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The Physical Fitness Components and Posture Screening of Female Competitive Dancers

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ABSTRACT

The purpose of this research project is to fill the lack of information on the physical components, amount of pain experienced, and past injuries of competitive dancers under the professional level. Little research has been performed in this population. A total of 15 female competitive dancers were tested between the ages of 15-18 years old. Body mass index (BMI), height, weight, muscular endurance, aerobic endurance, flexibility, and alignment were measured, and then a pain rating survey and injury questionnaire were anonymously completed by the subjects. The participants performed a three-minute, twelve-inch step test, push-ups and crunches test, sit-and-reach test, and posture screen test. These measurements were then statistically analyzed and compared. The BMI values were healthy for the participants' age, except for two dancers, and postural deviations were very small. Aerobic endurance was above the 75th percentile in eight dancers; all dancers except for one scored below the 40th percentile in abdominal endurance, but over half scored above the 60th percentile in pushups/upper body strength. Lastly, flexibility was high with almost every dancer scoring above the 75th percentile. There were no significant correlations found between BMI and aerobic endurance, crunches and pushups, or flexibility and posture. The most pain reported was in the lower back, and most injuries reported were in the ankles and lower back. It was found that there is a need for dancers to improve overall muscular fitness, given the potential to prevent further injuries and pain experienced from dance. More data should be collected in this particular population and comparison groups such as professional dancers.

INTRODUCTION

Athletes not only benefit from an extended recreational and social life, but they also benefit from stronger muscles, improved flexibility, an increase in their stamina, and improvements in their weight control (D'Souza, 1994). In a previous research study by the faculty of exercise and sport sciences at the University of Tartu, Estonia, it was found that female dancers had an average height of 170.9 meters, a body mass average of 57.3 kilograms, and a body mass index average of 19.6 kg·m^{-2} (Liiv et al, 2012). Liiv et al. states, "It has been argued that the physical demands on dancers from current choreography make their physical fitness level as important as their skill development," (p.429). During competitive dance routines, dancers appear to be performing at high energy-demanding phases. During dancers' times of training, their bodies are put through stress.

Dancers' Health

In order to keep up with the physical demands of dance, dancers must maintain a healthy lifestyle. One way to test whether a person is healthy is by calculating their body mass index. "Obesity is defined as a level of excess body fat that increases the risk of disease," (Yoke, 2006). Body mass index is calculated by dividing a person's weight in kilograms by their height in meters squared.

Dancers train their muscles to be able to hold positions for long periods of time, such as plies, balances, and more (Leonard, 2011). Thus, dancers typically have less difficulty when having to sustain extensive thigh exercises. Their legs are less prone to fatigue during exercises that require sustained strength and stamina (Lee). Also, Dancers rely largely on strong hips in order to help them avoid injuries and keep his or her body aligned properly (Lee). Leonard explains that the tensor fasciae latae is one hip flexor muscle in particular that can tighten the most, causing a restriction of function in other muscles such as the gluteal muscles. The tightening of the tensor fasciae latae can even cause iliotibial band syndrome. But, dancers typically do not suffer from a limited range of hip motion since they extend their legs outwards and upwards in all different directions.

In one study, researchers tested the benefits of social dancing on postural stability and physical performance in dancers at the age of 50 years or older (Zhang, Ishikawa-Takata, Yamazaki, Morita, & Ohta, 2007). The researchers used a sit-and-reach test to evaluate the flexibility in the participants' lower backs, and it was found that dancers have greater lower back flexibility than non-dancers. Flexibility is necessary in complimenting muscular strength, building efficiency in movement, coordination, and preventing injuries (Irvine, Redding, Rafferty, 2011). But, for flexibility to be beneficial, the specific muscle group being stretched needs to be isolated and focused on. Unfortunately, there are still concerns among dancers that increased muscle strength will have a negative effect on flexibility and aesthetic appearance. However, as Irvine, Redding, and Rafferty explain, research has shown that strength training can lead to better dancing and less dance injuries, without interfering with artistic and aesthetic requirements.

Dance Injuries

While regular exercise is beneficial, dance has shown a susceptibility to injury because it is a chronic stress that can lead to significant functional consequences (Jurcau & Jurcau, 2014). "Much of a dancer's ability is reliant on favorable anatomy, strength and flexibility," (Kennedy, Hodgkins, Colombier, Guyette, & Hamilton, 2007, p. 141). In dance, common injuries include the neck, shoulder, spine, knee, lower leg, and foot (Jurcau & Jurcau). As seen in ballet dancers, there is some consistency with the prevalence of injury (Milan, 1994). About 65-80% of injuries in ballet are lower limb injuries, about 10-17% of injuries in ballet are spinal lesions, and only about 5-15% of injuries are in the upper limb region. Injuries and their resulting pain are commonly found in dance (Jurcau & Jurcau). The majority of injuries in dance, including the foot, ankle, lower leg, lower back, and hip, are the result of overuse rather than trauma (Solomon & Russell, 2011). In particular, the foot, ankle, and lower leg areas are vulnerable to many injuries, and these injuries show up with more frequency in dancers as they get older. Dancers regard injury and pain as a way of life and are reluctant to go to healthcare professionals, for fear of long-term immobilization and possible unemployment (Kennedy et al.).Thus, it is very important to educate and emphasize to young dancers what they can do to prevent future injuries (Solomon & Russell).

