

Lumbosacral Injuries in Classical Ballet Dancers:
A Review of the Literature

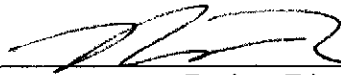
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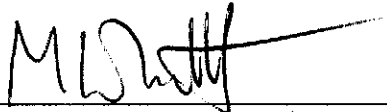
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INTRODUCTION

Ballet has been described as one of the most physically demanding activities, second only to football in the frequency, duration and intensity of practice and performance schedules.^{1, 2} The conditions under which a ballet dancer works and the difficult nature of mastering ballet technique, increase the likelihood that a dancer may acquire an injury. Research shows that sixty-three percent of ballet students have had an injury at some point during the time they were actively practicing ballet.³ The most common sites of injury for a classical ballet dancer are the ankle (22.2%), with the spine following close behind (17.6 %), and the foot (14.8%), knee (14.5%), hip (14.2%) and shin (5.4%) following the spine.⁴ Back injuries affect dancers of all ages and all skill levels. In many cases, the injury is severe enough to prevent a dancer from performing or practicing for weeks, months, or the rest of the ballet season. The Bureau of Labor Statistics, a division of the U.S. Department of Labor, reports that in March 1997, 791 dancers were surveyed. Of the 791 dancers, 90% had experienced an injury and 50% were injured badly enough to miss multiple workdays.⁵

Lumbosacral injuries may be a result of a single twist or fall, but in most cases they are due to repetitive microtrauma.⁶ These injuries affect not only the back, but other parts of the body such as the foot, ankle and knee.⁷

The literature reviewed in this paper focuses on what researchers believe to be the leading causes of low back pain in classical ballet dancers. A large section of the review concentrates on hyperlordosis, the abnormal increase in the forward curvature of the spine, which research has shown to be the most probable cause for lumbosacral injuries

in ballet dancers. The remainder of the paper discusses the contribution of turnout, common conditions and disorders, the impact of gender, aging, body type and extrinsic factors to low back pain.

Despite the fact that injuries are common among professional dancers, many of them will suffer through their injuries without seeking treatment, because it may have a negative impact on their career. The Bureau of Labor Statistics reports that of the 90% of dancers who were injured, 40% did not miss any workdays.⁵ Because dance injuries are consistently under-reported, partially due to fear of dancers losing their jobs, dance injuries and rehabilitation have been difficult fields to study. As a result of the small amount of scientific research in this area, many of the factors discussed in this literature review are based on the published theories of healthcare professionals.

HYPERLORDOSIS

The lumbar spine has a concave curve anteriorly, which is a secondary curve of the spine that develops as a result of assuming an erect, bipedal stance.⁷ The preservation of this curve is critical for proper biomechanics, as it helps to maintain the flexibility and strength of the vertebral column.⁷ Classical ballet dancers are instructed from an early age to maintain their lumbar spine in a flat position by using a posterior pelvic tilt. There are many positions in ballet that require the dancer to achieve excessive extension of the lumbar spine (e.g. an arabesque; Fig 1) which causes increased pressure on the lower back.⁸ If the dancer does not maintain the posterior pelvic tilt while holding these positions, hyperlordosis in the lumbar region may develop and cause low back pain.^{6, 7, 8, 9, 10, 11, 12, 13} When the normal lordotic curve of the lumbar spine is exaggerated stresses are placed on the vertebrae and the intervertebral discs.¹⁰ This has been thought to be due to weak abdominals, tight lumbodorsal fascia, and attempting to turnout at the hip by

increasing lumbar lordosis.⁶ The internal and external obliques, the transverse abdominis and the rectus abdominis are responsible for lowering the ribs, elevating the anterior pelvic rim, flexing, twisting and rotating the trunk. The contraction of these muscles during respiration may elevate intra-abdominal pressure and assist the erector spinae and vertebral column in supporting the erect body. The weakness of these muscles may affect the lower back and increase the risk of lower back injury.⁷

The iliopsoas muscle is an important stabilizer of the lumbar spine and pelvis, and a major determinant for posture and movement.¹⁴ Hypertonicity and contraction of the iliopsoas and the peripheral abdominal muscles is believed to be associated with hyperlordosis.¹¹ Tightness in the lumbodorsal fascia, hamstrings and anterior hip structures may also cause the dancer to increase the degree of lumbar lordosis while dancing.

