The Relationship between Posture and Balance in a Pilates Trained Population

A THESIS

Submitted to the Faculty of the School of Graduate Studies and Research of California University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Science

by

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CALIFORNIA, PA

THESIS APPROVAL

Graduate Athletic Training Education

We hereby approve the Thesis of

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<tr>
<td>5-7-07</td>
<td>Dr. Rebecca A. Hess, Advisor</td>
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<tr>
<td>05-07-07</td>
<td>Ms. Christine Romani-Ruby</td>
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<td>Dr. Joni L. Roh</td>
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ACKNOWLEDGEMENT

It seems that it was not that long ago when I came to the United States for the first time. I remember I was so excited about just standing on the land, listening to English, and imagining myself speaking English. All I knew at that time was that I liked English, sports, and communicating with people, but did not know where I was going in the future.

Six years has passed since then, and now I am at the completion of the master’s thesis. The last six years in the U.S. was very meaningful for me not only as an athletic trainer, but also as a person. Many people have helped me and supported me when I had difficulties and they made me think that I wanted to become a better person and return the favor to them by accomplishing something.

This master’s thesis is the culmination of what I have learned in the last six years as a student. Upon the completion of this thesis, I would like to take this opportunity to thank the people who have helped and supported me: my teachers, my coaches, my friends, my girlfriend and my family.

Dr. Hess, it was so much fun working with you on the thesis and on anything. Your knowledge and personality inspired me as a clinician and a person. You also taught me how fun it is to learn something. Chrissy, I could have never finished this thesis without you. Your Pilates and work ethics gave me the new view for the future. Dr. Roh, your insight from another point of view helped the completion of the thesis better.

For people at Cal U: Jamie F, Bill, Amanda, and Dr. Wagner, thank you for the fun year and your help. Coach B, Coach White, and the Cal U softball girls, thank you for the lessons and energy. My classmates, thank you for the fun time.

For people that I met at Indiana State University: Kellie, or Dr. Huxel, thank you for the kindness and a lot of help. Marcus, or Dr. Stone, thank you for your big lesson. Lori, thank you for the challenge and warmth. Paul, thank you for advice. Anthony, thank you for the work ethic and fun.

Finally, I would like to thank my girlfriend and my family: Yuko, thank you for the happiness. Emi, thank you for the joy. Gramma, Setsuko-san, thank you for the cheer. And mom and dad, thank you for your support, care and help for my completion of the challenge in the United States.
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INTRODUCTION

Since Joseph Hubertus Pilates introduced his exercise “Contrology” in 1926, Pilates has long been the exercise choice of dancers. More recently, Pilates has been brought into the health care and sports medicine field by dance medicine,\(^1,2\) and has increased in popularity among fitness professionals for the effect of strengthening core and improving posture as well as balance. Elite athletes and dancers alike use Pilates as a tool for enhancing their fitness condition.\(^1,2\) As its popularity increases, scientific research has supported the effects of Pilates.\(^2-6\) Pilates’ positive effects on dancers’ dynamic posture and balance in the elderly population are the examples.\(^2,3\)

Posture is one of the most important components of athletic ability since optimum posture leads to efficient neuromuscular function.\(^7,8\) Balance is another important component of athletic ability because of its implicit involvement in nearly all forms of movement.\(^9\) Both postural and balance control systems receive the afferent information from visual, vestibular, and proprioceptive inputs. The central nervous system (CNS) then interprets the information and chooses the appropriate musculoskeletal responses.\(^10\) Although Danis et al\(^11\) did not find a
relationship between standing posture and stability of subjects with vestibular hypofunction, results may be different in a healthy, balance-trained population. Specifically, the results may be different among those who have trained with yoga, tai-chi, or Pilates, by challenging the balance.

Balance has been categorized into static, semidynamic, dynamic, and functional balance. When testing static balance, a subject’s dynamic balance may not be challenged. Thus, testing functional balance in those individuals with better athletic ability may be more appropriate. The Star Excursion Balance Test (SEBT) and the Biodex Balance System (BBS) are two of the most reliable and valid ways to assess balance in a more functional environment by challenging the subject’s limits of stability (LOS). LOS refers to the outermost range of an area in space that a person can lean from the vertical position in any direction without losing balance.

Balance training is important to increase awareness of the LOS by creating controlled instability. During balance training, it is important that the sensory information coming into the CNS is optimal at the foot, the sacroiliac (SI) joint, and the cervical spine due to the
large amounts of proprioceptors at these areas. These concepts lead to Pilates as a way of balance training.

Practitioners describe Pilates as a unique method of body conditioning that uses a combination of muscle strengthening and lengthening, and breathing to develop trunk muscles and restore muscle balance to the musculoskeletal system. To perform the body conditioning effectively, there are eight principles; concentration, control, centering, flow, precision, breath, relaxation, and stamina, and two additional concepts, that of neutral spine and spinal articulation. With its unique principles, it has been shown that Pilates has significant effects on the core musculature and improves spinal stability. Additionally, one of the main Pilates concepts, neutral spine, suits the concept of a balance training program. As mentioned, some studies have reported positive effects of Pilates training on posture and balance separately, but not in comparison to each other. Therefore, the purpose of this study was to examine the relationship between posture and balance in a Pilates trained population.
METHODS

Research Design

This study used a small case descriptive design. The dependent variables included posture as scored by the Watson MacDonncha Posture Analysis (WMPA), the overall Limits of Stability (LOS) Score measured on Biodex Balance System (BBS), and the average of normalized eight directional excursion score on Star Excursion Balance Test (SEBT). The independent variable was group (healthy trained vs Pilates trained). Each variable was tested once. Testing order was randomized to control test effect, and all tests were conducted in a quiet room to minimize external effects. The strengths of the study were using existing reliable instruments, and to provide information on the correlation between posture and balance that had not been addressed clearly in the literature. Test results may be limited to the specific age group.
Subjects

Pilates trained adults (N = 8) and healthy trained adults (N = 6) were compared for posture and balance. Pilates trained participants were defined as those who had taken Pilates class at least six months for two hour sessions per week, or a year of one hour session per week, using both mat and universal reformer at least one-third of the time. The criterion was based on the former studies that had evaluated the effects of Pilates.\textsuperscript{3-6} Subjects were selected from local Pilates trained teachers or practitioners and non-Pilates trained adults who were faculty or staff working at California University of Pennsylvania and training a couple of times per week. Each subject was assigned to do LOS BBS, SEBT, and WMPA on the same day. A Subject Information Sheet (Appendix C1), photographic releases form (Appendix C2), and an informed consent form (Appendix C3) was completed by each subject prior to the study. The purpose and the procedure of the study were explained in the informed consent form. Any subjects who had suffered from any visual, vestibular, balance disorder, lower extremity injury and/or a concussion a year prior to the test were not included in the study. All subjects were required to wear spandex
shorts and tank top, or sports bra for the purpose of postural assessment.

Preliminary Research

Preliminary research was conducted to familiarize the researcher with the LOS BBS, SEBT, and WMPA procedures and scoring process. Procedures for each test were carefully followed according to manufacturer’s suggestion and valid research.\textsuperscript{15,25,26} All of the tests were conducted on two adult volunteers who were studying or working at California University of Pennsylvania.

During the Preliminary research, four practice sessions were found to be adequate for the learning effect in the SEBT instead of six. No changes in the score in the SEBT were observed after the four practice sessions, which was different from the report by Hertel et al.\textsuperscript{17}

Instruments

The instruments used in the study included: the SEBT, the LOS BBS, WMPA, subject information sheet (Appendix C1), SEBT score sheet (Appendix C4), LOS score sheet (Appendix C5), postural score sheet (Appendix C6), assessment
procedures for WMPA (Appendix C7), assessment criteria for WMPA (Appendix C8), and postural deviation sheet (Appendix C9).

SEBT

The SEBT is a functional test that quantifies lower extremity reach while challenging an individual’s LOS. The SEBT uses a star on the floor with eight lines, made with athletic tape, extending at 45° increments from the center of the grid. The athletic tape was marked by 5cm from the center of the grid for all eight directions for the measurement of the excursion distance. A higher score indicates that the subject has better balance. No standardized scores for the reach test have been reported to date. The reliability of the SEBT has ranged from .81 to .96.

LOS BBS

Test data such as overall LOS score and time to complete the test were obtained by the BBS. The BBS has been used as a tool to examine dynamic balance. The BBS is a multiaxial device that objectively measures and records an individual’s ability to stabilize the involved joint under dynamic stress. It challenges an individual
to maintain his or her balance while standing on a movable platform that tilts a maximum of 20° (from horizontal plane) in all directions.\(^2^7\) The amount of stability of the platform ranges from 8 (more stable) to 1 (less stable).\(^2^7\) An LCD screen provides visual feedback indicating where center of mass (COM) is on the platform.\(^2^7\) The BBS can be used to assess dynamic bilateral and unilateral postural stability on an unfixed surface, as well as dynamic LOS.\(^1^4\)

LOS can be defined as the maximum angle of a body that a person can lean from the vertical position in any direction without changing his or her base of support (BOS).\(^1^4\) The LOS score percentage is calculated as straight line distance to target divided by actual distance traveled times 100.\(^2^7\) Overall LOS score is calculated as the average of all the 8 targets,\(^2^7\) and the score is recorded on the LOS score sheet (Appendix C5). A higher score indicates better balance. The reliability of LOS on BBS has ranged from .77 to .89,\(^1^4\) and is comparable in terms of coefficients reported for the Functional Reach test and LOS test using the NeuroCom system (.73 to .92 respectively).\(^1^4\)

WMPA

WMPA\(^2^6\) was used to assess subject’s posture. Watson et al\(^2^6\) reported that the reliability of the posture scores
exceeded 85% for all aspects assessed. In the assessment procedure, four photographs were taken from anterior, left lateral, left posterolateral, and posterior view and qualitative and quantitative posture scales were determined.