Hip Injury

The most frequent complaint by ballet dancers, according to a 6-year survey done by Milan, was the painful snapping hip. Milan discusses that the painful snapping or clicking hip occurs inferomedially or laterally, and the physical therapist should distinguish either location. "The most important anatomical factor in classical ballet is a proper turnout of the lower extremities," (p. 122). The large range of external hip rotation in ballet dancers is the result of bony and/or soft tissue adaptations. Milan (p. 122) claims, "The insistence of a correct turnout by some instructors may contribute to lumbar spine and lower limb injuries in dancers who lack adequate hip external rotation."

Knee Injury

Knee injuries are also prevalent in ballet dancers, accounting for 14-20% of all ballet injuries (Milan). According to another research study done by Reid, peripatellar pain is reported to be the most common knee condition. Another research study looking at theatrical dancers internationally done by Washington, found something different, stating that ligamentous injuries were the most common knee injury. These differences may be due to the fact that the second study used self-reported questionnaires and surveys. Milan (p. 123) states, "some contributing mechanisms of knee injury include repetitive jumping, deep knee bends, and substandard footwear, poorly resilient dance surfaces, muscle imbalances, long hours of practice, and incorrect turnout." Two different knee conditions prevalent in ballet dancers are patellar tendonitis and Osgood-Schlatter disease. Patellar tendonitis involves inflammation of the sheath and adhesions between the sheath and tendon. Osgood-Schlatter disease is inflammation and irritation of the tibial tuberosity (Fitt, 1996). An active adolescent may feel soreness at the tibial tuberosity particularly during growth spurts; some authorities consider a fracture of the tibial tuberosity to be Osgood-Schlatter disease as well. One thing to note that Milan (p. 124) states is, "a decrease in quadriceps strength and function has implications in many disorders of the patellofemoral joint, particularly in female ballet dancers between 10 and 19 years of age."

Lower Leg Injury

Lower leg injuries are less prevalent than knee injuries. Lower leg injuries account for about 5-8% of ballet injuries, with the most common issue being shin splints (Milan). There are three primary conditions in dancers that predispose them to leg pain, and one of these is shin splints (Kennedy et al.). Some causes of shin splints are dancing on a hard, non-shock absorbing dance surface, the use of thin-soled or no shoes, incorrect turnout, and an insufficient warm-up prior to dancing (Milan). Not externally rotating from the hips during turnout can result in the dancer externally rotating the knee, ankle, and foot instead. Rolling in of the foot can be caused by this, which is similar to excessive foot pronation in runners, placing an additional strain on the muscles controlling pronation and may cause shin splint syndrome.

Ankle Injury

Ankle injuries are more prevalent in dancers than lower leg injuries. These injuries account for about 15-22% of ballet injuries, with the most common being an acute inversion sprain (Milan). Other ankle conditions prevalent in ballet dancers include Achilles tendonitis and flexor hallucis longus tendinitis because of the frequent and excessive stress placed upon these particular tendons. Inversion ankle sprains mainly damage the anterior talofibular ligament, which may result from the forced inversion of the plantar-flexed foot during poor landing from jumps, missteps, or while on demipointe (bearing weight on the metatarsal heads). Muscle fatigue and poor quality dance surfaces may also cause inversion ankle sprains.

Foot Injury

Foot injuries are almost as prevalent in dancers as ankle injuries are. Foot problems account for about 13-15% of ballet injuries (Milan). Milan (p. 125) states, "Acquired conditions of the great toe include hallux rigidus (osteoarthritis of the first metatarsophalangeal joint)." Hallux rigidus tends to occur early in a dancer's career, mostly from repeated en pointe and demipointe dancing, resulting in a painful restriction of hallux dorsiflexion. Plantar fasciitis is another condition that ballet dancers are prone to developing. When the plantar fascia is rendered stiff with dorsiflexion of all the metatarsophalangeal joints, the metatarsal heads are depressed, thus assisting in elevation of the medial longitudinal arch.

Spinal Injury

Injuries above the waist are also possible in dancers. Spinal injuries account for about 10-17% of ballet injuries, with the lumbosacral region of the spine being involved in approximately 69% of those spinal injuries (Milan). Spondylolysis is one common spinal injury that often occurs in young female dancers due to their early dance training that typically begins before the epiphyseal union of the pars interarticularis of the spine. Hyperextension and hyperlordosis of the lumbar spine, both common in ballet dancing, cause the pars interarticularis to be more vulnerable and can also cause damage to the intervertebral discs lying between the vertebrae.

Upper Limb Injury

Upper limb injuries are much less common in ballet, accounting for about 10% of injuries, with most of them resulting in the wrist and hand (Milan). Rotator cuff strain is a common shoulder condition, which can occur from falling onto an outstretched arm, or lifting another dancer. Acute injuries to the wrist occur typically when attempting to brace the body in a fall to the ground, but overuse injuries also develop in the wrist.

