provide shock absorption, and when it is exposed to excessive and often unbalanced loads, the disc breaks down and causes tearing and fissuring of the annulus fibrosus (Marieb et al., 2019). Disc herniation is where the inner nucleous pulposus bulges out of the annulus fibrosus. This can occur due to repetitive lifting especially with poor posture or can occur due to movements of combined rotation and forward flexion from the spine. Indications of disc herniation is pain into the leg that radiates with flexion of the spine and decreases with extension of the spine, pain with flexion and rotation, and widespread muscle spasm (Clark, 2017)

Strengthening Exercises

<table>
<thead>
<tr>
<th>Exercise Name</th>
<th>Muscle Group(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ab Warm up (Marching)</td>
<td>Spinal flexors and stabilizers</td>
<td>Lie on your back with knees bent 90 degrees and feet on the floor. Engage abs while maintaining neutral spine. Slowly raise one leg and return to the starting position. To increase difficulty, straighten legs or lie on a foam roller (with the roller lengthwise under your spine, head to tailbone) to increase needed stabilization</td>
</tr>
<tr>
<td>Exercise</td>
<td>Muscles</td>
<td>Instructions</td>
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</tr>
<tr>
<td>Single leg stretch</td>
<td>Spinal flexors and stabilizers</td>
<td>Lie on your back with legs stretched out. Curl the upper body up and bend one leg towards the chest using arms to support the working leg’s knee. Maintaining upper body flexion, alternate legs. This can also be done with the legs extended utilizing a scissoring motion of the legs. Use strong core muscle engagement throughout the exercise to stabilize the spine and pelvis. To modify, lift your legs higher off the floor.</td>
</tr>
<tr>
<td>Leg Lower</td>
<td>Spinal flexors and stabilizers</td>
<td>Lie on your back with knees bent 90 degrees and feet on the floor. Curl up slightly into spinal flexion with shoulder blades off the ground. Extend and externally rotate the working leg. Lower and raise working leg while maintaining spinal flexion and pressing low back into the floor</td>
</tr>
<tr>
<td>Swimming</td>
<td>Spinal extensors</td>
<td>Lie on stomach and engage abdominals. Raise upper body into spinal extension. Maintain length of the neck with the rest of the spine. Raise legs a few inches off the floor. Pulse with small, alternating arm and leg extensions as if you were swimming, using sniffing breathing technique: 4 quick inhales and 4 quick exhales. To modify, lift only arms or only legs, not both at the same time.</td>
</tr>
<tr>
<td>Spine arch</td>
<td>Spinal extensors</td>
<td>Lie on stomach and engage abdominals. Raise upper body into spinal extension while keeping legs relaxed on floor. Hold arms in second position for thirty seconds, fifth position for thirty seconds, and a V</td>
</tr>
</tbody>
</table>
position for thirty seconds. Relax into the starting position. To modify, barely lift the upper body off of the floor.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Side plank</td>
<td>Spinal lateral flexors</td>
<td>Lie on side with forearm flat on the floor, bottom elbow lined directly under shoulder and legs extended out in long line. Feet can either be staggered for more stability, or stacked for more of a challenge. Engage core and lift hips off the floor, forming a straight line from head to feet. Hold for 30 seconds to 1 minutes. Additional movements can be inserted to make this a dynamic exercise. Hip dips involve lowering the hips to ground and returning to plank position. Arm reach throughs with slight spinal rotation involve the arm starting reaching toward the ceiling and then threading it through the space between side body and floor. Maintain core engagement to protect the spine. For an easier modification, plank with knees on the ground and in alignment with the shoulders. Hip dips and arm reach throughs can be done in this modified position.</td>
</tr>
<tr>
<td>Single leg stretch with rotation</td>
<td>Spinal lateral flexors and spinal rotators</td>
<td>Assume the same movement of the single leg stretch with slight additions. Hold your arms bent and supporting the head (but not pulling on the head/neck). When folding the leg in, attempt to touch the opposite elbow to the folding knee and switch to alternate arm and leg. For a modification, keep knees bent while doing the motion. Or keep knees bent and feet on the ground and do cross lateral crunches to target the spinal rotators and lateral flexors.</td>
</tr>
</tbody>
</table>
## Stretching exercises:

<table>
<thead>
<tr>
<th>Exercise Name</th>
<th>Muscle Group(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child's pose</td>
<td>Spinal extensors</td>
<td>Kneel with sits bones resting on heels and chest resting on thighs. Extend arms over head and hold for up to 1 minute.</td>
</tr>
<tr>
<td>Cobra (Prone press up)</td>
<td>Spinal flexors</td>
<td>Lie on your stomach and press your upper body up using forearms to arch the spine. Keep abdominals engaged and maintain arch in upper back, not lower back. To modify, barely lift the upper body off the ground.</td>
</tr>
<tr>
<td>Spine twist</td>
<td>Spinal rotators</td>
<td>Lie on your back with one leg stretched out and the other bent. Rotate the spine using the opposing hand to guide the bent knee to the floor on the opposite side. Keep the other arm outstretched to help keep both shoulders on the floor.</td>
</tr>
<tr>
<td>Knees to chest</td>
<td>Spinal extensors</td>
<td>Lie on your back and bend both knees toward the chest using arms to hold them.</td>
</tr>
</tbody>
</table>
**Hip and Pelvis**

