**Impact of Spotting on Balance and Perceived Dizziness in Dancers and Non-Dancers**

## Introduction

Rationale

I have danced ballet professionally for most of my life and have always been told that spotting is how we keep our balance when turning on a vertical axis. Furthermore, it prevents dizziness after turning. Spotting is a general term used in dance which describes how the head turns as the body turns, as depicted in diagram 1. The head and gaze first stay at the original direction of the body, at the point where it has to move, it rapidly turns before the body, back to the original position. I have always been curious as to whether the effect of spotting is over exaggerated, or whether it is rooted in scientific biology. This curiosity was further stimulated by the human physiology chapter and my independent reading on neurology. As such I want to investigate to what extent spotting helps with balance and dizziness when turning.

*Diagram 1, Spotting (Photograph by Author, 2021)*

Theory

How does the vestibular system work:

The vestibular system is located in the inner ear, it's function is to provide the brain with information about spatial orientation of the head and body, providing information about movement and balance. The vestibular system is made up of three semicircular canals which register different directional motions. 1. Up and down movement, 2. Side-to-side movement, 3. Tilting movement (Vestibular Disorders Association). Each canal has receptors called maculae which are patches of small hairs with crystals called otoconia on them. There is also fluid inside the channels which affect the maculae when the head moves. The haircells register movement of the fluid, and signal the information to the brain

through the acoustic nerve (American Speech-Language-Hearing Association, 2020). Along with the vestibular system, vision and proprioception affects the sense of balance (the Royal Victorian Eye and Ear Hospital).

How does spinning affect this: Initially when turning, the fluid in the vestibular system, and thus the hair cells, move opposite of the motion of the head. Then, the fluid switches to flow with the movement of the head, causing them to straighten. When the hair cells are straight, the vestibular system does not register spinning. When you stop turning, the opposite is happening. The hairs move the direction your body was spinning, bending to that direction. This causes you to perceive yourself as turning, although you are not (Natalie Wolchover, 2012).

What is spotting supposed to do: Spotting helps level out the liquid in the vestibular system. It supposedly impacts the movement of the fluid inside the vestibular system, causing the hair cells to be straight for a longer period of time, thus decreasing the sense of spinning and the dizziness after (A. Schaerli, 2017).

## Research question

To what extent does spotting when turning repeatedly (15 turns to a 45 BPM beat) affect a person's balance depending on whether they are skilful spotters/ experienced dancers (ED), or are non-dancers (ND), measured in:

1. The time (seconds) they are able to stand on one foot with their eyes closed 5 seconds after turning.
2. The distance (cm) between their standing foot, and the foot which touches the floor as they lose balance.
3. Their sense of dizziness (qualitative scale of 0-10).

## Hypothesis

*Spotting whilst turning will, to an obvious and significant extent, improve the participants balance after turning due to its effect on the fluid in the vestibular system, there will also be a significant difference between experienced dancers and non-dancers due to their skill at spotting.*

Variables

Dependent: Time (seconds) participants are able to stand on one foot after turning, distance (cm) between standing foot and foot touching the ground, the participants' sense of dizziness after turning (0-10).

Independent: Whether participants are spotting or not, as well as the two experimental groups, non-dancers, and experienced dancers.

Controlled:

| Controlled variables | Method for controlling |
|---|---|
| Number of rotations and number of seconds turning | Metronome 45BPM held consistent. The duration is also kept consistent (20 sec). |
| Time since last meal | Experiment 2 hours after last meal. |
| Age of participant | Participants will be aged 16-19. |
| Other techniques for maintaining balance and avoid dizziness | Participants refrain use of different techniques for maintaining balance and avoiding dizziness. |
| Drinking stimulants prior to the experiment (coffee, alcohol etc.) | Participants asked not to drink coffee or tea in the hours prior to the experiment. |
| Time between trials | Participants rest 5 min between each trial. |

**Procedure**

There is no established, scientific procedure for this experiment, as such adapted the procedure of Schaerli's experiment to a school context. My choice of balance test is rooted in tests recommended to use in physiotherapy, adapted to be a test completable in short time after spinning, whilst the participants are still dizzy.

