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The Performance of Dancers on the Lower Quadrant Y Balance Test

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A capstone project submitted to the Graduate Faculty in Physical Therapy in partial fulfillment of the requirements for the degree of Doctor of Physical Therapy (DPT), The City University of New York
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THE CITY UNIVERSITY OF NEW YORK

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Abstract

The Lower Quadrant Y-Balance Test (YBT-LQ) is an evidence-based screening tool that measures one's ability to maintain unilateral stance while reaching the contralateral leg in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions. The purpose of this study was to observe the performance of collegiate dancers on the YBT-LQ and compare it with that of other athletic populations from previously published studies. 39 healthy collegiate dance majors at the Purchase College Conservatory of Dance (ages 17-24 years; mean years of dance training 12.9 ± 3.9 years) participated in this study. Subjects stood on the central platform of the YBT-LQ device and used one foot to slide the reach indicator in each direction. After 3 trials, each subject's highest score per direction for right and left sides was recorded and used to calculate the reach asymmetry score for each direction. Each reach distance score was normalized by subject leg length and used to compute a composite reach score. Mean values were calculated for each outcome and compared to mean values of other athletes available from the literature, using a one-sample t-test. The mean

reach scores for the dancers in each direction expressed as a percentage of leg length were: ANT: 75.0% ± 7.2%, PM: 121.6% ± 9.3%, and PL: 120.0% ± 8.7%. Mean composite reach score was 105.5% ± 7.7%. Mean reach asymmetry values were greatest in the PM direction (3.8cm ± 3.0cm) followed by the PL and ANT directions (2.8cm ± 2.1cm; 2.6cm ± 2.4cm). When compared to other groups of athletes, the dancers in this study performed superiorly in all outcome measures except for the ANT reach distance; dancers demonstrated a significantly superior performance compared to all other athletes in their composite score ($p < 0.005$), and PL reach distance ($p < 0.0005$). In the PM direction, dancers were observed to reach significantly further than all comparisons ($p<0.0001$), with the exception of professional soccer players ($p=0.04$). Dancers performed a significantly more symmetrical PL reach on each side when compared to all athletes ($p < 0.0001$) except professional soccer players ($p = 0.18$).The values outlined in this research demonstrate that dancers perform differently on the YBT-LQ than do other athletes. YBT-LQ normative values must be established for dancers before this test can be used as a screening tool for this population.

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Introduction and Background

Dance exists at the intersection of art and sport. On one hand, dancers are required to display expressiveness and artistry in movement. On the other hand, dance also requires great athleticism, coordination, strength, range of motion and motor control. The set of demands imposed on the dancer are unique in that they encompass not only tremendous feats of physicality, but also the requirement that certain aesthetic parameters be met. Thus, as compared with athletes in other sports, the physical demands placed on the dancer are more complex; a dancer does not merely execute a physically challenging activity, but also performs it in a way that meets the aesthetic codes of a particular style of dance. It is not simply the completion of a task for distance or time, but an artistic expression of a specific movement, emotion or idea.

The rigorous demands of dance training and performance make dancers prone to injury. Shah, Weiss & Burchette (2012) surveyed dancers in sixty-three American modern dance companies about their experiences with injuries. They found the overall rate of injury to be quite high (82%), which is comparable to rates found among football players (81%) (Shah, Weiss, & Burchette, 2012). Within this high incidence of injury in dancers, 74% occurred in the lower extremity (Shah et al., 2012). Shah found that the top five most common locations of dance injuries were the ankle (18%), low back (17%), knee (16%), foot (10%), and hip (9%).

Despite the prevalence of injury, researchers have found that professional dancers perform better on balance tests than do healthy age-matched individuals without any specific sport training (Crotts, Thompson, Nahom, Ryan, & Newton, 1996). Furthermore, collegiate dancers have been shown to perform better on balance tests than their athletic peers (Gerbino, Griffin, & Zurakowski, 2007).

Throughout the course of their training, dancers focus on symmetry, control, and balance. Maintaining balance, whether at a point of stillness or moving through space, is an essential aesthetic and athletic demand placed on dancers. Research has shown that training plays a very important role in the development of superior balance (Balter, Stockroos, Akkermans, & Kingma, 2004). Dance training employs a large number of balance exercises to prepare dancers to use these skills in an artistic way. It is likely that dancers acquire superior motor control and body awareness throughout their training, which allows them to perform extremely well on balance tests (Ambegaonkar et al., 2013; Kiefer et al., 2013).

Balance is used as a measurement of function for the lower extremity (Cote, Brunet, Gansneder, & Shultz, 2005), and can be classified into two types: static and dynamic. In static balance, the body maintains equilibrium while not in motion (Clark, Scott, & Sutton, 2012). In dynamic balance, the center of gravity moves in response to internal muscular activity and external stimuli (Kinzey & Armstrong, 1998; Clark et al., 2012). With respect to the athletic population, Munro & Herrington (2010) elaborate, "Dynamic postural control is described as the ability to maintain a stable base of support whilst completing a prescribed movement and underpins the performance of movement skills in the athletic population." (p.128). During a single phrase of movement, dancers are asked to balance in stillness and to maintain control over their body as they jump, land, turn and thrust themselves through space. Effective static balance strategies are important to dancers, especially for moments in choreography where they are required to maintain a shape while in unilateral stance. However, as an expressive form of movement, dance implies advancement through space, thus also requiring dynamic balance strategies.

Functional tests are essential for determining when it is safe for an individual to return to activities, athletic or otherwise (Colby, Hintermeister, Torry, & Steadman, 1999). As stated above, balance can be defined as a measurement of function for the lower extremity (Cote et al, 2005), thus physical therapists often use balance tests as tools when evaluating the lower extremity. Kinzey et al. (1998) describe the importance of testing balance: "Quantification of balance, or postural control, is often necessary to assess the level of injury or ability to function in order to initiate an appropriate plan of care." (pg.356). Given the differences between static and dynamic balance, Hubbard, Kramer, Denegar, & Hertel, (2007) examined whether it would be possible to test only static or dynamic balance to determine the level of functionality for both. They concluded that this would not be possible because static and dynamic balance measures were not correlated. They hypothesized that static and dynamic balance tests each challenge the sensorimotor system in a unique way.

Dynamic balance tests provide greater challenges to an individual's strength, range of motion and coordination. Static balance tests demand less of these parameters and therefore may not be sensitive enough to detect functional balance deficits in a physically active population such as dancers (Olmsted, Carcia, Hertel & Shultz, 2002). Research supports that dynamic balance tests are more effective than static balance tests in assessing function of an athletic subject (Wikstrom, Tillman, Smith, & Borsa, 2005; Olmstead et al., 2002). When examining how elite Australian footballers performed on a static balance test as compared to a dynamic balance test, Hrysomallis, McLaughlin & Goodman (2006) found that performance on the static test was only weakly associated with performance on the dynamic test, indicating that how an individual would perform on a dynamic test could not be inferred from a static test. Additionally, max medial-lateral center of pressure excursion values were found to be fifty-three percent greater during the dynamic test as opposed to static, thus demonstrating the greater challenge to stability during the dynamic balance tests as opposed to static, on the athletic subject.