The arabesque is a well-known and commonly used pose in classical ballet and is considered most aesthetically pleasing by instructors when the leg is extended behind the dancer at an angle greater than 90°. Unfortunately, many dancers are unable to extend their leg and/or maintain external rotation at this height due to tightness in anterior structures, such as the iliofemoral ligament or the hip flexors. To hide the limitations of their bodies, many dancers will compensate by hip hiking or by tilting their pelvis anteriorly in order to achieve the required position. It has been hypothesized that the smallest amount of variation in the leg while executing an arabesque requires compensation from the spine and/or hip joint while executing the arabesque.⁸ The arabesque may also cause hyperlordosis if the dancer's trunk is too vertical. Instead of holding the back completely upright, the dancer should move his or her upper body forward to minimize this lordosis, as the leg is raised posteriorly.⁸ Out of 100 cases of

low back syndromes observed in ballet dancers, Gelabert found that approximately 45% are related to those who lift their hip and 25% to those who forcefully try to raise their leg above 90° while keeping their back too straight in an arabesque.

The cervical, thoracic and lumbar regions of the spine have different capacities for flexibility. The thoracic spine is less flexible than the cervical spine because its facet joints and posterior spinous processes are oriented more vertically. Limited thoracic motion may make the arabesque a difficult position to achieve. To compensate, lumbar lordosis may increase, resulting in increased stress and risk of injury.¹⁵

Hyperlordosis of a dancer's spine occurs in static positions, but is also dynamic in nature and is frequently held while turning, jumping or lifting a partner. As a result, the dancer must learn to control the degree to which they extend the spine while dancing. The extension of the spine can be controlled and the lumbar lordosis reduced, by performing a posterior pelvic tilt.¹⁵ An average individual can learn to perform a posterior pelvic tilt while standing in a stationary position. Dancers have greater difficulty performing the posterior tilt because they must rely primarily on the abdominal and paraspinal muscles because the other muscles (e.g. the gluteals, hamstrings, hip extensors, etc.) are actively involved in dancing.⁶ If this posture is not maintained, low back pain will all too often plague the dancer. Poor spinal posture and technique can contribute to pelvic and lower extremity malalignment and injury.⁸

Genu recurvatum may contribute to postural changes. In ballet, many find it fashionable to hyperextend the knees to an angle of approximately 10°.⁹ This may cause a weight shift posteriorly over the heels instead of distributing it throughout the entire foot. This alteration may cause a dancer to assume an anterior pelvic tilt, increasing hyperlordosis.

The landings from the many jumps in ballet are believed to increase stress on the lower back because the proper technique for landing is contrary to proper biomechanics. The combination of poor technique, hyperlordotic back and/or hyperextension of the knees may all be contributing factors to low back pain.

Gracovetsky and colleagues (1988) studied the relationship between lumbar lordosis, angle of forward flexion of the trunk and compressive stress within the spine. Using a mathematical model, values were compared to values of spinal geometry and muscular activity during forward bending using opto-electronic motion analysis and an EMG data collection system. The degree of lordosis was measured and the lumbosacral angle and the angle of forward flexion of the spine with respect to the pelvis were calculated. To measure the angle of forward bending and lordosis, each subject was asked to bend forward and assume the most comfortable posture. The subject was then asked to remain in this position but to first increase and then decrease the lordosis. Measurements were then compared to the mathematical model.

The results revealed that the control of lordosis has a direct impact on the amount of compressive stress on the spine. This means that the pelvic tilt is beneficial because it allows one to adjust lordosis and reduce compressive stress on the spine. This is significant for a classical ballet dancer because if they do not control the degree of lordosis in their lumbar spine, excessive compressive stress will be put on the vertebral column, predisposing the dancer to low back pain.