After the photographs were taken, posture scales were determined by categorizing into three postural scores. Ten aspects of the posture, ankle posture, knee interspace, knee hyperextension and flexion, lordosis, kyphosis, scoliosis, round shoulders, abducted scapulate, shoulder symmetry, and forward head, are selected into three categories. Each category is assigned a score of 5, 3, or 1. A score of 5 corresponds to good body mechanics that ranges from no deviation to a level just above that of the next category. A score of 3 corresponds to a moderate deviation; a score of 1 corresponds to a marked deviation. The assessment procedures for each individual aspect of posture are described in depth in Appendix C7 and for the criteria in Appendix C8. Diagrams used to help make assessments of the various postural deviations are illustrated in Appendix C9. A transparency paper with a grid, another transparency with circle diameters, a protractor, and a ruler are used for the purpose of measuring postural deviations. Scores of the ten aspects of posture are then totaled for the overall posture score,
where higher scores indicate better posture. No standardized scores have been reported for the WMPA to date. Each score of the ten aspects and the total score are recorded on postural score sheet (Appendix C6).

**Procedures**

The study was approved by the California University of Pennsylvania Institutional Review Board (IRB) (Appendix C10). Prior to the study, the researcher sent e-mail to explain the concept of the study and offer the informed consent form (Appendix C3) to all subjects so that each subject understood the need and risks of involvement in the study. Qualifications for the subjects (mentioned in the subject section), requirements and testing dates, and approximate time frame for entire study, which was one hour, were also announced.

Before the tests, qualifications for the subjects were presented again. Once understanding and approving, subjects signed the informed consent form, completed the subject information sheet (Appendix C1), and completed the photographic release form (Appendix C2). Each subject chose a paper from a bowl in which a number representing one test was recorded. Tests were given in the described
random order. There was one minute of rest interval between practice trials and test trials, and five minutes of rest between the tests to minimize the effects of local fatigue. However, fatigue has not been addressed as a limiting factor during balance testing in previous studies.\textsuperscript{12-21,25,28} During the tests, subjects were asked to remove all jewelry, wear form-fitting shorts and tank top, and participate barefoot. Prior to beginning each test, the researcher explained the test procedure and method.

For the SEBT, each subject’s leg lengths were measured bilaterally using the anatomical lengths as the distance between the anterior superior iliac crests and the medial malleolus. The subject stood on one leg and reached to the furthest point of each direction with the other leg. The point reached was recorded in centimeters each time the subjects touched each direction. The reach direction was labeled as the direction from the stance leg.\textsuperscript{15,16} For instance, if a subject stood on the left leg, the left side of the leg was labeled as lateral, the front side was anterior and the front-right side was anteromedial. If the participant made a heavy touch, came to rest, lost balance, or could not return to the beginning position under control, the trial was discarded and the participant was asked to repeat that trial.\textsuperscript{15} The test was started at anterior
lateral side with the left as the stance leg and followed to anterior, anteromedial, and so on. After the trials with left stance leg were completed, the participant switched to the right stance leg and completed the same procedure. Before any data was recorded, four practice trials with the left stance leg in each of the eight directions were performed in order to reduce any potential learning effect.¹⁵,¹⁷ Three test trials were then performed and the average score of the 8 directions was recorded for each trial. The average score of the three trials was calculated and the calculated score was normalized to leg length by dividing the distance reached by leg length.¹⁶ The scores were recorded on the SEBT record sheet (Appendix C4).

During the LOS test, the researcher instructed each subject to stand on the BBS platform and maintain their balance on the unstable platform while chasing the moving target. The researcher set up the subject’s weight, height, platform firmness, difficulty level, and leg to test. Platform firmness was set for moderate and difficulty level was 50% in the bilateral stance.²⁵ All subjects had two practice sessions to be familiarized to LOS testing and to minimize the learning effects.¹⁴ For the test, total of eight target boxes showed up on the screen. Once the
subjects finished with the LOS testing, the LOS score and the time were recorded on the LOS score sheet (Appendix C5).

The standard procedures established by Watson et al was used for postural analysis component of the study. The first stage of the postural analysis procedure was taking four photographs of each subject. For taking photographs, a platform, 20cm high, 60cm long, and 40cm wide was used. There were three colored lines taped on the top. Red was vertical, blue was horizontal, and yellow was at a 45° angle from the left back corner to the front right corner of the box while facing the camera (Appendix C11). Two plumb-lines 1200mm apart were suspended to either side of the platform. Black and approximately 2mm thick cords were used for the plumb-lines. The background was vertical and white in color. A Sony Cyber-shot 4.1 mega pixel digital camera was used for photograph shooting.

The participant was asked to stand on a platform provided and an anterior, left lateral, oblique, and posterior view were taken (Appendix C11) after oral direction (Appendix C12) was given for consistency. The digital camera was placed on a tripod 3000mm from the front of the platform. The camera was placed perpendicular and centrally to the platform. The height of the center of the camera lens was 1200mm from the floor.
During the WMPA, the landmarks were marked on the subject (Appendix C13) while the person was standing on the box so that the markers were not moved with any motion. The markers were placed on: 1) the patellar notch and the greater trochanter of the left side; 2) anteriorly, both clavicle heads, both superior iliac spines, the tibial tuberosities, and the center of the patellae; and 3) posteriorly, C7, T3, T6, T9, T12, L3, L5, and the most prominent point of the sacrum, as well as the center of the calcaneus. Adhesive colored-dots 1cm in width were used as markers. The subject was asked to stand upright staring straight ahead with chin parallel to the ground and to fully extend elbows and knees for all four photographs. The fingers and thumbs were held relaxed at their side in the most comfortable position. If possible the subject’s heels were in contact with each other and the feet parallel. If the subject had genu valgum, the feet were placed as close as possible with the knees touching slightly.

Once pictures were taken, they were downloaded to the computer so that the pictures were printed onto 8”x11” sheet by using Microsoft Office Picture Manager (Seattle, Washington). Using the photographs, ankle varus and valgus, knee interspace, knee hyperflexion and hyperextension, lordosis, kyphosis, scoliosis S and C, rounded shoulders,
scapular winging/abduction, shoulder symmetry, and forward head were measured. To assess posture, a grid was placed over the top of the photographs using transparency paper that was lined up with one of the two plumb lines next to the participants when photographed. Another transparency was used with circle diameters for determining the degrees of lordosis and kyphosis. A protractor and ruler were also used when measuring the desired angles through the reflective marks on the landmarks. Upon assessing each posture, assessment procedures for WMPA (Appendix C7), assessment criteria (Appendix C8), and postural deviation sheet (Appendix C9) were used and the score was recorded on postural score sheet (Appendix C6).

Hypotheses

The following hypotheses were tested in this study:

1) There will be a positive relationship between posture (WMPA) and balance (LOS BBS and SEBT) scores.

2) There will be a difference in those scores due to group (healthy trained vs Pilates trained).
Data Analysis

The following data analyses were used in this study:

1) The Pearson correlation coefficient was used to determine the strength of the linear relationship between posture (WMPA) and balance (LOS BBS and SEBT) scores.

2) Paired t-tests were used to determine a difference in those scores due to group (healthy trained vs Pilates-trained).

These data analysis were performed using the SPSS 13.0 statistical software package at an alpha level of $\leq 0.05$. 

RESULTS

The purpose of the study was to examine the relationship between posture and balance in a Pilates trained population. Each subject was tested by using the SEBT, the LOS BBS and the WMPA in one day. The SEBT and the LOS BBS were used to examine subjects’ dynamic balance and the WMPA was used to examine subjects’ posture.

Demographic Data

There were eight volunteers as Pilates trained and six volunteers as healthy trained subjects. All eight Pilates trained volunteers had at least three years of experience in Pilates, and all six healthy trained volunteers did exercise at least three times a week for at least 40 minutes each time. Tests were conducted in the same way and by the same tester to increase internal validity. All subject information was collected by self-report (Table 1).
Hypothesis Testing

Hypothesis testing was performed by using the 14 subjects who joined the study. All of the hypotheses were tested at the $P \leq 0.05$ alpha level. Descriptive statistics for SEBT, LOS BBS, and WMPA are shown in Table 2.

Hypothesis 1: There will be a positive relationship between posture (WMPA) and balance (LOS BBS and SEBT) scores. The Pearson correlation coefficient was used to determine the strength of the linear relationship between balance (BBS LOS and SEBT) and posture scores (WMPA) within groups.

Conclusion 1: Weak correlations that were not significant were found between SEBT and WMPA ($r(12) = -0.288, P > .05$) and between LOS BBS and WMPA ($r(12) = -0.221, P$...
Balance score (with both LOS BBS and SEBT) was not related to posture score (with WMPA) in the study.

Hypothesis 2: There will be a difference in balance and posture scores due to group (healthy trained versus Pilates trained). The Paired t-test was used to determine difference in BBS LOS, SEBT, and posture scores between groups.

Conclusion 2: No significant difference between the groups was found for LOS BBS (t(5) = .982, P > .05), SEBT (t(5) = -2.03, P > .05), and WMPA (t(5) = .955, P > .05).

Table 2 outlines the total population scores.

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<td>SEBT 2*</td>
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<td>WMPA 2*</td>
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<td>3.72</td>
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* 1 = Pilates trained, 2 = Healthy trained
Additional Findings

The Pearson correlation coefficient was used for further testing to determine the strength of the linear relationship among age, gender, weight, height, and SEBT, LOS BBS, and WMPA scores for each group. A strong negative correlation was found ($r(6) = -.861$, $P = .028$) between age and SEBT score in healthy trained group, indicating a significant linear relationship between the two variables. Younger subjects had better score with SEBT in healthy trained group.