Currently there is not a gold standard for assessing dynamic balance (Olmstead et al., 2002). Previous methods of studying dynamic balance have included the use of a stationary force plate with an external challenge to the subject's balance, or a moving force plate on which the subject must maintain his or her balance (Kinzey & Armstrong, 1998). The Time to Stabilization (TTS) test measures the amount of time that it takes for the body to return to a pre-determined baseline of static balance after a challenge to the body's equilibrium (Colby et al., 1999; Wikstrom et al., 2005). While this type of test is useful for studying dynamic balance in a movement laboratory, force plates and computer programs to process the data are not readily available in most physical therapy clinics, training gyms or dance studios, nor would they be convenient during a clinical examination or screening process.

The Star Excursion Balance Test (SEBT) is another tool that has been used to assess dynamic balance. This test is simple, low cost, can be used easily in clinical settings, and does not require expensive equipment or software (Munro et al., 2010). The SEBT has established reliability with intrarater Intraclass Correlation Coefficient (ICC) ranging from 0.82-0.96 and interrater ICC from 0.81 - 0.93 after controlling for a learning effect (Hertel, Braham, Hale, & Olmsted-Kramer, 2006). During the test, the subject is required to maintain a unilateral stance while reaching with the contralateral leg in eight directions. These eight directions are indicated by tape on the floor. For each of the directions, the subject reaches as far as he or she can without placing any weight on the reach leg during touchdown. The tester marks this point of farthest reach. A reach is considered successful if the subject can return the reach leg to bilateral stance. The tester then uses a tape measure to record the distance from stance leg to marked point. The subject is given the opportunity to practice the test before scores are recorded because a learning effect has been associated with the performance of this test (Robinson & Gribble, 2008). There has been a lack of consensus in the literature regarding the amount of allowable movement and hand placement during this test, with different researchers utilizing differing constraints (Gribble, Hertel, & Plisky, 2012). The SEBT has been used safely with both injured and healthy athletic populations (Munro et al., 2010; Robinson & Gribble, 2008). A meta-analysis by Arnold, De La Motte, Linens, & Ross, (2009) found that tests using force plates tended to be more accurate than the SEBT in measuring dynamic balance in individuals with functional ankle instability. However the authors of that research acknowledge that testing with force plates is not likely to be feasible in most clinics, making the SEBT a more accessible, yet still valid and reliable, field test of dynamic balance.

Criticism of the SEBT has focused on two central issues: the time it takes to perform the test and the level of objectivity of the test. The subject must perform seventy-two reaches per leg (six practice and three test reaches in each of the eight directions) (Plisky, et al., 2009). The amount of time could be reduced if the number of reach directions could be reduced, or if the number of practice trials required could be justifiably reduced. Secondly, subjectivity and imprecision are introduced when the tester marks the point of farthest reach (Plisky et al., 2009). An instrumented method of determining farthest reach would substantially improve the objectivity of this test.

The Y Balance Test kit (YBT) was developed by Philip J. Plisky to address some of the concerns about the SEBT (Plisky et al, 2009). The YBT is available for evaluation of both the upper quarter (YBT-UQ) and lower quarter (YBT-LQ). The authors of this study have elected to observe dancers' performance on the YBT-LQ because the majority of dance injuries occur in the lower extremity (Shah et al., 2012). The YBT-LQ includes three of the original eight directions of the SEBT: the anterior (ANT), posteromedial (PM), and posterolateral (PL) (Plisky et al., 2009). Appendix A contains images of the equipment. This streamlining of the test is supported by research that found considerable redundancy in the eight tasks of the SEBT (Hertel et al., 2006). The creators of the YBT elected to include the ANT and PM directions because of their ability to identify individuals with chronic ankle instability. Additionally, hip abduction strength has been correlated with performance in the PM direction and hip extension strength has been correlated with performance in the PL direction (Plisky et al., 2009). Thus this test challenges multiple components of the lower extremity kinematic chain, while also providing the clinician with an overall functional picture of dynamic balance. To improve objectivity and accuracy of reach measurements, the YBT-LQ requires the subject to stand on a small platform and use the tip of her/his toe to push an indicator box along a piece of PVC pipe printed with centimeter gradations in each of three directions (See Appendix A for image). These changes have resulted in greater reliability; the YBT-LQ has an intrarater reliability ICC of 0.85-0.91 and interrater reliability ICC of 0.99-1.00 (Plisky et al., 2009). The YBT-LQ has been accepted as a simpler, quicker, and more reliable version of the SEBT, while still maintaining clinical convenience and minimal cost.

The outcome measures of the YBT-LQ are the reach distances in each of the three reach directions for each leg (normalized by leg length), a composite score for each leg (normalized by leg length), and an asymmetry score calculated from the difference between reaches on each side in each reach direction (not normalized). Research using the SEBT has established that the above are the parameters that indicate the presence of a dynamic balance functional deficit and increased risk for injury (Olmstead et al., 2002; Plisky, Rauh, Kaminski, & Underwood, 2006). The YBT-LQ can be used to assess individuals for deficits in dynamic balance that could predispose them to lower extremity injury. In a prospective study performed on high school basketball players, Plisky et al. (2006) found that players who had a difference between right and left reaches in the anterior direction of equal to or greater than 4cm were 2.5 times more likely to sustain an injury. The researchers also found that the female subjects who had decreased composite reach scores were 6.5 times more likely to sustain a lower extremity injury, as compared to the males in the sample. Therefore it is essential to consider both a subject's composite score, as well as his/her asymmetry score in determining if a functional limitation exists.

Dance researchers have called for functional tests to "assess conditions corresponding to real demands in dance training" (pg. 100) to describe a dancer's functional strength (Liederbach, 1997). Many of the tasks involved in dance activities require the dancer to stabilize on a supporting leg while performing a gesture with the other leg, which is exactly the task performed during the YBT-LQ. Dancers must be able to maintain postural stability while reaching outside of their base of support. The YBT-LQ is a test that provides objective, quantifiable, measureable data to describe the dancer's ability to perform this task. In a description of a comprehensive dance screen utilized by the Harkness Center for Dance Injuries, the balance-testing component described was a static unilateral stance with eyes closed (Liederbach, 1997). While this provides valuable information regarding the state of the dancer's proprioceptive system, balancing with eyes closed is not a task that is typically performed during dance activities. A functional test included in this assessment involves observing the ability of the dancer to stabilize in unilateral stance after landing out of a jump. While jumping is an essential task performed in all styles of dance, therefore making this an essential function to evaluate, it is not the same task as stabilizing one leg while reaching outside the base of support with the contralateral leg. Because it addresses an essential task performed in dance, the YBT-LQ has the potential to be a valuable addition to comprehensive dance screening programs.

Plisky et al. (2009) identified the need for clinically relevant normative values (norms) for different populations of individuals on the YBT-LQ. When examining how different groups of athletes (basketball players, gymnasts and soccer players) performed on balance tests, including the SEBT, Bressel, Yonker, Kras & Heath (2007) found that each group performed differently. The authors hypothesized that the specific demands of each sport resulted in the development of unique balance strategies leading to the variation in performance.

