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# The Relationships Among Proprioception, Balance, and Cognitive Perception of Body Awareness in College Students

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Murray State University Honors College

Honors Thesis

Certificate of Approval

# The Relationship Among Proprioception, Balance, and Cognitive Perception of Body Awareness in College Students

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Approved to fulfill the
requirements of HON 437

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# The Relationships Among Proprioception, Balance, and Cognitive Perception of Body Awareness in College Students

Submitted in partial fulfillment

of the requirements for the

Murray State University Honors Diploma

Courtney Helmick

May 2023

## Abstract

**Introduction:** Proprioception is an important physiological function that is essential for activities of daily living as well as exercise and sport performance. Integration of proprioceptive signals plays a key role in both static and dynamic balance. Previously, researchers have assessed the relationship between balance and proprioception, however, the effect of cognitive perception of body awareness has not previously been included in this research. The aim of this pilot study was to explore the relationships among lower extremity proprioception, dynamic balance, and cognitive perception of body awareness in college students.

**Methods:** Nineteen apparently healthy college students (age 21.26 ± 1.10 years, 12 female, 7 male) were recruited to voluntarily participate in this pilot study. An online survey of body awareness, Limits of Stability Test on the Biodex Balance System, and the Lower Extremity Position Test (LEPT) were used to measure cognitive perception of body awareness, balance, and proprioception, respectively. In order to establish test-retest reliability, 9 participants were randomly selected to repeat the test of proprioception one week following the initial data collection.

**Results:** The LEPT yielded a questionable, but approaching acceptable, test-retest reliability ($\alpha$=.692). Balance and proprioception scores were moderately correlated ($P$=.031). Limb dominance had no significant impact on proprioception ($P$=.511). Previous dance and gymnastics experience had a medium effect size on balance performance ($g$=.502). Average LEPT error can reliably predict balance scores, accounting for 24.6% of the variance in scores ($P$=.026). Survey results were not related to balance ($P$=.188) or proprioception ($P$=.565) outcomes.

**Conclusion:** The results of this pilot study found that balance is correlated with proprioception, proprioceptive ability is able to predict balance competence, limb dominance does not have a significant impact on proprioceptive ability, and participation in dance and gymnastics may result in improved balance. The LEPT still requires further improvements, but may be an acceptable clinical tool with financial feasibility, ease of administration, and time efficiency for quantifying proprioceptive ability compared to tools of higher precision.

Future research should explore the impact of including an educational familiarization trial, control for LEPT starting joint position with an initial knee angle of 90° flexion, and a neutral ankle position (90° angle between the foot and leg) and consider the influence of muscle activation using electromyography. The role of cognitive perception of body awareness should be researched to a greater extent in order to determine its influence on balance and proprioception.

## Table of Contents

## List of Tables and Figures

### Tables



### Figures

## INTRODUCTION

### Review of Literature

Proprioception allows oneself to perceive their body's position and movement, and can be divided into 4 key components: joint position sense, kinesthesia, sense of force, and speed and directional changes in velocity.[1-3] Information relevant to these components is detected by sensory receptors including Pacinian corpuscles, Ruffini corpuscles, golgi tendon organs, and muscle spindles, then sent to the spinal cord and brain.[4] The interpretation of this sensory input allows the body to detect it's position and movement, as well as coordinate movements.[1]

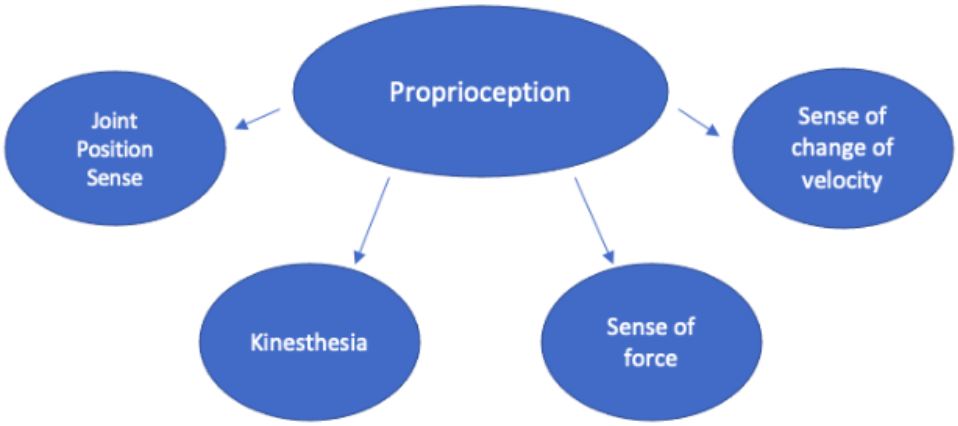


**Figure 1.** Key components of proprioception [3]

Proprioception is an essential physiological function for balance.[2, 5] An extensive volume of research has been conducted over balance and proprioception and found that they are strongly correlated. Proprioceptive input is estimated to account for 70% of the sensory input received for balance control.[6] In addition to proprioception, inner ear vestibular awareness, and visual information also impact balance. The distribution of this data is shown in Figure 2.