Equipment

Measuring tape, uncertainty +-1.00 cm due to human error

Timer, uncertainty +-0.5 seconds due to human error

iPhone to record experiment and to project metronome


Procedure

1. Provided participants with consent form detailing procedure and ethical considerations, all participants signed prior to experiment. (Appendix)
2. Taught participants to spot through showing diagram 1 and allowing 15 minutes to practice to 45BPM.
3. Participants practice the balance test as pictured *(photograph by author, 2021)*: stand on one foot, eyes closed, arms close to body. When no longer able to maintain balance, place the second foot on the floor, as close to the standing one as possible.
4. Conducted control trial where participants do the balance test without spinning prior, ended test after 1 min. Filmed the balance test each time to accurately measure seconds balancing. When they stopped balancing, the distance between the inner part of their feet (cm) was recorded.
5. Filmed participants turning for 20 seconds *while spotting* to a beat of 45 BPM (15 turns +- 1).
6. 5 second break, then conducted balance measurement as detailed in step 3 while still filming and asked participants to rate their dizziness on a scale from 0-10.

Maintain 5 min rest between step 6 and step 7

7. Filmed the participants turning for 20 seconds *without spotting* to a beat of 45 BPM (15 turns +-1).
8. Repeat step 6.
9. The participants again ranked their dizziness on a scale from 1-10.
10. For safety and ethical reasons, ensured participants were hydrated and stable after the experiment.
11. Reviewed films recording the time (sec) the participants balanced as according to the balance test, reviewing the videos slowed down after the experiment allowed for increased precision and decreased uncertainty in the seconds balancing.

Special considerations

Turning may be an uncomfortable experience, and this experiment will likely induce feelings of dizziness and nausea. To ensure the experiment is conducted ethically, a thorough consent form was provided and signed by participants before the experiment (appendix). They are aware they can leave at any point, and there are breaks between trials. Safety considerations of participants falling is minimal as the participants are given rest and can stop at any point if they feel at risk or otherwise uncomfortable. Space is cleared around the participants such that they will not bump into anything. No Covid-19 restrictions applied at time of experiment. There are no environmental considerations in this experiment.

**Results**

Qualitative data:

As the participants completed the turning section of the experiment, they rated their dizziness on a scale of 0-10, the difference between their answer after spotting and after not spotting was recorded. The average difference was 1.75. This means that participants rated their dizziness higher after turning without spotting to a significant extent. 1 participant recorded feeling dizzier after spotting, I consider this an outlier.

I established that participants complete 5 minutes of rest between trials, but participants consistently stated that their dizziness and imbalance disappeared after 1-2 minutes. I upheld 5 minutes rest for consistency, but this may not be necessary. I observed that participants were visibly disoriented initially after turning, but within the 5 second break between turning and balancing, disorientation decreased significantly. Furthermore, after the balance test was completed, most participants expressed feelings of nausea, this decreased from uncomfortable to mild within 1 minute. No participant expressed feelings of dizziness or nausea after 3 minutes. During the balance test, many participants were jumping around on their standing foot to keep their balance. I did not stop the test at this point, this is discussed in my evaluation.

Data and Processing

Uncertainty in seconds balancing is +-0.50 sec. Determined by reviewing one video of balancing 5 times and recorded when the participants' foot touched the floor each time I viewed the video. I averaged the value and calculated SD. The absolute value of the SD was 0.46 seconds, rounded to 0.50. I repeated the same procedure to establish cm uncertainty. This resulted in an SD of 0.89 cm, rounded to 1cm.

*Table 1. Average time (sec) experienced dancers and non-dancers balanced on one foot after turning for 20 Sec, with (S) or without spotting (NS). Full data in appendix.*

| Type of turning | ND (sec) +-0.50 | SD | ED (sec) +-0.50 | SD |
|---|---|---|---|---|
| No turning | 58.9 | 3.4 | 60.0 | 0.0 |
| Turning, NS | 4.2 | 1.8 | 6.0 | 2.4 |
| Turning, S | 12.8 | 10.9 | 20.3 | 8.5 |
| % Difference S and NS | 267.64 | | 259.48 | |