Norms for evaluating dancers have not been established for the YBT-LQ, however are necessary because dancers have been shown to perform differently on balance tests than other non-dance athletes. Gerbino et al (2007) compared standing balance abilities of dancers and soccer players, and found that dancers performed on par with their athletic peers in fifteen of the outcome measures, and better in the remaining five. The dancers demonstrated a significantly decreased sway index (measure of movement within one standard deviation of the center of pressure during a period of time) during the conditions of standing with eyes open, standing on a foam mat and after landing from a jump. Additionally, dancers demonstrated significantly shorter center acquisition times (measure of how well the subject can find balance after perturbation) during standing with eyes open and landing from a weight shift tests. The dancers' superior performance in the landing out of a jump and weight shift tests indicate that the dancers performed better than soccer players particularly when the tasks involved aspects of dynamic balance. This example supports the need for dancers to have their own standardized norms for objective testing for the YBT-LQ; the established values based on a non-dance athletic population may not be sensitive enough to determine functional dynamic balance deficits in dancers.

The purpose of this study is to observe the performance of collegiate dancers on the YBT-LQ and compare these values to those of other athletic populations as reported in the literature. We hypothesize that the mean reach scores for dancers will be larger and that dancers will demonstrate a more symmetrical performance in each direction than other groups of non-dance athletes as reported in the literature.

Methods

Research Design: This study was designed as a prospective observational analysis to observe the performance of dancers on the YBT-LQ, compare their scores to those of non-dance athletes previously reported in the literature, and investigate any association between scores and history of injury. The outcome measures examined were individual reach scores and composite reach score (normalized by leg length), as well as the difference in reach distance between contralateral limbs (not normalized by leg length).

Subjects: Subjects were recruited from the Purchase College Conservatory of Dance through the use of flyers and class announcements. The Conservatory of Dance is a multidisciplinary pre-professional dance-training program within the State University of New York (SUNY) Purchase, which requires an audition as part of the application process. The dancers in the program were selected on the basis of skill from an international application pool. The criteria for admission to the program, as described by the Conservatory's website, include "Talent and potential as a performer; Prior training and the ability to demonstrate a knowledge of modern dance and/or classical ballet techniques; Musicality; Good physical proportions in a healthy body that is injury free" ("Dance Admissions," n.d., para.1, 3, & 4).

The curriculum of the Conservatory consists of daily ballet and modern technique classes supported by additional classes in ballet partnering, modern partnering, improvisation, *pointe*, composition, somatics [classes that focus on developing awareness of the experience of movement], dance history and music theory. Additionally, dancers rehearse for and perform in numerous productions with choreography by guest artists, faculty or other students ("Conservatory of Dance," n.d., para. 2, 3, 4, & 5). Students spend an average of thirteen hours in technique classes and fifteen hours in rehearsal every week.

Liederbach (1997) identified the tremendous variability between the demands placed on each artist as one of the challenges of studying dancers. Professional dancers tend to vary in both the type of technique classes they take and the frequency with which they take them. The performance demands placed on each dancer depend on the type of company and number of roles each individual is responsible for performing. Dancers in a pre-professional collegiate program, where enrollment is a requirement, are typically involved in a comparable number of hours of dance activity to professionals, however with a greater degree of structure to these activities because of a standardized curriculum. Although it would be impossible and undesirable to create a perfectly homogenous sample where the demands placed on each dancer were equal, the choice to select subjects from a standardized program reduced the variability in the activities to which the dancers were exposed.

The authors of this study determined that it was advantageous to select dancers who were participating in multi-disciplinary training due to current trends in professional companies where dancers are expected to seamlessly adapt to a variety of different choreographic styles, with influences from a variety of dance techniques. Examining such dancers, rather than those who were focused only on one genre, provides a wider applicability to the larger dance population, and more accurately represents the nature of the dance world today.

Subjects were included if they met the following inclusion criteria: full time student in the program, between the ages of 18 and 25, and able to read and understand English. Participants were excluded if they lacked medical clearance for full participation in dance activities, or if they met any exclusion criteria outlined by Gorman, Butler, Ruah, Kiesel, & Plisky (2012), which included lower extremity amputation, vestibular disorder, currently under treatment for inner ear, sinus infection, respiratory infection or head cold, and cerebral concussion within the previous three months.

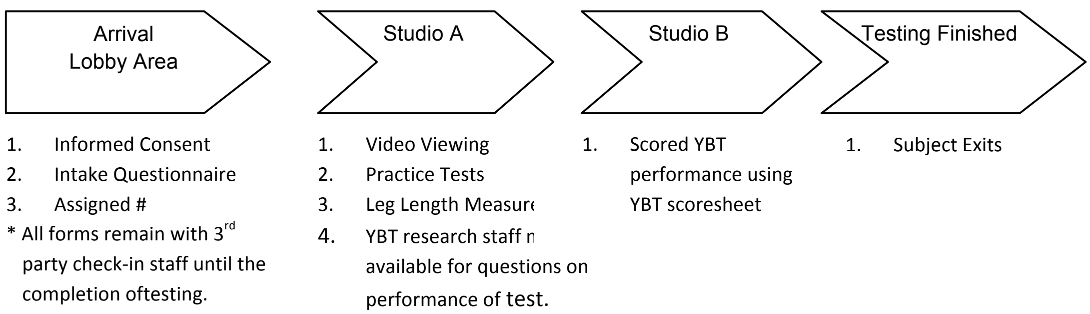
Materials: Testing was conducted using The Y Balance Test Kit™ manufactured by Functional Movement Systems. A standard non-elastic tape measure was used to measure leg length from the inferior aspect of the anterior superior iliac spine to the inferior aspect of the medial malleolus of the supine subject. A computer with a fifteen inch screen was used to show subjects the YBT-LQ instructional video as available on the Move2Perform website ("What is Move2Perform?" n.d., video)." Per YBT-LQ instructions, a representation of the YBT was created using cloth tape markings on the floor to allow participants to complete the six practice reaches prior to testing.

Procedures: Testing took place in two dance studios at SUNY Purchase. Studios were referred to as Studio A and Studio B. Upon arrival, subjects were directed to the lobby to complete an intake questionnaire (sample in Appendix B) and an informed consent document approved by The Hunter College Human Research Protection Program (HRPP) Office. The questionnaire provided information on the subject's age, gender, years and style emphases of dance training, medical and surgical history, and injuries within the preceding twelve months. A third party, not involved in the study, collected the forms and questionnaires, and retained them for the duration of test administration. Questionnaires did not contain subject's names, but were assigned a number that corresponded to a number on each subject's score sheet (sample score sheet in Appendix C), thus protecting the privacy of the individual and blinding the researchers to the subject's history during testing.

Upon completion of paperwork, participants proceeded to Studio A to view a brief video about how to perform the Y Balance Test, according to the Functional Movement Systems™ protocol contained in the kit. After viewing, the video subjects completed six practice trials on each leg in each direction on a taped out representation of the YBT, as recommended by YBT protocols. Members of the research team were available for any questions (JM and HC). One member of the research team (AM) measured each subject's leg length with a tape measure, from the most inferior aspect of the anterior superior iliac spine to the most distal portion of the medial malleolus (as described in Appendix D), and recorded this number on each subject's score sheet.

Participants were then directed to Studio B to complete the test on the YBT equipment. A single member of the research team (ML) administered all testing. Another member (TS) recorded reach scores to the nearest half-centimeter on the score sheet (Appendix C). As defined by the YBT protocol (Appendix D), the furthest of three successful reaches was utilized for analysis. This was repeated for each direction: ANT, PM and PL for each leg.