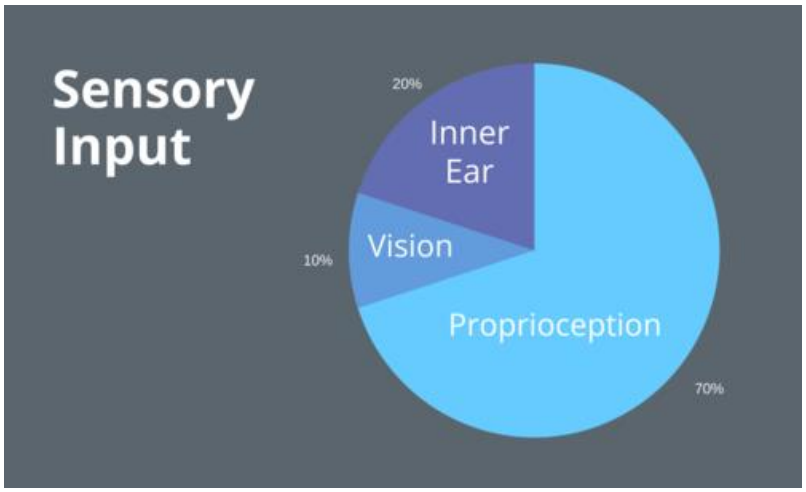


**Figure 2.** Sensory input for balance control [6]

A decline in proprioception has been observed with aging. This deficit can be accounted for due to the deterioration of the nervous and musculoskeletal systems with age.[7-9] Conditions that may result in proprioceptive impairment include arthritis, joint replacement surgery, herniated discs, multiple sclerosis, stroke, Parkinson's disease, Huntington's disease, peripheral neuropathy, focal dystonia, and amyotrophic lateral sclerosis (ALS).[8] As an individual ages or is diagnosed with one of the previously mentioned conditions, their proprioceptive ability is compromised, which leads to impaired postural balance and increased fall risk.[1-2, 5, 7-10] This realization is of great concern due to the high incidence of falls, and negative health outcomes resulting from falls. Of more concern, 55.8% of accidental deaths in older adults are accounted for by falls.[11] An individual can decrease their risk of falling through balance and proprioception training, but fewer than 20% of older adults meet the recommendations for balance and coordination activities (≥2 days/week).[12] In addition to reducing fall risk, balance and proprioception are essential for older adults in maintaining independence and performing activities of daily living.[4, 12] Injuries, loss of independence, and fear of falling all contribute to a decreased quality of life after falling. Many individuals who reported difficulties with balance stated that this deficit prevented them from participation in exercise, social events, and driving.[13]

In college students and adults, proprioception and balance abilities are beneficial for daily motor functions.[2, 4-5, 14] Proprioception in these populations is most commonly impacted negatively by ankle sprains and anterior cruciate ligament injuries.[1-2, 5, 8, 10] These injuries are common in sports; therefore, after suffering an injury, proprioception is impaired, and risk of re-injury increases. Another study found that poor balance performance was significantly correlated with increased knee and ankle injuries during sport participation.[15] Balance training can be beneficial for athletes to improve their performance and reduce their risk of injury.[16]

Proprioception is also closely related to body awareness. The three categories of body awareness include interoception, exteroception, and proprioception.[17-18] Body awareness is reliant on perception which involves the cognitive processes that allow oneself to be aware of themselves and their surroundings. For this pilot study, the researchers focused specifically on the participants' personal perception of their own body awareness. The interpretation of these body awareness inputs leaves a mental impression that can be altered by an individual's attitudes, beliefs, experience, and learning.[18] Research has demonstrated that an optimistic perception leads to improved sport performance, while a pessimistic perception leads to poorer performance.[19]

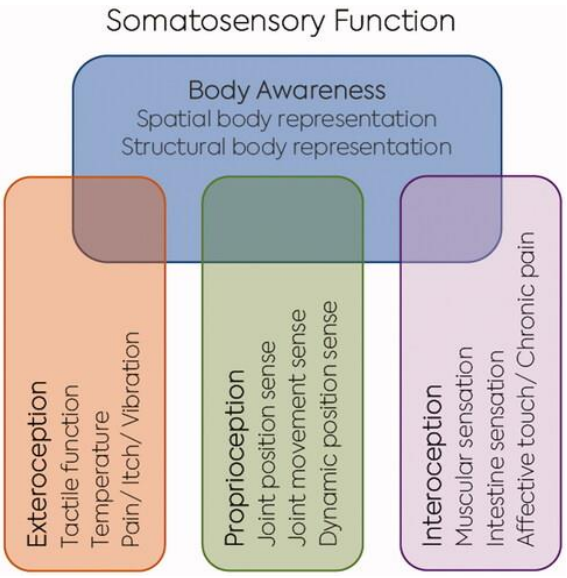


**Figure 3.** Categories and modalities of somatosensory function [17]

## Purpose

The purpose of this research was to determine the relationships among dynamic balance, lower extremity proprioception, and cognitive perception of body awareness in apparently healthy college students. This pilot study utilized a new clinical tool for measuring proprioception, and began to explore the influence of cognitive perception on balance and proprioception. The results of this pilot study can assist practitioners in designing interventions to help prevent, assess, and treat neuromotor impairments.[20-21]

## Hypotheses

The researchers hypothesized that improved proprioception would be correlated with improved dynamic balance. The researchers also hypothesized if an individual's cognitive perception of their body awareness was greater, then they would perform better on the test of proprioception.

# METHODS

## Study Design

Current tests of balance and proprioception are often expensive and not clinically feasible.[1-2, 10] Consequently, there is a lack of valid and reliable tools to quantify proprioceptive deficits, and proprioceptive abilities are rarely measured in clinical settings.[1, 8] Additionally, balance and proprioception are vastly complex processes and cannot be accurately assessed using one tool.[2] A battery of test protocols would be recommended for a complete, well-rounded assessment of balance or proprioception. For this reason, current protocols in research are widely variable and lacking in standardization. This inconsistency causes difficulty when comparing studies and treatment outcomes due to differing procedures of intervention and testing methods.

The researchers in this pilot study sought to develop a test of proprioception that would be clinically feasible, and easy to administer. The Lower Extremity Position Test (LEPT) was selected. This is a tool that recently emerged and is still being developed. The

LEPT utilizes passive joint position reproduction to quantify proprioceptive abilities.[1] The researchers attempted to improve the original protocols by providing each participant with knee high pantyhose, and instructing them to allow their foot to glide over the nylon ironing mesh. The purpose of this change was to minimize friction, and to allow for more cutaneous sensory input. This test is a cheap and simple alternative to expensive tools with higher precision, which allows the LEPT to be used more practically in clinical settings. However, the lower cost and simplicity of procedures may forfeit some precision and accuracy of proprioceptive measures.

