Dancer Performance on the Lower Quarter Y Balance Test: A Longitudinal Study

Megan DeHey
Graduate Center, City University of New York

Kelly Kaems
Graduate Center, City University of New York

Molly Saunders
Graduate Center, City University of New York

Gabrielle Schneider
Graduate Center, City University of New York

Recommended Citation
DeHey, Megan; Kaems, Kelly; Saunders, Molly; and Schneider, Gabrielle, "Dancer Performance on the Lower Quarter Y Balance Test: A Longitudinal Study" (2015). CUNY Academic Works.
https://academicworks.cuny.edu/gc_etds/814
DANCER PERFORMANCE ON THE LOWER QUARTER Y BALANCE TEST: A LONGITUDINAL STUDY

by

MEGAN DEHEY
KELLY KAEMS
MOLLY SAUNDERS
GABRIELLE SCHNEIDER

A capstone research project submitted to the Graduate Faculty in Physical Therapy in partial fulfillment of the requirements for the degree of Doctor of Physical Therapy. The City University of New York.
2015
This manuscript has been read and accepted for the Graduate Faculty in Physical Therapy in satisfaction of the dissertation requirement for the degree of Doctor of Physical Therapy.

Gary Krasilovsky, PT, PhD

Date

Chair of Examining Committee

Jeffrey Rothman, PT, Ed.D

Date

Executive Officer
Abstract

Dancer Performance On The Lower Quarter Y Balance Test™: A Longitudinal Study

by

MEGAN DEHEY
KELLY KAEMS
MOLLY SAUNDERS
GABRIELLE SCHNEIDER
Clinical Adviser: Mark M Lusk
Faculty Adviser: Susan Pivko

Purpose: There is a need in the current literature for further information regarding dancer performance on the Y Balance Test (YBT). This study tracked the test scores of a group of dancers to assess change over time and relationship of balance scores to injury risk. It is hoped that clinicians may be able to use the information found in this study to more accurately screen dancers for asymmetries, deficits, and changes over time using the YBT. Such screenings would allow for more effective care and better assessment of readiness to return to dance.

Method: A group of 12 dancers between 18 and 23 years of age were recruited as volunteers from the State University of New York (SUNY) at Purchase Conservatory of Dance. All participants signed informed consent forms. Both the Hunter College Human Research Participation Program and the SUNY Purchase Institutional Review Board approved this research. The subjects filled out questionnaires and were assessed using the YBT on two dates, 14 weeks apart. The questionnaires documented years of training, injury history and current injury status. The standardized YBT protocol delineated by Plisky et al. (2009) was used. The researchers hypothesized that the subjects’ scores would remain the same or even improve during the study. Data Analysis: Scores were compiled for each subject’s reach distances, and
injury status was recorded. Composite reach scores were subsequently calculated. All reach
distances were normalized using subject leg length for comparison between subjects. Reach
scores were analyzed for statistical significance using a confidence level of 95% (2x standard
error) and an independent t-test analysis (p<0.05) was performed to assess relationship of injury
to reach distance. **Results:** No statistically significant change in reach scores was found for the
group as a whole, and no correlation of reach distances with presence of injury was found for the
group as a whole. Some individuals did show significant changes, but no pattern was discernible
with relation to injury. **Discussion/Conclusion:** Further research is needed on the performance
of dancers on balance tests such as the YBT. It is possible that more sensitive instruments or
more dance-specific normative values are needed to truly assess dancers’ balance performance
and injury risk.
Acknowledgements

The members of this research group wish to express their sincere gratitude and appreciation to the following people, without whom this project would not have been possible:

To our clinical advisor Dr. Mark Lusk, DPT, CFMT (Premier Physical Therapy) for conceiving and sharing his research vision, and for his dedication and assistance throughout each step of this journey; Dr. Susan Pivko, BPT, Cert. MDT, DPT, our faculty advisor, for her guidance, expertise and dedication which kept this project moving forward; Dr. Gary Brooks, PT, DrPH (Associate Professor, SUNY Upstate Medical University) for his excellent statistical analysis and insight; Dr. Suzanne Babyar, Dr. Gary Krasilovsky & the entire Hunter College Faculty for their support, constructive criticism and professional advice throughout our academic careers; Dr. Wallie Wolfgruber, the dancers, faculty & staff of SUNY Purchase Conservatory of Dance for welcoming us onto their campus and allowing us to utilize their remarkable talents; Phillip Plisky, DSc, PT, Robert Butler, PT, DPT, PhD, & Paul Gorman, PTA, ATC, CSCS (YBT-LQ Researchers) for their research, dedication and insights into the Y-Balance Test and functional movement testing; Heather Cole, Jinny McGivern, Anna Morejon & Tiffany Sudol, authors of a previous YBT dance study, for their contribution to the research topic, their wonderful photographs, and helpful advice. Finally, we would like to thank our family and friends for their love, patience and never-ending support.
# Table of Contents