Testing Process Flow



Statistical Analysis**: Descriptive statistics were performed to analyze the performance of thisdancer population. Means, standard deviations, and standard errors were calculated for each of the three reach distances for both right and left legs (scores normalized by leg length), for normalized composite reach scores, and for reach differences between sides for each direction (not normalized). An independent samples t-test was performed to examine the difference in asymmetry scores per direction for those who reported an injury compared to those who did not (alpha = .05). A one-sample t-test was performed to analyze how dancers' scores compared with mean scores of other athletes available from previously published studies. To decrease the likelihood of a type-1 error, a Bonferoni correction was used for comparisons. Alpha was set to .007 for the comparison of the composite and individual reach scores, and alpha was set to .008 for the comparison of asymmetry scores. All analyses were performed using SAS v. 9.1.

**Gary Brooks PT, DrPH, CCS performed all statistical analysis.

Results

Description of sample: 42 subjects completed intake paperwork. 2 subjects did not complete testing due to scheduling conflicts. 1 subject's data was excluded from analysis due to subject's age being outside the inclusion criteria. The final subject count utilized for data analysis was 39. No subjects reported any adverse events during or after testing.

Please see Table 1 for the demographics of our subjects. Our sample consisted of 31 females and 8 males, with a mean age of 19.5 years (S.D. 1.8). The mean years of dance training for this sample was 12.9 (S.D. 3.9). The majority of our sample reported a multidisciplinary dance training background; 48.7% were trained in ballet and modern techniques, and 23.1% were trained in ballet, modern, and jazz techniques prior to admission to Purchase College. Table 2 shows the full distribution of the dancer's training emphasis. With injury defined on the intake questionnaire as "pain that has lasted greater than 7 days and has restricted your ability to participate fully in dance class or performances", 74.4% of our sample reported an injury to the lower quarter during their dance careers and Table 3 shows the numbers of subjects reporting multiple injuries. Frequency of injury by location and time is described in Table 4. Injury locations were reported for the low back and ankle (35.9% and 30.8%, respectively), followed by the knee (23.1%), foot (20.5%), and hip (15.4%). 41.0% of our sample reported at least one injury within the previous month.

Description of dancer's performance on YBT-LQ: Tables 5 and 6 describe the performance of the dancers on the YBT-LQ for both reach distance and symmetry. The mean reach scores in each direction, expressed as a percentage of leg length, are as follows: ANT: 75.0% ± 7.2%, PM: 121.6% ± 9.3%, and PL: 120.0% ± 8.7%. Mean composite reach score was 105.5% ±

7.7%. Mean reach asymmetry values were greatest in the PM direction (3.8cm ± 3.0cm) followed by the PL and ANT directions (2.8cm ± 2.1cm; 2.6cm ± 2.4cm respectively.)

Relationship between history of injury and outcomes: Table 7 shows the mean asymmetry scores by injury status within three months and greater than three months prior to data collection. A reported injury was associated with a higher asymmetry score for all directions except the PL direction for injuries within three months (3.2cm uninjured versus 2.4cm injured). The independent samples t-test found no significant differences between those who were injured and uninjured, but the difference in the anterior direction trended towards significance for injuries within three months ($p=0.056$).

Comparison to other groups of athletes: We drew comparisons between our subjects and groups of athletes from three YBT-LQ studies published prior to 2013:

- High school single-sport athletes to high school multiple sport athletes (Gorman et al., 2012).
- Soccer players at the high school, collegiate, and professional levels (Butler, Southers, Gorman, Kiesel, &Plisky, 2012)
- High school basketball players (utilizing a taped out version of the YBT, not YBT equipment) (Plisky et al., 2006).

When compared to other groups of athletes, the dancers in this study performed superiorly in all outcome measures except for the ANT reach distance; dancers achieved a significantly greater composite score ($p < 0.005$) and PL reach distance ($p < 0.0005$). Dancers reached significantly further in the PM direction ($p < 0.0001$) than all other athletes that we compared to, with the exception of professional soccer players ($p = 0.04$).

In the ANT direction, the dancers performed more symmetrically than the groups of non-dance athletes, but not significantly so ($p < 0.54$). In the PM direction, dancers' asymmetry score was comparable to that of the other athletes ($p < 0.95$). Dancers performed a significantly more symmetrical PL reach when compared to all athletes ($p < 0.0001$), except professional soccer players ($p = 0.18$).

Discussion

The purpose of this study was to observe the performance of dancers on the YBT-LQ and to compare how dancers performed on this test when compared to non-dance athletes previously observed on the YBT-LQ in the literature.

Descriptive Data:

Subjects: The dancers in this sample reported a mean of 12.9 years of dance training prior to entering the Conservatory, which is comparable to that of other groups of American collegiate dancers in the literature. The subjects observed by Crotts et al. (1996) reported a mean of 14.9 years of training, and the subjects participating in a study by Batson (2010) reported a mean of 9.6 years of training.

74.4% of this study's sample reported a history of injury to the lower quarter. These findings are similar to that of Weigert and Erickson, who published self-reported injury incidence for collegiate dancers between 67% and 77% (Weigert, 2005; Weigert & Erickson, 2007). The highest reported injury locations in this study's sample were the low back (35.9%) and ankle (30.8%). When observing the foot and ankle as a single complex, 43.6% of our sample reported an injury to these structures. Numerous studies have found a high prevalence of dance injuries in the foot and ankle (Garrick & Requa, 1993; Liederbach, 1985; Liederbach, Dilgen & Rose, 2008; Quirk, 1984; Solomon, Solomon, Micheli & McGray, 1999). Liederbach et al. (2008) studied injury rates over a five year period among ballet and modern dancers in a university and three professional companies; the foot and ankle accounted for the majority of injuries in both ballet and modern dancers (57%

and 47%, respectively) and the spine accounted for the next highest portion of injuries (12% in ballet dancers, 16% in modern dancers).

Reach Distance: Overall, the subjects in this study were observed to reach substantially farther in the PM and PL directions than in the ANT direction, with PM and PL reach distances exceeding 100% of the measured leg length. ANT reach distances did not exceed 75%. The researchers postulate that subjects were able to achieve scores greater than 100% of their leg length due to the difference between the method of leg length measurement and the functional length of the reaching limb. Per YBT-LQ protocol, the leg length measurements were made between the inferior lip of the anterior superior iliac spine and the distal portion of the medial malleolus. This method of measurement does not account for the added length across the ankle-foot complex during plantar flexion of the reach limb, nor for the ability of the subject to rotate the stance hip to reach further.

Another possible contributor to the greater reach scores in the posterior directions as opposed to the anterior reach directions may be the result of dance training. If an individual rotates the reach hip forward and lifts the stance heel, the anterior reach distance may increase. However, when dancers are trained to perform this movement, they are taught to keep their hips square and their stance heel on the ground. Performing the anterior reach in the manner that they were trained could have prevented the subjects from utilizing these alternate strategies, thus limiting how far they reached in this direction. The ingrained patterns of squaring the hips forward did not appear to factor into the performance of posterior reaching tasks.

Dancers have been observed by other researchers to demonstrate greater range of motion and greater strength in the end ranges hip external rotation than non-dancers (Gupta, 2004). The posterior reach directions have been shown to challenge the muscles of the hip to a greater degree than the anterior direction (Plisky et al., 2009). The subjects in this study may have been able to exploit increased range of motion and strength of their hip musculature to achieve more impressive reaches in the two posterior directions.