METHODS

Subjects

The subjects tested in this study were female competitive dancers between 15-18 years of age. There were 15 female competitive dancers that participated in this study. The subjects volunteered to participate and they were given no compensation. This study was approved by Winthrop University's Institutional Review Board. All participants of 18 years of age signed an informed consent form. Those under 18 years of age obtained parental consent and completed a youth assent form.

Methods

Each participant completed each set of tests individually, one at a time. The participant was asked to remove her shoes so that data collection would be consistent. The participants were allowed to put their shoes back on if they wanted some extra support when completing the physical tests.

The tests took place at two different dance studios in the Southeastern United States. First, the participant's height was measured using a stadiometer (Seca) borrowed from the physical education department. The participant stood with her back to the stadiometer and the sliding horizontal headpiece located on the stadiometer was placed on the top of the participant's head in order to give the most accurate height measurement. Each participant's height was measured in centimeters. Next, the participant's weight was measured in pounds using a Conair Corporation scale. Using these two measurements (height and weight), each participant's body mass index was then calculated. The participant's BMI was calculated by dividing her weight in kilograms by her height in meters squared. After her height and weight were measured, the participants' alignment was then measured using the PostureScreen application (Trinity, Florida) on an iPad electronic device.

Once the tests that required no physical activity were completed, the tests that required exercise began. Endurance was the first physical component tested. The participant was asked to complete the YMCA three-minute, twelve-inch step test. Four risers were used on each side along with a base platform. Each riser was two inches tall and the base platform was four inches tall, totaling in twelve inches. Four risers were stacked on top of one another on either side with the base platform secured on top of the risers. A metronome application was used on the iPad electronic device and set to 96 beats per minute. This ensured that the participant stepped at the same speed for a constant three minutes. Immediately after the three minutes were complete, the participant sat down on the base platform of the step. Within five seconds of the participant completing the step test, the researcher found her pulse, and counted the number of pulses for one minute.

The next physical component tested was the participant's abdominal muscle endurance. First, the participant was told to lie on her back with her feet flat on the floor on a SCORE Bio-Check II™ Mat. The participant's arms remained by her sides with her hands flat on the mat. The researchers placed two strips of tape on either side of the mat. The first strip of tape designated where the participant's fingertips should be at a resting position, and the second piece of tape was farther down the mat closer to her feet, designating where her fingertips should be when they complete a sit up. The participant was not restricted to a certain amount of time, but instead was to remain on the same beat as the metronome on the iPad device, which was set to 50 beats per minute. The participant was told to do as many sit ups as she could at this speed without stopping. The amount of sit ups completed by the participant was counted and recorded and compared to the average and percentile norms (ACSM, 2014).

The same mat was used to test the participants' upper body muscular endurance. The participants were told to do as many pushups as they could do without stopping, with no time restraint and no specific cadence. The participant began face down on the mat, hands in line with her shoulders, and performed the pushups with her knees and toes remaining on the ground. The participant performed the modified version of pushups for women. The amount of pushups the participant completed was counted and recorded. The test was discontinued when participants could not maintain the correct form on two pushups. The score was then compared to the norms (ACSM, 2014).

The last test the participants completed was the flexibility test. A Figure Finder Flex-Tester® sit and reach box (Rockton, Illinois) was used for this test. The subject sat on the ground facing the equipment with her legs extended straight out in front of her, and feet flat up against the Flex-Tester®. The participant's heels were at the 15" mark on the box. Sitting up straight with her legs extended in front of her, the subject exhaled and flexed her trunk, reaching her extended arms out in front of her with one hand on top of the other, with her palms facing down toward her legs. As she flexed at the spine and reached forward, the participant's fingertips pushed the moving slider forward, which measured their degree of flexibility. The participant paused for two seconds to take each measurement. The participant performed this particular test three different times. The researchers then read the measurements, recorded the best one of the three attempts and compared these measurements to the norms (YMCA).

Once the physical components were tested, the participants were then asked to complete a pain rating survey (Margolis et al., 1986). The participants were told to complete the pain rating survey marking the location of any pain they experience on "a regular basis." The definition of "a regular basis" was left up to the participant. The participants also completed a sliding scale of how intense the pain is and how much it causes them discomfort on a 1-10 scale.

The subjects were also asked to complete an injury questionnaire based off of injuries they have suffered from that resulted from dance. Any injury from any time during their participation of dance was taken into consideration. The definition of the term "injury" was left up to the subject.

Data Analysis

Descriptive statistics were calculated to show the means and standard deviations. Statistical correlations compared the different physical components among the dancers.

RESULTS

The purpose of this research project was to learn more about the physical abilities and components of female competitive dancers at the pre-professional level between the ages of 15-18. This field needs more research done on the strengths and weaknesses of these particular dancers and if any of their physical components correlate with each another.

Table 1. Front view alignment deviations. This table shows how much each subject's alignment deviated from what is considered to be their "proper" alignment in seven different areas of the body from the front view.