Kujala et al. compared maximal lumbar flexion and extension in ballet dancers (mean age 11.8), athletes (gymnasts and figure skaters with mean age 11.7) and sedentary controls (mean age 11.9) in a three year longitudinal study with training in an attempt to increase flexibility in this region. At the beginning and the end of the study the subjects

were measured for lumbar sagittal mobility between T12 and S2 by obtaining the traces of the back surface curvature in maximal flexion and maximal extension.¹²

The results showed that ballet dancers, athletes and non-athletic controls did not have a significant difference with regard to maximal lumbar flexion or extension, either at the baseline or at the end of the three years. This means that in most cases, children and adolescents cannot increase their maximal lumbar flexion or extension by training. An attempt to exceed the maximum in either direction may cause excessive loading on specific anatomic structures of the low back and cause low back pain.¹²

Though most of the literature reviewed cited hyperlordosis as a major contributor to low back pain, more recent research in this area has shown that maintaining a posterior pelvic tilt may actually increase compressive stress on the spine. In a study done in the department of physical therapy at the University of Pittsburgh Medical Center researchers examined the effects of two different alignments of the pelvis and three different loads on electromyographic activity of the erector spinae and oblique abdominal muscles during squat lifting and lowering.¹⁶ Subjects were asked to lift and lower the loads using an anterior pelvic tilt and then using a posterior pelvic tilt. The electromyography showed greater activity of the erector spinae muscles while lifting and lowering using an anterior pelvic tilt, as opposed to a posterior pelvic tilt. This finding suggests that the greater trunk muscle activity occurring with the anterior pelvic tilt position may ensure optimal muscular support for the spine while handling loads, reducing the risk for low back injuries.¹⁶

TURNOUT

Turnout is defined as the external rotation of the ballet dancer's legs and feet¹⁷, and is an important skill for the ballet dancer to possess, as the degree of turnout which is

considered aesthetically pleasing is 180° (Fig 2 and 3). The 180° turnout is achieved by externally rotating the hips 70° bilaterally, externally rotating the tibiae 5° bilaterally and externally rotating the feet 15° bilaterally.¹⁸ Every movement in ballet passes through one of the five positions which require turnout, so it is an essential component of ballet. Ryan and Stevens reported that one of the most serious training errors may be forcing the feet to maintain a 180° angle when the hips cannot rotate that far. In order to achieve maximal turnout many dancers will increase lumbar lordosis by anterior pelvic tilt because it allows increased external rotation of the hip. This is possible as the acetabular shelf is much deeper posterosuperiorly than posteroinferiorly.¹⁸ Forceful compensation for reduced external hip rotation leads to musculoskeletal injuries in dancers.^{3, 19, 20} A tight psoas can restrict external rotation of the fixed lower extremity, causing the dancer to force turnout at the ankle. The forced turnout causes pronation of the feet, which produces internal femoral rotation and an increase in lordosis and further psoas shortening.⁷

Coplan investigated the relationship between a dancer's turnout and self-reported injury. He assessed the difference between the functional turnout and the compensated turnout of thirty college level ballet dancers. Functional turnout was defined as the position the dancer assumed while they were in a stationary position. Compensated turnout was the difference between the range of passive hip external rotation and the functional turnout. Subjects were given a questionnaire and asked to report any injuries they had during their dance career. The group was then split into a non-injured group and an injured group.

Examiners measured the amount of motion for passive hip internal rotation, external rotation and turnout in first position. The functional turnout angle, the angle of

turnout a dancer assumed in first position, was then measured by asking the dancer to assume first position and then tracing the feet on a piece of paper. Finally, the compensated turnout was found by calculating the difference between the functional turnout and the passive turnout.

Coplan discovered that twenty-one out of thirty students had functional turnout that exceeded their passive hip external rotation range of motion. Dancers with a self-reported history of injury had a greater compensated turnout compared to those in the non-injured group and therefore the injured group had a greater risk of injury to the lower back or lower extremities ($p < 0.006$).

COMMON CONDITIONS/DISORDERS

The stresses and strains of repetitive dance training may lead to microscopic injury. If the rate of occurrence of the microtrauma exceeds that of tissue healing, then macroscopic overuse injury will occur.^{10, 21} Muscle imbalances can develop because of ballet's repetitive nature which may cause low back pain. In a study by Koutedakis, Frischknecht and Murthy, it was found that ballet dancers have strong quadriceps, but do little or no strength training involving the hamstrings outside of dance or within dance itself. The quadriceps and the hamstrings are crucial in the development of a proper lumbo-pelvic rhythm and an optimal distribution of forces acting on the spine.²² Weak hamstrings in relation to strong quadriceps can cause low back problems by putting stress on the lower spine and causing hyperlordosis. There is speculation that multiplanar gliding movements occur at both the pubic and sacroiliac joints, and the maintenance of this motion is essential for proper biomechanics of the pelvis and the lower spine. Muscular imbalances at the sacroiliac joints may be a major source of lower back pain.⁷