**TITLE PAGE** ........................................ 1

**COPYRIGHT PAGE** .................................. II

**APPROVAL PAGE** .................................... III

**ABSTRACT** .......................................... IV

**ACKNOWLEDGEMENTS** .............................. VI

**TABLE OF CONTENTS** ............................... VII

**LIST OF TABLES** .................................... VIII

**LIST OF FIGURES** .................................. IX

**INTRODUCTION** ................................. 1
   B\_ALANCE ........................................... 1
   B\_ALANCE S\_CREENING T\_OOLS ..................... 3
   R\_ELIABILITY AND V\_ALIDITY OF THE S\_TAR E\_XCURSION B\_ALANCE T\_EST ..... 4
   D\_EVELOPMENT OF THE Y B\_ALANCE T\_EST: I\_MPROVEMENTS TO THE SE\_BT ..... 6
   C\_LINIMETRIC P\_ROPERTIES OF THE Y B\_ALANCE T\_EST .......................... 7
   N\_EED FOR THE S\_TUDY .............................. 9
   P\_URPOSE ........................................... 10

**METHOD** .......................................... 11
   S\_UBJECTS ......................................... 11
   I\_NSTRUMENTATION ................................ 12
   P\_ROCEDURES ...................................... 12

**DATA ANALYSIS** .................................. 15

**RESULTS** ......................................... 16
   D\_ESCRIP\_TION OF SAMPLE ......................... 16
   O\_BSERVATION OF PERFORMANCE OVER TIME .......... 17
   R\_ELATIONSHIP BETWEEN HISTORY OF INJURY AND OUTCOMES ..................... 17

**DISCUSSION** ...................................... 17
   L\_IMITATIONS ...................................... 20
   C\_ONCLUSION ...................................... 21

**TABLES** ........................................... 22

**REFERENCES** ...................................... 23
List of Tables

Table 1. Sample Demographics

Table 2. Mean Group Reach Scores

Table 3. Individual Change in Reach Score and Injury Status
List of Figures

Figure 1. Y Balance Test Mechanism

Figure 2. Reach Directions of the YBT
Introduction

Balance

Balance, both static and dynamic, and a keen sense of proprioception are essential components of athletic activity. Nashner (1993) describes balance as a “complex process involving the coordinated activities of multiple sensory, motor, and biomechanical components; calling upon visual, vestibular, and somatosensory inputs” (p.261). Furthermore, coordinated actions of the lower extremity and trunk muscles control the hip, knee, and ankle joints to create balanced movements (Nashner, 1993). Plisky et al. (2009) report unilateral balance and dynamic neuromuscular control are required for sport. These coordinated movements can impact athletic ability.

Just as all athletes need balance to control movement and remain physically healthy, dancers learn to find their center of gravity in order to maintain balance, produce fluidity of movement, and lower the probability of injury (Crotts, Thompson, Nahom, Ryan, & Newton, 1996). Dance is similar to other sports in that it requires intense training, strict discipline, and athletic prowess. However, dance demands its own set of unique physical abilities. A study by Crotts et al. (1996) found professional dancers have better balance abilities than non-dancers of a similar age. Fifteen dancers were tested for balance against a control group under six different conditions while standing on one leg. The dancers performed significantly better than the control group, particularly in the most challenging balance tests. It has also been demonstrated that dancers exploit a more variable set of learned strategies for balance (Batson, 2010). In her 2010 study, Batson tested balance in 33 dancers ages 20.1 ±1.4 years from two contemporary dance conservatories, and found variability between subjects and within each subject. For
example, certain dancers used deeper knee and hip flexion to accomplish the balance tasks, while others performed the test by swinging their leg out with a straight knee. The dancers also incorporated versatile movements of the upper torso, head and eyes. Batson (2010) suggests the adaptive balance strategies stem from years of physical dance classes, and the variety in performance execution may be accounted for by differences in dance training (classical versus modern release-based training).

Although research has clearly shown balance dysfunction and proprioceptive deficits to be a risk for injury in athletics, studies conducted on dancers have been more inconclusive (Batson, 2010; Clark & Redding, 2012; McGuine, Greene, Best, & Leerson, 2000; Nashner, 1993). McGuine et al. (2000) found preseason balance measurements served to predict susceptibility to ankle injury in 210 male and female high school basketball players. Research on dancers has not been as straightforward or predictable. Clark & Redding (2012) tested 85 contemporary dance students (men & women with a mean age of 19) to explore potential links between balance and dancers’ previous lower limb injuries and susceptibility to future lower limb injuries. Postural sway was calculated by having the participants perform static and dynamic balance tasks on a pressure pad. Information on previous lower limb injuries was collected before testing via a self-report survey, and the dancers also completed a survey at the end of the ten-month trial to report any injuries sustained during that time. Results from the study found a link between previous injury and postural sway, indicating certain balance tasks may identify proprioceptive deficits in dancers stemming from previous injury. However, unlike McGuine et al.’s (2000) study that connected balance instability with future injury in basketball players, Clark & Redding’s (2012) research did not connect greater postural sway with future lower limb injuries in dancers. The results were even contrary to expectations as the dancers
with poor postural stability had a 15% chance of future injury, while those with good balance were found to have a 47% chance of future injury.