In order to measure balance, a Biodex Balance System was utilized. Previous researchers have determined that the Biodex is a reliable and valid clinical measure of postural balance.[22-23] An individual's center of pressure can be determined using ground reaction forces that are measured using a force plate.[24] The force plate can be locked to perform static balance tests or unlocked to perform dynamic balance tests. The difficulty of dynamic balance tests can be increased by adjusting the force plate stability.[25] There are 12 levels with 1 being the most unstable, and 12 being the most stable. When the force plate is completely unlocked, a maximum of 20° of tilt in any direction is available.[24]

An online survey was used to measure cognitive perception of body awareness and collect demographic data from the participants (Appendix A).

In order to establish test-retest reliability of the LEPT, half of the participants were randomly selected to repeat this assessment one week after the original data collection.

**Participant Recruitment**

Approval for this pilot study was granted by the Murray State University Institutional Review Board (IRB). Participants were recruited through class announcements and social media posts (Appendix B). Nineteen apparently healthy college students (age 21.26±1.10 years, 12 female, 7 male) volunteered to participate in this pilot study and met the inclusion criteria (apparently healthy, 18-24 years old, with no medical conditions or medications that impact balance).

**Protocols**

Upon arrival in the testing lab, participants were briefed and reviewed the informed consent document (Appendix C) with one of the researchers. After voluntarily signing the informed consent document, participants completed the online survey. Participants completed both the balance and proprioception tests in no particular order, depending on the availability of each test. One week after the original data collection, 9 randomly selected participants repeated the LEPT.

The online survey was created using Qualtrics$^{XM}$ to collect demographic data, as well as participants' cognitive perception of their body awareness. Fourteen items from the Body Awareness Rating Questionnaire (BARQ) were selected based on sitting and standing body awareness, and relevance to the testing population.[26] Each item was scored using the rating scale shown in Table 1. The participants were instructed to select the rating that best indicated how each statement applied to themself, and not to spend too much time on any statement. The scores from all 14 questions were added to determine a total scale score for each individual.

**Table 1.** Survey rating scale

| | |
|---|---|
| 1 | Strongly disagree |
| 2 | Somewhat disagree |
| 3 | Neither agree nor disagree |
| 4 | Somewhat agree |
| 5 | Strongly agree |

The test kit for the LEPT was prepared by stacking and taping 2 foam poster boards together, and securing a nylon ironing mesh to them using thumbtacks. On the poster board a starting line was drawn, as well as two additional lines at 12 and 22 cm away from the start line. To perform the test, participants were blindfolded, sitting in a standard chair, wearing knee high pantyhose, and began with their big toes aligned with the start line. Participants

were instructed to allow their foot to smoothly glide across the surface of the ironing mesh and were familiarized with this motion before performing the test. Then in a randomized order, the tester slid their foot forward to one of the lines, and back to the starting line. Next, the tester slid the same foot forward, and the participant told the tester to stop when they thought their foot had reached the line which it had previously stopped at. The error between the target endpoint and actual endpoint was measured for each trial to the nearest half of a centimeter and recorded on the data collection sheet (Appendix D). This procedure was performed twice to each line on both feet for a total of 8 trials.

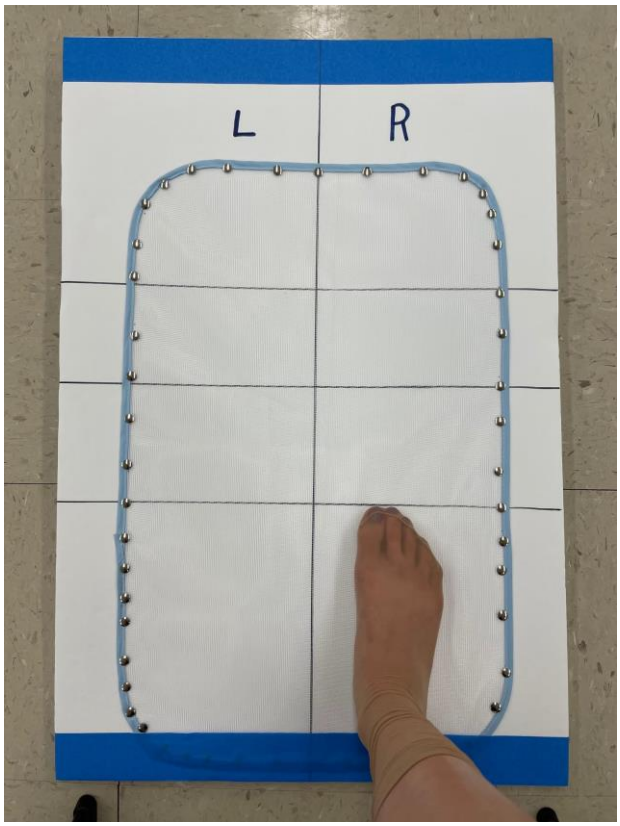


**Figure 4.** Lower Extremity Position Test kit

Balance was measured using a Biodex Balance System. The Limits of Stability Test (LoS) was utilized with a platform setting of 12. The hold time was set to .25 seconds, and tracing was turned on. To perform the test, the participants stepped onto the force plate, placing their feet aligned on the grid as indicated by the Biodex based on height. Participants

were wearing close-toed shoes during this test and were familiarized with the protocols through verbal instruction. Participants were instructed to keep their arms by their sides, avoid using the handlebars for assistance, and to complete the test as quickly and accurately as possible. The Biodex screen displayed 9 dots as shown in Figure 5. A cursor on the screen indicated the location of the individual's center of pressure, and to complete the test, the individual shifted their center of pressure from the middle dot to one of the outside dots, then back to the middle, hovering over each dot for a minimum of .25 seconds. They performed this procedure for each of the 8 dots on the outer circle, in a random order, and the test was performed 3 times by each participant. The Biodex determined the time to completion for each trial, and calculated a directional control score (DCS) for each dot by dividing the distance traveled from the middle dot to the outside dot, by the straight-line distance from the middle dot to the outside dot. The equation used for this calculation is provided in Figure 6. The quotient of this calculation was multiplied by 100, then expressed as a percentage for each of the 8 outside circle dots. The results of all 8 outer circle scores were averaged for an overall DCS. The tester also recorded the number of balance errors committed during each trial on the data collection sheet (Appendix E).