Anecdotal notes were taken for further findings. Subjects generally had a better score with their body leaning away from the reaching leg in the SEBT. However, Pilates trained subjects tended to stand up straight, while Healthy trained subjects tended to lean. Pilates trained subjects had the tendency to stand upward due to the lesson they had for Pilates training. This finding is important since Pilates trained subjects may have better scores once they were instructed the detail procedure in the SEBT.

A paired-samples t test was used to compare the mean age of Pilates trained group to that of healthy trained group. The mean of the Pilates trained group was $52.17 \pm 7.44$, and the mean of the healthy trained group was $39.67 \pm$
11.26 (Figure 1). A significant difference in mean age between the two groups was found ($t(5) = 3.66, P = .015$).

Figure 1. The comparison of mean age between Pilates trained group and healthy trained group.
DISCUSSION

Discussion of Results

The primary findings indicated no significant relationship between posture (WMPA) and balance (LOS BBS and SEBT) scores. It is known that both postural and balance control systems receive the afferent information from visual, vestibular, and somatosensory inputs. The CNS then interprets the information and chooses the appropriate musculoskeletal responses. In that case, it is easy to assume that there is close relationship between posture and balance.

Maintaining ideal posture is vital for normal muscle length-tension and force-couples, as well as joint kinematics to enhance neuromuscular efficiency. If one component of the posture is out of alignment, it creates predictable patterns of tissue overload and dysfunction. This can lead to decreased neuromuscular control which results in abnormal joint movement and proprioception. Abnormal proprioception may lead to abnormal interpretation of body position by the CNS and it results in abnormal musculoskeletal response. Human beings control posture and balance by using ankle, hip, and/or stepping strategies as
musculoskeletal response to the information sent from the CNS. Postural distortion may also affect these strategies due to inefficient use of muscles and lead to balance deficiencies.

While it logically makes sense, a correlation between balance and posture has not been supported. Danis et al. conducted a study for relationship between standing posture and stability and could not find the correlation as well. In the discussion, the author says, “Individuals with larger postural deviations may benefit from postural correction to improve stability. Larger postural differences may have a higher correlation to stability.” Indeed in our study, postural scores were relatively high even in comparison to Mills’ study in which Pilates training was used over weeks. This difference indicates that a more thorough and well-learned regimen of core training as used in the healthy trained group and Pilates trained group establishes a better posture.

It also might have been better if there was more specific direction regarding the procedure by which the SEBT and LOS BBS needed to be conducted. According to Guskiewicz et al., the SEBT is classified as the first type of semidynamic balance in which the person transfers the
COG over a fixed BOS to selected ranges and/or directions within the LOS while standing on a stable surface, whereas the LOS is the second type of semidynamic balance in which the person maintains the COG over a fixed BOS while standing on a moving surface or unstable surface. It has also been reported that the SEBT is a functional test for quantifying lower extremity reach while challenging an individual’s limits of stability, and the LOS BBS is a functional test in which subjects reach points that are within their LOS. In this case, LOS BBS examines how fast the person can regain postural equilibrium while maintaining balance. To have a higher score, it seemed that the person had to have good flexibility and core strength in the SEBT while maintaining good control of the COG to reach each target for the LOS BBS in our study. The mean score for the SEBT with the standard procedure stated by Gribble has not been reported. Average scores for LOS BBS have reportedly ranged between 29.0714 ± 10.00 to 28.71 ± 7.42, and 34.389 ± 10.39 to 31.833 ± 8.49. Similar scores were recorded in the current study for LOS BBS.

In the SEBT, we found that Pilates trained subjects tended to stand upright while non-Pilates trained subjects leaned the torso to increase their leg reach as far as
possible. This tendency could be due to the way Pilates is typically taught, such as “neutral spine”, “reaching out the top of the head towards the ceiling”, and from a neutral pelvic position. These learned body positions were held throughout the SEBT test and might have affected the scores negatively. Therefore, instructions regarding the way subjects stand and reach during the SEBT need to be added to testing procedures.

In the LOS BBS, subjects had a difficult time becoming accustomed to the process of the examination. Two to three practice sessions have been used to eliminate learning effects in previous and preliminary research. Although subjects had two practice sessions based on Ishizuka’s study, some of the subjects still could not understand how the test needed to be done while scores remained similar across three to four trials. The number of practice sessions to decrease learning effects in the LOS BBS should be further established.

The other main finding was that there was no difference in balance and posture scores due to group (healthy trained versus Pilates trained). Pilates is especially known for its ability to increase strength of the core, and as a unique form of exercise since it is performed in a lying position for the most part. This
is achieved by recruitment of intrinsic muscle groups to maintain alignment on the floor and/or reformer while challenging the ROM and strength of the extremities. It is also reported that Pilates training increased the contraction of the transversus abdomius and lumbopelvic stability by Herrington et al. Proper control of core musculature improves proprioception in the spine, thus improving neuromuscular efficiency and that leads to improved balance. In this way, Pilates may have positive effects on the proprioception by increasing the awareness of body without additional balance control in the standing position. It is also suggested that the goal of balance training is to increase proprioceptive input of the SI joint and the cervical spine through pelvic and cervical neutral, which are two of the main concepts of Pilates. McMillan et al and Hall have reported positive effects of Pilates training on balance in dancers and the elderly.

Age significantly affected the SEBT score of healthy trained group. Since age has been reported to negatively affect posture and balance, this finding is significant since it means that despite the significant effect of the age, the Pilates trained group had similar scores to the healthy trained group and other average scores reported in college-aged athletes. In another words, Pilates
training is as effective on balance as other traditional exercises.

In addition, the current study by Gribble et al,\textsuperscript{39} found that time-of-day influences static and dynamic postural control. Since we did not set an exact time frame for the study, the time-of-day in which each subject participated might have affected the balance scores.

Standing upright may also have affected the SEBT score of Pilates trained group since subjects generally had better score with bending over and reaching out the lower extremity in the SEBT. Pilates trained subjects also mentioned that their skill and confidence in balancing have improved over the years since they started Pilates training. These findings demonstrate that further research is warranted within specific age-ranges with specific direction for the SEBT.

Conclusions

It is still unknown whether there is any relationship between posture and balance. In the current study, all of the subjects had similar posture scores that were relatively high across a wide range of age. That similarity made it difficult to examine any correlation
between the posture and balance scores. In addition, more comparable scores might have been obtained on the SEBT and LOS BBS using more specific procedures for both tests. Meanwhile, we found that Pilates training may be as effective on posture and balance as other exercises, or possibly more effective than the others. Despite the age and standing habit, Pilates trained adults were comparable in posture and balance scores to healthy trained adults and college-aged athletes. This finding is important since Pilates is performed in a lying position for the most part and may be used for those who cannot bear weight and/or the elderly population as effectively as for other populations.

Recommendations

It is still unknown whether there is any relationship between posture and balance. Further research is recommended with individuals with poor posture and more specific direction for the procedures of the SEBT and LOS BBS. Additionally, the results suggest that Pilates can potentially be used for posture and balance training as another form of exercise, especially for those who cannot bear weight. Using the same age group and specific directions for the SEBT may aid in different results.
REFERENCES


APPENDICES
APPENDIX A

Review of the Literature
Pilates has increased its popularity among fitness professionals for the effect of strengthening the core while improving posture and balance. Elite athletes and dancers alike use Pilates as a tool for enhancing their condition.\textsuperscript{1,2} Pilates exercises have been theorized to develop a strong core, create a balance of strength and flexibility, train efficient movement patterns, create a long and lean appearance, and emphasize the mind body connection. As its popularity increases, scientific research has been done to support some of those effects.\textsuperscript{2-6} Pilates effect on dancer’s dynamic posture and on balance in an elderly population were also found to be positive.\textsuperscript{2,3}

Posture and balance are two of the key components of integrated training and critical parts of athletic performance and injury prevention.\textsuperscript{7,8} They are also controlled through the same mechanisms.\textsuperscript{7} Although Danis et al\textsuperscript{11} could not find correlation between standing posture and stability, results may change in a different population with different assessments. Therefore, the primary purpose of this review of the literature is to discuss the relationship among posture, balance and Pilates. The topics that will be discussed include posture and balance, balance testing and training, and Pilates and balance.
Posture and Balance

Posture is one of the most important components of athletic ability since optimum posture leads to efficient neuromuscular function. Balance is another important component of athletic ability because of its implicit involvement in nearly all forms of movement. Terms such as postural control, postural equilibrium, and postural stability are used interchangeably with balance. While posture is defined as a composite of the positions of all the joints of the body at any given moment, balance can be viewed as the alignment of joint segments in an effort to maintain the center of gravity (COG) to prevent falling. Both postural and balance control systems receive the afferent information from visual, vestibular, and somatosensory inputs. The central nervous system (CNS) then interprets the information and chooses the appropriate musculoskeletal responses.

Posture and Postural Deficits

Maintenance of postural equilibrium includes sensory detection of body motions, integration of sensorimotor information within the CNS, and execution of appropriate musculoskeletal responses. When body position is sensed
by the somatosensory, vestibular, and visual senses, the CNS organizes an appropriate motion within the hip, knee, and ankle of the lower extremity.⁷ If an athlete stands with poor posture, it is possible that position of body is sensed incorrectly, and selection of the correct motions become less efficient.⁸ This may be critical for athletes in terms of preventing injury and improving performance.

Standard posture has been defined using a posterior and lateral view.¹² In the posterior view, an imaginary line should run from the midline of the skull, through the midline of the pelvis, spine, sternum, and midway between the lower extremities and the heels. Laterally, an imaginary line should run from slightly posterior to apex of coronal suture, through external auditory meatus, bodies of most of cervical vertebrae, shoulder joint, bodies of lumbar vertebrae, slightly posterior to axis of hip joint, slightly anterior to axis of knee joint, and slightly anterior to lateral malleolus. Although there is no standard approach for measuring posture, Watson et al.¹⁴ used 114 adolescent males, age 15-17, and established a reliable technique for the assessment of posture.