Certain movements in ballet predispose the sciatic nerve to trauma and also increase the chances of acquiring sciatica due to a discogenic condition. External hip rotation is a common movement in classical ballet and one of the muscles responsible for this movement is the piriformis. The piriformis passes through the sciatic notch along with the sciatic nerve and as a result, contracture or hypertrophy of this muscle may cause the sciatic nerve to become entrapped resulting in pain.¹¹

A foramen between the pedicles, disc and facet joint of two adjacent vertebrae allows passage of the nerve root from the spine, and injury to any of these structures can result in nerve root irritation.¹⁰ Spondylolysis is a common cause of low back pain in ballet dancers, resulting from repetitive microtrauma producing stress fracture(s) to the posterior elements of the vertebrae, particularly the pars interarticularis. Hamilton reports an incidence of spondylolysis in fifteen to twenty percent of dancers with back symptoms.²³ The anatomy and biomechanics of the lumbar spine serve to selectively concentrate shear stress at the pars interarticularis²⁴ and repetitive extension or flexion and extension combined with rotation, causes excessive anterior shear forces on this structure.²⁵ The pars interarticularis is the narrowest section of the vertebrae in the lumbar region so it provides the origin for most neural arch stress fractures.²⁶

Dancers with spondylolysis experience pain that increases with motion, causing aching or cramping during hyperextension of the back (e.g. the arabesque position) and forward bending. This condition may occur in dancers whose lumbar spines are stiff and tight, resulting in a great muscular pull on the vertebrae. This is especially a concern for dancers who lift the back leg too high in an arabesque or keep their back too vertical in this position.⁸ Female dancers are more likely to develop spondylolysis because they begin their dance training at an earlier age. When training begins before the epiphyseal

union, the fibrous connective tissue is more vulnerable to trauma than if the bone was fully developed.⁷

If spondylolysis is not treated it may lead to spondylolisthesis, the forward movement of one vertebra over an adjacent vertebra.¹¹ The progression of spondylolysis to spondylolisthesis occurs at a heightened rate in the nine to fifteen year-old age group because of the growth spurt, but is rare after the age of eighteen.²⁷ Spondylolisthesis is believed to have a hereditary predisposition.²⁸ Pain associated with spondylolisthesis is a result of the protective force of the muscle spasm against the slippage of the vertebra and pressure on the nerve roots by the disc of the displaced vertebra.⁸

Vertebral body fractures may be caused by microtrauma which causes damage to the anterior portions of the vertebral endplates. Those fractures result from the repetitive flexion in the lower back and may cause the development of Schmorl's node, an upward and downward protrusion of a spinal disc's soft tissue into the bony tissue of the adjacent vertebrae. Vertebral body fractures may also contribute to Scheuermann's disease, a skeletal disease causing increased kyphosis, the abnormal increase in the outward curvature of the thoracic spine. In professional dancers, tight lumbodorsal fascia causes forward flexion to occur in the thoracic spine instead of the lower lumbar spine increasing the incidence of Scheuermann's disease. Lumbar hyperlordosis and thoracic hyperkyphosis also contribute to the frequency of Scheuermann's disease.¹¹ Stress fractures of the vertebra(e) may be the result of undue stress of the muscular pull on vertebrae in dancers whose bodies are unfit for the demands of technique and forceful attempts to raise the leg too high behind the body or with the back too straight.⁸

Discogenic back pain may cause back stiffness, abnormal gait or loss of hamstring flexibility. Dancers may be tested for adolescent disc disease using magnetic

resonance imaging (MRI) and the results of this diagnostic imaging may demonstrate a genetic predisposition to this condition. A clover-shaped spinal canal and short pedicle both create a narrowed vertebral canal and are anatomical features of the dancer that put them at higher risk for developing discogenic back pain.¹¹

Inflammation of a disc, disc protrusion or frank disc herniation may also cause discogenic back pain. Forward flexion of the lumbar spine results in the increase in load on the lumbar discs compared to a neutral, upright stance. This is especially true for male dancers who may lift their partners with their arms outstretched in front of them.²⁹