*Graph 1. Average time (sec) experienced dancers and non-dancers balanced on one foot after turning for 20 sec, with or without spotting, with standard deviation.*

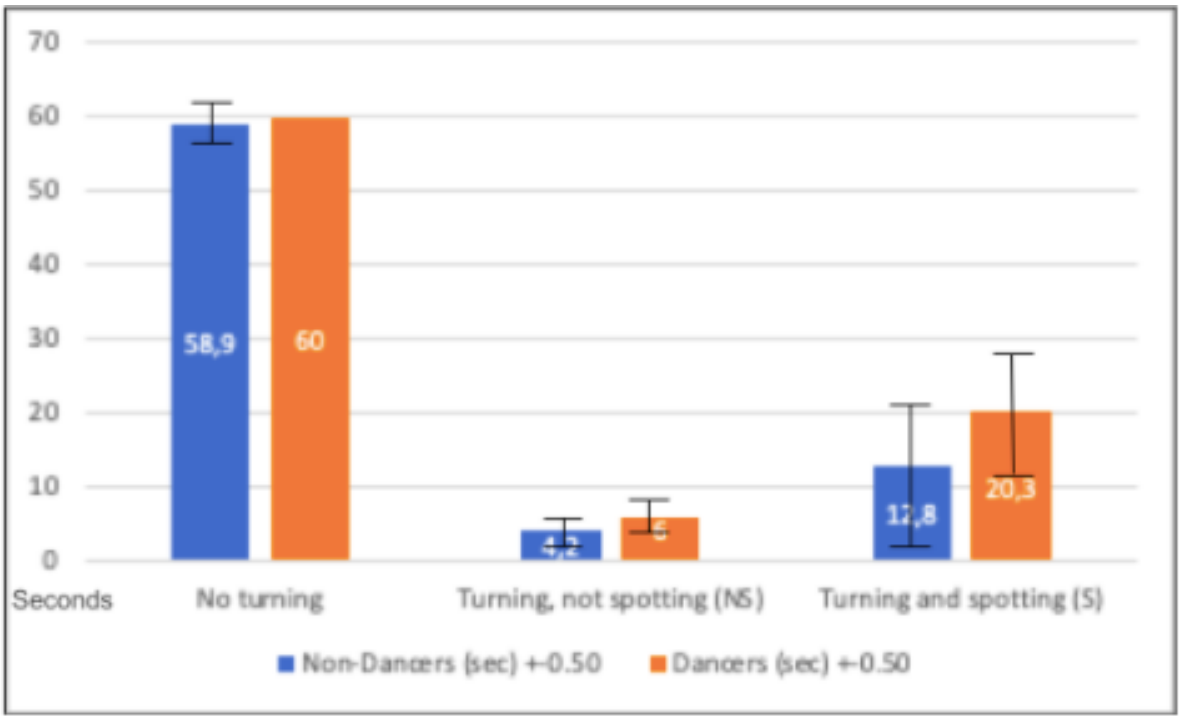
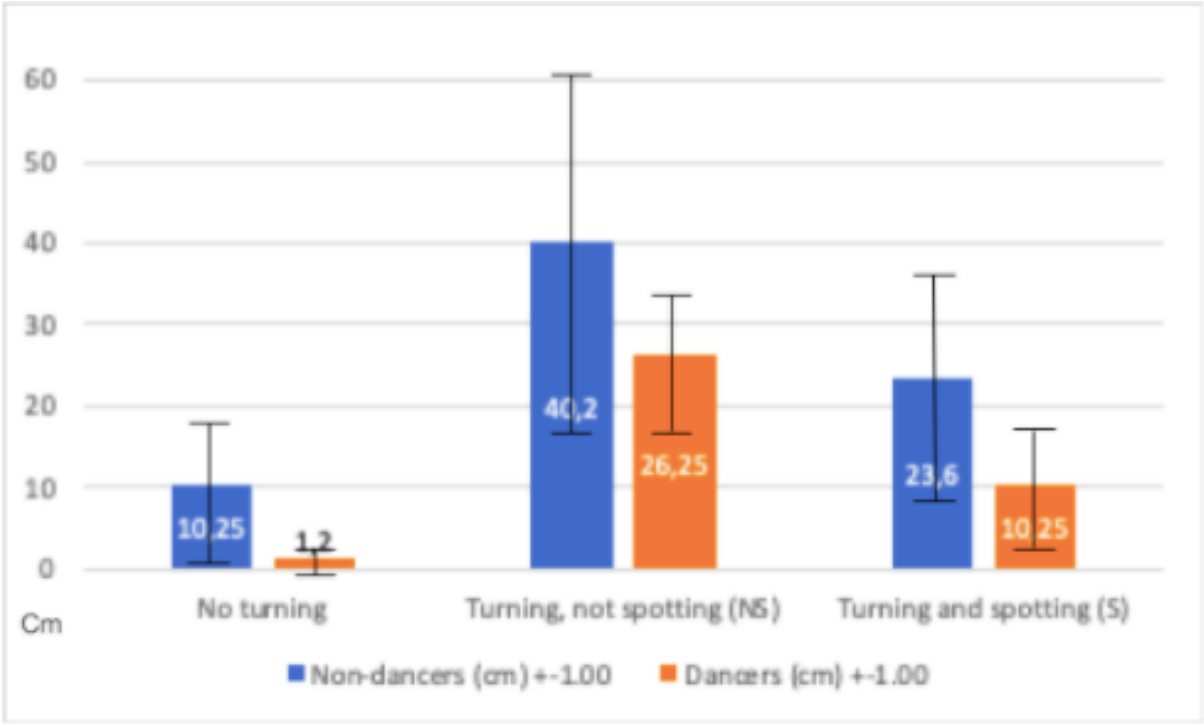