The previously mentioned study by Batson (2010) on 33 pre-professional dancers also found inconclusive results when testing dancers for balance. Administering single-leg balance tasks using the Star Excursion Balance Test (SEBT), Batson (2010) sought to screen dancers with and without a history of lower extremity injury. The basic test was given along with three modifications to increase balance challenges and simulate real dance training conditions. The results, contrary to Clark & Redding’s (2012) study, did not find a significant difference in balance ability between dancers with and without previous lower extremity injury. Additionally, dancers were found to balance and reach comparable distances with both limbs regardless of the side of lower extremity injury. These differences in findings between dancers and other populations and dancers in separate studies may be due, in part, to dancers’ unique performance on commonly used balance tests. Dancers, who intensely train to achieve stabilization while in one position and while moving through space, seem to utilize successful movement and proprioceptive strategies to maintain balance (Crotts et al., 1996). It is possible that many of the studies on balance in dancers are inconclusive due to lack of sensitivity in the evaluation methods that may not accurately reflect a dancer’s specialized training and superior performance in that area of movement. In examining dancers for balance capability, there is a need for a test that truly challenges a dancer’s balance and dance-specific set of normative values in order to determine a true injury risk or a true capability of returning to performance.

**Balance Screening Tools**

Functional balance screening tools are often employed to test balance ability in athletic populations. However, because dancers tend to have exceptional balance and control, it is
important to explore screening tools that may accurately score a dancer’s ability. In 1995, Gary Gray designed the SEBT to challenge postural control, strength, range of motion, and proprioception (Coughlan, Fullam, Delahunt, Gissane, & Caulfield, 2012). The test requires the participant to maintain a single-legged stance in the center of a grid while maximally reaching the opposite leg along a set of eight multi-directional lines equally spaced 45° apart and metered with a tape measure. Using the distal end of the reach foot, the participant touches the farthest point on each line that he/she can reach without compromising equilibrium (Hertel, Braham, Hale, & Olmsted-Kramer, 2006). The greatest of three trials for each reach direction is then analyzed, and the greatest reach distance from each direction is summed to yield a composite reach distance for analysis of the overall test performance (Plisky, Rauh, Kaminski, & Underwood, 2006).

**Reliability and Validity of the Star Excursion Balance Test**

Dallinga, Benjamimse, & Lemmink (2012) conducted a comprehensive systematic review of relevant studies performed between 1966 and 2011 examining the reliability, and injury-prediction capability of different screening methods. Their review highlighted the SEBT as both reliable and predictive of lower extremity injury. Furthermore, based on a systematic review of over a decade of research (Gribble, Hertel & Plisky, 2012), the SEBT is considered a “reliable measure and a valid dynamic test to predict risk of lower extremity injury, to identify balance deficits in patients with lower extremity conditions, and to be responsive to training programs in healthy participants and those with lower extremity conditions” (p. 339).

Olmsted, Garcia, Hertel & Shultz (2002) used the SEBT to test balance in 20 patients ages 19.8 ± 1.4 years with chronic ankle instability (CAI) to determine if the tool could detect balance deficits in patients. When compared with a control group of 20 uninjured subjects ages
20.2 ± 1.4 years matched by sex, sport, and position, the CAI group had significantly lower mean reach scores in all eight directions (mean: 78.6cm versus 82.8cm, p < 0.05) and significantly lower total reach scores when standing on injured limbs vs. uninjured limbs (78.6 cm versus 81.2 cm, p < 0.05). Thus, Olmsted et al. (2002) concluded that the SEBT appears to be an effective means of determining reach deficits both between and within subjects with unilateral CAI.

Akbari, Karimi, Farahini, & Faghihzadeh (2006) evaluated balance in 30 male athletes ages 22.8 ± 4.8 years with acute lateral ankle sprains. Using the SEBT, they determined that the mean distance reached when balancing on the involved leg (mean ± SD: 84.97cm ± 10.26cm, p < 0.025) was significantly less than the mean distance reached when balancing on the uninvolved leg (mean ± SD: 86.80cm ± 9.34cm, p < 0.025).

Herrington, Hatcher, Hatcher, & McNicholas (2009) sought to determine if decrements of SEBT reach distance were associated with ACL deficiency (ACLD). Administering the SEBT on 25 ACLD patients (17 male and 8 female, mean age 30 SD 4.5) and 25 matched controls, significant differences were found in the anterior, lateral, posteromedial, and medial directions between the control group and affected limbs of the test group. In addition, significant differences were found between control limbs and the unaffected limbs of the patients in the medial and lateral directions.

Though Olmsted et al. (2002), Akbari et al. (2006), and Herrington et al. (2009) determined that the SEBT could detect balance differences in those with current chronic or acute ankle injury or ACLD, these studies did not explore whether the tool could be employed as a predictor of future injury or draw a relationship between balance scores and how they may differ depending on the sport. Furthermore, the sample sizes were limited and the researchers did not
test subjects more than once over a longer period of time to assess whether scores remained constant.