FRONT VIEW ALIGNMENT DEVIATIONS							
ID	Head Shifted	Head Tilted	Shoulders Shifted	Shoulders Tilted	Ribcage Shifted	Hips Shifted	Hips Tilted
D1	No	2.8° left	No	No	0.56" left	0.50" right	2.2° right
D2	0.29" left	2.3° right	0.42" left	3.3° left	0.58" left	0.56" left	No
D3	No	3.2° left	No	No	0.29" left	0.64" left	3.6° left
D4	0.60" right	5.9° right	1.02" left	No	No	0.60" left	2.1° right
D5	No	3.5° left	0.30" left	2.6° left	0.42" left	0.34" left	No
D6	0.10" right	No	No	No	0.57" left	0.22" right	No
D7	5.32" left	144.0° right	0.51" left	No	0.26" left	0.49" left	No
D8	0.40" left	3.9° right	0.42" left	No	No	2.15" left	No
D9	0.29" right	No	No	No	0.40" left	0.42" right	No
D10	0.17" left	No	No	No	0.52" right	0.29" left	2.8° right
D11	0.16" left	No	0.23" right	No	0.22" right	0.34" left	No
D12	0.42" left	No	0.43" right	No	0.28" right	No	3.2° right
D13	0.46" left	2.5° left	0.40" left	5.6° left	0.74" left	0.60" left	No
D14	0.49" right	No	0.31" right	No	0.20" left	0.27" left	3.6° right
D15	0.14" right	No	0.84" left	6.6° left	No	0.84" left	No

Table 2. Side view alignment deviations. This table shows how much each subject's alignment deviated from their proper alignment in seven different areas of the body from the side view.

SIDE VIEW ALIGNMENT DEVIATIONS						
ID	Head Weight	Head Shifted	Head Now Weighs	Shoulders Shifted	Hips Shifted	Knees Shifted
D1	8.9 lbs	1.88" forward	25.6 lbs	No	1.42" forward	0.12" forward
D2	12.5 lbs	0.43" backward	7.1 lbs	0.76" forward	1.66" forward	1.88" forward
D3	8.6 lbs	1.73" forward	23.4 lbs	0.61" forward	No	0.61" forward
D4	9.8 lbs	1.17" backward	1.7 lbs	No	1.74" forward	1.32" forward
D5	12.5 lbs	0.27" forward	15.9 lbs	0.71" backward	0.64" backward	0.88" forward
D6	11.6 lbs	0.65" forward	19.2 lbs	0.55" forward	0.17" forward	1.72" forward
D7	9 lbs	1.61" forward	23.6 lbs	0.11" forward	0.88" forward	1.17" forward
D8	9.8 lbs	3.07" forward	39.7 lbs	1.16" forward	0.61" forward	1.48" forward
D9	9.3 lbs	0.90" forward	17.7 lbs	0.43" backward	0.29" forward	1.81" forward
D10	9.8 lbs	0.34" forward	13.2 lbs	0.31"forward	0.17" forward	1.24" forward
D11	10.6 lbs	0.61" forward	17.1 lbs	0.33" forward	0.61" forward	1.12" forward
D12	9.4 lbs	1" forward	18.7 lbs	No	0.4" forward	1.9" forward
D13	7.9 lbs	1.09" backward	0.7 lbs	1.37" forward	0.28" backward	1.4" forward
D14	11.5 lbs	1.14" forward	24.7 lbs	0.62" forward	0.55" forward	0.55" forward
D15	9.2 lbs	0.11" backward	8.2 lbs	1.56" forward	1" forward	1.74" forward

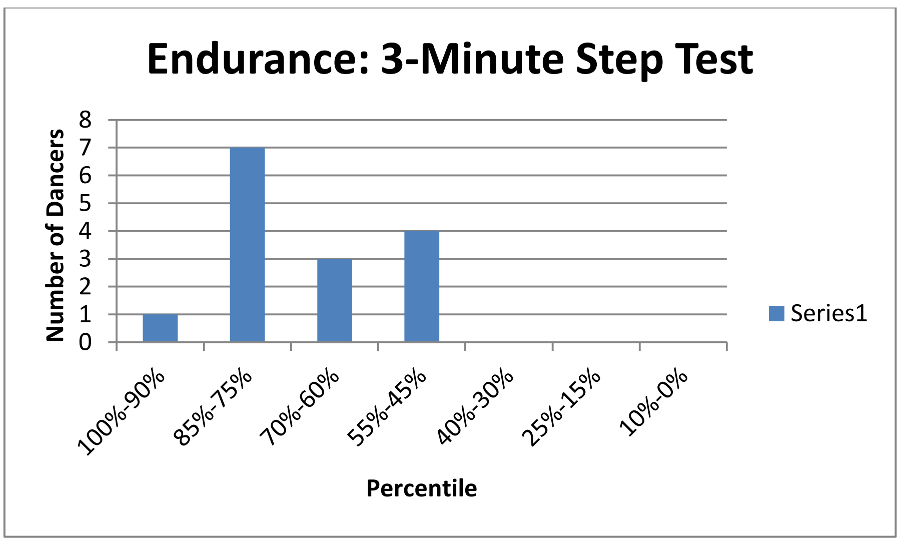

Figure 1. Cardiovascular endurance results from a 3-minute, 12-inch step test. This chart displays how many dancers tested into each percentile range with their cardiovascular endurance.