Maintaining ideal posture is vital for normal muscle length-tension and force-couples as well as joint kinematics to enhance neuromuscular efficiency.⁸,¹² If one
component of the posture is out of alignment, it creates predictable patterns of tissue overload and dysfunction leading to decreased neuromuscular control and initiates the cumulative injury cycle. Such patterns of poor posture have been referred to as postural distortion patterns and specifically termed as: 1) lumbo-pelvic-hip postural distortion pattern (increased lumbar lordosis and an anterior pelvic tilt); 2) upper-extremity postural distortion pattern (rounded shoulders and a forward head posture); and 3) lower-extremity postural distortion pattern (flat feet and knock-knees). These distortion patterns can lead to arthrokinetic dysfunction in which a biomechanical dysfunction results in abnormal joint movement and proprioception.

Proprioception

Proprioception, along with vision, is considered to be one of the most important mediators of balance and postural awareness. Proprioception is defined as the sensory modality of touch that encompasses the sensation of joint movement and joint position. Proprioception, which includes structures of the somatosensory system, receives input from the peripheral articular and musculotendinous receptors which detects changes in length and tension of
muscle, and information regarding joint position and motion. Mechanoreceptors, located in the skin, muscle, and joint send proprioceptive information to the CNS. Skin receptors detect skin stretching caused by joint rotation. The muscle spindle and the Golgi tendon organ (GTO) are the two primary muscle mechanoreceptors. The muscle spindle has both sensory and motor innervation. It detects the length of the muscle and the rate of change of length and send the signal to the CNS. The muscle spindle also contains contractile fibers that are controlled by Gamma motor neurons from the spinal cord. The GTO is a muscle mechanoreceptor located at the musculotendinous junction in series with the extrafusal muscle fibers. It is sensitive to tension and rate of tension in the skeletal muscle and functions to prevent over contraction and over stretching of the muscle. Articular mechanoreceptors, which include Pacinian corpuscles and Ruffini endings, detect sensation of joint motion, joint position sense, and sensation of change in joint position. The information received from proprioception visual, and vestibular receptors is sent to CNS and analyzed to select musculoskeletal motion in order to control balance.
Controlling Balance

Balance is defined as the alignment of joint segments in an effort to maintain the COG within an optimal range of the maximum limits of stability (LOS). As important for postural control, sensory organization, sensory integration, and motor control are the essential components for controlling balance. Sensory organization involves those processes that determine the timing, direction, and amplitude of corrective postural actions based upon information obtained from the vestibular, visual, and proprioception inputs.

The vestibular system receives information from the vestibules and semicircular canals of the ear, which can be used in three different ways in order to maintain posture. This information can be used to maintain body posture by controlling eye musculature so as to maintain visual focus when the head changes position, to maintain upright posture and for conscious awareness of body and joint position as well as motion. The visual system provides the body with visual cues for use as reference points in orientating the body in space. It is generally agreed that the proprioception and vision are the primary sources of balance and postural awareness.
The inputs gathered by vision, vestibular and proprioception are processed at three distinct levels of motor control: the spinal level, the brainstem; and the higher brain centers.\textsuperscript{18,19} The spinal level provides for dynamic muscular stabilization and synchronization of muscle activation patterns based on spinal reflexes as well as activity received from higher levels of the CNS.\textsuperscript{18,19} The brain stem processes information from the proprioceptors, vestibular, and eyes via the cerebellum nuclei for the maintenance of posture and balance.\textsuperscript{18,19} The higher brain centers, such as motor cortex, basal ganglia, and cerebellum, are responsible for cognitive programming of musculoskeletal motion.\textsuperscript{18,19} The gathered and processed information results in the use of one of three suggested movement strategies called the ankle, hip, and stepping strategy.\textsuperscript{7}

### Ankle, Hip, and Stepping Strategies

Human beings control posture and balance by using ankle, hip, and stepping strategies that result from different types of perturbations in stance.\textsuperscript{7} The ankle strategy shifts the COG while maintaining the placement of the feet by rotating the body as a rigid mass about the ankle joint\textsuperscript{7} and is used when the perturbation is relatively
The hip strategy helps control motion of the COG through the initiation of large and rapid motions at the hip joints with antiphase rotation of the ankles and is used once the body is unable to maintain the balance with the ankle strategy only. The stepping strategy is the last strategy to use to prevent a fall by stepping or stumbling.

These strategies may be affected by postural distortion since once muscle imbalance occurs, a person cannot use those ankle and hip muscles efficiently. This leads to the incorrect use of those strategies and results in balance deficiencies.

In that case, it is easy to assume that there is close relationship between posture and balance. However, few published studies have been completed to examine the relationship between balance and posture. Danis et al studied the relationship between standing posture and stability of subjects with vestibular hypofunction and could not find correlation between posture and stability. A limitation to this study was that it was conducted for specific population without challenging the subject’s balance. It is reasonable to think that if balance score is compared between active people who have good and poor posture by challenging their limits of stability (LOS), a
high correlation of posture and balance may be found. The testing procedures for balance will play an important role in finding an accurate correlation.

Balance Testing and Training

Assessing athletes’ balance ability and supplying the right balance training for athletes are important tasks for sports medicine professionals in terms of preventing injuries and improving performance. Star Excursion Balance Test (SEBT) and Limit of Stability (LOS) system using Biodex Balance System (BBS) (some say Biodex Stability System\textsuperscript{20-22}) have been explained as two of the most useful tools to examine dynamic balance.\textsuperscript{23-29} However, there is some confusion among the articles regarding the definition of dynamic balance.

According to Hinman,\textsuperscript{29} tests of static balance require movement of a person’s center of mass (COM) within a stationary base of support (BOS) and tests of dynamic balance require that both the COM and the BOS are moving. If this classification is used, the SEBT cannot be classified as a dynamic balance test. On the other hand, Gribble et al\textsuperscript{24} mentions that dynamic postural control involves completion of a functional task without
compromising one’s base of support, and the SEBT is one such test that provides a significant challenge to an athlete’s postural control system. After reviewing these statements, there is a need to classify the types of balance before describing balance testing and training.

Classification of Balance

While balance has been defined as the alignment of joint segments in an effort to maintain the COG within an optimal range of the maximum limits of stability (LOS), Guskiewicz et al. has suggested further classification of balance. They divide balance into four types: Static; semidynamic; dynamic; and functional balance. Static balance occurs when the center of gravity (COG) is maintained over a fixed BOS, such as single-leg stance. Semidynamic balance involves one of two possible activities: (1) the person transfers the COG over a fixed BOS to selected ranges and/or directions within the LOS while standing on a stable surface, such as functional reach test; or (2) the person maintains the COG over a fixed BOS while standing on a moving surface or unstable surface, such as the BBS.

Dynamic balance involves the maintenance of the COG within the LOS over a moving BOS, usually while on a stable
surface, and it requires the use of stepping strategy. Functional balance is the same as dynamic balance with the inclusion of sport-specific tasks such as throwing and catching. Based on the classification, the SEBT can be thought of as a functional test to examine athletes’ type one semidynamic balance and the BBS is another functional test for type two semidynamic balance.

**Star Excursion Balance Test (SEBT)**

The SEBT is best described as a functional test that quantifies lower extremity reach while challenging an individual’s limits of stability. Subjects stand on one leg in the middle of a grid. The grid is made with 8 lines of athletic tape, extending at 45-degree increments from the center of the grid (Anterior-Lateral, Anterior, Anterior-Medial, Medial, Posterior-Medial, Posterior, Posterior-Lateral, Lateral or AL, A, AM, M, PM, P, PL, L, respectively). Once in place the subject tries to reach to the furthest point of each line with their lower extremity. On reaching the furthest point, subjects lightly touch the point, so that the weight is not distributed to the leg, and then return their leg back to the center of the star. The point reached is marked and
the distance from the center of the grid is measured.\textsuperscript{23} The distance is used as the balance score.

Kinzey et al\textsuperscript{28} examined the reliability of the SEBT and the result was ranging from .67 to .87. However in this SEBT, the subject was examined for only four diagonal directions: AL, AM, PM and PL. In the test, subjects were also instructed to stand within the square box at the center point and to use the right leg when reaching along the lines to the subject’s right while using the left leg as the support limb and vice versa. Hertel et al\textsuperscript{25} studied the intratester and intertester reliability as well as learning effects during the SEBT for eight diagonal directions. Intratester and inter tester reliability were .78-.76 and .35-.84 on day 1 and .82-.96 and .81-.93 on day 2, respectively.\textsuperscript{25} He reported significant learning effects and the longest excursions occurred during trial seven to nine for all directions and, thus, suggested the need of at least six practice trials to record baseline data.\textsuperscript{25} Gribble et al\textsuperscript{24} later examined the role of foot type, height, leg length, and range of motion (ROM) measurements on excursion distances for the SEBT and found that leg length and height were significantly correlated to reach distance. Because of the correlation between leg length and height with leg length being more correlated to reach
distance, they normalized the raw scores to leg length by dividing the distance reached by leg length.\textsuperscript{24}

Other researchers have reported additional possible uses of the SEBT. Earl et al\textsuperscript{27} found that some muscle activation of the lower extremity during SEBT is direction dependent. This finding may be used to decide which direction is the best for specific rehabilitation of particular muscles. Olmsted et al\textsuperscript{26} found the possible use of SEBT to detect unilateral chronic ankle stability. While the SEBT is considered to be one of the reliable measurement and training tools for LOS, the Biodex Balance System (BBS) is another reliable tool.\textsuperscript{29,31}

\textbf{Biodex Balance System Limits of Stability}

The limits of stability (LOS) training and testing on the BBS is described as a functional test in which subjects reach points that is within their LOS and examine how fast the person can regain postural equilibrium while maintaining balance.\textsuperscript{29} The BBS is a multiaxial device that objectively measures and records an individual’s ability to stabilize the involved joint under dynamic stress.\textsuperscript{32} It challenges an individual to maintain his or her balance while standing on a movable platform that tilts a maximum of 20° (from horizontal plane) in all directions.\textsuperscript{29} The
amount of stability of the platform ranges from 8 (more stable) to 1 (less stable). An LCD screen provides visual feedback on where the center of mass (COM) is on the platform. The BBS can be used to assess dynamic bilateral and unilateral postural stability on an unfixed surface, as well as dynamic LOS.