In a study designed to determine if SEBT reach distance was associated with risk of lower extremity injury among high school basketball players, Plisky et al. (2006) determined that players with a side-to-side discrepancy in reach distance > 4 cm were 2.5 times more likely to sustain a lower extremity injury (p < 0.05), and that girls with a composite reach score of <94% of their leg length were 6.5 times more likely to sustain a lower extremity injury (p < 0.05). This led the researchers to suggest that the SEBT may be more effective than other tests in identifying athletes at a greater risk for future injury.

To assess the reliability of the SEBT reach distances and limb length measurements, Plisky et al. (2006) also conducted a pilot study prior to the basketball season with 10 female and 4 male basketball players (n = 28 limbs) and found that the intrarater reliability using Intraclass Correlation Coefficients (ICC) and method error ranged from 0.82 to 0.87 for the three reach directions and 0.99 for limb length, indicating good intrarater reliability. Following the season, 10 male and 10 female players who participated in the study (n = 40 limbs) completed the SEBT protocol an additional time, revealing good test-retest reliability with the ICC ranging from 0.89 to 0.93 and the method error coefficient ranging from 3.0% to 4.6%. Plisky et al. (2006) thus provided evidence testing a larger sample size over a full basketball season that components of the SEBT are reliable and predictive for measures of lower extremity injury in high school basketball players.

**Development of the Y Balance Test: Improvements to the SEBT**

A number of limitations in the SEBT have been identified, including lack of efficiency and clinical feasibility. The YBT was developed in efforts to address many of the major
shortcomings of the SEBT. The SEBT takes a significant amount of time for a participant to complete (six trials, and three measures in each of eight directions, totalling 144 reaches) and it has been shown that requiring all eight reach directions is redundant (Herrington et al., 2009; Hertel et al., 2006; Plisky et al., 2006). In an effort to improve clinical feasibility of the SEBT in measuring dynamic balance, the Y Balance Test™ (YBT) examines three rather than eight directions – anterior, posteromedial (associated with hip abduction strength) and posterolateral (associated with hip extension), looking for side-to-side symmetry and composite reach distances.

The SEBT is formed by placing tape on the floor at prescribed reach angles. However, there is the possibility of variability here, and studies have shown that there is also difficulty for the examiner in monitoring stance-foot for movement while simultaneously marking the subject’s reach distance on the tapes (Gribble et al., 2012). The YBT uses a manufactured measurement device with scaled measurement dowels in each of the three directions, and the subject pushes an indicator along these scales. The indicator also standardizes reach height (not accounted for by the SEBT), and remains at the furthest distance once pushed, increasing measurement accuracy.

With the SEBT there are also many variations in reach protocol across studies (Gribble et al., 2012; Plisky et al., 2009). The YBT uses a standard testing protocol across studies, including subject practice sessions, order of reaches and normalization of scores to account for leg length to improve interrater reliability and minimize effect of fatigue on stance limbs.

**Clinimetric Properties of the Y Balance Test**

In the examination by Plisky et al. (2009), single limb stance excursion distances were measured using the YBT on a sample of 15 male collegiate soccer players ages 19.7 ± 0.81
years. ICC’s were used to determine the reliability of the test. Two raters observed all testing at the same time, both blinded to each other’s scoring. Participants completed a second round of the test approximately 20 minutes later using a single rater to measure intrarater reliability. The ICC for intrarater reliability ranged from 0.85 to 0.91 and from 0.99 to 1.00 for interrater reliability. Composite reach score reliability (which accounts for leg length measurements to normalize the reach distances) was found to be 0.91 for intrarater reliability and 0.99 for interrater reliability. These results led to the conclusion that the YBT has good to excellent intrarater and interrater reliability, and is thus a reliable test for measuring single limb stance excursion distances while performing dynamic balance testing for this particular population.

To examine inter-rater test-retest reliability of the YBT in a military setting using novice raters, Shaffer, et al. (2010) administered the YBT to 64 healthy active duty soldiers ages 25.2 ± 3.8 years. The maximal average reach distances of three trials were recorded by two different raters for each participant in each direction at baseline and 48 hours post primary testing. ICC’s and standard error of the measurement (SEM) were calculated on each reach distance and composite score. ICC values for interrater reliability maximal reach ranged from 0.80 to 0.85 with an associated SEM ranging from 3.1 to 4.2cm for each direction. ICC values for interrater reliability with the average of three trials ranged from 0.85 to 0.93 with an associated SEM range of 2.0 to 3.5cm for each direction. The novice raters thus demonstrated good interrater reliability and an acceptable level of YBT error. Shaffer et al. (2010) also found that 20 subjects had differences in anterior reach of right/left limbs > 4 cm, which researchers postulated could be a predictor of future injury based on previous studies that showed side-to-side reach distance discrepancies > 4cm as predictive of injury (Plisky et al., 2006).
Gorman, Butler, Rauh, Kiesel, & Plisky (2012) used the YBT to assess whether scores differed between single-sport athletes and multiple sport athletes. They compared 92 single-sport high school athletes with 92 multi-sport high school athletes matched in age, gender and sport. Though composite reach scores and reach direction asymmetry measures resulted in no significant difference between groups, Gorman et al. (2012) showed the reliability and validity of the YBT in measuring dynamic balance in a larger population of high school athletes.