According to the physical testing, the highest amount of dancers tested into the 75-85 percentile range for endurance. These results can be seen in Figure 1. This percentile range was considered, "Good," and meant that the subjects had 85-93 pulses within one minute of competing the 3-minute, 12-inch step test. There were some subjects that tested into the 45-55 percentile range, also known as, "Average." In this category, subjects would have about 104-110 pulses within one minute of completing the step test.

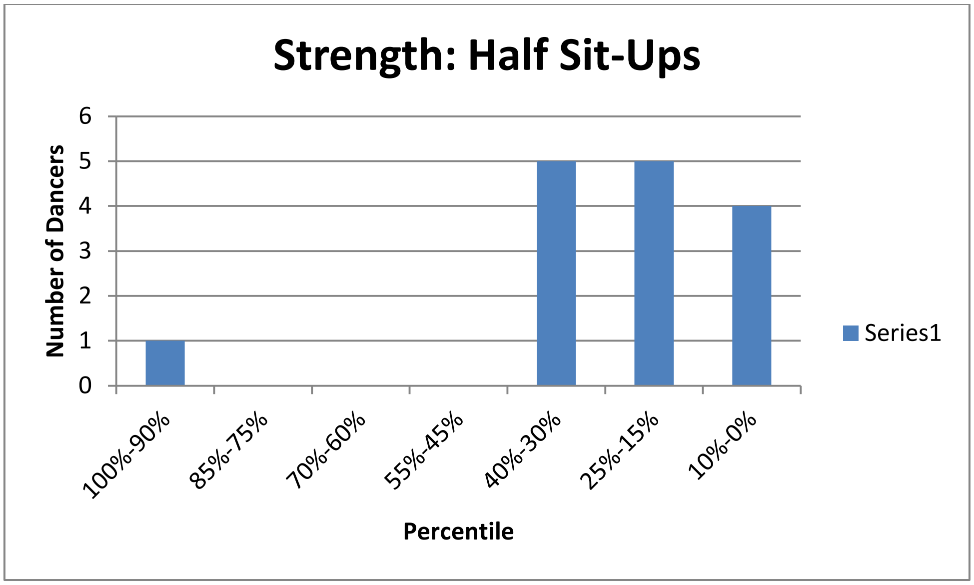

Figure 2. Muscular endurance results from a half sit-ups test. This chart illustrates how many dancers tested into each percentile range with their abdominal strength.

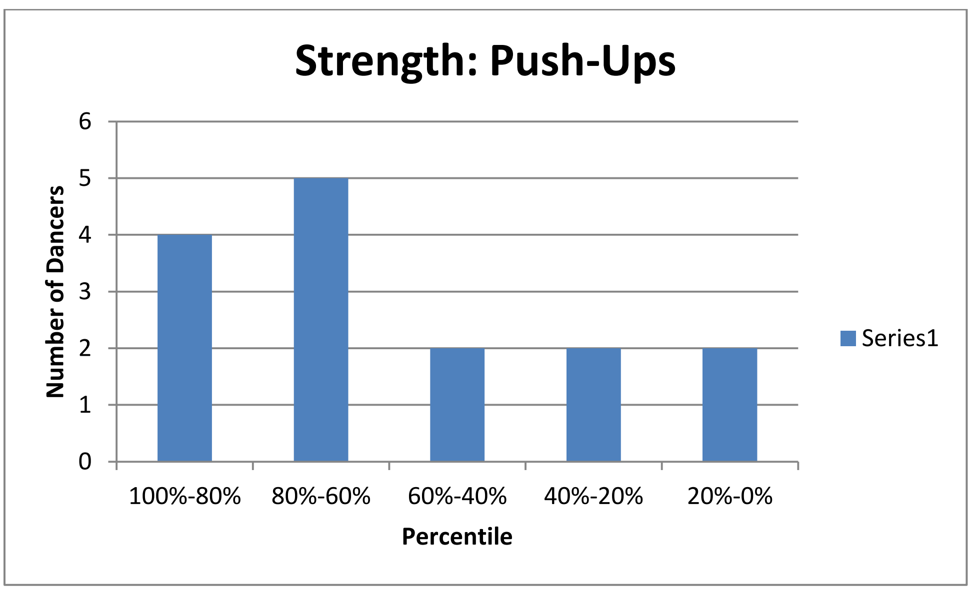

Figure 3. Muscular endurance results from a push-ups test. This chart shows how many dancers tested into each percentile range with their arm strength.