LOS can be defined as the maximum angle of a body that a person can lean from the vertical position in any direction without changing his or her BOS. Although the supporting surface moves along with the body’s COM with BBS, the percentage of normal LOS is calculated in a way. In Hinman’s study, the reliability of LOS system of BBS is described ranging from .77 to .89. Although he states the possible limitation to variability for functional balance due to the limitation of the tilting angle of the platform, LOS assesses how smoothly and quickly a person is able to lean to one’s LOS.

Balance Training

To maintain balance, it is necessary to have a functional awareness of the BOS to better accommodate the changing COG. The goal of balance training is to increase awareness of the LOS by creating controlled instability and this is done by first normalizing the peripheral
 proprioceptive structures, then correcting muscle balance, and finally facilitating a correct motor program.$^{13,33}$

Proprioception is the most important aspect of balance training since altered proprioceptive information can lead to changes of the motor programming within the CNS.$^{7,8,13,33}$ There are a large amount of proprioceptors located in the foot, the sacroiliac (SI) joint, and the cervical spine and the exercise should be performed without shoes and the pelvis and cervical spine in neutral position so that proper stimulation of those joints are ensured throughout a movement.$^{33}$

In a balance training program, patients progress through three stages (static, dynamic, and functional) in different postures, bases of support, and challenges to their center of gravity.$^{7,13,33}$ In the static phase, emphasis is placed on developing a stable pelvis and patients are challenged to maintain their COG by using passive weight shifts or perturbations.$^{33}$ The challenge elicits reflexive and automatic postural reactions that teach the patient pelvic stabilization in a more functional position.$^{33}$ In dynamic phase, the patient begins building on the stable pelvis by performing movements of the upper and lower extremity, gradually adding resistance to the movements.$^{7,34}$ Example for the exercise is T-band kicks.$^{7,33}$ The final
stage of a balance training program is functional progression of postures with extremity movement with a stable pelvis.\textsuperscript{7,33} These include walking, squats, lunges, steps, jumps, and running.

Balance exercise should elicit automatic and reflexive muscular stabilization, challenging the patient to maintain postural control under a variety of situations.\textsuperscript{33} While several methods, such as balance boards, foam pads, elastic bands and braces,\textsuperscript{7,13,33-39} have been used to train the patients’ balance, some health care professionals mention possible use of Pilates as a balance training.\textsuperscript{4,40,41}

Pilates and Balance

The popularity of Pilates has recently increased over the past decades in health care and sports medicine field as well as fitness field\textsuperscript{1,4-6,40,41} which has influenced research studies to examine the effects of Pilates.\textsuperscript{2-6} Hall\textsuperscript{3} studied the effects of Pilates based training on balance in an elderly population and found positive effects.

Practitioners describe Pilates as a unique method of body conditioning that uses a combination of muscle
strengthening and lengthening, and breathing, to develop trunk muscles and restore muscle balance to the musculoskeletal system.\textsuperscript{40} Since Joseph Hubertus Pilates introduced his exercise “Contrology,” Pilates has long been the exercise choice of the dance world and was brought into health care and sports medicine field by dance medicine.\textsuperscript{1,2}

**Introduction to Pilates**

Joseph H. Pilates was born in Dusseldorf, Germany, in 1880.\textsuperscript{1,42} As a child he suffered from asthma, rickets, and rheumatic fever.\textsuperscript{1} He studied gymnastics, boxing, yoga, and karate, all in an effort to improve his health and he developed the method of “Contrology,” or conscious muscle control.\textsuperscript{1,40} As a circus performer and a self-defense trainer, his method gained popularity in Germany.\textsuperscript{1} He used Pilates to help World War I interns recover from injury and illness more quickly and to help rehabilitate non-ambulatory patients.\textsuperscript{40} In 1926, Pilates emigrated to the United States and built a studio to train clients in New York near the New York City Ballet studios.\textsuperscript{1} There, Contrology soon gained a following in the dance community as the method benefited dancers by improving fitness and performance while reducing injury-recovery time.\textsuperscript{1}
Upon developing his method, Pilates created his spring-resistance apparatus as well as mat exercises. The method now consists of more than 500 beginning to advanced exercises that are performed in supine, prone, and side-lying positions on a mat or machines. To perform these exercises effectively, there are eight principles of Pilates, concentration, control, centering, flow, precision, breath, relaxation, and stamina, and two additional concepts, that of neutral spine and spinal articulation.

Pilates as Core Training

Since all movement comes from a stable center, it is important to learn how to use the core correctly and breathing is essential for core stability. The neutral alignment of the spine is also important in order to have the most functional and pain-free posture. Pilates is especially known for its ability to increase strength of the core, or “the powerhouse”, as Joseph Pilates called it. This is achieved by recruitment of intrinsic muscle groups to maintain alignment while challenging the ROM and strength of the extremities.

The powerhouse consists of shoulder girdle, torso, and pelvic girdle stabilizers. The transversus abdominis (TrA), lumbar multifidus, pelvic floor (PF), diaphragm, and
Hip and shoulder girdle musculatures contribute to the posture and spinal stability.\textsuperscript{4,8,33,40,43} Studies show the TrA as a primary stabilization muscle of the lumbopelvic region.\textsuperscript{40} The TrA is continually contracted during trunk movement and is responsible for a contraction pattern with PF.\textsuperscript{40} Lumbar multifidus cocontracts with the TrA to provide stiffening of the lumbar spine via its attachments to the thoracodorsal fascia as well.\textsuperscript{40} It is documented that an increased TrA contraction was sustained in all spinal positions and was greatest when the lumbar spine was neutral.\textsuperscript{40} Herrington et al\textsuperscript{4} found that Pilates training increased the contraction of the TrA and lumbopelvic stability.

Diaphragmatic contraction aids in torso stabilization and is associated with voluntary contraction of the TrA by drawing in the abdominal wall.\textsuperscript{40,41,43} When a person inhales deeply, the diaphragm drops and allows more air to enter the lungs.\textsuperscript{43} This will increases the pressure within the abdominopelvic cavity and lead to greater core stability of the trunk.\textsuperscript{43}

Lumbo-pelvic-hip and upper-extremity postural distortion may occur by imbalance of muscles around the hip and shoulder joints.\textsuperscript{8} These distortions can cause joint and movement dysfunction which leads to injury.\textsuperscript{8} Pilates
exercises may correct those distortions by enhancing the work of the muscles.

**Pilates for Balance Training**

Proper control of core musculature improves proprioception in the spine, thus improving neuromuscular efficiency and that leads to improved balance.\textsuperscript{13,33} It has been studied that Pilates improves a person’s core strength.\textsuperscript{3,4} It has been suggested that Pilates may have positive effect on the proprioception by increasing the awareness of the body.\textsuperscript{2,40,41} McMillan et al\textsuperscript{2} found positive effects of Pilates based training on dynamic posture in dancers as well as Hall\textsuperscript{3} did on balance in elderly population. It is also suggested that the goal of balance training is to increase proprioceptive input of the SI joint and the cervical spine through pelvic and cervical neutral.\textsuperscript{33} Theoretically then, it is possible that Pilates based training could improve balance in the active population.
Summary

Pilates has increased its popularity among fitness professionals for the effect of strengthening core and improving posture as well as balance. As popularity increases, Pilates’ effects on posture, core strength, and flexibility have been studied\(^2\)\(^-\)\(^6\) as well as posture control and balance.\(^2\),\(^3\)

Balance is one of the key components of integrated training and a critical part of athletic performance and injury prevention.\(^7\) Posture is also one of the most important components of athletic ability since optimum posture leads to efficient neuromuscular function.\(^8\) In both balance and postural control systems, the afferent nerves receive the information from visual, vestibular, and somatosensory inputs, and the CNS interprets the information and chooses the appropriate musculoskeletal responses.\(^7\) Danis et al\(^10\) studied the relationship between standing posture and stability of subjects with vestibular hypofunction and could not find correlation between posture and stability. However, the results may be different in a healthy, balance-trained population by challenging the balance.

Balance can be defined as static, semidynamic, dynamic, or functional balance.\(^7\) The SEBT and BBS are one of the
most reliable and valid ways to assess balance in more functional environment.\textsuperscript{20-29} With these instruments, the subject’s LOS is challenged and thus, they allow tester to find closer connection between the subject’s testing score and the functional balance skill.\textsuperscript{20-29}

Balance training is important to increase awareness of the LOS by creating controlled instability.\textsuperscript{13} Proprioception is the most important aspect of balance training since altered proprioceptive information can lead to changes of the motor programming within the CNS.\textsuperscript{7,8,13,33} There are a large amount of proprioceptors located in the foot, the sacroiliac (SI) joint, and the cervical spine. For this reason, the exercise should be performed without shoes and with the pelvis and cervical spine in a neutral position so that proper stimulation of those joints are ensured throughout a movement.\textsuperscript{33} Since one of the main focus of Pilates is neutral pelvis and spine, this theory leads to Pilates as a type of balance training.