Need for the Study

Reliability and validity of the SEBT and YBT have been established in assessing dynamic balance, and normative baseline measures have been reported for some athlete groups including basketball (Plisky et al., 2006) and soccer players (Plisky et al., 2009). However, other research has shown that there is significant variation in normative values between athletes and non-athletes, as well as among different types and levels of athletes (Butler, Southers, Gorman, Kiesel, & Plisky, 2012). Thorpe and Ebersole (2008) studied the performance of female soccer players as compared to females who did not play soccer on the SEBT, and determined that the soccer players performed significantly better. This suggests that the SEBT may be sensitive to training status and/or sports-related adaptations. In the study by Bressel, Yonker, Kras, & Heath (2007) the SEBT was used to evaluate the dynamic balance of female collegiate soccer, basketball, and gymnastic athletes, with basketball players scoring significantly lower than soccer players. Soccer players often perform single-leg reaching movements outside their base of support while passing, shooting, and receiving, and this may explain why their performance on the SEBT was better. This suggests that different sports may impose different physical, proprioceptive, and sensorimotor challenges on an individual that would cause them to perform differently on dynamic balance tests.
As mentioned previously, dancers perform better in balance evaluations than non-dancers. Ambegaonkar et al. (2013) found that dancers had higher SEBT scores overall than non-dancers, with significantly greater reach distances in the medial and posterior medial direction. These differences could be a result of the specific balance training that is inherent in dance suggesting that the SEBT may be sensitive to training status and/or sports-related adaptations, highlighting the need to establish different normative values for athletes including dancers based on the specific demands of their sport. Batson (2010) finds the SEBT to be a potentially effective clinical tool for assessing the dynamic balance of dancers, but suggests that more research is necessary and that variations may need to be made in order to make this a more valid test for dancers. The current study will establish how a dancer’s performance on the YBT will be affected over time. Knowledge gained through this study will help provide clinicians with a more effective way to use the YBT to assess dancers.

Purpose

The purpose of this study was to track YBT values of male and female dancers in a college conservatory program over an academic semester to determine if variations occur. Due to the consistent and regimented training of a conservatory dance program, we hypothesize that the dancers’ scores should remain the same or even improve on the YBT throughout the testing period. However, issues such as injuries, fatigue, and overtraining may cause the dancers scores on the YBT to suffer. The information gathered in this study may help clinicians to identify asymmetries, deficits, and changes in scores over time using the YBT when working with the dance population. The information gained in this study on dancers’ long term balance performance may help clinicians to predict injury risk, allow for more effective preventative care, and contribute to a protocol for assessing readiness to return to dance after an injury.
Method

In this study, a group of 12 dancers from the State University of New York (SUNY) at Purchase Conservatory of Dance were assessed at two points over the course of the spring academic semester to assess consistency, improvement or degradation of balance performance over time and to monitor injury occurrence over the period.

Subjects

The subjects were recruited as volunteers via flyers and email announcements at the SUNY Purchase Conservatory of Dance. The participants were limited to students of one conservatory in order to keep a consistent study population and environment over time. For the purposes of this study, all participants were between the ages of 18 and 25 upon intake and enrolled in the SUNY Purchase dance program, which sets a baseline competitive skill level dictated by SUNY admissions. Exclusion criteria for initial testing were as described by Gorman et al. (2012): lower extremity amputation, vestibular disorder, lack of medical clearance for participation, undergoing treatment for inner ear, sinus or upper respiratory infection or head cold, or cerebral concussion within the previous 3 months. Exclusion criteria added were: psychological impairment, students under 18 years of age or over 25 years of age, and non-English speaking students. For subsequent testing dates, exclusion criteria included only lack of participation in the initial testing date. All other injuries and illnesses listed above for the initial testing date may have excluded the subject from performance of the YBT itself on the subsequent dates, but subjects were still asked to fill out the questionnaire regarding injuries on each testing date.
Both the Human Research Participation Program (HRPP) at Hunter College and the SUNY Purchase Institutional Review Board (IRB) approved this research. Only volunteers who met all inclusion criteria and signed the informed consent forms were cleared for participation in the study.

**Instrumentation**

All testing was conducted with use of the YBT mechanism, pictured below.