This section will focus on the hips and pelvic girdle. This region is composed of three major structures of the skeleton. There are two os coxa that join with the sacrum to form the pelvic girdle. The sacrum, as noted previously, is a continuation of the spinal column and is composed of fused vertebrae. The os coxa attach to posterior sides of the sacrum and they have an additional connection to each other which is anterior and forms the pubic symphysis. The pelvis has several bony landmarks, important areas for reference or muscle and ligament attachment. For the purpose of this research, not all will be mentioned. On each os coxa, there is a protuberance called the anterior superior iliac spine (ASIS) which juts out at the forward end of the iliac crest. The ASISs, iliac crests, and pubic symphysis are important to note for pelvic tilt anomalies which will be covered later. Another important bony landmark is the acetabulum, commonly referred to the hip socket, in which the femoral head sits to form the acetabulofemoral joint, the hip joint. The hip joint is a very stable ball and socket joint, with about 70% of the femoral head being in contact with the acetabulum. It has a very large range of motion which can explore circumduction and rotation; this is necessary for dance.

As with any other region of the body, proper alignment is crucial to correctly and healthily execute dance moves. Pelvic tilt is a main idea to keep in
mind when dancing as deviating from neutral can contribute to lower back and hip injuries. There are six main deviations from a neutral pelvis position. Neutral pelvis, in a standing position, is where the left and right ASIS and the pubic symphysis are vertically lined up. It can be helpful to view these areas as a two dimensional triangle. Deviations from neutral stem from these three points shifting. Anterior and posterior pelvic tilt is when the ASIS points are in front of or behind of the pubic symphysis. This is commonly referred to arching the lower back and tucking the pelvis in dance classes. Right and left lateral tilt is when one ASIS point is raised higher than the other one; this can be thought of as raising one side of your pelvis. The last two are right and left rotation which occurs when one ASIS point rotates forward causing the spine to twist slightly. Any of these tilts can be indications of skeletal or muscular imbalances and can also be contributing to chronic hip injuries.

Dancers put significant strain on their hip joints and its surrounding muscles and ligaments. In dance, the hip has the most required range of motion, second only to the shoulder. Thus, there is much emphasis on hip and leg flexibility. In dance moves, such are grande jete or grande battement, dancers are required to achieve movement from standing to a full split in mere seconds. In addition to the intense flexibility requirements, the hip and pelvis are vital weight bearing areas. They sustain large loads of weight from the body trunk, head, and
arms. The compression load on the hip can reach three times body weight during walking and at least five or six times during running or stair climbing. Sustaining the amount of weight and muscular forces makes the hips susceptible to injury. The hip joint is also where the majority of external and internal rotation occurs in dancers. In ballet, there is much emphasis on turn out (external rotation) which causes many dancers to work beyond the muscular and skeletal abilities and force turnout. This can cause severe chronic injuries. Forcing turnout affects the hip joint but often causes dancers to anteriorly tilt their pelvises and torque their knees; this can also cause chronic injuries in the lower back and knee, respectively.

Hamstring muscle strain is a common injury in dancers. This occurs when the hamstring is being excessively and passively stretched and when the leg is working eccentrically to control the leg going into hip flexion. Key examples of these factors are stretching for long periods in the splits and hamstring involvement in a grande battement or any other leg extension. In essence, a muscle strain is when a muscle gets overstretched or torn. In hamstring muscle strains, the pain is usually localized to the general back of leg area. This can be on the belly of the muscle (mid thigh) or on the surrounding tendons (near the hip or knee joints where the muscle inserts). The pain can occur when stretching or engaging (contracting) the injured muscle. Hamstring muscle strains are often a result of
muscle imbalances, muscle weakness, muscle fatigue, and poor warm up. Muscle imbalances and fatigue can result in limited control of the muscle and corresponding limb which is why strains occur as a result of these issues.

Another common injury is snapping hip syndrome, often referred to as dancer’s hip, which involves the snapping, clicking or popping in the hip region. In most cases, the snapping is a result of a muscle or tendon moving over a bony structure of the hip. One such instance is when the iliotibial band (IT band) passes over the greater trochanter. In a standing position, the IT band is posterior to the greater trochanter and in hip flexion the IT band rolls anterior to the greater trochanter. The more common type of snapping hip syndrome is referred to as internal snapping hip syndrome. This is when the iliopsoas, a deep hip and thigh muscle, shifts around the femoral head. This commonly occurs when returning to a neutral body position from flexion or abduction. In dancers, this is seen as returning to fifth position from a front or side extension. Internal snapping hip syndrome is usually due to the loss of external rotation in leg extensions. Strengthening of the hip flexors and abductors is recommended for snapping hip syndrome.