While the hip is in hyperextension, there is high pressure in the intervertebral discs produced by the rotary force on the disc, which can cause microtears in the annulus of the disc. Once this occurs and the body attempts to repair the damage, scar tissue is produced. Scar tissue in this area produces a narrowing of the intervertebral space and looseness of the ligaments, more specifically the anterior and posterior longitudinal ligaments. Looseness in these ligaments leads to instability between the vertebral bodies. Wear and tear caused by many years of dancing may cause an avulsion of the nucleus, causing pressure to be put on nearby nerve roots which may result in back pain.⁸

Dancers with and without stress fractures have been compared with regard to menstrual status, menstrual history, oral contraceptive use, calcium intake and the number of hours a day training. Data were collected on 54 females, included the style and dance technique used, the floor surface, season length, number of performances in the season, tour length, vacation time and the size of the company. The dancers were asked to record their intake of calcium rich foods and were also asked to fill out a questionnaire with regards to age, height, weight, dance training history, age of menarche, menstrual history, oral contraceptive use and stress fracture history.³⁰

Seven percent of the female dancers studied had stress fractures in the spine. The results suggest that a dancer who had been amenorrheic for greater than six months had approximately a 93% greater chance of obtaining a stress fracture. It was found that the P value between dancers in the injured group and those in the non-injured group was < 0.001. The longer the duration of the amenorrhea (> 6 months) the greater chance the dancer had of acquiring a stress fracture. This finding is also supported by Warren et al., who showed that dancers who experienced amenorrhea for more than six months and practiced for more than five hours a day had a greater chance of acquiring a stress fracture than those who practiced for less than five hours and did not experience amenorrhea for more than six months.³¹

The average professional ballet dancer is twenty-three years old, is about 152 cm to 168 cm (5' to 5 1/2') in height, weighs 49 kg (107 lb) with 13-16% body fat.³ The most sought-after look by ballet companies includes long, lean limbs with a short torso. This physique is not ideal from a biomechanical stand point because the long limbs act as levers on the back, exerting a force which is not balanced by the abdominal muscles, especially if they are weak. Many dancers are prone to eating disorders or suffer from malnutrition because of the physical appearance required by ballet schools, companies and future employers. Without the proper nutritional levels of calcium and vitamin D, dancers are prone to scoliosis and stress fractures of the spine.⁷

GENDER

Male ballet dancers are often plagued with lower back pain as they assume a hyperlordotic position when initiating or executing lifts with their female partners. Lifts are frequently choreographed in such a way that the male dancer cannot assume the correct position for lifting before execution.⁶ Once the habit of maintaining a lordotic

back is ongoing, these male dancers will be more prone to use this posture at other times, increasing the possibility of injury.⁶ When a male's arms are outstretched away from the body, especially when loads are involved, there may be an increase in the risk of disc-related pain or even herniation where the pulpy disc center extrudes through a tear in the fibrous annulus and causes pain because of pressure put on neural elements of the spine.³²

AGING

As a dancer ages, degeneration can occur in the lumbar vertebrae as a result of many years of stress. Degeneration may include erosion of the cartilage surface of the vertebrae and joint space narrowing. Joint space narrowing is commonly associated with osteophyte formation. Joint pain from osteoarthritis of the facet joints, pain will occur when the space between the two bones is narrowed and the nerve root adjacent to the facet is irritated.¹¹

Dancers who begin their careers at a young age might experience pain due to a "transient 'overgrowth' syndrome" during their adolescent years. In this condition the bony parts of the spine outstrip the tendons and ligaments during a growth spurt resulting in tight lumbodorsal fascia, calf muscles, hamstrings, weak abdominal muscles.¹¹

Male dancers often experience injuries due to a later start in their career, which is typically around the age of sixteen. In order to keep up with their female counterparts, who start training at the age of eight, they take on a large number of classes at once, leading to fatigue and predisposing them to injury. Many male dancers will also practice unsupervised, developing poor technique or attempting steps that they are technically not prepared for physically.⁹