*Table 2. Average distance (cm) experienced dancers and non-dancers had between the inner part of feet after standing on one foot after turning, with or without spotting. Full data in appendix.*

| Type of turning | ND (cm) +-1.00 | SD | ED (cm) +-1.00 | SD |
|---|---|---|---|---|
| No turning | 10.3 | 9.6 | 1.2 | 1.7 |
| Turning, NS | 40.2 | 23.7 | 26.3 | 9.1 |
| Turning, S | 23.6 | 14.0 | 10.3 | 7.2 |
| % Difference | -36.46 | | -63.17 | |

*Graph 2. Average distance (cm) experienced dancers and non-dancers had between the inner part of feet after standing on one foot after turning, with or without spotting, with standard deviation.*




I completed a paired T-test to establish whether spotting had a significant impact on balance for dancers and non-dancers. The paired T-test enables a comparison between two different trials on the same group.

*Table 3. Paired T-Test (excel) measuring difference in results between spotting and not-spotting for both experimental groups and both measuring modes (cm, sec)*

| T-Test | Significance Level | Degrees of Freedom ($n_1+n_2-1$) | Obtained P-Value | Significant Difference? |
|---|---|---|---|---|
| Non-dancers, S and NS, (sec) | 0.05 | 19 | 0.036 | Yes |
| Dancers, S and NS, (sec) | 0.05 | 19 | 0.00023 | Yes |
| Non-dancers, S and NS, (cm) | 0.05 | 19 | 0.0049 | Yes |
| Dancers, S and NS, (cm) | 0.05 | 19 | 0.000037 | Yes |

I performed an unpaired T-test to distinguish whether there was a significant difference in results between the two groups. Unpaired T-test allows you to investigate the difference between experimental groups rather than experimental trials.

*Table 4. Unpaired T-Test (excel) measuring difference in results between experimental groups. spotting and not-spotting, both modes of measuring (sec, cm)*

| T-Test | Significance Level | Degree of Freedom ($n_1+n_2-2$) | Obtained P-Value | Significant Difference? |
|---|---|---|---|---|
| Not spotting, ED and ND, (sec) | 0.05 | 18 | 0.083 | No |
| Spotting, ED and ND, (sec) | 0.05 | 18 | 0.133 | No |
| Not spotting, ED and ND, (cm) | 0.05 | 18 | 0.095 | No |
| Spotting, ED and ND, (cm) | 0.05 | 18 | 0.017 | Yes |

## Discussion

Analysis

Graph 1 shows an increase in sec balancing for both experimental groups between spotting and not spotting. Additionally, the experienced dancers balanced for a visibly obvious longer time than the non-dancers, the difference being greatest when spotting. Graph 2 shows an obvious difference in distance between feet when turning with spotting and without spotting. Turning with spotting had significantly smaller distance between feet in both groups, but dancers consistently have a smaller distance between their feet than non-dancers.