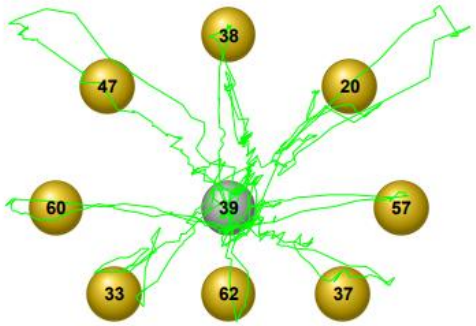


**Figure 5.** Limits of stability screen display and results

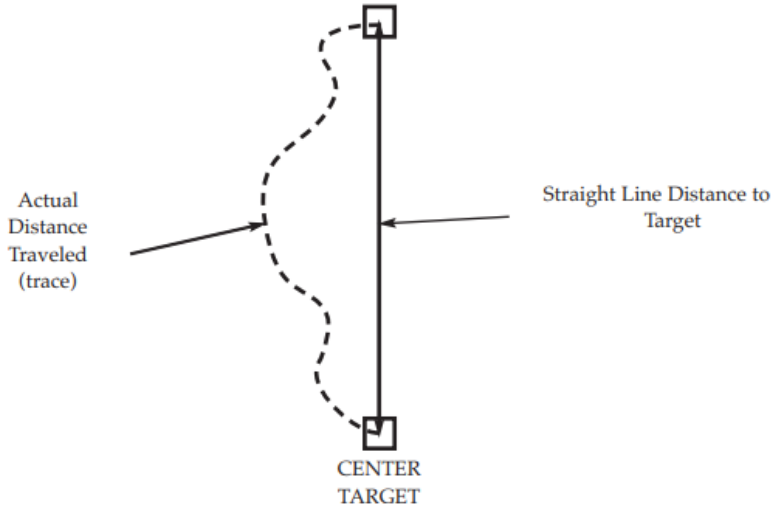


**Figure 6.** Methods for calculating directional control score [27]

### Statistical Analysis

Version 28.0.1.1 of SPSS (IBM Corp., Amonk, New York) was used to perform statistical analysis of the test results. The mean and standard deviation was calculated for the results of each test. Reliability was calculated using Cronbach's alpha and intraclass correlation coefficients. An independent sample T-test used Hedge's correction to determine if there were any significant differences between groups. Pearson's correlation coefficient was used to determine the relationships between variables, and a simple linear regression was used to determine the relationship and shared variance between LEPT error and DCS. Statistical significance was set at $P<.05$. Dependent variables included the average overall DCS, average error on the LEPT, and survey scale score.

## RESULTS

### Participant Characteristics

Demographic data collected from the survey is shown in Table 2. Participants reported their age, sex, ankle injury history, and their dominant leg. Table 3 displays previous formal sport participation, as well as current National Collegiate Athletics Association (NCAA) sport participation.

**Table 2.** Participant characteristics

| | **All (*n* = 19)** |
|---|---|
| Age, mean ± SD | 21.26 ± 1.10 |
| Sex (%) | |
| Male | 7 (37) |
| Female | 12 (63) |
| History of ankle injuries (%) | |
| Not applicable | 9 (47) |
| Right ankle only | 4 (21) |
| Left ankle only | 2 (11) |
| Both ankles | 4 (21) |
| Dominant leg (%) | |
| Right | 16 (84) |
| Left | 3 (16) |

**Table 3.** Participant sport participation

| | **All (*n* = 19)** |
|---|---|
| Previous sport participation (%) | |
| Dance | 3 (16) |
| Football | 2 (11) |
| Gymnastics | 5 (26) |
| Horseback riding | 1 (5) |
| Martial arts | 1 (5) |
| Skiing | 2 (11) |
| Swim | 2 (11) |
| Yoga | 1 (5) |
| None of the above | 10 (53) |
| Current NCAA sport participation (%) | |
| Baseball | 1 (5) |
| Softball | 1 (5) |
| Track and field | 1 (5) |
| Not applicable | 16 (84) |

**Survey**

After analyzing the data, the survey scale score was found to have an acceptable reliability ($\alpha$=.787). The participants scored themselves an average of 54.95 points out of 70 possible points. The distribution of these results is demonstrated in Figure 7.

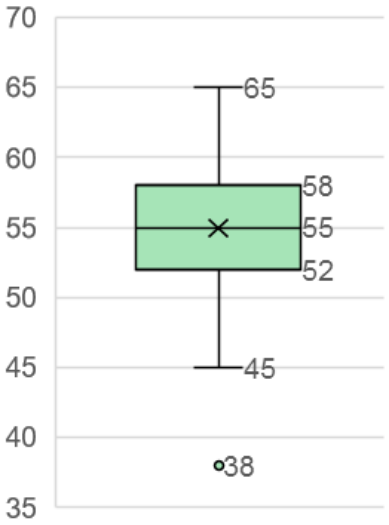


**Figure 7.** Survey scale score distribution

**Proprioception Test**

The test-retest reliability of the LEPT was questionable, but approaching good (*α*=.692). However, a moderate correlation was found between the first and second tests for the 9 subjects who retested (*r*=.553). This relationship is shown in Figure 8. Based on the independent samples t-test, there was no significant difference between the group of subjects who re-tested, and those who did not (*P*=.282).