Figure 1. Y Balance Test Mechanism

(Picture Credit: Ben Morejon)

**Procedures**

Testing took place in a dance studio on the SUNY Purchase campus. The intake and testing were separated into: paperwork and intake, instructional video, practice session on simulated YBT taped out on the floor, leg length measurement and finally scored YBT testing on the device. Each of these steps was administered by a different examiner, but the examiner in each step remained consistent across all subjects and both testing dates to ensure consistency. All examiners were certified in the administration of the YBT. Upon arrival, each subject was asked to sign informed consent, and then given a number identifier. The subjects filled out a brief
questionnaire on their individual dance background and a general injury history prior to entering the testing studio. Once in the studio, subjects were shown the “Y Balance Test Group Testing Procedure” directional video, then given the opportunity to practice on a simulated Y Balance Test taped out on the floor. Each subject was directed to perform six practice trials in each of the three test directions on each leg. Six practice trials were performed prior to the formally scored YBT, due to the significant learning effect found with the SEBT where the longest reach distances occurred after six trials followed by a plateau (Plisky et al., 2009). The same video instruction and practice sessions were used on all testing dates. After the practice session, the subjects’ leg lengths were measured. The examiner equalized each subject’s pelvis by passively aligning the pelvis and straightening the legs, then measuring, in centimeters, from the inferior aspect of the anterior superior iliac spine to the distal aspect of the medial malleolus. This enabled normalization of scores for comparisons between subjects and to normative data.

Participants were then directed to perform the scored test on the YBT equipment. The scoring examiner was blinded to the participants’ questionnaire responses or prior performance scores at the times of testing. The following YBT testing protocol is the standardized protocol developed by Plisky et al. (2009) and was used for all of the testing dates.

The subject performs the test with bare feet to remove the possible interference of different shoe types. The subject stands on one leg on the center footplate with the most distal aspect of the toes just behind the red line for the starting position. The subject maintains the single leg stance while reaching with the free leg in the anterior, posteromedial and posterolateral directions (Figure 2). All directions are labeled and scored in reference to the stance foot, not the reaching foot. For example, a subject’s Right Anterior reach indicates that the subject is standing on the right leg, and reaching in the anterior direction with the left foot (Figure 2).
The protocol for testing is three trials in each reach direction, with the maximum reach of the three trials recorded for scoring. The testing order is right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral. The stance foot is alternated to prevent fatigue and improve consistency (Plisky et al., 2009).

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 in half centimeters (e.g. 67.0, 67.5, 68.0). 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 or shoves the reach indicator using momentum), 3) uses the reach indicator for stance support (e.g. places foot on top of the reach indicator), or 4) fails to return the reach foot to the starting position under control. Stance foot motion is allowed (wobbling or lifting of the heel or forefoot) as long as the toes are maintained behind the starting line. Body motions are also allowed (e.g. arm waving, leaning) as long as the prior listed disqualifications do not occur.
Eighteen dancers met the inclusion criteria for the initial testing date and were recruited for the study at the beginning of the spring semester (Table 1 - Sample Demographics). The research team returned 14 weeks later, at the end of the spring semester, and re-tested subjects. Participants were notified via email of the second data day, and 12 subjects returned. Subjects were retested using the protocol identical to the first testing date. Subjects filled out a follow-up questionnaire to record new injuries since baseline test, viewed the instructional video and performed the six practice reaches before performing the final scored test.

**Data Analysis**

Composite reach scores were calculated by taking the mean of the greatest reach in each direction. The composite reach scores were then normalized to allow for comparison between studies and subjects. The subject’s reach distances were normalized by presenting them as a percentage of the subject’s leg length (composite score divided by subject’s leg length and multiplied by 100). Normalized composite scores and directional scores were used for comparisons during data analysis.

Standard deviations and standard errors were calculated for each direction, for the composite scores, and for the group’s mean scores. The margin of error for meaningful change was set at 2 standard errors, corresponding to the 95% confidence intervals set as statistical significance. Using these margins of error, each subject and the group as a whole were analyzed for meaningful change from baseline to subsequent measurement.

In addition, information was gathered on subjects’ prior injury history and any new injury between baseline testing and subsequent testing. The injury information was based on body part (e.g. hip, knee, ankle, back) and side of the body (R, L, Bilateral). When based on body part or
side of the body, the sample sizes were very small, so for analysis, the injury status was
categorized as “injury” vs. “no injury.” Baseline scores and subsequent scores (difference
scores) were compared to injury status to check for correlation between new injury status and
difference in score from baseline. The p-values were derived from independent samples t-tests
to assess correlation between injury and change in YBT reach score. Statistical significance was
set to p < 0.05.