Acetabular labral tears are also very common amongst dancers. The acetabular labrum is a unique structure to the hip joint. It is a cartilage pad that rims the hip joints. It acts as the main cushion between the femoral head and
acetabulum. Acetabular labral tears can occur from repetitive and extreme leg movements, which makes it very common in dancers. These repetitive and extreme movements cause impingement between the femur and acetabulum. This compresses the labrum excessively and can cause tears over long periods of time. Lewis et al found that injury to the anterior portion of the labral is most common due to wear from hip flexion and external rotation. Optimizing strength, flexibility, and correct muscle activation can help to reduce impingements and prevent this injury (Kern-Scott et al., 2011).

As noted earlier, the left and right os coxae connect to the sacrum at the sacroiliac joints (SI joints). These joints are very stable and only a small amount of movement can healthily occur. Sacroiliac joint pain syndrome can result from the amount of stress and force that is exerted on these joints in dancers. Cher et al. notes that sacroiliac joint pain syndrome is considered pain around or in the region of the sacroiliac joints. This can be caused by inflammation, trauma, and mechanical dysfunction. The slight motion that can occur around these joints makes them susceptible to pain when the body is constantly experiencing misalignment. Pain is often over one or both joints and can spread to the buttocks, groin, and thigh. This injury can limit hip mobility and range of motion and can cause weakness in the gluteus medius (hip abductor) and tightness in the piriformis (hip rotator).
The piriformis is a deep outward rotator muscle that is greatly used to obtain and maintain external rotation in dance. Inflammation of the piriformis muscle is termed piriformis syndrome. Adverse irritation can occur in the sciatic nerve as a side effect of piriformis syndrome. Pain is generally localized to the mid-buttocks, where the muscle is located, and is aggravated when the muscle is contracted and stretched. There can also be a dull pain when dancers sit after long periods of dancing. Because of the close nature of hip and back injuries, piriformis syndrome is expected to be often coupled with general back pain or injuries. As noted above, this is also commonly tied with sacroiliac joint pain syndrome.

Because the piriformis can become shortened and tightened from continual external rotation (e.g., from turning out), stretching of the piriformis and other external rotators is important.

Strengthening exercises:

<table>
<thead>
<tr>
<th>Exercise Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Lunges</td>
<td>Hip extensors</td>
<td>Begin standing with legs a hips width apart. Step forward into a lunge. Keep the front knee lined directly above the ankle and lunge until the back knee hovers just above the floor. Return to starting position. Pulses and holds can be added</td>
</tr>
<tr>
<td>Exercise</td>
<td>Muscle Groups</td>
<td>Description</td>
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</tr>
<tr>
<td>Leg lifts</td>
<td>Hip flexors</td>
<td>Lie on the back with the working leg extended and the other leg bent at a 90 degrees. Slowly lift the extended leg until it reaches 90 degrees. Leg can be parallel or rotated out depending on muscle group focus. Elastic bands can be wrapped around both thighs to give added resistance. For modification, the working leg can be bent.</td>
</tr>
<tr>
<td>Psoas wall hold (stork stand)</td>
<td>Hip flexors of the gesture leg and abductors of the supporting leg</td>
<td>Stand with feet hip width apart. Lift and bend the working leg to about hip height. Keeps hips level. Hold in hip flexion for 30 seconds and return to beginning position.</td>
</tr>
<tr>
<td>Floor mountain climbers</td>
<td>Hip flexors</td>
<td>Assume plank position on hands instead of forearms. Keep spine neutral and supported by engaging the abdominals and deep core muscles of the low back. Draw one knee towards the chest and return it to plank position.</td>
</tr>
<tr>
<td>Bridges</td>
<td>Hip extensors</td>
<td>Lie on your back with legs bent at a 90 degree angle and feet on the floor. Engage abdomen.</td>
</tr>
</tbody>
</table>
and slowly lift hips up into bridge. There should be a straight line from knees to hips to chin. Hold the bridge for 30 seconds to one minute. Pulses can also be done by lowering hips back to ground and returning to the bridge. One legged pulses can also be done for higher difficulty. Gluteus muscles can be further targeted with this by walking the feet closer to the body.

<table>
<thead>
<tr>
<th>Donkey Kick</th>
<th>Hip extensors</th>
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</thead>
<tbody>
<tr>
<td>Start on all fours with knees hip width apart, shoulder directly above hands, and core engaged to support neutral spine. Slowly extend the working leg behind you keeping both hips parallel to the ground. Keep lifted leg low and do not arch your back. Return to starting position.</td>
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<thead>
<tr>
<th>Hip extension with resistance</th>
<th>Hip Extensors</th>
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<tbody>
<tr>
<td>Stand with feet hips width apart and elastic band around ankles. Maintaining a straight line in your body, pull your working leg back as far as you can while keeping your leg straight and your spine and pelvis</td>
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</tbody>
</table>
stationary. Slowly return to the starting position. The elastic band can be placed lower on the legs (at ankle level) to increase resistance. Begin with lower resistance bands and work up to using higher resistance bands.