Another possible factor for explaining the dancer's ability to reach substantially further in the posterior directions than the anterior direction may be related to another prompt given during dance training. Dancers are often cued to "Keep your weight forward." It is possible that dancers had better developed balance strategies when the stance leg was anterior to the gesture leg, as it is when performing the posterior reaches, and were thus able to reach much farther.

History of Injury & Asymmetry: Previous studies have found that the YBT-LQ is sensitive enough to differentiate between healthy and injured subjects (Hertel et al, 2006). The findings in this study suggest that the scores of recently injured dancers do not significantly differ from those of uninjured dancers. During subject intake, injury was defined as "pain lasting greater than seven days and restricting your ability to participate fully in dance activities." Subjects were asked to provide information on their history of injuries to the low back and the lower extremity over the previous year. Independent samples t-test revealed no significant relationship between a history of injury and asymmetry scores (alpha = .05), although there was a general trend for those who reported an injury to have a higher asymmetry score, with the exception of one direction. Interestingly, in the PL direction those who reported a newer injury actually performed more symmetrically than those who reported being uninjured. In the ANT direction the association between asymmetry scores and injuries trended toward significance for injuries reported as occurring within the three months prior to data collection. This was the only direction that approximated a significant association between injury history and asymmetry scores. Further research is needed to determine if the YBT-LQ is truly a sensitive enough test to identify balance deficits in injured dancers.

To the authors' knowledge, at the time of writing, no other study has looked specifically at the performance of dancers on the YBT-LQ. Previous research has examined dancer's performance on the SEBT (Ambegaonkar et al., 2011; Batson, 2010; Filipa, Smith, Paterno, Ford, & Hewett, 2013). Filipa and colleagues examined the relationship between SEBT scores and functional turnout angle in young dance students, ages 5 to 9 years. Filipa utilized the ANT, PM, and PL directions of the SEBT, in essence the YBT-LQ without the platform and reach indicator box. The young dancers' mean composite scores were 81.4% and 81.9% (dominant and non-dominant limbs, respectively), which are significantly lower than the scores achieved by our subjects (Filipa et al., 2013). The difference between the scores of the young dancers and the scores of the collegiate age dancers in this study support the need for age-specific norms.

Ambegaonkar et al. (2011) observed the performance of dancers versus active non-dancers on an abbreviated version of the SEBT consisting of the AM, M and PM directions. The authors observed that the dancers reached significantly further in the PM direction as compared to the other two directions evaluated. Our research supports this finding, with the dancers in our sample also reaching further in the posterior directions as compared to the ANT direction. This demonstrates that dancers' tend to perform better in the posterior reach directions as compared to other directions.

Comparative Data: The manufacturers of the YBT-LQ put out a call for sports specific normative values because previous research has found that significant differences exist in how different groups of athletes perform on balance tests (Gerbino et al., 2006; Schmit, Regis, & Riley, 2005; Li, Xu, & Hoshizaki, 2009; Hrysomalis, 2011). The results of this study support this idea, in that dancers also perform differently on balance tests than other groups of athletes.

With respect to distance reached, the only parameter where dancers did not perform better than other groups of athletes was the ANT reach score. Single and multi sport high school athletes, as well as high school soccer players and high school basketball players, reached farther in the ANT direction although not significantly so. The only comparison that achieved statistical significance was that with high school basketball players (p< .0001). It is important to note that the study of high school basketball players used a taped out version of the YBT-LQ, rather than the YBT-LQ tool. Recent research has shown that subjects use different kinematic strategies in the anterior direction when on and off the YBT apparatus, which leads to a greater anterior reach score when off the tool (Fullam, Caufield, Coughlan, & Delahunt, 2014). This may be an explanation the difference in results. Fullam et al. (2014) did not note this difference in strategy for the posterior directions.

Butler et al. (2012) observed that as soccer players progressed from high school to collegiate to professional levels, the mean ANT reach scores decreased; they speculated that a history of ankle injuries could lead to decreased closed chain dorsiflexion range of motion. The ANT reach score (not the PM or PL scores) is significantly correlated with ankle dorsiflexion on the stance limb, and Hoch, Staton, & McKeon (2011) postulate that dorsiflexion range of motion accounts for 28% of variability in scores in the ANT direction. It is important to note that the groups that reached further in the ANT direction were all groups of high school athletes, whereas our sample was made up of collegiate age dancers. It is possible that the hypothesis of Butler et al. (2012) is applicable to explain the decreased reach distances in this direction for our sample as well, as dancers have been observed to have a high rate of injuries to the ankle, and over 30% of this study's sample reported a history of ankle injury (Shah et al., 2012). When the collegiate age dancers in this sample are compared to both the collegiate and professional level soccer players, the dancers were observed to achieve greater reach distances in the ANT direction, although not significantly.

Despite the lower ANT reach score, our sample's composite reach score was significantly higher than all the athletic populations to which comparisons were made in this study. This is largely due to the superior scores achieved by dancers in the PM and PL directions. Dancers reached significantly farther in the PL direction than all other groups of athletes to which they were compared. Dancers reached farther in the PM direction than all other groups of athletes compared to, and the statistical comparison was significant against all groups except professional soccer players. It is possible that dancers reached further in the posterior directions than the other athletes for similar reasons to why they reached further in the posterior directions as compared to anterior within themselves. The posterior directions have been shown to correlate with measures of hip strength, and dancers have been shown to have greater strength at the end ranges of hip external rotation (Plisky et al., 2009; Gupta, 2004).

The researchers in this study compared the symmetry of performance in each direction between dancers and high school single and multi-sport athletes, as well as high school, collegiate and professional soccer players. Information on symmetry was not published for the high school basketball players group. In the ANT direction, dancers performed a more symmetrical reach than all the other groups of athletes to which they were compared. Statistical significance was achieved for comparisons with multi-sport high school athletes and high school soccer players. In the PL direction dancers performed more symmetrically than all other groups, with significantly greater symmetry in comparison to all groups, except professional soccer players. With respect to the PM direction, dancers performed as or more symmetrically (but not significantly so) than all groups to which they were compared, with one exception. College soccer players were observed to have a more symmetrical reach than the subjects in our sample, although not significantly. This is the only group and direction in which athletes demonstrated a more symmetrical performance than dancers and it is interesting the note that they were the only group considered at a professional level. It is possible that to achieve success in a professional level of competition, soccer players needed to develop the skill of reaching outside their base of support in a manner that resembled the PM reach direction. With respect to overall performance and symmetry, although sports skills are generally trained bilaterally, it is possible that dancer's training contains an increased emphasis on consistently performing tasks bilaterally, therefore accounting for dancer's generally more symmetrical performance.