When analyzing the dancers' strength, by looking at Figures 2 and 3, it is obvious that the subjects were stronger in push-ups than in half sit-ups. The highest amount of dancers tested among the 0-10 percentile, 15-25 percentile, and 30-40 percentile ranges for half sit-ups. The 0-10 percentile range is classified as, "Very Poor," and means that the subjects completed 11-25 half sit-ups. The 15-25 percentile range is classified as, "Poor," and means that the subjects completed 28-33 half sit-ups. The 30-40 percentile range is classified as, "Below Average," and means that the subjects completed 34-38 half sit-ups. With the push-ups strength test, the highest amount of dancers tested into the 60-80 percentile range, which is much higher than the results of the strength test for half sit-ups. This means that the most girls tested into the "Very Good" category, and completed 21-29 push-ups.

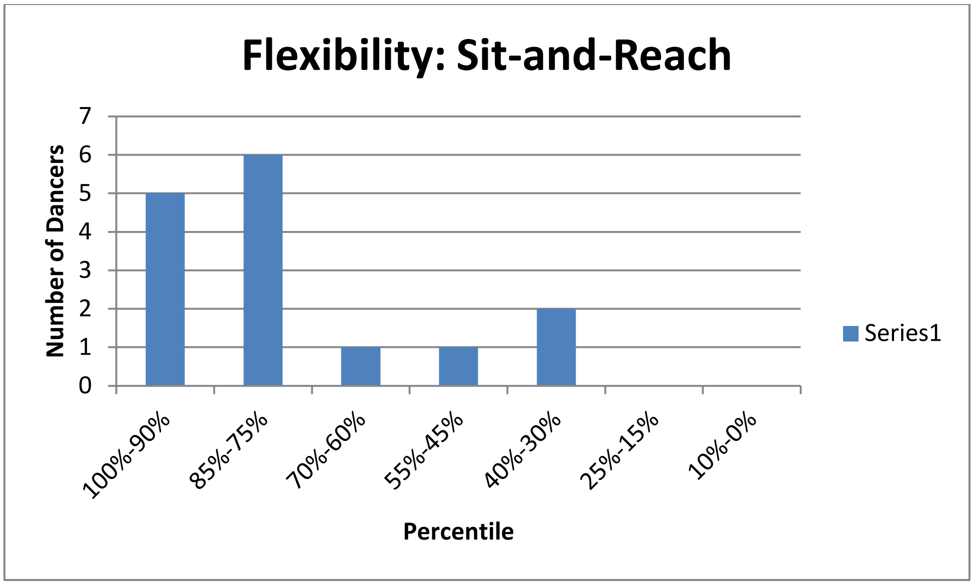

Figure 4. Flexibility results from a sit-and-reach test. This chart displays how many dancers tested into each percentile range according to their flexibility.

The flexibility results can be found in Figure 4. The highest amount of dancers tested in the 75-85 percentile range for flexibility, and the next largest category was the 90-100 percentile range. The 75-85 percentile range is categorized as "Good," whereas the 90-100 percentile range is classified as "Excellent." In the 75-85 percentile range, subjects reached 22 inches, whereas those that tested in the 90-100 percentile reached 24-29 inches.

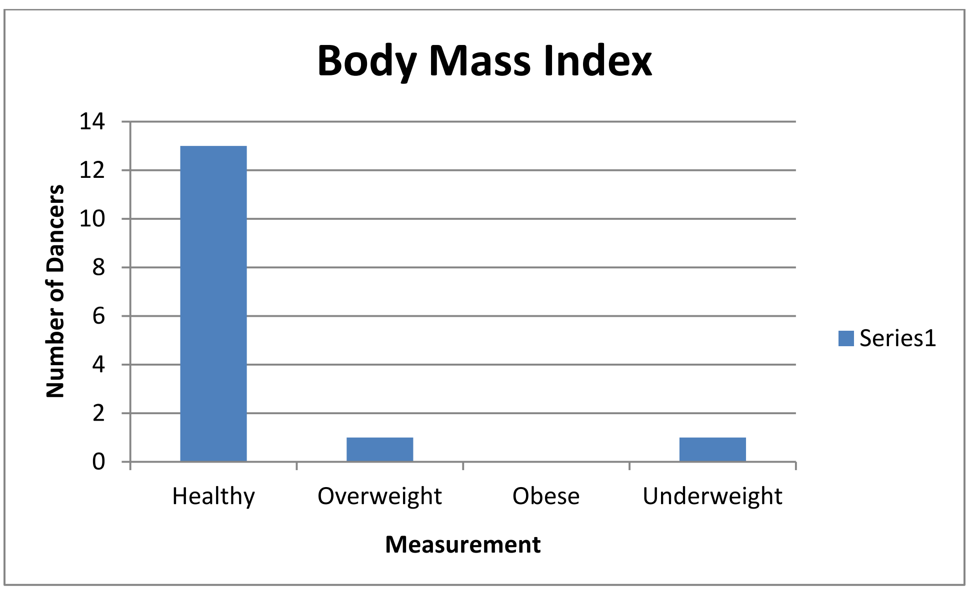

Figure 5. Body mass index results. This chart illustrates how many dancers were considered healthy, overweight, obese, or underweight from measuring their height and weight.