<table>
<thead>
<tr>
<th><strong>Prone arabesque</strong></th>
<th><strong>Hip extensors</strong></th>
<th>Lie on your stomach with legs extended and arm out to the side. Engage your abdominal muscles. Lift upper back and lift arms to fifth position. Raise the working leg about 15-20 degrees off the ground. The position should resemble a low arabesque position. This exercise is good to target spinal and hip extensors. Modification to protect the spine: only lift the legs, not the back.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Side leg raise</strong></td>
<td><strong>Hip abductors</strong></td>
<td>Stand parallel with feet hip width apart and with an elastic band around ankles. Slowly raise the working leg to 45 degrees to the side while maintaining parallel position. Return to starting position. This can also be done lying on your side. Begin with</td>
</tr>
<tr>
<td>Exercise</td>
<td>Muscle Group</td>
<td>Instructions</td>
</tr>
<tr>
<td>-------------------------------</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Side walks</td>
<td>Hip abductors</td>
<td>Start with feet hip width apart in a semi-seated position with an elastic band around the ankles. Keeping legs bent, take a step to the side and back to starting position. Begin with lower resistance bands and work up to using higher resistance bands.</td>
</tr>
<tr>
<td>Cross side leg raise</td>
<td>Hip adductors</td>
<td>Start standing with feet hip width apart and elastic band around ankles. Lift the working leg to the opposite side of the body, crossing over midline. Working leg can be kept parallel or externally rotated. Return to starting position. Begin with lower resistance bands and work up to using higher resistance bands.</td>
</tr>
<tr>
<td>Lying leg lifts</td>
<td>Hip adductors</td>
<td>Lie on the side and support the head with your arm. Cross stationary leg and bend it over the working leg. Stationary leg should be rotated (passe position) with the foot relaxed on the floor in front of the working leg knee. Keep</td>
</tr>
</tbody>
</table>
the working leg parallel and lift it off the ground. Pulse the leg for 30 seconds and return to the starting position.

Clamshell

<table>
<thead>
<tr>
<th>Exercise Name</th>
<th>Muscle Group(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lunge Stretch</td>
<td>Hip flexors</td>
<td>Go to a lunge position. Keep weight on the front foot and make sure to stack the front knee directly over the front ankle. Extend the back leg with weight on back knee or on toes. Rotation of the upper body can occur to target different hip flexors. To do so, place both hands on the same side of the front leg and allow the spine to rotate slightly. To modify, stand up, decrease depth of lunge, and gently tilt pelvis backward.</td>
</tr>
<tr>
<td>Knee to chest</td>
<td>Hip extensors</td>
<td>Lie on your back with your legs extended. Draw one knee into the chest and hold with hands.</td>
</tr>
<tr>
<td>Pose</td>
<td>Muscles</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
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<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pigeon</td>
<td>Hip flexors and extensors</td>
<td>Sit with your right knee bent and your left leg extended behind you. Pull the right heel in toward your left hip, or if your hips are more open, inch your right foot away from you. Make sure your left hip is always pointing down toward the mat. If it begins to open up toward the ceiling, draw your right foot back in toward your body. Body can remain upright or can bend and rest on the front thigh. This stretch is only appropriate for dancers with significant range of motion. Stop if knee pain occurs.</td>
</tr>
<tr>
<td>Sitting hamstring stretch</td>
<td>Hip extensors</td>
<td>Sit with one knee bent and to the side (passe position) and extend the other leg to the front along the floor. Lean forward from the hips until the desired stretch is felt.</td>
</tr>
<tr>
<td>Lying hamstring stretch</td>
<td>Hip extensors</td>
<td>Lie on your back with one leg extended on the floor. Keep the other leg straight and gently draw it closer to the body with the arms. It should resemble a front extension while on the ground. Make sure to keep hips level.</td>
</tr>
<tr>
<td>Lateral lunge</td>
<td>Hip abductors</td>
<td>Stand in parallel. Cross and extend one foot behind the other. Bend the standing knee. For additional stretch, extend the arm and arch the body toward the extended leg. Place the other arm on an extended leg for additional support.</td>
</tr>
<tr>
<td>Piriformis stretch</td>
<td>Hip abductors</td>
<td>Sit on the floor with your legs stretched in front of you. Bend one leg and cross it over the extended leg, place the foot next to the extended knee. Gently hold bent knee and twist the spine in opposition.</td>
</tr>
<tr>
<td>Pretzel stretch</td>
<td>Hip abductors and</td>
<td>Lie on your back. Cross your left foot</td>
</tr>
<tr>
<td>Exercise</td>
<td>Muscles</td>
<td>Instructions</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>extensors over your right quad, and bend your right knee. Hold the back of your right leg and gently pull it toward your chest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side developpe stretch</td>
<td>Hip adductors</td>
<td>Lie on one side with the bottom leg extended and the top leg in a side developpe. Keep both legs externally rotated. Grab the foot or lower leg of the top leg and pull it closer to your body until desired stretch is achieved. This can be done standing on one leg as well.</td>
</tr>
<tr>
<td>Side lunge</td>
<td>Hip adductors</td>
<td>Start in the lunge stretch as described above. Rotate the extended leg, allowing your hips and shoulders to open. Bring both arms in front of your body for support. To ensure safety of the knee (avoiding hyperflexion), keep your bent knee directly aligned with your ankle and do not allow the angle of that joint to be smaller than 90 degrees.</td>
</tr>
<tr>
<td>Frog stretch</td>
<td>Hip internal rotators</td>
<td>Lie on your back with both knees bent and the feet together. Gently use your hand to push the knees closer to the ground</td>
</tr>
<tr>
<td>Knees in stretch</td>
<td>Hip external rotators</td>
<td>Lie on your stomach with knees bent and feet toward the ceiling. Gently use your hand to pull the feet apart and towards the ground. Make sure to keep both knees together.</td>
</tr>
</tbody>
</table>
Leg and Knee