There are several factors that may account for the dancer's generally superior performance on the YBT-LQ. There are many similarities between the tasks performed as part of the YBT-LQ and the dance technique exercises performed in classes studied by our subjects. The actions of reaching one leg in a specific direction while flexing the stance leg mimics *tendus* with *plies devante* (Appendix E: Figures 1a & 1b), *a la seconde efface* (Appendix E: Figures 2a & 2b), and *derrière croise* (Appendix E: Figures 3a & 3b). These movements are trained bilaterally during the course of dance classes; therefore this may contribute to the generally more symmetrical performance of dancers on this test. Additionally, dancers are trained to hold a position while allowing the body to make constant small adjustments to stay balanced, especially during dynamic tasks such as a *pirouette* (rotations around a vertical axis while maintaining balance on a single leg) (Lott & Laws, 2012). These micro-adjustments may create a heightened proprioceptive awareness, as dancers must be able to make miniscule changes in their body's position during a dynamic task, thus allowing the dancers to make minor adjustments to maintain stability as they performed YBT-LQ tasks. Compared to non-dancers, dancers have exhibited greater static proprioceptive joint awareness of the ankle, knee, and hip joints during a joint-position matching task (Kiefer et al, 2013). The development of this heightened awareness during years of training may have contributed to dancer's ability to reach generally greater distances, with a greater degree of symmetry, than the other groups of athletes to which they were compared.

Clinical Implications: The SEBT, the predecessor to the YBT-LQ, has been examined in the contexts of differentiating between injured and uninjured lower extremity limbs, as an outcome measure to gauge the efficacy of rehabilitation programs, and, in one population (high school basketball players), to predict the risk of future injury (Gribble, Hertel, & Plisky, 2012). The YBT-LQ has the capacity to perform similar functions because the YBT-LQ is essentially an instrumented version of the SEBT, and requires the individual to perform similar tasks to the original test. The values found in this study are the first step towards developing normative values for dancers.

Clinically relevant normative values for the YBT-LQ will be tremendously useful to physical therapists who work with the dance population. The YBT-LQ is a demanding test with respect to lower extremity range of motion, strength, and motor control, therefore deficits in any one of these areas would manifest as a decreased performance on this test. Norms will provide clinicians with a baseline for comparison, so that when they are performing screening programs for dancers, the individuals with deficits in dynamic balance may be identified, and interventions implemented to potentially prevent injury. If dancers are evaluated against values generated from groups of non-dance athletes, it is possible that balance deficits may be missed, as this study demonstrates that dancers performed superiorly on this test than other groups of non-dance athletes.

Additionally, the YBT-LQ may have a role to play in assessing the efficacy of rehabilitation programs on injured dancers. Hale, Hertel, & Olmstead-Kramer (2007) used the SEBT as a pre and post test to examine the efficacy of a comprehensive rehabilitation program targeted toward improving unilateral chronic ankle instability (CAI). They found that at the end of the 4-week program of balance training, the composite scores for subjects' injured limbs had improved, thus decreasing the asymmetry between sides. The reduction in asymmetry between sides and increase in composite reach scores indicated that the subject's dynamic balance had improved, thus their risk for injury decreased. Dancer specific norms are essential to provide clinicians with the most appropriate target values to use in the course of a rehabilitation program for the purposes of goal creation, discharge planning and determining when a dancer is safe to return to dance activities. By preventing injury, effectively rehabilitating injuries that do occur, and establishing standard criteria for a return to dance activities, it is possible that clinicians will be able to assist dancers in more safely participating in dance activities, thereby may help to prolong their career. In order for therapists to do this, a greater understanding of how dancers perform on the YBT-LQ is necessary, along with determination of which cut scores are most appropriate to use when determining return to sport criteria.

Limitations of Research and Directions for Future Research: A primary limitation of this research is that too few subjects were used to qualify this as a normative study. The observed differences in symmetry and reach distance between dancers and other athletes indicate that if a dancer is judged by standard values from another sport, the dancer may be considered to have sufficient balance skills, while in actuality may not be fully capable of meeting the demands of dance training and performance. These results demonstrate the need for a several hundred subject normative study to develop dancer-specific normative values.

A further limitation of this study is that it examines a subset of dancers of a specific age who train in a specific set of techniques, preventing our results from being generalized to a broad spectrum of dancers, especially those studying other techniques. The Purchase College Conservatory of Dance is a university level program and its curriculum primarily focuses on ballet and modern (both classical and contemporary) techniques. Future research should focus on other specific sub groups of dancers including those who train and perform only a single technique, as well as those where the multi-disciplinary training encompasses other combinations of techniques such as jazz, musical theater, African, tap or ballroom. Furthermore, following the design described by Butler et al. (2012), it is important that the performance of different age groups of dancers be examined on the YBT-LQ.

This study did not standardize subject's pre-test activity levels on the day of data collection and on the days that preceded it. The study was conducted on Friday, November 2, 2012 four days after Hurricane Sandy hit New York, on Monday, October 29. The storm resulted in four days of school closure, thus the dancers had not been participating in technique classes for approximately one week prior to the collection of data. It is impossible to determine how much the preceding week of relative inactivity impacted the subject's performance of the test. Testing took place during a Conservatory Wellness Day, which consisted of massage, meditation, yoga, and nutrition workshops. Thus, although established YBT-LQ protocols were followed (six practice reaches, followed by three test reaches for each direction with each lower extremity), the dancer's level of activity prior to testing varied and did not include their standard regimen of technique classes. Although this may mimic conditions where dancers are rehearsing, auditioning and performing without an adequate warm-up, it has been found that a dynamic and static stretching protocol can significantly improve balance (Morrin & Redding, 2013). Future research may want to examine the effect of warm-up on performance of this test, and to establish standards to control for dancer activity levels prior to testing so that normalized values can be established that represent peak dancer performance. Additionally, this study did not control for timing of testing. Testing ran from 9am until 6pm. Standardizing testing time may give more uniform results, however no significant differences were found between morning and afternoon scores. Testing in this more variable manner may better mimic the realities of a dancer's schedule and the constraints that therapists and trainers will face when trying to administer the YBT-LQ in the clinic or as part of a pre-participation injury screen.

When collecting data on the subject's history of injury, the questionnaire utilized for this study did not ask subjects to specify whether their injuries were on the left or right side. This made it impossible for the authors to examine how injury impacted reach distance for the healthy versus injured legs, although the symmetry scores did reveal where dancers demonstrated side-side differences in performance of the test. Future studies should include a more detailed method of injury reporting, including information such as date of injury, the side affected, how long the injury took the subject out of dancing, and when the subject returned. Liederbach, Hagins, Gamboa, & Welsh (2012) provide recommendations for standardizing reporting of injuries and dance activities as part of the IADMS Standard Measures Consensus Initiative.

A limitation of the YBT-LQ is that it requires the subject to expend a maximal effort to achieve the furthest reach distance, and although the subject is cued to do so, it is impossible to gauge whether an individual is actually reaching as far as they are able. Robinson & Gribble (2008) observed that there may be a trend toward "movement economy" (pg. 367) as subjects performed repeated trials of this test, thus resulting in subjects not achieving a maximal reach on each trial as they become more familiar with the task. In observations of our subjects performing the six practice reaches prior to testing, it was noted that certain persons performed better when given vocal encouragement (Verbal encouragement was not provided during test reaches which took place in another room). Motivation is a crucial component in any performance (Cook & Crewther, 2012). Although dancers are typically intensely focused and driven, it is entirely likely that, like other athletes, despite intentions to perform their best at all times, they perform better when highly motivated by a competition or performance (Huffmeier, Krumm, Kanthak, & Hertel, 2012). A future study should examine the effect of pressure or encouragement from an outside source on the performance of this test.

In order to establish standards for the implementation of injury prevention interventions and return to sport criteria for dancers, a prospective longitudinal study design, similar to that of Plisky et al. (2006), is needed. This study would observe the performance of dancers on the YBT-LQ at the start of a season or training period, track injuries that occurred during that period, and then re-test dancers at the end of the season. This data would provide information on how the YBT-LQ correlates with risk of injury and could be used during pre-season screening procedures, as an injury prevention tool.