Practitioners describe Pilates as a unique method of body conditioning that uses a combination of muscle strengthening and lengthening, and breathing, to develop trunk muscles and restore muscle balance to the musculoskeletal system.\textsuperscript{40} While Pilates has significant effects on the client’s core and improves the spinal
stability, the main concepts, that of neutral spine, also suits the SMT program. Thus, it is possible that Pilates based training may improve balance in the active population.
APPENDIX B

The Problem
Statement of the Problem

The use of Pilates for strengthening core musculature and improving posture as well as balance has been largely recognized among fitness professionals. As its popularity increases, some scientific research has been done to support the effects of Pilates.\textsuperscript{2-6} Pilates’ effect on dancers’ dynamic posture and on balance in the elderly population were also found to be positive.\textsuperscript{2,3}

While postural and balance control mechanisms resemble each other,\textsuperscript{7} research support on the relationship between the two is limited to date. If posture and balance correlate each other, could the correction of posture be a useful tool to the athletic trainer? Thus, the purpose of this study was to examine the relationship between posture and balance with a Pilates trained population.

Definition of Terms

The following definitions of terms were further defined for this study:

1) Balance – the alignment of joint segments in an effort to maintain the COG within an optimal range of the maximum limits of stability (LOS).\textsuperscript{7}

2) Biodex Balance System (BBS) – a functional test in which subjects reach points that is within their LOS
and examine how fast the person can regain postural equilibrium while maintaining balance.\textsuperscript{30}

3) Contrology – the method Joseph H. Pilates developed for conscious muscle control.\textsuperscript{1,41}

4) Dynamic Balance – the maintenance of the COG within the LOS over a moving base of support.\textsuperscript{7}

5) Functional balance – the maintenance of the COT within the LOS over a moving base of support with the inclusion of sport-specific tasks.\textsuperscript{7}

6) Limits of Stability (LOS) – the maximum angle of a body that a person can lean from the vertical position in any direction without changing his or her base of support.\textsuperscript{30}

7) Pilates – a method of body conditioning that uses a combination of muscle strengthening and lengthening, and breathing, to develop trunk muscles and restore muscle balance to the musculoskeletal system.\textsuperscript{41}

8) Postural Distortion Patterns – patterns of poor posture which creates predictable patterns of tissue overload and dysfunction leading to decreased neuromuscular control and initiates the cumulative injury cycle.\textsuperscript{8}
9) Proprioception - the sensory modality of touch that encompasses the sensation of joint movement and joint position.\textsuperscript{9}

10) Semidynamic balance - it involves one of two possible activities: 1) The person maintains their COG over a fixed BOS while standing on a moving surface or unstable surface; or 2) the person transfers their COG over a fixed BOS to selected ranges and/or directions within the LOS while standing on a stable surface.\textsuperscript{7}

11) Star Excursion Balance Test (SEBT) - a functional test that quantifies lower extremity reach while challenging an individual’s LOS.\textsuperscript{27}

12) Static Balance - the COG is maintained over a fixed base of support while standing on a stable surface.\textsuperscript{7}

13) Watson MacDonncha Posture Analysis (WMPA) - a reliable technique for the assessment of posture which Watson et al established.\textsuperscript{15}

Basic Assumptions

The followings were basic assumptions of this study:

1. All participants gave a maximum effort during testing.

2. The equipment was calibrated and work properly during this study.
3. Testing instruments (STAR balance test, LOS test, and WMPA) were valid and reliable.

Limitations of the Study

Generalizability of test results to: (1) Pilates trained adults who have joined a Pilates class for at least 6 months of 2 one hour sessions per week or for a year of a 1 hour session per week or; (2) healthy adults within the specific age range.

Significance of the Study

The primary scope of this study is to examine the relationship between posture and balance in a Pilates trained population. Pilates has increased its popularity among fitness professionals for the effect of strengthening core and improving posture as well as balance. Elite athletes and dancers alike use Pilates as a tool for enhancing their condition.\textsuperscript{1,2} Pilates exercises have been theorized to develop a strong core, create a balance of strength and flexibility, train efficient movement patterns, create a long and lean appearance, and emphasize the mind body connection. As its popularity increases, some scientific research has been done to support some of these
Pilates’ effect on dancer’s dynamic posture and on balance in an elderly population were also found to be positive. These research findings shed a new light on the relationship of posture and balance.

Posture and balance are two of the key components of integrated training and critical parts of athletic performance and injury prevention. They are also controlled through the same mechanisms. Although one study could not find correlation between standing posture and stability, results may be different in a different population with different assessments. This study is critical in terms of verifying the relationship between posture and balance in a Pilates trained population. This study may lead to the use of evaluation for posture as another set of evaluation for balance or vise versa. Furthermore, this study may also lead to the use of Pilates as another set of therapeutic exercises to consider in sports medicine field.
APPENDIX C

Additional Methods
APPENDIX C1

Subject Information Sheet
Subject Information Sheet (subject#: )

Age: _______ Gender: (Male/Female) Weight: _______ kg (____ Ib)

Height: _______ cm (____ in) Leg length: _______ cm Shoe size: _______ cm

1. What regular exercise activities are you involved in? How many times? How long? Please answer from the sport that you spend more time.
   I. __________________ (____ times/week) (____ min./each)
   II. __________________ (____ times/week) (____ min./each)
   III. __________________ (____ times/week) (____ min./each)
   IV. __________________ (____ times/week) (____ min./each)
   V. __________________ (____ times/week) (____ min./each)
   VI. __________________ (____ times/week) (____ min./each)

2. Pilates experience (Pilates experienced subjects only. Please circle the number that suit your Pilates experience the best):
   I. Do you have any Pilates certificate?
      i. (Yes/No)
      ii. If yes, what is it (are they)?
          __________________________________________
          __________________________________________
   II. How long have you performed Pilates?
      i. 6 months
      ii. 1 year
      iii. 2 years
      iv. 3 years or more
   III. How often do you attend or practice the session?
      i. _______ times per week
   IV. How long is each session?
      i. 30 minutes
      ii. 1 hour
      iii. 2 hours
      iv. 3 hours or more

3. Anecdotal note (for the researcher):
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
APPENDIX C2

Photographic Release Form
Photographic Release Form
Watson MacDonncha Photographic Posture Analysis

Subject # __________
Date __________

The researcher requests the use of photographic material for parts of her study and possibly future presentations. The material will be used for the research project as the researcher has described in the informed consent document that you have signed. These materials may be used for professional publications, professional conferences, websites, and pictorial exhibits related to the study.

The researcher also emphasizes that the appearance of these materials on certain media (websites, professional publications, news releases) may require the transfer of copyright of the images. This means that other individuals may use your image. Regarding the use of your likeliness in photographs, tapes, or recordings, please check one of the following boxes:

I do ____
I do not ____

Give unconditional permission for the investigator to utilize photographs of me.

_______________________________ ______________
Signature Date

Note: Even should you choose not to allow your image to be used, the researcher can still benefit from your inclusion as a research study participant.

*The form used by permission from the author.*
APPENDIX C3

Informed Consent Form
Informed-Consent Form

1. Daisuke Yamaguchi, ATC, has requested my participation in a research study at California University of Pennsylvania. The title of the research is *The Relationship between Posture and Balance in a Pilates Trained Population*.

2. I have been informed that the purpose of the research is to examine the relationship between posture and balance in a Pilates trained population.

3. My participation will involve limits of stability (LOS) balance testing on the Star Excursion Balance Test (SEBT) and the Biodex Balance System (BBS), and a posture examination using Watson-Macdonncha postural assessment. All of the testing will be conducted on one day in the B5 laboratory room and the athletic training room in Hamer Hall for approximately one hour each subject.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. The possible risk is a fall during the LOS testing on the BBS where the risks of falling will be minimized by a spotter. Any injuries that may occur during the balance testing can be treated at the Athletic Training room at Hamer Hall provided by any certified athletic trainer of the graduate student researcher, Daisuke Yamaguchi. The risk is no more than normal physical activity that normal adults would be exposed during daily activity. There is no associated risk in assessing standing posture.

5. I understand that there are no feasible alternative procedures available for this study.

6. I understand that the possible benefits of my participation in the research include understanding the effectiveness of Pilates and contributing to existing research and enhancing the understanding of Pilates training.
7. I understand that the results of the research study may be published but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Daisuke Yamaguchi will maintain all documents in a locked file cabinet where only the student researcher and research advisor can access.