The T-tests performed in table 3 show a significant difference in results for both groups and both modes of measurement. This means that spotting consistently resulted in better balance. The significance level used in biology (0.05) was surpassed in all paired T-test meaning there is minimal possibility that the results were random. However, my averages have major standard deviations. This seems to be because of certain participants whose data were major outliers, such as participant number 6 who balanced for 41 seconds after spotting, 25 seconds longer than the closest non-dancer. This may be due to naturally having better balance, or an anomaly which could not be reproduced.

The results obtained support my hypothesis that spotting significantly improves balance and diminishes dizziness. Whilst I hypothesize that this is because the liquid in the vestibular system experiences less inertia when initially beginning to spin, leaving the hair cells more straight from the beginning, there may be other factors of balance which spotting assists. For example, visual consistency, when spotting, your gaze remains at one point, this could influence your balance by decreasing de-orientation. Therefore, I cannot be certain that spotting helps with balance solely due to possible effect on the vestibular system.

My data shows a high degree of certainty that spotting affects balance positively. To consider the validity of this outcome, I researched studies that measured the effect of spotting on balance in a similar way. Andrea Schaerli has published two studies on the effect of spotting on balance, also considering how skilled the participants are at spotting (Andrea Schaerli, 2018). Comparing her obtained results with mine is not possible as she

measures balance using a three-dimensional motion capture system and COP displacement using a force plate. Her studies do however support my hypothesis that spotting increases balance, Study A had an obtained p-value of 0.047 showing a significant difference as well (A. Schaerli, 2017). Taking this scientific context into account, I argue that my obtained results are valid and support my hypothesis, although the standard deviation is large, and the techniques of measuring balance can be improved.

Evaluation

In Andrea Schaerli's study B, skill of spotting is considered and concludes that better spotting techniques result in a significant increase in balance. My experienced dancer group has a higher average sec balancing than non-dancers, but through performing an unpaired T-test, I concluded that there is not a significant difference. However, when measuring the distance between the participants' feet after the balance test when spotting, there was a significant difference between the groups, the p-value obtained was 0.017. With these results in consideration, I conclude that skill at spotting may impact how effective it is at improving your balance but cannot be determined by my obtained values. My experiment may have resulted in insignificant differences as my experienced dancers are not professional dancers as in Schaerli's study. She may have observed a significant difference in results as the difference in skill between her groups was greater in her experiment. As such, my experiment could be improved through only using professional dancers in my ED group. This was not possible in the completed experiment as I did not have access to such dancers. However, my experimental groups were quite large considering the scale of my experiment, having 10 people in each group. Schaerli conducted her experiment with 6 professional dancers which may have given her the opportunity to have higher skilled, fewer, dancers. A higher level of dance skills would be desirable in my experiment, but I think having bigger groups was the best solution for my issue of who to include in the experiment due to my limited access to professional dancers.

Investigating the effect of spotting on balance and dizziness when turning is of great application to all dancers. Knowing the scientific effect in detail may lead to improving the technique for increased effect. Furthermore, to many people knowing the scientific basis for certain actions increases their motivation to perform such actions correctly as they know

that there is a proven, positive outcome. Knowing how well spotting usually improves balance can also help dancers determine whether they are spotting correctly or not.

In the paired T-tests in table 3, major significant differences were shown, with p-values ranging from 0.000037 to 0.036. I initially doubted the validity of such results as it seemed the difference was too significant. When considering that spotting may not only impact balance through balancing the fluid in the vestibular system and straightening out the hair cells faster, but also through visual stability and increased neck stability due to deliberate physical movement, I conclude that spotting has a significant and obvious impact on balance. In my rationale, I consider that spotting is ingrained in ballet dancers from a young age and the importance and impact of it is consistently stated. There is a consensus in the ballet world that spotting does dramatically improve balance, as such, I consider that my data does not only coincide with peer-reviewed studies (M. Schaerli 2017, 2018), but is also applicable to the real world.