With age comes a decrease in flexibility. As dancers lose their flexibility, they may try to overcome their stiffness by overworking their bodies. This can cause damage

to the skeletal structure and muscles, causing scar tissue to develop in the muscular fascia and fibers. Often times, internal bleeding in the muscle can occur as a result of tears from continuous exaggerated pull on the muscle.⁸

BODY TYPE

The bodies of ballet dancers are very diverse and some authors have suggested that in certain individuals, the low back region is not well-suited for extensive ballet training. People with a longer-than-average spine have large lumbar vertebra and comparatively smaller intervertebral discs which will theoretically inhibit them from reaching the desired hyperextension of the spine, because the vertebrae will meet sooner.⁸ The longer length of the spine may be accompanied by relatively short tendons and ligaments with muscles that are less flexible. These dancers will have a difficult time with the flexibility requirements.⁸ Longer backs and tight hip muscles and ligaments, which are most often found in males, have been suggested to cause lower back pain. This body type has more difficulty achieving a higher arabesque position than the average person and as a result, the individual will often lift the hip, or keep the back too straight, or a combination of the two.⁸

Short spines and narrow hips may also predispose a dancer to low back pain, due to the challenge of assuming the turnout position. To achieve this position many dancers will strain their joints in the lower extremities which will eventually affect the lower back.⁸

Dancers with a round back have very acute angle at the lumbar area. In this instance all of the curves in the back influence the other curves, more so than people in the general population. While dancing if there is any correction to the spine, as in the forward pelvic tilt, tension will be produced in the lower back and their condition may be

worsened. Those that have a straight spine have a sharp angle at the lumbar area and this body type has an inflexible back and will most likely develop poor technique to achieve the positions such as the arabesque. This type of back is also easily fatigued and does not absorb the shock from jumps well, predisposing the individual to injury.⁸ Ballet dancers born with enlarged transverse processes or a laterally fused mass are predisposed to pseudoarthrosis formation. The mass may directly come in contact with the iliac wing or the sacrum, resulting in degenerative changes and pain with movement.

EXTRINSIC FACTORS

The practice surface for the dancers may also have an impact on the incidence of back injuries. Poor impact absorption by the dance surface may result in increased stress on the lower extremities and lumbar spine.³³ Many dancers have clauses in their contracts that state they will not be required to perform over cement surfaces. As a result, many dance studios are now being built with shock absorbing floors to make landing jumps and executing dances easier on the body.¹¹ Inclined stages also put a dancer at risk for injury.¹

A variety of injuries, including to the spine, may be caused by inadequate warm-up. When the muscles are not warmed-up and stretched properly before executing dances that include movements requiring flexibility, muscles can be strained. This may occur if the ballet dancer is active in short bursts. If a dancer is constantly cooling down during rests, he or she may be prone to injury.⁹

A dancer should be trained specifically for the performance he or she is working towards. Perfecting the technique that is required of the dancer may have preventative benefits. If a dancer takes on an unfamiliar style which requires using the body differently the risk for injury may be increased.⁹

A dancer who begins the season in poor condition may also be at risk of an injury. As the dancer begins the long, grueling hours of practice an injury may be sustained from not being in the condition necessary for the performance level. If an injury occurs at the beginning of the season, many dancers are reluctant to take time off for the injury to heal. This can lead to chronic injuries, as discussed previously.⁹

CONCLUSION

A majority of the literature concerning lumbosacral injuries in ballet dancers has shown that hyperlordosis is the most likely cause of low back pain. Hyperlordosis results from a wide variety of causes, ranging from not maintaining a posterior pelvic tilt, to holding the back too straight in an arabesque, to genu recurvatum. The chances of acquiring lumbosacral injuries through hyperlordosis can be significantly lessened by receiving dance instruction from a professional who is familiar with technique errors and how to correct them. When students and professionals are more aware of the proper techniques and the flaws that may occur in classical ballet, they are less likely to obtain a low back injury.

Turnout is associated with hyperlordosis, as many ballet dancers will try to achieve a turnout of 180° by increasing lumbar lordosis. Possessing a turnout of 180° is not physically possible for a majority of people, so when dancers forcefully turnout they compensate in other areas, increasing the likelihood that they will attain a lumbosacral injury and experience low back pain.