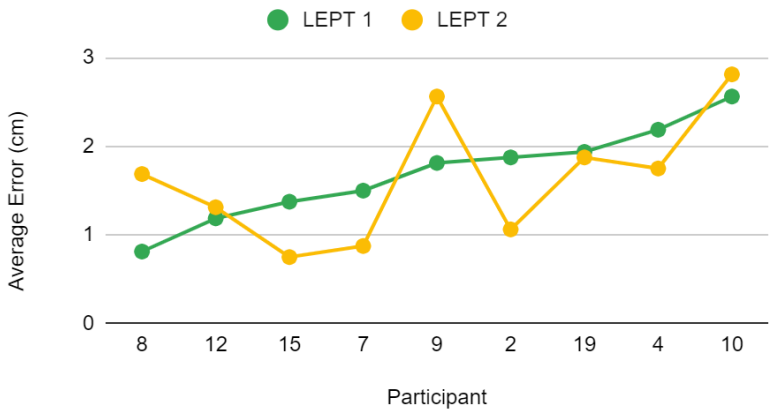


**Figure 8.** Test-retest results of the Lower Extremity Position Test

Average error during the first LEPT was 1.49 ± .57 cm. Retest participants averaged an error of 1.63 ± .72 cm. Participants had a tendency to undershoot the target endpoint. Between tests 1 and 2, 66.9% of all 224 trials were undershot. Only 11.6% of trials had no error, with the remaining 21.9% of trials being overshot.

**Balance Test**

On the LoS test, the trial 1 overall DCS results were significantly different from trials 2 ($P$=.013) and 3 ($P$=.009) results, and therefore served as a familiarization trial. An acceptable reliability and good intraclass correlation coefficient were determined between trials 2 and 3 of the LoS test ($\alpha$=.767). Participants averaged an overall DCS of 24.71 ± 5.40% between trials 2 and 3. Time to completion was 65.87 ± 10.69 seconds on average. Researchers differentiated balance errors on the data collection sheet by upper extremity and lower extremity movements; however, none of the participants corrected a balance error by adjusting their foot placement. The number of balance errors committed during trials 2 and 3 was only .82 ±1.47. Nearly half of the participants (47%) committed no balance errors during the second and third trials of the LoS test.

**Variable Relationships**

The relationships among overall DCS, average LEPT error, and survey scale score are shown in Figure 9. The test results of this study indicate a moderate negative correlation between overall DCS and average LEPT error, which was significant ($r$=-.495, $P$=.031). However, survey results were not significantly correlated with the balance ($r$=.141, $P$=.565) or proprioception ($r$=.188, $P$=.440) results.

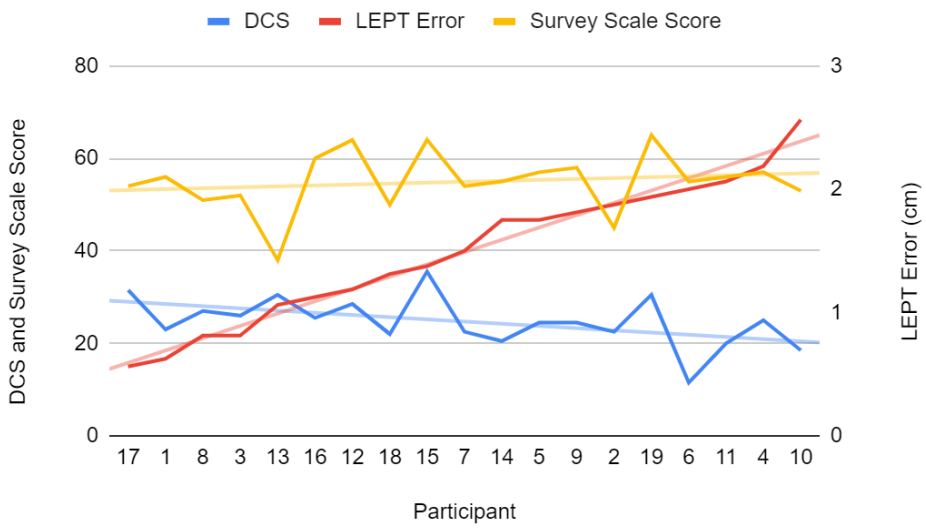


**Figure 9.** Relationships among directional control score, Lower Extremity Position Test error, and survey scale score

The researchers determined that average LEPT error can reliably predict balance scores, accounting for 24.6% of the variance in scores (*P*=.026). The results of this regression analysis suggested that for every 1 cm of additional error on the LEPT, overall DCS can be expected to decrease by 4.401.

A weak negative correlation was found between overall DCS and number of balance errors committed (*r*=-.268) however, this result was not significant (*P*=.266). A very significant negative correlation was found between the time to completion and overall DCS (*r*=-.846, *P*<.001). Individuals who scored higher on the LoS test were also able to complete the test faster. This inverse relationship is displayed in Figure 10.

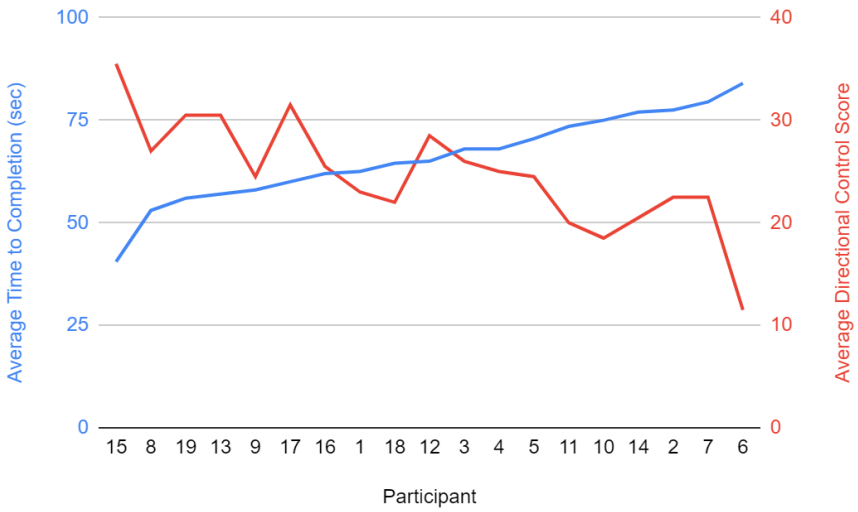


**Figure 10.** The relationship between directional control score and time to completion

When assessing the impact of leg dominance on proprioceptive performance for all 19 participants, no significant difference was found. These results can be seen in Figure 11.