In the following table I consider factors in my experiment that likely influenced the results negatively and suggest plausible solutions.

| **Factors influencing results** | **Possible solutions** |
|---|---|
| Inaccurate mode of measuring balance. In planning this experiment, my largest struggle was how to measure balance quantitatively. Whilst my test tests balance in a somewhat accurate way, improving this experiment may be done through more accurate tests. | Part of the Berg scale used in professional physiotherapy (Physiopedia), is a test walking in a straight line and measure the distance from that line, I did not use this test as it would be difficult to quantify exact cm from line at every point but could be done with professional equipment. |
| Learning curve. Non-dancers may have had a learning curve in spotting during the 20 seconds of turning with spotting because the skill is new. Additionally, there | Teach spotting some days before the experiment so that participants could better grasp the skill. I would also encourage more thorough practice of the balance test. |

| | |
|---|---|
| may have been a learning curve in how to complete the balance test. | |
| Movement during the balance test, participants were asked to move minimally when balancing, yet some jumped around a lot, causing a lot of movement across the floor. I did not cut off the balance test when this occurred. | A circle with a diameter of 1 meter or less could be drawn around the participant for their balancing test. If the participant moves outside of the circle, the balance test is stopped. |
| Too small experimental groups, My experimental groups consisted of 10 people, totalling at 20 participants. | More people in both experimental groups would produce more reliable results and minimize the effect of outliers and thus minimize SD. |
| Only one trial, the experiment was only completed once. This can have resulted in outliers which may have had data consistent with the other participants if they completed the experiment several times. | I would have each participant complete the experiment at least 3 times over the course of one week and then calculate an average for each participant which I would use as their result. |

**Conclusion**

There is a significant and obvious difference in balance after turning and spotting and turning without spotting, both in time (sec) balancing on one foot and in distance (cm) between the inner part of both feet after balancing. There was also an obvious difference in the participants' rating of their dizziness, meaning that turning with spotting resulted in decreased sense of dizziness. The participants' skill at spotting (dancers or non-dancers) had some effect on their balance after turning, as observed by the significant difference in distance between feet after the balance test, but the difference cannot be deemed overall significant from this experiment alone. Whilst my exact obtained results may not be entirely accurate due to my procedure, the conclusion that spotting does increase balance and decrease dizziness remains valid due to the high degree of significant difference reported in table 3.

**Appendix**

List of references


1. *Gaze Behaviour in Dance,* Andrea Schaerli, 2017, Institute of Sport Science, University of Bern. *https://boris.unibe.ch/105542/1/Schaerli_Andrea_Final_Abstract.pdf*
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4. *The Human Balance System: A complex coordination of central and peripheral systems,* Vestibular Disorders Association, 2020. *https://vestibular.org/wp-content/uploads/2011/12/Human-Balance-System_36.pdf*
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6. *Why Does Spinning Make You Dizzy?* Natalie Wolchover, Livescience, 10.April 2012, Accessed 26.May 2021. *https://www.livescience.com/33828-spinning-dizzy.html*
7. *Berg Balance Scale,* Physiopedia, Accessed 1.June 2021. *https://www.physio-pedia.com/Berg_Balance_Scale*


*Consent Form signed by all participants*

Biology II Consent Form

Dear participant,

For my IB Biology individual investigation, I am carrying out a study on the effect of spotting on balance and dizziness after turning. This is why I wish to study how far you travel when attempting to balance on one foot after turning, and timing how long you are able to stand on one foot.

Following is the procedure:

1. One evening I will teach you how to spot correctly when turning, on another evening we will complete the experiment.
2. The day of the experiment I will test your balance, then have you turn with spotting, test your balance, give you a break and then have you turn without spotting and testing your balance for the final time.

I ask you to sign for the statements below:

- I am informed about the nature of the experiment
- I am aware that I have the opportunity to withdraw from the experiment at any time
- I understand that my information will be treated as confidential and my anonymity will be protected
- The experiment will be conducted in a way where I will not be harmed in any way
- I will be debriefed when the experiment is completed and have access to the results
- I will be videotaped as I am doing the experiment in order to ensure accuracy of results. These videos will not be shared outside of the experiment.