Conclusions

This research supports the findings of previous studies by demonstrating dancers' superior dynamic balance abilities compared to other groups of athletes, thus indicating the need for YBT-LQ normative values to be established for dancers. The values from this study allow for baseline comparisons to be made when evaluating college-age dancers. These dancer-specific YBT-LQ values may assist physical therapists in screening uninjured dancers for dynamic balance deficits, determining if a balance training intervention was successful, and establishing return to sport criteria for dancers.

Tables

Table 1 - Demographics & Years of Training (n=39)

Variable	Male	Female	Sample
Sex	8 (20.51%)	31 (79.49%)	39
Mean Age (years)	~	~	19.5 (1.8)
Mean Years of Training	~	~	12.9 (3.9)
**years (standard deviation)*			

Table 2 - Training Emphasis (n=39)

Technique	Female	Male	Total	% Sample
Ballet only	4	0	4	10.26%
Modern only	5	1	6	16.38%
Jazz only	0	0	0	0%
Ballet and Modern	15	4	19	48.72%
Ballet and Jazz	0	0	0	0%
Jazz and Modern	1	0	1	2.56%
All	6	3	9	23.08%
Dancers circled which techniques were emphasized in their training on an intake questionaire.				

Table 3 - Total Numbers of Reported Injuries (all locations and all times) (n=39)

# of Reported Injuries	# of Subjects Reporting Injuries	% Sample
0	10	25.64
1	14	35.9
2	8	20.51
3	5	12.82
4	1	2.56
74.36% total injured		

Table 4 - Injury Distribution of Sample by Time and Location (n=39)

All date ranges refer to time period prior to data collection date.

	< 1 month	1-3 months	3-6 months	6-12 months	> 1 year	Total Injuries by Location	% Sample by Location
Foot	3	4	1	0	0	8	20.51
Ankle	4	2	0	3	3	12	30.77
Knee	3	2	1	0	3	9	23.08
Hip	3	1	0	1	1	6	15.38
Low Back	6	2	1	1	4	14	35.9
Total Injuries by Time Frame	19	10	3	5	11	~	~
% Sample	*41.03%	25.64%	7.69%	12.82%	28.21%		

*3 subjects sustained 2 injuries within 1 month prior to data collection (n=16)

Table 5 - Normalized Reach Scores by Direction (n=39)

Reach Direction	**Average Normalized Score** means of the average of R & L normalized scores		
	Male	Female	Sample
Composite	105.0 (8.4)	105.7 (7.7)	105.5 (7.7)
Anterior	73.9 (8.4)	75.3 (7.0)	75.0 (7.2)
Posteromedial	121.8 (8.2)	121.6 (9.7)	121.6 (9.3)
Posterolateral	119.4 (9.6)	120.2 (8.7)	120.0 (8.7)
**reach distance (standard deviation)*			
***Compsite Score = Sum of greatest reach in each direction/(3 x leg length) x 100*			

Table 6 - Symmetry Scores (n=39)

Reach Direction	**Absolute Difference**		
	Male	Female	Sample
Anterior	2.9 (2.4)	2.5 (2.4)	2.6 (2.4)
Posteromedial	3.8 (4.4)	3.8 (2.6)	3.8 (3.0)
Posterolateral	2.4 (1.3)	2.8 (2.2)	2.8 (2.1)
**reach distance (standard deviation)*			

Table 7 - History of Injury and Asymmetry Scores (n=39)

Reported injuries within the last 3 months (n= 22 injured)						
Mean Asymmetry Scores	3.2	1.7	4.5	2.9	2.4	3.2
	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured
	Anterior		Posteromedial		Posterolateral	
	p = .056		p =.092		p = .232	

Reported injuries prior to previous 3 months (n= 16 injured)						
Mean Asymmetry Scores	3.4	2	4.8	3.2	3.2	2.4
	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured
	Anterior		Posteromedial		Posterolateral	
	p = .085		p = .089		p = .244	

*No significant differences between the asymmetry scores of injured and uninjured dancers (alpha >.05).

**Dancers who reported injury within the last 3 months demonstrated a more symmetrical performance than the uninjured dancers in the PL direction.

Table 8 - Comparisons Between Dancers and Other Groups of Athletes (n=39)

	The Performance of Dancers on the YBT-LQ. n= 39			*Gorman et al:* ***Multiple Sport Athletes*** n=92		*Gorman et al:* ***Single Sport Athletes*** n=92		*Butler et al:* ***High School Soccer Players*** n=38		*Butler et al:* ***College Soccer Players*** n=37		*Butler et al:* ***Professional Soccer Players*** n=44		*Plisky et al:* ***High School Basketball Players***** *n=235*	
Variable	**Mean**	**SD**	**95% CI**	**Mean**	**p**	**Mean**	**p**	**Mean**	**p**	**Mean**	**p**	**Mean**	**p**	**Mean**	**p**
Composite Score*	105.5	7.7	103.0-108.0	**97.1**	<.0001	**97.1**	<.0001	**98.4**	<.0001	**100.9**	0.0006	**101.8**	0.0046	**100.9**	0.0006
ANT Reach Score*	75.0	7.2	72.6-77.3	76.4	0.1951	75.5	0.5861	76.2	0.0864	72.8	0.0864	72.2	0.0287	**83.9**	<.0001
PM Reach Score*	121.6	9.3	118.9-124.6	**109.1**	<.0001	**108.2**	<.0001	**111.0**	<.0001	**115.2**	<.0001	118.5	0.0443	**113.4**	<.0001
PL Reach Score*	120.0	8.7	117.2-122.8	**105.8**	<.0001	**107.4**	<.0001	**108.2**	<.0001	**114.6**	0.0004	**114.7**	0.0005	**100.4**	<.0001
ANT Reach Diff (cm)	2.6	2.4	1.8-3.3	3.6	0.0084	2.8	0.5137	3.4	0.0303	2.8	0.5137	3.3	0.0544	N/A - no differences given	
PM Reach Diff (cm)	3.8	3.0	2.9-4.8	4.3	0.3376	4.6	0.1189	3.9	0.8904	3.5	0.4921	3.8	0.9451		
PL Reach Diff (cm)	2.8	2.1	2.1-3.4	**5.0**	<.0001	**4.3**	<.0001	**4.3**	<.0001	**4.2**	<.0001	3.2	0.1836		