Results

Description of sample

On the first testing day, 18 subjects were tested (8 male and 10 female). On the
subsequent testing date, 12 subjects returned and only these 12 subjects’ results were used for
final analysis. The baseline reach scores are listed in Table 2 (Mean Group Reach Scores). The
anterior reach mean (SE) was 73.9 cm (1.68), the posteromedial reach was 123.4 cm (2.90), and
posterolateral reach was 121.9 cm (2.83), with a mean composite reach of 106.4 cm (2.29). Of
the 12 subjects to complete the study, 5 were male and 7 were female, with a combined mean
(SD) years of dance training of 10.5 (4.0). Table 3 (Individual Change in Reach Score and
Injury Status) depicts the frequency of injuries at baseline and the frequency of new injuries for
the 12 returning subjects. To be defined as an injury for the purposes of this study, the injury
must have been sustained within the last 3 months since baseline testing and must have been
serious enough to cause the subject to refrain from dance for some amount of time. Via the
questionnaire, 10 subjects reported a total of 15 new injuries since initial testing. Two of the
returning subjects reported no new injuries at follow-up.
Observation of performance over time

No significant difference was found in overall reach scores between the test dates when considering the mean value for the total sample, shown in Table 2 under the Mean Difference column. Table 2 depicts performance over time in the 12 subjects that returned for follow-up, utilizing the measure of Standard Error (SE) derived from the mean scores. In looking at the raw data, the YBT scores did show statistically significant change in some individual subjects and directions. These changes were noted in both improvement and degradation (positive and negative values) in performance, illustrated in Table 3.

Relationship between history of injury and outcomes

Utilizing an Independent Samples t-test, no significant difference was found in any of the three reaches between subjects with and without an injury. There was also no significant difference in the composite reach score between injured vs. non-injured subjects. Table 3 outlines the difference between reaches of dancers who reported no injury in the past year and dancers who reported an injury within the previous 12 months.

Discussion

The purpose of this study has been to track YBT values of male and female collegiate level dancers over an academic semester to determine if change in balance scores and injury status occurs. Mean group performance on the YBT over the academic semester did not show a clear pattern of statistically significant change. In addition, when analyzing subjects as a group, the current research did not find an association between YBT scores and presence of a new injury.
As originally hypothesized, no significant changes were detected in the dancers’ group scores between the first and second testing dates. Evidence from past research determined that dancer’s employ excellent balance abilities due to their regimented and specialized training (Ambegaonkar et al., 2013; Batson, 2010; Crotts et al., 1996). Constantly practicing both static and dynamic balance, dancers have been found to possess a higher degree of skill than the normal population and even trained athletes (Ambegaonkar et al., 2013; Crotts et al., 1996). The inconclusive findings from the current study support the previous research on this topic. The dancers as a group were consistent in their balance ability and maintained a high level of performance over time.

Even though overall group analysis using mean scores displayed no apparent change between the two test dates, statistically significant change did occur within certain individual subjects. For the anterior reach direction, three individuals exhibited real improvement above baseline scores upon follow-up, while one subject declined. On the posteromedial reach, two subjects demonstrated real improvement while one was found to have meaningful decline (Table 3). For the posterolateral direction, one subject demonstrated real improvement and three had degradation of values. Using the composite reach scores, one subject demonstrated real change in advancement of scores while one declined. Therefore, there appears to be improvement or degradation in performance of the YBT in particular individuals that is harder to see in overall group statistical calculations.

Dancers have been found to display excellent balance abilities. Overall the dancers in this study proved to be consistent with balance scores over a semester’s time. However, looking at the individual level, there appears to be some discrepancy in ability between the first and second testing dates. Could there be an underlying factor that led to improvement or degradation...
in balance? The limitations of the current study make it difficult to ascertain a cause with certainty. One possible explanation for the individual improvement found in certain subjects is the benefit from prior practice and performance of the YBT test. Dancers are trained and required to master choreography quickly and are therefore experts of movement acquisition. They may recognize a past balance activity and rise to the challenge with even greater competency the next time they are asked to perform the same skill. As seen in previous studies, dancers have an exceptional capability to adapt and conform to balance challenges (Batson, 2010).

Another possibility for change seen in individual scores may be a relation to factors such as injury, illness or fatigue. This current study attempted to track injuries in order to explain any difference in scores over time. Past research on athletes has found balance instabilities help predict future injuries (McGuine et al., 2000), and the YBT has proven sensitive in its ability to detect functional deficits related to injury in a non-dance population (Hertel et al., 2006). However, research on dancers has yielded inconclusive results when trying to connect balance ability with current or past lower extremity injuries (Batson, 2010; Clark & Redding, 2012). It is possible that old or new injuries may correlate to the increases or decreases seen in YBT individual reach scores. For example, if a dancer was not at peak level performance for the initial testing date due to an injury, the first score may not reflect his or her best balance abilities. Improvement on the second date would then represent the recovery from injury and increase in fitness level. It may also be suggested that a new injury could cause a decline in balance scores upon follow-up testing. 10 of the 12 dancers participating in the study experienced a new injury between the initial and second testing dates. The new injuries may have impacted reach scores in certain subjects. Looking at individual degradation in scores, there may be a trend toward
injury causing change as certain subjects with a new injury experienced a decline, yet some individuals with new injuries experienced an increase in reach scores. Was this difference due to the type and severity of the injury? Future research may choose to track and analyze the type and severity of injury more closely to ascertain the relationship between injury and balance ability. This study found no correlation between new injury status and balance when analyzing the composite reach scores, which makes it difficult to account for the decline in scores, observed in particular subjects.

Lastly, this study may have simply uncovered natural existing variance as individual balance ability may fluctuate from day to day. Quite possibly a single subject will not remain perfectly consistent with balance scores each time he or she is tested and this may or may not suggest a meaningful longitudinal difference.