Body mass index was calculated for each of the 15 female dancers that participated in this study. These results can be found in Figure 5. The highest amount of dancers tested into the "Healthy" or "Normal" range. This meant that they were not overweight, obese, nor underweight. Although, there were some dancers that tested into the overweight category and underweight category, there was only 1 dancer in each of these percentile ranges.

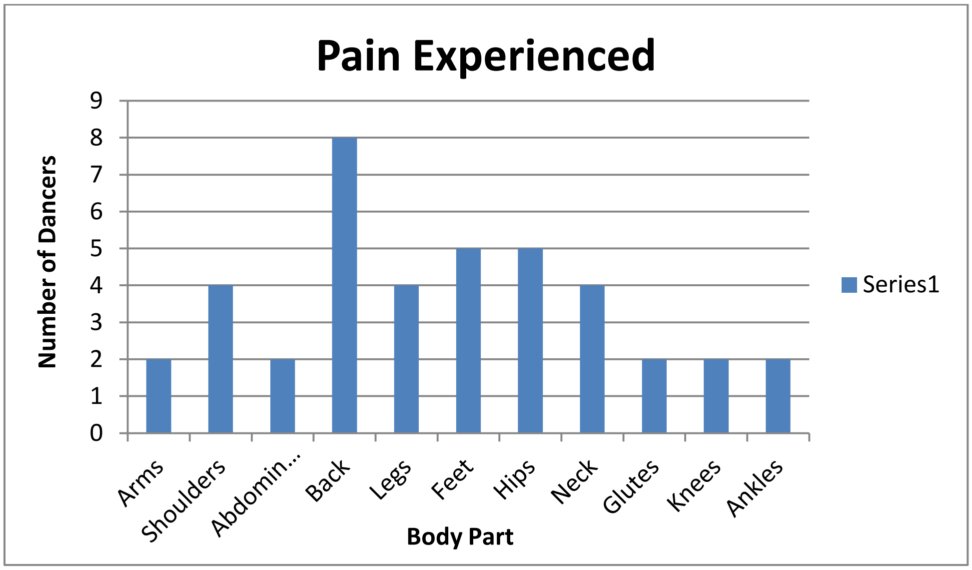

Figure 6. Pain experienced in different body parts resulting from dance. This chart shows how many dancers experience pain on a regular basis in different areas of the body due to dance.

The most common area of the body that the dancers complained of experiencing pain was the back. The least common sites of pain were the arms, abdominals, glutes, knees, and ankles.

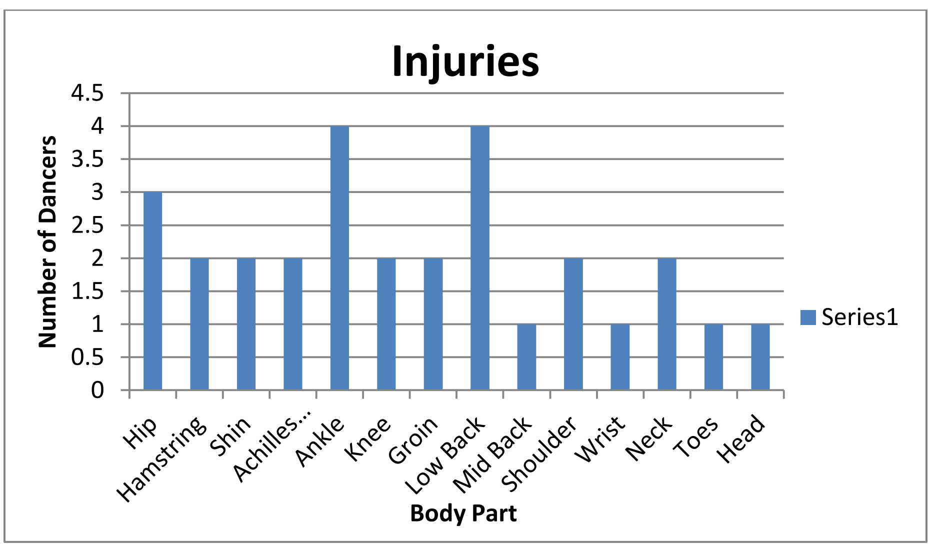

Figure 7. Injuries that dancers suffered from resulting from dance. This chart displays how many dancers have suffered an injury in different parts of the body due to dance.

The most common sites of injury were the ankles and low back. The least common sites of injury were the mid back, wrist, toes, and head.

Table 3. Descriptive statistics. This table shows the mean, standard deviations, and normal measurements for each physical component tested.

Variable	*Mean*	*Std. Deviation*	*Norm*
Age	17.13	1.18	---
Height	162.85	5.97	---
Weight	128.85	18.1	---
Endurance	93	9.31	52-81
Sit-Ups	31.8	14.74	68-91
Push-Ups	21.46	10.4	30 & up
Sit-and-reach	22.47	2.52	24-29

Table 4. Correlations. This table shows the Pearson correlation (*r*) and significance value (*p*) for each of the variables compared to each other.