** = percent leg length*

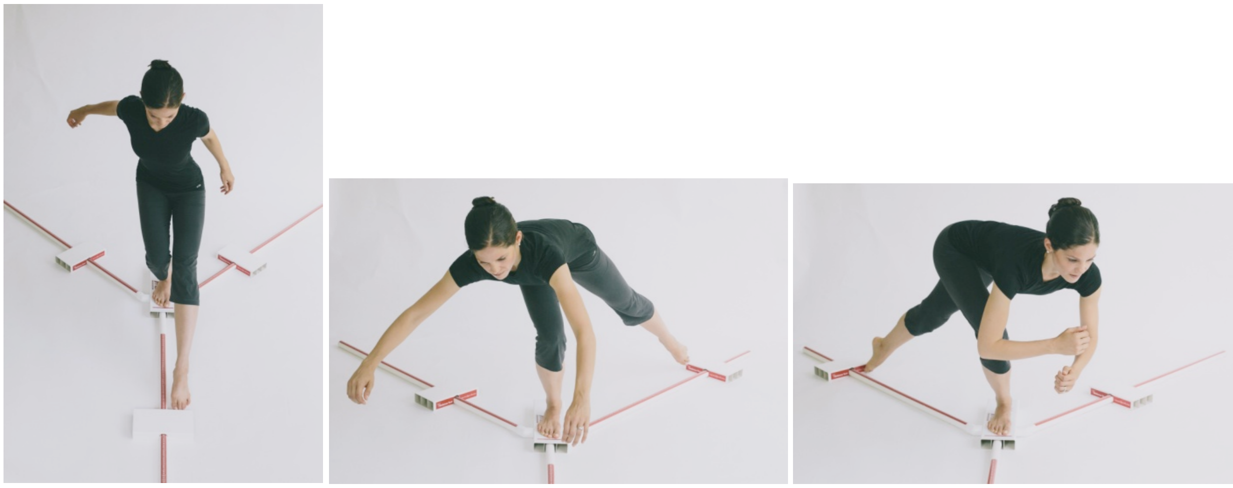
*** = Study used the 3 directions of the YBT taped out on the floor (Similar to SEBT).*

Single reach score is the average of right and left mean scores.

BOLD = Statistical Significance (Composite & Reach Scores alpha > .007) (Reach Diff alpha >.008)

Appendices

Appendix A: Images of the YBT-LQ (photos: Ben Morejon)



The YBT-LQ: Anterior (ANT), Posteromedial (PM) & Posterolateral (PL) reaches

Appendix B:

CITY UNIVERSITY OF NEW YORK
Graduate Center - Hunter College Campus
Department of Physical Therapy

Project Title: A validity study of the Y Balance Test to evaluate symmetry in a dancer population

Intake Questionnaire

Assigned Subject # ______

Age ______________

Gender ______________

Years of Training ______________

Training Emphasis (circle all that apply) modern jazz ballet tap

Previous Surgeries

____

Medical Diagnoses

____

Have you had any of the following in the past few months? Please place an "X" in any applicable space. (Pain is defined here as pain that is not "performance pain" that has lasted greater than 7 days and has restricted your ability to participate fully in dance class or performances.)

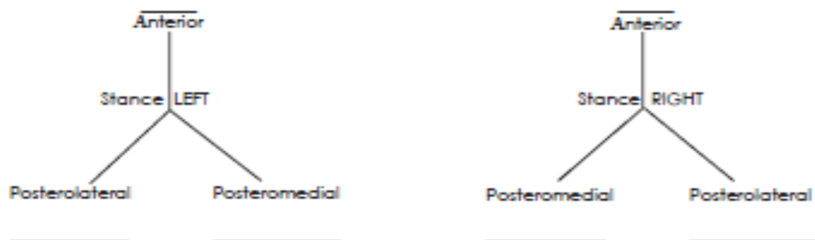
	<1 month	1-3 months	3-6 months	6-12 months	>1 year
Foot pain					
Ankle pain					
Knee pain					
Hip pain					
Low back pain					

Appendix C:

Score Sheet for Y Balance Test™ & Limb Length

Athlete Name: ______________________________ Date: ____________________

RIGHT Limb Length: ____________________



	Left	Right	Difference
Anterior			
Posteromedial			
Posterolateral			

*** Difference should be less than 4 cm. for return to sport and preparticipation screening ***

$$\text{Composite Score} = \frac{(\text{Anterior} + \text{Posteriomedial} + \text{Posterolateral})}{(3 \times \text{Limb Length})} \times 100$$

Composite	
Right	
Left	

("What is Move2Perform?" n.d.)

Appendix D:

Y Balance Test™ Protocol:

Have the individual practice 6 trials on each leg in each of the 3 reach directions prior to formal testing. This is because researchers have found a significant learning effect with the SEBT where the longest reach distances occurred after 6 trials followed by a plateau. Practice can occur off of the device. If you are testing a large group, have everyone practice while waiting to be tested. The test is performed with the shoes off. The person should stand on 1 leg on the center foot plate with the most distal aspect of the toes just behind the red starting line. While maintaining single leg stance, the person reaches with the free limb in the anterior, posteromedial, and posterolateral directions in relation to the stance foot. In order to improve the reproducibility of the test establish a consistent testing protocol. The recommended testing order is 3 trials standing on the right foot reaching in the anterior direction (right anterior reach) followed by 3 trials standing on the left reaching in the anterior direction. This procedure is repeated for the posteromedial and the posterolateral reach directions. The specific testing order is right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral.

The person stands on the platform with toes behind the line and pushes the reach indicator in the red target area in the direction being tested. The maximal reach distance is measured by reading the tape measure at the edge of the reach indicator, at the point where the most distal part of the foot reached in half centimeters (e.g. 68.5, 69.0, 69.5 cm). The reach is discarded and repeated if the subject: 1) fails to maintain unilateral stance on the platform (e.g. touches down to the floor with the reach foot or falls off the stance platform), 2) fails to maintain reach foot contact with the reach indicator on the target area while in the reach indicator is in motion (e.g. kicks the reach indicator), 3) uses the reach indicator for stance support (e.g. places foot on top of reach indicator), or 4) fails to return the reach foot to the starting position under control. The starting position for the reach foot is defined by the area immediately between the standing platform and the pipe opposite the stance foot. The greatest successful reach for each direction is used for analysis. The greatest reach distance from each direction is summed to yield a composite reach distance for analysis of overall performance on the test.

Lower Limb Length: After the person lifts the hips off the table, the examiner passively straightens the legs to equalize the pelvis. The person's right limb length is measured in centimeters (to the nearest half centimeter) from the most inferior aspect of the anterior superior iliac spine to the most distal portion of the medial malleolus.

Score Analysis

The difference between the right and left reach distance is calculated for each direction. This difference should not be more than 4cm. The total (composite) reach distance compared to limb length is also calculated by adding the three reach directions together and dividing by 3 times limb length (in cm) then multiplied by 100.

("What is Move2Perform?" n.d.)

Appendix E: Photos of dance movements similar to the YBT-LQ

Tendu with *plies devante*

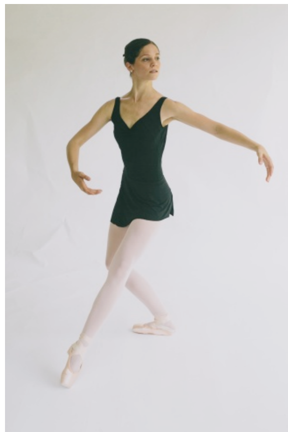



Figure 1a Figure 1b

Tendu a la seconde efface


Figure 2a Figure 2b

Tendu derrière croise

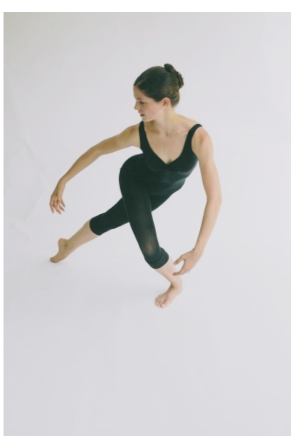



Figure 3a Figure 3b

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