The knee is composed of two joints which combine to make what we consider the knee joint. The first is the tibiofemoral joint. As the name suggests, this joint is formed by the joining of the top of the tibia and the bottom of the femur. The primary functions of this joint are flexion and extension. There is minimal internal and external rotation that can occur only when the knee is flexed. There are very strong ligaments that support the knee in various positions. They act to provide stability when the joint is extended and provide flexibility and mobility when the knee is bent. Two types of paired ligaments are found. The collateral (medial and lateral) ligaments run longitudinal or parallel to the knee and provide stability in the frontal plane. The cruciate (anterior and posterior) ligaments cross over each other internally in the joint and connect the femur and tibia to provide stability in the sagittal plane. The second joint of the knee is the patellofemoral joint which is where the patella (knee cap) and the femur join to create a gliding joint. The primary functional role of the patella is knee extension. The patella increases the leverage the quadriceps tendon can exert on the femur by increasing the angle at which it acts. The patella is attached to the tendon of the quadriceps femoris muscle, which contracts to extend/straighten the knee.
Achieving the perfect aesthetic for dance can put considerable strain on the knees. Even seemingly non-extreme dance moves can subject the knee to chronic injuries. Grande plies are one such movement. Almost every form of dance has a version of a grande plie in it. In ballet, it is often a movement incorporated in the very first warm up exercise at the barre. Jazz and modern also incorporate the grande plie heavily in warm up and choreography. The reason this ubiquitous dance move is potentially dangerous to the body is because of the extreme flexion it requires of the knee while weight-bearing, usually with the added strain of rotation. Grande plies have been known to put significant strain on the meniscus (cartilaginous pads in the knee joint for shock absorption and stability), posterior cruciate ligament (PCL) and the patellofemoral joint. Ample knee extensor strength and control is needed to safely perform a grande plie.

As with the hips, forcing turnout to maintain the “perfect” dance aesthetic can severely and chronically damage the knees and lower legs. It is easier and more common to force turn out from the knee joint than the hip joint. This is easy to achieve when planting the feet on the floor to desired amount of rotation when the knees are bent and then extending the knees. This is possible because of the small amount of internal and external rotation available in slight knee flexion. This creates significant torsion and stress on both the tibiofemoral and patellofemoral joints when the knees are straightened. The primary source of turnout should be
focused from the hip joint and young dancers should be taught to enter into a position with extended legs, to avoid the possibility of forced turn out.

Hyperextension of the knee is also a prevalent injury source. Most people would say that a dancer with hyperextension in the knees is able to achieve a more aesthetic look, specifically with ballet dancers. However, hyperextension can be dangerous and should be controlled to prevent injuries. To correct hyperextension, dancers must limit the degree of hyperextension that they will let occur in standing positions and during movement. It is important to be cognizant of proper alignment, with the knees directly above the ankles. Focusing on contracting the hip flexors (quadriceps) and hip extensors (hamstrings) will help support proper alignment. For dancers with natural hyperextension, correct alignment will feel like standing and dancing in constant knee flexion so additional strengthening of hamstrings may be needed to correct this.

According to Laprade et al. the most common knee injuries in sports involve the medial cruciate ligament (MCL). There is data that shows this injury has a higher prevalence in male athletes and dancers. Sprain or tears can occur to the MCL due to forces applied to the outside or lateral side of the knee. These forces can come from standing in fifth position or improper ankle and knee alignment. The severity of a MCL injury is based on the degree of stretch or tear that has been done to the muscle. Symptoms of this injury include a popping noise
upon injury, pain and tenderness along the inside of the knee (the location of the MCL), general instability of the knee, and locking or catching of the knee joint.

The anterior cruciate ligament (ACL) is also one of the most torn ligaments in the human body. This ligament can be injured when forces are applied to the knee when the femur is rotated inwards and the tibia is rotated outwards. Dancers can be highly susceptible to this injury; forced turn out usually results in an inwardly rotated femur with an outwardly rotated tibia. Dancers often get this injury when landing a one-legged jump, or sauté, and landing in the above described position or when the knee is in hyperextension. Fatigue can also contribute to this injury as loss of external rotation from the hip is often a result of fatigue. Often dancers will describe the instant of the injury as a pop and will not be able to continue dancing. There may also be perceived instability of the knee. It can often be described as the knee slipping out of place and the tibia and femur shift with the compromised ligament.