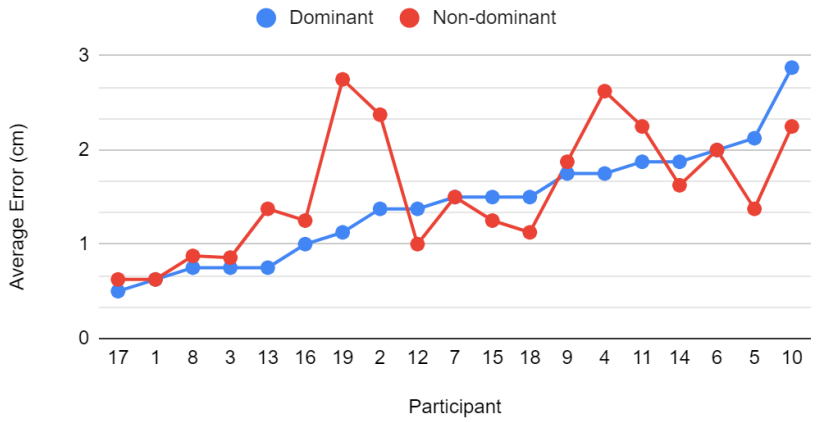


**Figure 11.** The relationship between directional control score and time to completion

Previous sport participation in dance and gymnastics did show a medium effect size on balance performance (Hedge's *g*=.502). There was no significant difference between proprioception in dancers and gymnasts (*n*=5) compared to the rest of the population sample (*n*=14).

When exploring the impact of ankle injury history, there was no significant difference between proprioceptive performance in individuals' previously injured extremities (right ankle injuries *P*=.435, left ankle injuries *P*=.650) compared to non-injured extremities.

Current sport participation also resulted in no significant difference between overall DCS (*P*=.944), average LEPT error (*P*=.666), and survey scale scores (*P*=.304) of current athletes and non-athletes.

## DISCUSSION

### Interpretation

The researchers' primary hypothesis that improved lower extremity proprioceptive performance would be correlated with improved dynamic balance performance was supported by the outcomes of this research. This result can be explained by the close relationship between balance and proprioception, as discussed previously.

Many findings from this study corroborate the results of previous research. The original study by Ofek et al. that developed the LEPT also found a fair test-retest reliability for young adults using the LEPT, and fair to good test-retest results adults.[1] Therefore, this test may be able to more accurately measure proprioception in older populations, and the impact of age on reliability of this test should be explored further. Previous research has also demonstrated that limb dominance has no significant effect on proprioception.[16] This finding may be due to the low level of intensity of this test. Limb dominance may have a more significant effect as difficulty of the test increased.[16] Individuals may be able to perform specialized movements, such as kicking a ball, with more accuracy in their dominant limb; however, this difference is not relevant to simple lower extremity movements. There is actually no consensus in current research as to whether or not dominance of lower extremity limbs even exists.[28] In regards to sport performance, test results were also consistent with previous research findings. A systematic review of athletic involvement and balance found that gymnasts had the best balance out of all other athletes.[15] However, no significant difference in proprioception test results based on dance and gymnastics experience was

determined. These results were likely skewed by the performance of Participant 19, who had recently undergone ankle surgery, and was weight-bearing for just 2 weeks before participating in this pilot study. This ankle injury appeared to have a significant impact on their proprioceptive performance. Before this injury, their right foot was their dominant foot, however, their left foot performed considerably better during the LEPT (*P*=.053). Due to the poor right foot performance during the LEPT, and the inclusion of this result in the group of previous dancers and gymnasts, the proprioception test results of Participant 19 may have negatively impacted the average proprioceptive ability of previous dancers and gymnasts participating in this study. This relationship should be explored further with a larger sample of dancers and gymnasts.

The results of Participant 19 indicate that ankle injuries may have a temporary negative impact on proprioceptive ability. On average, the impact of ankle injuries was not significant; however, for recent injuries such as in Participant 19, a large decline in proprioceptive ability was observed in the injured limb. This result is consistent with the findings of previous research.[1-2, 5, 8, 20] Future studies could explore the extent and duration of impact of ankle injuries on proprioceptive ability.

The hypothesis that increased cognitive perception of body awareness would be correlated with improved lower extremity proprioceptive performance cannot be confidently accepted based on the results of this study. Surprisingly, on average, the individuals who performed poorer on the LEPT, scored themselves higher on the BARQ than the individuals who scored above average on the LEPT. This outcome may be due to the Dunning-Kruger Effect, in which an individual who has low competency in a certain area overestimates their abilities in that area.[29] A visual representation of how competency is compared to confidence regarding the Dunning-Kruger Effect is provided in Figure 12. Research findings on the Dunning-Kruger effect are inconsistent, but this result should be further explored in future research.