Conditions such as spondylolysis, spondylolisthesis, stress fractures and disc herniation are common injuries among ballet dancers, causing low back pain. Micheli's research shows that most classical ballet injuries are due to repetitive microtrauma, the category into which these injuries would fit. The incidence of overuse injuries in the

lumbosacral area is increased if the pressures of having an extremely lean body have an effect on the dancer. Deficiencies in vitamins and nutrients as well as having experienced more than six months of amenorrhea will add to the likelihood of obtaining this type of injury.

Gender, aging, body type and extrinsic factors may contribute to lumbosacral injuries in classical ballet dancers. The lifts that are an integral part of the male ballet dancer's choreography may be executed with a hyperlordotic back and if this is the case, low back pain may result. Aging has an impact on the rate of degeneration of the intervertebral discs, a decrease in flexibility and conditions such as transient overgrowth syndrome. The stresses put on the dancer's back over the course of many years of training also influence the likelihood of low back injuries. There is a special concern for males who begin their ballet training at a later age because they practice at a high intensity, and frequency in order to catch up to their female counterparts. Body type is not as an important factor although few or no scientific studies have been conducted in this area. Extrinsic factors such as dance surface, inadequate warm-up and beginning the ballet season in poor physical condition also impact the chance of a low back and other injuries.

Based on the theories and research compiled concerning lumbosacral injuries in classical ballet dancers the following recommendations have ensued:

- Maintain a well-balanced, nutritional diet
- Complete an adequate warm-up before dancing
- Have the student and the teacher educated in the area of proper technique
- Seek treatment when injured
- Know the limitations of your body

Putting these recommendations into practice does not guarantee that a dancer will be injury-free, but may lessen the chance that they will acquire an injury during their dancing career.

Research in the field of dance medicine has increased over the past few decades, but scientific studies in this area still need to be conducted as much of the information is theoretical. Studies specifically concerning the maintenance of the posterior pelvic tilt and the avoidance of hyperlordosis should be researched more rigorously as new studies show that holding this position may actually increase the likelihood of low back pain, contrary to the professionals of dance medicine in the past. The incidence of osteoarthritis and the affect of body type on the rate of low back injury are other areas where there is a lack of scientific evidence.

The studies of lumbosacral injuries in ballet have not been extensive so much of the information in this literature review is based on the opinions of healthcare professionals whose interests lie in dance. Many of the scientific studies mentioned in this literature review use data from other activities and then applied to dancing by healthcare professionals who are interested in dance. Though dance medicine is not yet a large field, it has made tremendous progress over the last twenty years. Since the 1980s partnerships have been formed between dance organizations and medical practitioners creating organizations such as the International Association of Dance Medicine and Science, the Performing Arts Medical Association and the Dance Science and Somatics Committee of the National Dance Association.³⁴ Educational opportunities have also emerged in the field of dance medicine and special interest groups have formed within professional health organizations like the American Physical Therapy Association and the National Athletic Trainers' Association.³⁴ As large organizations continue to show

support and fund research, dance medicine will continue advance and provide assistance to dancers for years to come.



Figure 1: arabesque position



Figure 2: turnout



Figure 3: turnout

¹Bronner, Shaw & Brownstein, Bruce. "Profile of Dance Injuries in a Broadway Show: A discussion of Issues in Dance Medicine Epidemiology." *The Journal of Orthopaedic and Sports Physical Therapy* 1997; 26: 87-94.

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³ Ryan, Allan J. & Stephens, Robert E. "The Epidemiology of Dance Injuries." *Dance Medicine: A Comprehensive Guide*. Chicago & Minneapolis: Pluribus Press & The Physician and Sportsmedicine, 1987. 3-15.

⁴ Rovere, George D., Webb, Lawrence X., Gristina, Anthony G., Vogel, Judith M. "Musculoskeletal Injuries in Theatrical Dance." *The American Journal of Sports Medicine*. 1983; 11:195-199.

⁵ Bureau of Labor Statistics: U.S. Department of Labor. March 1997.
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⁶ Micheli, Lyle J. "Back Injuries in Dancers." *Clinics in Sports Medicine*. 1983; 2: 473-484.

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- ¹¹ Micheli, Lyle J., Soloman, Ruth, Soloman John, Gorbino, Peter G. "Low Back Pain in Dancers." *Medscape Orthopaedics & Sports Medicine eJournal*. (1999).
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