The menisci are c-shaped cartilaginous pads that sit between the bottom of the femur and top of the tibia. They provide the joint with cushion and shock absorption and aid in smooth joint coordination. When the tibiofemoral joint malfunctions, the surfaces of the femur and the tibia can grind on the meniscus and cause injury to the menisci. Due to the actions and other factors that contribute to this injury, the medial menisci are more often injured compared to the lateral
menisci. Dancers are subject to meniscus injuries because of repetitive work in external rotation, forcing turn out, and floor work. Weight bearing while twisting the joint has been shown as a cause of this injury and those combined mechanisms are often seen in modern and jazz floor work (e.g., a “hurdler stretch position”).

The following signs and symptoms may follow injury to the meniscus: swelling or stiffness, pain when twisting or rotating the knee, difficulty with full extension and flexion, locked knee feeling, and instability. Grande plies can be particularly difficult and painful to execute with a meniscus injury. There can also be a popping sound at the time of injury.

Patellofemoral pain syndrome, also known as anterior knee pain, is pain at the front of the knee, around the patella (kneecap). Sometimes called "runner's knee," it's more common in people who participate in activities that involve running and jumping. The knee pain often increases when you run, walk up or down stairs, sit for long periods, or squat. Patellofemoral pain syndrome does not have a known or direct cause. It can be associated with overuse or muscular imbalances surrounding the knee. In some cases, there is visible injury to the cartilage on the underside of the patella. Some conditions have been thought to contribute to patellofemoral pain syndrome such as knee hyperextension, weak knee extensors, or an increased Q angle or knocked kneed alignment.

Strengthening exercises:
<table>
<thead>
<tr>
<th>Exercise name</th>
<th>Muscle group(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamstring curls</td>
<td>Knee flexors</td>
<td>Start with your weight on one leg and arms supported with a wall or chair. Lift the heel of your free foot towards your buttocks and return to the starting position. Ankle weights can be added to the ankle or elastic band can be tied around the working foot and anchored by the supporting foot.</td>
</tr>
<tr>
<td>Bridges</td>
<td>Knee flexors</td>
<td>Lie on your back with legs bent at a 90 degree angle and feet on the floor. Engage abdomen and slowly lift hips up into bridge. There should be a straight line from knees to hips to chin. Hold the bridge for 30 seconds to one minute. Pulses can also be done by lowering hips back to ground and returning to the bridge. One legged pulses can also be done for higher difficulty.</td>
</tr>
<tr>
<td>Knee extensions</td>
<td>Knee extensors</td>
<td>Sit in a chair with legs bent at a 90 degree angle. Wrap an elastic band around both ankles. Extend one knee to a straight (not hyperextended) position while the elastic band is anchored with the supporting leg. Return to starting positions.</td>
</tr>
<tr>
<td>Step ups</td>
<td>Knee extensors and hip extensors</td>
<td>Place one foot on a step bench, platform, or the lowest step on a staircase. Keeping your pelvis level, bend your knee and slowly lower the opposite foot to the floor. Lightly touch your toe to the floor, then rise back up.</td>
</tr>
</tbody>
</table>
It is important to note that many muscles grouped as knee flexors are the same muscles grouped as hip extensors. Consequently, one muscle identified as a knee extensor is also a hip flexor. Thus, there is ample crossover between strengthening exercises for joint specific injury prevention. The main difference between the targeted exercises is which joint is acting as the focal point. In most of the hip strengthening exercises, the knee joint can remain extended to allow greater focus on the hip joint. In most of the knee strengthening exercises, the hip joint can remain stationary to focus on the knee joint.

Stretching Exercises

<table>
<thead>
<tr>
<th>Exercise name</th>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamstring stretch</td>
<td>Knee flexors</td>
<td>Stand on one leg with the other leg lifted and supported on a higher surface (a table or chair). Keep hips level and fold over the lifted leg to reach the desired stretch. See Hip and Pelvis exercises for additional modifications.</td>
</tr>
<tr>
<td>Quad stretch</td>
<td>Knee extensors</td>
<td>Stand with feet hips width apart and bend one leg towards buttocks. Grab the foot with the same side hand and gently pull toward buttocks. Keep the hips level and extend the lifted leg back slightly</td>
</tr>
</tbody>
</table>
Foot and Ankle

The ankle and foot region consists of the tibia and fibula and the 27 bones that compose the foot. Because of the high number of bones, there are many joints to consider when looking at movement of the foot and ankle. The foot is composed of 7 tarsals, 5 metatarsals, and 14 phalanges. The rear foot is composed of the talus and calcaneus (heel), the mid foot includes the navicular, cuboid, and the three cuneiforms, and the forefoot includes the metatarsals and phalanges (toes). The tibia and fibula are joined at the tibiofibular joints and are supported by four strong ligaments and a ligamentous sheet. This joint is vital for stability of the ankle joint. The ankle joint is termed the talocrural joint and is composed of the tibia, fibula and talus; dorsiflexion and plantar flexion occur at this joint. The talus also forms a joint with the calcaneus called the subtalar joint and another joint with the navicular which is part of the transverse tarsal joints. These joints allow the foot to invert, evert, abduct, adduct, plantar flex (slight), and dorsiflex (slight). The combined ranges of motion of these two joints allow the feet to pronate and supinate. Additional joints are located between the rest of the foot bones but will not be examined in depth for this research.
Arches are a very specialized structure of the foot. The foot bones are not arranged in a single plane but are arched. The foot has three arches: two longitudinal (medial and lateral) arches and one anterior transverse arch. They are formed by the tarsal and metatarsal bones, and supported by ligaments and tendons in the foot. Their shape allows them to act in the same way as a spring, bearing the weight of the body and absorbing the shock produced during locomotion. The flexibility conferred to the foot by these arches facilitates functions such as walking and running. The medial longitudinal arch is designed to allow the foot to trespass uneven surfaces and absorb shock while the lateral longitudinal arch is for stability. The transverse arch runs perpendicular to its fellow arches and aids in support and shock absorption. Another key structure is the plantar fascia which is a band of connective tissue that runs on the plantar or bottom surface of the foot. It acts as the main support for the medial longitudinal arch and, therefore, plays a key role in stabilizing the foot in action that requires pushing off the ground to propel such as jumping or running.