8. I have been informed that I will not be compensated for my participation.

9. I have been informed that any questions regarding to the research or my participation in it, before or after my consent, will be answered and my individual scores or abstract of this study will be informed after completion of the study by:
   Daisuke Yamaguchi, ATC
   947 Cross Street Apt#2
   California, PA 15419
   812-878-0568
   Yam1523@cup.edu
   Or by the graduate thesis advisor:
   Rebecca Hess, PH.D
   133 Hamer Hall
   California University of Pennsylvania
   California, PA 15419
   724-938-4359
   Hess_ra@cup.edu

10. I understand that written responses may be used in quotations for publication but my identity will remain anonymous.

11. I have read the above information. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

Subject's signature ________________________________
Date __________________

Other signature (if appropriate) ________________________________
Date __________________
12. I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

13. I have provided the subject/participant a copy of this signed consent document if requested.

Investigator's
Signature _______________________________ Date ________

Approved by the California University of Pennsylvania IRB
APPENDIX C4

SEBT record sheet
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<th>Px 2</th>
<th>Px 3</th>
<th>Px 4</th>
<th>Px 5</th>
<th>Px 6</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Total mean score of 3 tests</th>
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L stance leg total mean score = 
R stance leg total mean score = 
L excursion score = L mean (____) / L leg length (____) = 
R excursion score = R mean (____) / R leg length (____) = 

74
APPENDIX C5

LOS Score Sheet
## LOS Score Sheet

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<th>Subject#</th>
<th>Date</th>
<th>Foot position</th>
<th>Overall LOS</th>
<th>LOS time</th>
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APPENDIX C6

Postural Score Sheet
| Subject # | Ankle | Knee interspace | Knee hyper ext/flex | Lordosis | Kyphosis | Scoliosis | Round shoulders | Abducted scapulae | Shoulder symmetry | Forward head | Total score |
|----------|-------|----------------|-------------------|----------|----------|-----------|----------------|------------------|------------------|--------------|-------------|-------------|
| 1        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 2        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 3        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 4        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 5        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 6        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 7        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 8        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 9        |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 10       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 11       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 12       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 13       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 14       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 15       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 16       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 17       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 18       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 19       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
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| 21       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 22       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 23       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 24       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 25       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 26       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 27       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 28       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 29       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
| 30       |       |                |                   |          |          |           |                 |                  |                 |              |             |             |
APPENDIX C7

Assessment Procedures for WMPA
1. Ankle Posture

a. Purpose: to assess the degree of valgus or varus of the heel.

b. Photograph use: the anterior and posterior position.

c. Postural deviation examination: The qualitative assessment involves placing a horizontal grid line across the narrowest point of the Achilles tendon on the photograph, the intersection of the grid line and the Achilles tendon is selected as the pivot point for the axis of a 360° protractor. Two measures are observed: 1) the degree of deviation from a vertical line of the Achilles tendon cord (Achilles angle); and 2) the degree of deviation from the vertical of the mid line of the heel (calcaneus angle). The horizontal grid line was considered as 0°.

d. Categories: If the degree of the Achilles is less than seven then a score of five is assigned. If the degrees are in between 7-10 then a score of three is assigned. If the degrees are measured greater than 10 a score of one is assigned.
2. Knee inter-space

a. Purpose: to assess the degree of genu varum and of genu valgum.

b. Photograph use: anterior and posterior position.

c. Positioning: the subject is asked to stand with both feet together pointing forward with knees fully extended. In some subjects this is not possible due to the existing degree of genu valgum. Also in some subjects both feet and medial epicondyles of the knees are touching. For the purpose of this assessment, if the space between the most medial points of the femoral epicondyles, when the ankles are touching, is greater than four mm on the photography, the participant will be considered to have genu varum.

d. Categories: The qualitative scale is used to assign the degree of genu varum. However, if the medial femoral epicondyles are touching, and a space existed between the medial malleoli of the ankles, the subject is considered to be genu valgum. If both areas are just touching a score of five are assigned. If a degree of overlap (i.e. one knee crossing in front of the other) at
the knees is noted a three will be assigned. If the overlap is significant then a one will be assigned.

3. Knee Hyper-extension/ hyper-flexion

a. Purpose: to assess the position of the knee in relation to the hip and ankle.

b. Photograph use: the lateral position.

c. Posture deviation examination: the alignment of the markings on the knee and hip and the anterior aspect of the distal tibia at its narrowest point are used to aid in the assessment. The vertical axis is aligned with the hip, knee, or tibia. The alignment of three points gives an indication of the nature and degree of hyperflexion or hyperextension.

d. Categories: Deviations also indicated the existence of a forward or backward lean of the body. In this case the greater trochanter is forward or behind in relation to the patellar notch and the lateral malleolus. Any apparent deviation greater than that illustrates as moderate hyper-flexion as assigned a score of one.
4. Lordosis

a. Purpose: to assess the degree of lordosis.
b. Photograph use: the lateral and oblique position is used.
c. Posture deviation examination: the degree of lordosis.
d. Categories: circles of various diameters which represent the different lordotic deviations as represented by the qualitative scale are used as an aid in the assessment. A circle of 7cm in diameter corresponds to a posture score of five, 4.5cm diameter circle corresponds to a three, and a 3cm circle corresponds to a one. Images of these circles can be transferred on top of the photographs if necessary for judgement. The circles and segments are placed against the lordosis curvature evident on the photograph to either support or reconsider the qualitative assessment made.

5. Kyphosis

a. Purpose: to assess the degree of kyphosis.
b. Photograph use: the lateral and oblique position.
c. Postural deviation examination: the degree of kyphosis.
d. Categories: similar to the lordosis assessment procedure, circles of various diameters are used to aid assessment. A score of five corresponds to a circle of a diameter of 9cm, a score of three corresponds to a circle diameter of 7cm, and a score of one corresponds to a diameter of 6cm. The C7 is considered to be the superior aspect of the kyphosis curve. Observation of upper and lower aspects of the kyphosis curve is important in making a qualitative assessment. The upper thoracic region in some individuals have a great degree of forward flexion; this is considered in making an assessment. The degree of extension of the lower thoracic region is carefully observed. The degree of kyphosis is often be obscured by the presence of abducted scapulae. The anterior left oblique angle photograph is examined to make the assessment.

6. Scoliosis C and S

a. Purpose: to assess the rotolateral curvature of the spine.
b. Photograph use: the posterior position.
c. Posture deviation examination: The participant is first analyzed using the qualitative rating scale. A 360° protractor is used as an additional aid. The posterior view photograph is placed under the grid and vertically aligned using the plumb lines visible on the photograph. The photograph is positioned so that a horizontal grid line passed through the center of the trunk region. An axis of a 360° protractor is aligned with the horizontal gridline. The vertical axis of the protractor is then rotated and aligned between the center of the base of the spine and the vertebral prominent.

d. Categories: no deviation is assigned a five. If the deviation from the horizontal gridline is between 1.5° and 3° the participant is assigned a score of three and if the deviation is greater than 3° the participant receives a score of one. A shoulder asymmetry may be present, skin creases may be visible and/or scapular position may be elevated on one side.

7. Round or forward shoulder
a. Purpose: to investigate any abnormal position of the shoulder girdle.
b. Photograph use: the lateral position.
c. Posture deviation examination: the shoulders are pushed forward towards the upper chest.
d. Categories: if the subject’s shoulders are behind the upper chest a score of five is assigned. If the front of the shoulders is in line or slightly forward or behind the chest a score of three is assigned. If the front of the shoulders is clearly in front of the upper chest a score of one is assigned.

8. Abducted/winged scapulae

a. Purpose: assessing if the scapulae is in an abducted and/or upward rotation.
b. Photograph use: the lateral and oblique position.
c. Posture deviation examination: the condition sometimes represented itself as a protrusion of the medial border of the scapulae and/or the inferior angle of the scapulae.
d. Categories: if the inferior angles and portions of the medial borders of the scapulae are clearly visible a score of three is assigned. If the inferior angles are protruding excessively and/or
all the medial borders and scapular spines are visible a score of one is assigned.

9. Shoulder symmetry

a. Purpose: to examine the symmetry of the shoulders
b. Photograph use: anterior and posterior position.
c. Posture deviation examination: one shoulder is aligned with a horizontal line with the plumb-lines using a landmark such as the head of the clavicle. The distance of the opposite shoulder from the horizontal gridline is measured. A deviation may be present in shoulder symmetry because of a lean in the total body which will be visible when using the grid transparency. The shoulders will still be measured and the scored if they are uneven because of a lean.
d. Categories: A deviation in between 1mm and 2.5mm on the photograph is assigned a score of three. A deviation greater than 2.5mm is given a score of one. Both anterior and posterior view photographs are used in this assessment. In some cases a deviation is apparent on only one view. If a deviation is apparent on either view a defect is considered to exist.
10. Forward Head

a. Purpose: to examine the degree of forward flexion of the cervical spine and also the degree of head protraction.

b. Photograph use: the lateral position.

c. Posture deviation examination: The degree of cervical flexion and head protraction is quantitatively measured from a lateral view photograph. A horizontal line on the grid is positioned at the point where the neck meets either the upper chest or shoulders. Generally, a very unambiguous notch is visible. The angle from vertical of the point where the horizontal gridline intersects the spine and the external auditory meatus is considered to be the degree of cervical flexion. The angle between the anterior notch, the external auditory meatus and the vertical is considered to be the degree of head protraction.

d. Categories: Head protraction angles of <5°, between 5-10° and >10° equated to categories 1, 3, and 5 respectively

*The form used by permission from the author.*
APPENDIX C8

Assessment Criteria for WMPA
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<th>Score of a 5</th>
<th>Score of a 3</th>
<th>Score of a 1</th>
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</thead>
<tbody>
<tr>
<td>1. Ankle valgus or varus</td>
<td>&lt; 7 degrees</td>
<td>7-10 degrees</td>
<td>&gt; 10 degrees</td>
</tr>
<tr>
<td>2. Knee interspace</td>
<td>Ankle’s together; medial epicondyles touching</td>
<td>1. Medial epicondyles touching; medial malleoli not touching. 2. Medial malleoli are touching but there is 1-3mm between the medial epicondyles.</td>
<td>1. Medial epicondyles are more than 4mm apart; medial malleoli are touching. 2. Q angle is measured more than 15° for women and more than 12° for males.</td>
</tr>
<tr>
<td>3. Knee hyperflexion or hyperextension</td>
<td>A line can be drawn straight through the thigh and lower leg. No marked deviation.</td>
<td>Moderate deviation from the midline either in extension or in flexion.</td>
<td>Extreme deviation from the midline either in extension or in flexion.</td>
</tr>
<tr>
<td>4. Lordosis</td>
<td>Circle with a diameter of 7cm</td>
<td>Circle with a diameter of 4.5cm</td>
<td>Circle with a diameter of 3cm</td>
</tr>
<tr>
<td>5. Kyphosis</td>
<td>Circle with a diameter of 9cm</td>
<td>Circle with a diameter of 7cm</td>
<td>Circle with a diameter of 6cm</td>
</tr>
<tr>
<td>6. Scoliosis</td>
<td>Vertical line drawn through vertebral markers; no deviation.</td>
<td>Moderate deviation: 1.5-3 degrees of the vertical line.</td>
<td>Extreme deviation: greater than 3 degrees deviation from the vertical line.</td>
</tr>
<tr>
<td>7. Shoulder; rounded</td>
<td>Shoulders are behind the upper chest.</td>
<td>Shoulders are slightly forward of the upper chest.</td>
<td>Shoulders are in front of the upper chest.</td>
</tr>
<tr>
<td>8. Shoulder Symmetry</td>
<td>No difference in symmetry.</td>
<td>Deviation greater than 1mm-2.5mm</td>
<td>Deviation greater than 2.5mm</td>
</tr>
<tr>
<td>9. Shoulder abducted winged scapulae</td>
<td>No deviation from a slight outline of the scapulae.</td>
<td>Inferior angles and portions of the medial border are clearly visible.</td>
<td>Inferior angles were protruding excessively and/or all the medial borders and scapular spines are visible.</td>
</tr>
<tr>
<td>10. Forward head Posture</td>
<td>Head protraction angle is less than 5 degrees.</td>
<td>Head protraction angle is in between 5-10 degrees.</td>
<td>Head protraction angle is greater than 10 degrees.</td>
</tr>
</tbody>
</table>