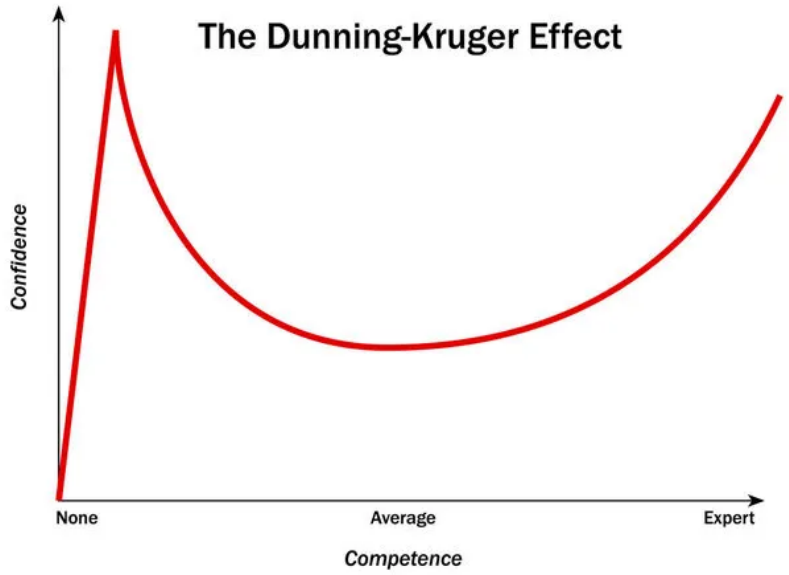


**Figure 12.** The Dunning-Kruger Effect [29]

**Limitations**

There were many limitations to this pilot study. First of all, a small sample of convenience was used, therefore these results cannot be generalized. Also, intratester reliability was not tested to determine the consistency and accuracy of data collection methods. Some confounding factors that were not controlled for during the LEPT include level of muscle activation, starting position angle of the hips, knees, and ankles, and velocity of sliding the foot.[2] Additionally, body mass and foot wear were not controlled, which may have an impact on the LoS test results.[24, 30] Lastly, proprioception and balance are extremely complex mechanisms that cannot be adequately assessed with only one test.[2] A battery of tests may be more accurate in assessing overall balance and proprioceptive abilities.

**Considerations for Future Research**

Future research should incorporate more controlling of the confounding factors previously mentioned. Researchers should also consider including familiarization trials, especially when using the Biodex. Participant 12 was familiarized with the Biodex before participating in this research. This individual received the highest overall DCS on the first trial

out of all of the participants; however, when comparing the average overall DCS of the second and third trials only, participant 12 was in the 70th percentile of the sample population. They may have been able to perform better in the first trial due to their previous experience with the Biodex.

A potential follow-up study should explore the impact of proprioception education on proprioceptive performance and cognitive perception of body awareness. Techniques such as yoga, tai chi, or mindfulness could be utilized to improve proprioception.[8, 31]

## CONCLUSION

In conclusion, the results of this pilot study generally corroborate previous research. The researchers found that balance is correlated with proprioception, limb dominance does not have a significant impact on proprioceptive ability, participation in dance or gymnastics may result in improved balance, and ankle injuries may temporarily impair proprioceptive abilities. The LEPT may be an acceptable tool that is cheaper, easier to administer, and more feasible than clinical tools of high precision. The role of cognitive perception of body awareness should be researched to a greater extent in order to determine its influence on balance and proprioception.

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**Appendix A** Survey

1. Enter your participant ID.
2. Identify your sex.
3. Enter your current age in years.
4. Which is your dominant leg.
5. Have you ever suffered an ankle injury?
6. Have you ever formally participated in any of the following sport activities for an extended period of time (greater than or equal to 1 year). Check all that apply.
    Dance
    Football
    Gymnastics
    Horseback riding
    Marching band
    Martial arts
    Skiing
    Swimming
    Wrestling
    Yoga
7. If you are currently a Murray State athlete, or are participating in a sports club, state the sport.

Instructions: Please read each statement in the right hand column, and then click on the rating that BEST indicates how much the statement generally applies to you. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:
1 = Strongly disagree
2 = Somewhat disagree
3 = Neither agree nor disagree
4 = Somewhat agree
5= Strongly agree

1. I pay attention to the way I move.
2. My muscles are often tense without me knowing why.**
3. I never sit comfortably.**
4. I am able to coordinate my body.
5. I avoid paying too much attention to the way I move.**
6. I sense if my joints are tense or flexible.
7. In standing, my feet have good contact with the ground.
8. I am not aware of my habit positions.**
9. Body signals help me find my limits.
10. I am stable on my feet
11. My body sensation helps me find comfortable positions
12. I usually move smoothly.
13. I am not aware of how I'm standing.**
14. I avoid sensing my body.**

** indicates reversed question

**Appendix B** Participant Recruitment Text

Exercise Science faculty and junior Courtney Helmick are conducting research over balance and body self-awareness. They are looking for college students who are willing to participate in this pilot study and have no current injuries or neurological limitations in the knees or feet. The study consists of a brief survey, test of proprioception, and balance test utilizing the Biodex Balance System. If you would like to participate, please fill out the Google Form linked below, and you will be contacted via email to sign up for a 20 minute time slot for testing. If you have any questions, contact Courtney at chelmick@murraystate.edu or Dr. Reeves at breeves3@murraystate.edu.

https://docs.google.com/forms/d/e/1FAIpQLScN-x9OoScrM6_rCia1als7bOcpdAkzNv9nCE0ZwjQ6WSz69g/viewform?usp=sf_link

**Appendix C** Informed Consent

## Consent to Participate in a Research Study

**KEY INFORMATION FOR:** The relationship among proprioception, balance, and cognitive perception of body awareness, in college students.

We are asking you to choose whether or not to volunteer to participate in a research study. The purpose of this research study is to evaluate the relationship among cognition, proprioception, and balance in male and female college students. This document will provide important information to help you decide whether or not to participate.

**WHAT IS THE STUDY ABOUT AND HOW LONG WILL IT LAST?**
Balance is an important skill-related component of physical fitness that is essential for performing exercise and daily tasks. Integration of proprioceptive signals plays a key role in balance. This study will compare dynamic balance to lower extremity proprioception. Extensive research has previously been conducted over balance and proprioception, but the effect of cognitive perception of kinesthesia has not previously been included in this research. An online survey of body awareness, limits of stability test, and lower extremity proprioception test will be used to explore the relationship between cognitive perception of body self-awareness, proprioception, and balance in college students

The study will take approximately 20 minutes. Half of the participants will only complete the tests once, while the other half of the participants will complete these tests on two separate occasions.

**VOLUNTEER FOR THIS STUDY?**
You may choose to participate if you are: 1) between 18-24 years of age, and 2) apparently healthy. The results of this study may assist in developing effective interventions to improve balance performance in college students.