Although there was no correlation found between performance on the YBT and new injuries, there may still clinically significant information to gather from this study. As stated previously, there have been differences in YBT scores found between numerous groups, including differences between active and inactive individuals (Thorpe et al., 2008), different types of activity (Bressel et al., 2007), and different levels of activity (Butler et al., 2012). In addition, other studies have found the YBT sensitive enough to detect balance deficits related to injury in a young population (Hertel et al., 2006). Therefore, clinicians who work closely with dancers may still be able to utilize the YBT for balance assessment if more sensitive parameters for dancers are developed.

Limitations

Certain limitations must be noted and may or may not correlate to the lack of findings in the present study. The small sample size is a primary limitation that makes it difficult to discern
patterns within the data. Furthermore, the high dropout rate led to an even smaller number of subjects for analysis. Due to practicality and scheduling factors this study is limited in the number of testing dates and the range between dates. It is difficult to divulge longitudinal information within one semester, as this may not be enough time for change to occur. Another limitation is the limited dance population used for testing. The dancers from SUNY Purchase have various backgrounds but are a small and young sample of the dance population. There are certainly many other styles of dance and dancers with professional careers who may perform differently when evaluated on the YBT.

**Conclusion**

Although no statistically significant relationships were found between the group’s YBT performance over time or injury status, individual changes suggest that these relationships may exist and that there is need for future research into the YBT for the dance population. The values found in this study may be beneficial to clinicians for comparison when evaluating dancers for return to dance readiness following an injury or to screen dancers for risk of injury. These values may also be a useful tool in evaluating the efficacy of treatment on a dancer.

Future studies may want to incorporate more testing dates, more subjects, dancers with more varied training styles, and a longer time period when looking at longitudinal change in dancers’ YBT scores. Research on the subject may be valuable to define more sensitive testing parameters on the YBT to reflect the dance population’s unique balance and movement attributes to ensure that injury risk is accurately assessed.
## Tables

### Table 1 – Sample Demographics

N = 18; (12 returned for follow up testing)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Ages</th>
<th>Average Years of Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (n = 8)</td>
<td>18 – 23</td>
<td>8.6</td>
</tr>
<tr>
<td>Female (n = 10)</td>
<td>18 – 21</td>
<td>11.9</td>
</tr>
</tbody>
</table>

### Table 2 – Group Mean YBT Reach Scores

<table>
<thead>
<tr>
<th>Direction</th>
<th>SEx2</th>
<th>Pre</th>
<th>Post</th>
<th>Mean Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant</td>
<td>3.36</td>
<td>73.9 cm</td>
<td>74.9 cm</td>
<td>1.0</td>
</tr>
<tr>
<td>PM</td>
<td>5.80</td>
<td>123.4 cm</td>
<td>123.4 cm</td>
<td>0.1</td>
</tr>
<tr>
<td>PL</td>
<td>5.66</td>
<td>121.9 cm</td>
<td>121.5 cm</td>
<td>-0.5</td>
</tr>
<tr>
<td>Comp</td>
<td>4.58</td>
<td>106.4 cm</td>
<td>106.6 cm</td>
<td>0.2</td>
</tr>
</tbody>
</table>

### Table 3 – Individual Change in Reach Score and Injury Status

<table>
<thead>
<tr>
<th>Subject</th>
<th>Ant (SE - 3.36)</th>
<th>PM (SE - 5.80)</th>
<th>PL (SE - 5.66)</th>
<th>Comp (SE - 4.58)</th>
<th>Injury at Baseline</th>
<th>New Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.31707</td>
<td>0.6098</td>
<td>0.3049</td>
<td>2.7439</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>1.64835</td>
<td>-1.0989</td>
<td>-6.5934</td>
<td>-2.01465</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>1.17647</td>
<td>-4.4118</td>
<td>-1.4706</td>
<td>-1.56863</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>4</td>
<td>4.34783</td>
<td>9.5109</td>
<td>-2.7174</td>
<td>3.71377</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>8</td>
<td>0.83333</td>
<td>-0.5556</td>
<td>-2.5</td>
<td>-0.74074</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>10</td>
<td>5.29412</td>
<td>0.8824</td>
<td>11.1765</td>
<td>5.78431</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>11</td>
<td>-2.16216</td>
<td>-10.5405</td>
<td>-8.6486</td>
<td>-7.11712</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>12</td>
<td>-4.90798</td>
<td>-1.5337</td>
<td>-1.227</td>
<td>-2.55624</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>13</td>
<td>0.57143</td>
<td>6.8571</td>
<td>5.4286</td>
<td>4.28571</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>14</td>
<td>-0.96774</td>
<td>-3.5484</td>
<td>4.5161</td>
<td>0</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>5.7065</td>
<td>3.8043</td>
<td>3.17029</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>16</td>
<td>-0.8427</td>
<td>-1.1236</td>
<td>-7.5843</td>
<td>-3.18352</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>
References