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APPENDIX C9

Postural Deviation Sheet
Fig. 1.—Ankle posture. Fig. 2.—Knee interspace. Fig. 3.—Knee hyper-extension/flexion. Fig. 4.—Lordosis. Fig. 5.—Kyphosis. Fig. 6.—Scoliosis "C".

*Referred from Watson et al.⁴-five
*Referred from Watson et al.\textsuperscript{15}
APPENDIX C10

Institutional Review Board Approval
California University
of Pennsylvania

PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects

(Reference IRB Policies and Procedures for clarification)

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**Project Title:** The Relationship between Posture and Balance in a Pilates Trained Population

**Researcher/Project Director:** Daisuke Yamaguchi

**Phone #** (812) 878-0568

**E-mail Address:** yam1523@cup.edu

**Faculty Sponsor (if required):** Dr. Rebecca A. Hess

**Department:** Health Science and Sports Studies

**Project Dates:** January 2007 to April 2007

**Sponsoring Agent (if applicable):**

**Project to be Conducted at:** Hamer Hall Athletic Training Room at California University of Pennsylvania

**Project Purpose:** ☑ Thesis ☐ Research ☐ Class Project ☐ Other

Keep a copy of this form for your records.

---

**Required IRB Training**

The training requirement can be satisfied by completing the online training session at [http://cme.nci.nih.gov/](http://cme.nci.nih.gov/). A copy of your certification of training must be attached to this IRB Protocol. If you have completed the training at an earlier date and have already provided documentation to the California University of Pennsylvania Grants Office, please provide the following:

**Previous Project Title**

**Date of Previous IRB Protocol**

---

Draft, April 7, 2005
Please attach a typed, detailed summary of your project AND complete items 2 through 6.

1. Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(es) or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.

   The purpose of this study will be to examine the relationship between balance and posture using Pilates trained and healthy adult population. Pilates trained participants will be defined as those who have taken Pilates class at least six months for two hour sessions per week, or a year of one hour session per week. Any subjects who are suffered from any visual, vestibular, balance disorder, serious lower extremity injury and/or a concussion a year prior to the test will not be included in this study. Each subject will be measured for the limits of stability (LOS) balance using the Star Excursion Balance Test (SEBT) and the Biodex Balance System (BBS) as well as posture with the Watson-MacDonncha posture analysis (WMPA) using a small case descriptive research design. It is hypothesized that there will be a positive relationship between balance (LOS and SEBT) and posture (WMPA) scores. The data will be analyzed using Paired t tests and a Pearson correlation coefficient provided by SPSS 13.0. An alpha level of ≤.05 will be used for significance.

2. Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.

   a. How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.

   The possible risks and/or discomforts include falling down during the limits of stability testing. The risks of falling will be minimized by a spotter. Any injuries that may occur during the balance testing can be treated at the Athletic Training room at Hamer Hall provided by any certified athletic trainer of the graduate student researcher, Daisuke Yamaguchi. The possible benefits of participation in the study include understanding the effectiveness of Pilates and contributing to existing research knowledge, and enhancing the understanding of Pilates.

   b. How will you insure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.

   Pilates-trained adults (N=6≥18yo) and apparently healthy adults (N=6≥18yo) will be compared for posture and balance. Pilates trained participants will be defined as those who have taken Pilates class at least six months for two hour sessions per week, or a year of one hour session per week, using both mat and universal reformer at least one-third of the time. Subjects will be selected from local Pilates-trained teachers or practitioners and solicited by e-mail. Anybody who have suffered from any visual, vestibular, balance disorder, lower extremity injury and/or a concussion within the last one year will not be included in the study.

   c. How will you obtain informed consent from each participant or the subject's legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.

   An informed consent form will be completed and signed by all subjects before participating in this study at the day of the testing. A copy of the form is attached to this form. Each signed form will be kept by the researcher.

Draft, April 7, 2005
Data will be collected during spring semester but no later than spring break. All subjects are supposed to come in once for testing for balance and posture. All collected data which will be identified by subject number will be maintained by the researcher in a secure location in which the researcher and research advisor can access.

3. Check the appropriate box(es) that describe the subjects you plan to use.

- [ ] Adult volunteers
- [ ] Mentally Disabled People
- [ ] CAL University Students
- [ ] Economically Disadvantaged People
- [ ] Other Students
- [ ] Educationally Disadvantaged People
- [ ] Prisoners
- [ ] Fetuses or fetal material
- [ ] Pregnant Women
- [ ] Children Under 18
- [ ] Physically Handicapped People
- [ ] Neonates

4. Is remuneration involved in your project? [ ] Yes or [x] No. If yes, Explain here.

5. Is this project part of a grant? [ ] Yes or [x] No If yes, provide the following information:
   
   Title of the Grant Proposal ________________________________
   Name of the Funding Agency ________________________________
   Dates of the Project Period ________________________________

6. Does your project involve the debriefing of those who participated? [x] Yes or [ ] No
   
   If Yes, explain the debriefing process here.

   I will release results of the tests to the athletes after the study is completed by way of a poster presentation paper in the spring semester.

7. If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix ___ in the Policies and Procedures Manual.
Project Director's Certification
Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

Project Director's Signature

Department Chairperson's Signature

Student or Class Research

Student Researcher's Signature

Supervising Faculty Member's Signature if required

Department Chairperson's Signature

ACTION OF REVIEW BOARD (IRB use only)

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

Approved [ ] Disapproved [ ]

Chairperson, Institutional Review Board

Date 02-01-07

Draft, April 7, 2005
APPENDIX C11

Participant Placement Diagram
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APPENDIX C12

Oral Direction for Photography
Watson MacDonncha Posture Analysis
Using Photography

Oral Directions during Photography:

I. **PICTURE #1**: Please hold the sign with your subject number in front of your chest.

II. **PICTURE #2**: Please stand upright staring straight ahead with chin parallel to the ground and fully extend the elbows and knees.

III. Please hold your arms relaxed and at your side.

IV. If possible your heels will be touching with your feet parallel over the red line.

V. If your knees are pressing together very hard and your heels are not touching, please place your knees slightly touching, leaving your ankles to be naturally comfortable.

VI. In this case please bend your knees and lower your body and return to the original position.

VII. **PICTURE #3**: Please turn 90 degrees to your right again and place your feet parallel with the blue line. Stand upright staring straight ahead with your chin parallel to the ground and fully extend your elbows and knees.

VIII. **PICTURE #4**: Now please turn 45 degrees to your right and place your feet together over the yellow line. Stand upright staring straight ahead with your chin parallel to the ground and fully extend your elbows and knees.

IX. **PICTURE #5**: Please turn 45 degrees to your right and place your feet parallel with the red line and face the back wall. Stand upright staring straight ahead with your chin parallel to the ground and fully extend your elbows and knees.

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APPENDIX C13

Anatomical Landmarks during Photography
ANATOMICAL LANDMARKS FOR PHOTOGRAPHY

#1 ANTERIOR VIEW: 10 pts total
Clavicle heads
Ac & Sc joints
ASIS
Center of the patellae
Tibial tubercostis

#2 LEFT LATERAL VIEW: 4 pts total
Ear: pinna
Auricle
Bih joint
Bilater trochanter
Patellar notch

#3 POSTERIOR VIEW: 9 pts total
C7
T3
T6
T12
L3
L5
Sacrum
Center of calcaneous

23 markers total
10 Anterior
4 Left lateral
9 Posterior

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REFERENCES


ABSTRACT

TITLE: The Relationship between Posture and Balance in a Pilates Trained Population

RESEARCHER: Daisuke Yamaguchi

ADVISOR: Dr. Rebecca Hess

DATE: May 2007

RESEARCH PROBLEM: Master Thesis

PURPOSE: The purpose of the study was to examine the relationship between posture and balance in a Pilates trained population.

PROBLEM: Few research studies have been conducted to support the relationship between posture and balance as well as the Pilates training effects on posture and balance.

METHOD: This study used a small case descriptive research design. Eight Pilates trained and six non Pilates trained volunteers participated in this study. All of the testing was administered on one day for approximately one hour each subject.

FINDINGS: There was no relationship between posture and balance scores and there was no difference in posture and balance scores between Pilates trained adults and healthy trained adults.

CONCLUSIONS: It is still unknown if there is any relationship between posture and balance. Meanwhile, despite the adverse effects of the age and standing habit, Pilates trained adults were comparable in posture and balance to healthy trained adults.