The foot and ankle region absorb a considerable amount of stress in dancers. If not from jumping, turning, and weight bearing, the feet are almost always engaged in a distinct pointed or flexed position. It is widely accepted that this region of the body sustains more injuries than any other due to the incredible amounts of compression forces that act on it.
Ankle sprains are one of the most common ankle injuries. Studies have shown their prevalence as up to 50% of dancers experiencing ankle sprains. As noted before a sprain is the stretching or tearing of ligaments, in this case of the ankle. Ankle sprains in dancers tend to involve injury to multiple ligaments. This is because the more common foot positions that make the joint vulnerable to sprain are inversion coupled with plantar flexion. This could occur if a dancer is landing from a jump and not maintaining proper alignment of the foot (sickling the foot). The ankle joint is more subject to injury in a plantar flexion (releve and pointed foot). In this position, specific supporting ligaments are stretched to a vertical orientation which make it more susceptible to injury if the ankle gets added tensions by inversion. Due to this, sprains are more common on the lateral or outside of the ankle than the medial side. Upon injury, dancers may feel immediate pain along with a tearing or popping sensation in the ankle area. It is likely that there will be swelling along the outside of the ankle after the injury is sustained. There can also be pain when moving the ankle into a plantar flexed or inverted position. Depending on the severity of the sprain, ankle joint instability may also be a side effect.

Plantar fasciitis is a common foot injury in dancers. This involves the tearing and inflammation, or in severe cases the rupturing, of the plantar fascia. The plantar fascia is a thick sheet of tissue that connects the calcaneus (heel bone)
to the toes. It also plays a vital role in supporting the longitudinal arches of the feet. This injury is often associated with repetitive jumping which is why it has such a high prevalence in dancers. Symptoms of plantar fasciitis are usually pain, tenderness, and stiffness at the base of the heel. This can often result in morning stiffness with the description of “feet being stiff as a board”.

Achilles tendinopathy or tendonitis, is inflammation or injury to the achilles tendon. The Achilles tendon is the largest tendon in the body and it is built to withstand considerable amounts of force. It is a band of tissue that connects the calf muscles to the calcaneus. Achilles tendinopathy is usually the result of overusing the tendon. The prevalence of this injury in dancers is due to releves, jumps, turns, and pointe work. This injury is characterized by pain, tenderness, and swelling of the Achilles tendon, specifically a couple inches about its attachment point to the heel. There can also be morning stiffness associated with this as well as general tenderness and stiffness throughout the day. Actions such as releves that involve engaging the tendon or plies that stretch the tendon can cause pain.

Tibial stress syndrome, or more commonly known as shin splints is pain in the front of the shins (anterior tibia). This is characterized by activity-related pain and tenderness of the shin. This injury is typically caused by tearing or damage to the tibial membrane. Symptoms can be pain, tenderness, or aching of the shin. The
muscles typically involved in shin splints are the ankle inverters, which resist falling into a pronated position. This is one reason why dancers are susceptible to shin splints. Pronation of the feet is a very common side effect of forced turn out. Additionally dancers can be trained to pronate non-weight bearing feet for aesthetic reasons. It is commonly referred to as “winging” the feet.