Signature_____

Date_____

*Table 5. Difference in Perception of Dizziness for All Participants (qualitative scale 1-10). Uncertainty cannot be quantified as it is probabilistic in nature.*

| Participant | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
|---|---|---|---|---|---|---|---|---|---|---|
| Difference in rating of dizziness (NS-S) | *1* | *1* | *0* | *1* | *2* | *3* | *3* | *-1* | *3* | *2* |

| Participant | *11* | *12* | *13* | *14* | *15* | *16* | *17* | *18* | *19* | *20* |
|---|---|---|---|---|---|---|---|---|---|---|
| Difference in rating of dizziness (NS-S) | *2* | *3* | *1* | *1* | *3* | *2* | *3* | *2* | *2* | *1* |

*Table 6. Measure of Time (seconds) Non-dancers Balanced on one Foot After turning for 20 seconds, with and without spotting.*

| Participant | Not turning (max 60 sec) | Turning, NS (sec) +-0.50 | Turning, S(sec) +-0.50 |
|---|---|---|---|
| 1 | 60 | 1.50 | 14.40 |
| 2 | 60 | 7.00 | 15.50 |
| 3 | 60 | 3.20 | 12.50 |
| 4 | 60 | 7.30 | 5.60 |
| 5 | 60 | 3.10 | 5.00 |
| 6 | 60 | 4.30 | 41.80 |
| 7 | 48.80 | 2.70 | 5.50 |
| 8 | 60 | 5.40 | 5.90 |
| 9 | 60 | 3.50 | 10.70 |
| 10 | 60 | 4.10 | 11.30 |

*Table 7. Measure of Time (seconds) Experienced Dancers Balanced on one Foot After turning for 20 seconds, with and without spotting.*

| Participant | Not turning (max 60 sec) | Turning, NS (sec)+-0.50 | Turning, S (sec)+-0.50 |
|---|---|---|---|
| 11 | 60 | 4.80 | 6.30 |
| 12 | 60 | 2.10 | 9.00 |
| 13 | 60 | 5.70 | 23.10 |
| 14 | 60 | 7.10 | 16.80 |
| 15 | 60 | 2.30 | 16.20 |

| | | | |
|---|---|---|---|
| 16 | 60 | 6.30 | 30.20 |
| 17 | 60 | 8.10 | 27.40 |
| 18 | 60 | 7.60 | 31.10 |
| 19 | 60 | 10.20 | 22.50 |
| 20 | 60 | 6.10 | 14.70 |

*Table 8. Distance (cm) non-dancers had between the inner part of feet after standing on one foot after turning, with or without spotting.*

| Participant | Distance initial balance exercise (cm) +-1.00 | Distance turning NS (cm) +-1.00 | Distance turning S (cm) +-1.00 |
|---|---|---|---|
| 1 | 13 | 43 | 22 |
| 2 | 0 | 33 | 23 |
| 3 | 25 | 64 | 30 |
| 4 | 8 | 24 | 15 |
| 5 | 11 | 47 | 21 |
| 6 | 0 | 30 | 39 |
| 7 | 24 | 90 | 51 |
| 8 | 1 | 4 | 4 |
| 9 | 0 | 27 | 7 |
| 10 | 5 | 48 | 23 |

*Table 9. Sistance (cm) experienced dancers had between the inner part of feet after standing on one foot after turning, with or without spotting.*

| Participant | Distance initial balance exercise (cm) +-1.00 | Distance turning NS (cm) +-1.00 | Distance turning S (cm) +-1.00 |
|---|---|---|---|
| 11 | 0 | 43 | 27 |
| 12 | 0 | 15 | 4 |
| 13 | 0 | 17 | 6 |
| 14 | 0 | 23 | 5 |
| 15 | 3 | 27 | 6 |
| 16 | 1 | 33 | 16 |
| 17 | 5 | 17 | 10 |
| 18 | 0 | 35 | 8 |
| 19 | 1 | 23 | 13 |
| 20 | 0 | 31 | 4 |