**WHAT ARE KEY REASONS YOU MIGHT CHOOSE NOT TO VOLUNTEER FOR THIS STUDY?**
You may choose not to participate if you are 1) under the age of 18 years, 2) over the age of 24 years, 3) currently taking any medications that may impact balance performance 4) have any existing neurological or orthopedic conditions that may impact balance performance. The risks associated with this exercise training study are no greater than what would be associated with participating in any light physical activity.

**DO YOU HAVE TO TAKE PART IN THE STUDY?**
If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any services, benefits, or rights you would normally have if you choose not to volunteer.

**WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS OR CONCERNS?**
If you have questions, suggestions, concerns regarding this study, or you want to withdraw from the study contact Dr. Brenda Reeves (breeves3@murraystate.edu) or Courtney Helmick (chelmick@murraystate.edu) of Murray State University, School of Nursing and Health Professions.

**DETAILED INFORMED CONSENT:**

**ARE THERE REASONS WHY YOU WOULD NOT QUALIFY FOR THIS STUDY?**
You do not qualify for this study if you are under the age of 18 years, over the age of 24 years, are taking any medications that may impact balance, or have existing neurological or orthopedic conditions that may impact balance.

**WHERE WILL THE STUDY TAKE PLACE AND WHAT IS THE TOTAL AMOUNT OF TIME INVOLVED?**
Participants will sign up for a testing time slot. At their indicated test time, each participant will report to Oakley Applied Science room 408N, voluntarily sign the informed consent document, and complete a brief online survey of body self-awareness. Next, the participants will be familiarized with the Lower Extremity Position Test (LEPT) by verbal instruction and demonstration using the upper extremity. Then the participants will perform three trials of the LEPT on each leg. The participants will also perform three trials of a limit of stability balance test using the Biodex Balance System. After completing all of the tests, the participant will be briefed, and provided with their baseline results as well as guidance toward exercises for improvement.

**WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?**
During balance testing, bodily injury resulting from accidental falls may occur. By adhering to all guidelines and proper techniques, any risks will be minimized. In addition, you may discontinue your participation at any time. While risks cannot be perfectly predicted, there is no expectation of anything more than “normal risks” associated with participation in exercise to be associated with this study.

**WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?**

Participants will benefit by receiving baseline information on their balance and proprioceptive abilities. They will also be provided with guidance to seek additional exercises for balance and proprioception improvements.

**IF YOU DON’T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?**
If you do not want to participate in the study, there are no other choices except not to take part in the study.

**WHAT WILL IT COST YOU TO PARTICIPATE?**
There are no costs associated with taking part in this study.

**WHO WILL SEE THE INFORMATION THAT YOU GIVE?**
When we write about or share the results from the study, we will write about mean, aggregate, or combined information. All of your information will be coded, encrypted, and kept on the password-protected computer of the research investigator. Your name or any other identifying information will be kept confidential. All identifiable information will be shredded at the conclusion of the study. The coded data will be stored minimally for 3 years with an electronic file with a secure log-in and password combination, and in print in the primary investigators’ locked offices (405 N. Applied Science).

**CAN YOU CHOOSE TO WITHDRAW FROM THE STUDY EARLY?**
Your participation in this study is strictly voluntary, and you have the right to withdraw from participation at any time without penalty, loss of rights, or retaliation in any manner.

In addition, the researchers conducting the study may need to remove you from the study if:

- you are not able to follow the directions and procedures, or
- they find that your participation in the study is more risk than benefit to you

If you choose to leave the study early, the data collected until that point will remain in the study database, and may not be removed.

**WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?**
There are no rewards, monetary or otherwise, associated with participating in this study.

**WHAT IF NEW INFORMATION IS LEARNED DURING THE STUDY THAT MIGHT AFFECT YOUR DECISION TO PARTICIPATE?**
You may discontinue your participation in the study at any time. However, if the researchers learn new information that could change your mind about remaining in the study, that information will be disclosed to you. At that point, you may choose to withdraw from the study without penalty.

**WHAT ELSE DO YOU NEED TO KNOW?**
There will be supervising faculty on the research team assisting with data collection and entry at different times during the study. All members of the research team have appropriate training. The information that you are providing will no longer belong to you.

This research study may lead to new findings and educational knowledge, as well as assist in developing effective interventions to improve balance and proprioception of young adults.

**WILL YOUR INFORMATION BE USED FOR FUTURE RESEARCH?**
All identifiable information (e.g., your name, etc.) will be removed from the data collected in this study, and any aggregate data or results may be presented, published, or used for future research without your additional informed consent.

**SIGNATURES**
This consent includes the following:

- Key Information Page
- Detailed Consent

I understand my rights and responsibilities as a participant, and I voluntarily consent to participate in this study.
I understand what the study is about, and how and why it is being done. I will receive a signed copy of this consent form after it has been signed.

| | |
|---|---|
| _____ **Printed name of research subject** | **Date**_____ |
| _____ **Signature of research subject** | |
| _____ Printed name of [authorized] person obtaining informed consent | _____ Date |

If you have questions or concerns about this research study, you may contact one of the following persons:

Dr. Brenda Reeves, FACSM
breeves3@murraystate.edu
207-809-5688

Courtney Helmick
chelmick@murraystate.edu
636-875-9220

**Appendix D** Lower Extremity Position Test Data Collection Sheet

Participant ID _____

| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 | Trial 7 | Trial 8 |
|---|---|---|---|---|---|---|---|---|
| Foot (R/L) | | | | | | | | |
| Distance | | | | | | | | |
| Error (cm) | | | | | | | | |

**positive error indicates overshooting target distance, negative error indicates undershooting target distance

Average right leg error _____ Average 12 cm error _____

Average left leg error _____ Average 22 cm error _____

Overall average error _____

**Appendix E** Limits of Stability Test Data Collection Sheet

Participant ID _____

| | Trial 1 | Trial 2 | Trial 3 | Average |
|---|---|---|---|---|
| Balance error (touch on handle bar) | | | | |
| Balance error (step/adjust foot placement) | | | | |
| Time (sec) | | | | |
| Direction Control Score | | | | |