**Strengthening exercises:**

<table>
<thead>
<tr>
<th>Exercise name</th>
<th>Muscle group(s)</th>
<th>Exercise description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calf raises</td>
<td>Plantar flexors</td>
<td>Stand on one foot with the other foot touching the ankle (coupe). Slowly rise onto releve, pause, and lower to the starting position. This can also be done with both feet on ground for modification or with leg extended away from body for added difficulty.</td>
</tr>
<tr>
<td>Calf raises with tennis ball</td>
<td>Plantar flexors</td>
<td>Place a tennis ball between your ankles on the bony protrusion on the inside of your ankles. Without releasing the ball, rise to releve, pause, and lower slowly. The tennis ball help to engage your inner leg and lower leg muscles to help with ankle stability.</td>
</tr>
<tr>
<td>Plantar flexion with resistance</td>
<td>Plantar flexors</td>
<td>In a seated position with legs in front of you, loop</td>
</tr>
<tr>
<td>Exercise</td>
<td>Muscles</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
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</tr>
<tr>
<td>an elastic band around the bottom of your foot and anchor it with your two hands. Begin with your foot flexed and slowly point your foot. Slowly return back to the starting position.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heel walks</td>
<td>Dorsiflexors</td>
<td>Stand with slightly bent knees and feet a hips width apart. Shift your weight to your heels, allow the toes and arches to lift from floor. Walk around on your heels.</td>
</tr>
<tr>
<td>Dorsiflexion with resistance</td>
<td>Dorsiflexors</td>
<td>Sit with one leg extended and the other leg bent. Arms can be used to hold bent leg in place. Loop an elastic band around the bottom of the extended foot and over the top of the bent foot. Bend foot enough to make sure the band is taut. The bent foot will have to be partially flexed to secure the band. Then bring the bent foot to full dorsiflexion, pause, and return to partial dorsiflexion.</td>
</tr>
<tr>
<td>ABCs</td>
<td>Plantar flexors, dorsiflexors, inverters, and eveters</td>
<td>Sit with your legs and feet extended. Trace out the letters A-Z with your feet.</td>
</tr>
<tr>
<td>Doming</td>
<td>Arches</td>
<td>Sit with your knees bent</td>
</tr>
</tbody>
</table>
and feet planted on the floor. Keep your heel stationary and slide your toes along the floor toward your heel. Be careful not to scrunch your toes.

Stretching Exercises:

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Achilles and Calf Stretch</td>
<td>Plantar flexors</td>
<td>In a standing position, keep both legs parallel and place one leg in a small lunge with the knee straight. Make sure to keep both heels as close to the floor as possible. To deepen the stretch, gently and slightly bend the back knee while keeping the heel on the floor.</td>
</tr>
<tr>
<td>Standing shin stretch</td>
<td>Doriflexors</td>
<td>Stand with knees slightly bent and one foot pointed so that the top of the foot and toes rest on the floor. Keeping your toe firmly on the ground, pull the stretching leg forward so you feel a stretch from the top of your stretching foot through your shins. Make sure not to invert or evert your foot.</td>
</tr>
</tbody>
</table>
Plantar Fascia Toe Stretch

This can be done seated or standing against a wall for a deeper stretch. When seated, cross the foot across the knee and grab the toes with the hand. Pull the toes into extension. For a deep stretch, stand facing a wall and lean the toes against the wall with the heel on the ground and the foot in slight dorsiflexion.

Conclusion

This thesis acts as a guide to young and collegiate dancers who are interested in injury prevention and want to take initiative steps. A myriad of issues contribute to the high injury prevalence found in dancers. In addition to the ones outlined in this thesis, improper technique, muscular imbalances, and overuse (e.g., “pushing through pain”), there are many others to consider and can be outside the realm of an individual dancer’s control. Examples of these are flooring, weather, training, and nutrition. Over all, this thesis seeks to contribute to injury prevention through supplementary muscular conditioning, while not trying to dissuade dancers from seeking professional help when needed.
Appendices

The following pictures show the exercises that were identified in the tables for each body region. Please see descriptions of how to perform and modify the exercises in each respective table. Dancers with current or past injuries should seek guidance from their physician for clearance to perform any of these exercises.

**Shoulder and Scapula Strength Exercises**

Front Arm Raise:

Lateral Arm Raise:

Serratus Push Up:
Standing Row (standing and sitting):

Internal Rotation:
External Rotation:

Shoulder and Scapula Flexibility Exercises

Across the Chest:
Wall Stretch:

Chest Expansion:

Pendulum:
Spine Strength Exercises

Ab Warm Up:
Single Leg Stretch:
Leg Lowers:

Swimming:
Spine Arches:

Side Plank with Rotation:

Single Leg Stretch with Rotation:
Spine Flexibility Exercises

Child’s Pose:

Cobra:
Spine Twist:

Knees to Chest:
Hip and Pelvis Strength Exercises

Lunges:

Leg Lifts:
Psoas Wall Hold (Stork Pose):
Floor Mountain Climbers:

Bridges:

Donkey Kicks:
Hip Extension with Resistance:

Prone Arabesque:
Side Leg Raise:

Side Walks:

Cross Side Leg Raise:
Lying Leg Lifts:

Clamshell:
Hip Flexibility Exercises

Lunge Stretch:

Knee to Chest:

Pigeon:

Sitting/Lying Hamstring:
Lateral Lunge Stretch:

Side Develope Stretch:

Frog Stretch:

Piriformis Stretch:
Pretzel:

Side Lunge:

Knees in Stretch
Leg and Knee Strength Exercises

Hamstring Curl:

Knee Extensions:
Step Ups:

Leg and Knee Flexibility Exercises

Hamstring Stretch (see also variations in Hip and Pelvis section):
Quadriceps Stretch:

Foot and Ankle Strength Exercises

Calf raises (single and double leg):

Calf Raises with Ball:
Plantar Flexion with Resistance:

Dorsiflexion with Resistance:
Heel Walks:

Doming:

Foot and Ankle Flexibility Exercises

Achilles and Calf Stretch:
Standing Shin Stretch:

Plantar Fascia Toe Stretch (sitting and against wall)
References