Variables Compared	*r*	*p*
BMI-Endurance	.025	.93
Sit Ups-Push Ups	.333	.224
Sit/Reach-Hips shifted side	-.191	.496
Sit/Reach-Knees shifted side	.172	.539

DISCUSSION

The cardiovascular endurance results should be somewhat concerning since these dancers are athletes. Ideally, they should all be testing in the "Good" or "Excellent" categories for cardiovascular endurance, because "the greater a dancer's aerobic capacity, the longer they can work at moderate heart rates before becoming fatigued," (Irvine, Redding, Rafferty, 2011). There is some room to improve in this physical aspect, because the highest percentile range is 90-100 and classified as, "Excellent." In the "Excellent" category, subjects would have anywhere between 52-81 pulses within one minute of completing a cardiovascular endurance exercise.

Although there is still room for improvement with the upper body strength in these dancers, there is more need for improvement with the half sit-ups and abdominal strength. These dancers may have more strength in their arms than in their abdominals due to the increase in demand for not only male dancers to be able to lift other dancers, but female dancers to be able to lift as well. There is a growing expectation in dance that female dancers should be able to lift other dancers and not rely on the males to do all of the lifting in dance routines. This may result in the dancers paying more attention to their arm strength, and less attention to their abdominal strength, resulting in weak abdominal muscles. But, in order to properly lift another dancer, one must also have strong abdominal muscles for stabilization. So, these low scoring abdominal strength tests are somewhat concerning.

The dancers were expected to test very well with flexibility since that is what most of their sport is based off of. Most of a dancers' technique comes from their ability to be very flexible. Although these are good results, some dancers tested into the 30-40 percentile range, which is fairly low. So, for a select few of them, there is room for improvement on their flexibility. One reason why these dancers may have tested better in flexibility than in strength is because the role of strength training in dance is usually misunderstood, according to Irvine, Redding, and Rafferty (2011). Dancers are concerned with the possibility of muscle strength negatively affecting flexibility and aesthetic appearance, although research states that this does not happen. Dancers need to be better educated on the health and physical components of dance, especially when it comes to strength and flexibility.

A healthy or normal body mass index is one that falls between a 5 and 85 percentile range, according to the National Center for Health Statistics (2000). Less than 5% is considered underweight, above 85% is considered overweight, and above 95% is considered obese. Although the dancers that did not test into the "Normal" category should work on gaining or losing weight, these results are not extremely concerning since the majority tested healthy.

It was expected that these dancers would suffer the highest amount of injuries to their ankles because many sources discussed the prevalence of ankle injuries in elite dancers. "Dancer's feet are the instruments on which their art depends," (Kennedy, Hodgkins, Colombier, Guyette, Hamilton, 2007). According to Milan, "Ankle problems constitute 15-22% of ballet injuries," (1994). It would be expected that the most pain would be experienced in the ankles as well, but this was not the case for these dancers. Other dance injuries that are common in dance are the lower leg, low back, and hip, according to Solomon and Russell. This observation was consistent with these results, since three dancers suffered from a hip injury, and four suffered from a low back injury, as seen in Figure 7.

When looking at correlations between these physical components, there are no correlations between any of the results, which is somewhat surprising. These results can be found in Table 4. It would be expected that the higher a person's body mass index is, the lower their cardiovascular endurance would be, and vice versa. But, according to these results and statistical analyses, there is no correlation. A Pearson Correlation value of $r=.025$ is extremely low, showing almost no correlation between body mass index and cardiovascular endurance level. Also, the statistical tests showed that there was a significance value of $p=.930$, which means these results were not statistically significant. We also ran statistical correlation analyses on the sit-ups and push-ups data. These tests showed that there was no correlation between the sit-ups and push-ups, because there was a Pearson Correlation value of $r=.333$. There was also a significance value of $p=.224$, meaning that there was no statistically significant difference between these two physical components. Lastly, we ran statistical analyses on the sit-and-reach flexibility test, and two different alignment components. The two alignment components statistically tested with flexibility were how much the dancers' hips were shifted from the side view, and how much their knees were shifted from the side view. These two alignment components were chosen to be tested alongside flexibility because flexibility mainly focuses on the lower back, hips, and hamstring muscles. Between the sit-and-reach test results and alignment results of the hips, there was a Pearson Correlation value of $r=-.191$, meaning there was practically no correlation between the two variables. The significance value was $p=.496$, which means that there was no statistically significant difference among these variables. Between the sit-and-reach test results and alignment results of the knees, there was a Pearson Correlation value of $r=.172$, meaning that there was no correlation between these two physical components. The significance value was $p=.539$, which meant that there was no statistically significant difference between these two variables.

Since these statistical results showed little to no correlation and no statistically significant difference may be due to the low number of subjects that participated in this study. A fairly low number of subjects results in less data being available, and little statistical power is evident. Another possibility for these unexpected results would be Type I error. It is possible that the two researchers involved in collecting the data measured the physical components differently or inaccurately.

In the future, it would be possible to add more young female competitive dancers to this study, as well as possibly add in female high school track athletes. This would give an opportunity to analyze and compare the two groups of athletes and learn why they may be different or similar in their physical components and posture screening.

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