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Investigation the Relationship Between Spin Deformity and Foot Plantar Pressure

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Abstract: Plantar decompression is the area of pressure that acts between the foot and the foot

Support surface during daily motor activities. Information derived from ex. Manometers are important in gait and posture research for lower extremity diagnosis Problems, and this paper reviews the properties of plantar foot sensors as reported in the literature on In addition to the plantar pressure measurement systems applied to a variety of research problems.

The strengths and limitations of current and older wireless systems are discussed A suitable plantar pressure system was proposed to measure the high-pressure distributions and to know the deformation of the spine through measurements of some angles of the body through the plantar pressure under the foot with high accuracy and reliability. The new system is based on high linear pressure sensors without deceleration. The results were three parts. The first part is a photographic analysis of the system, the second part is the results of the plantar pressure, and the third is a comparison between the results to show the effect of the position deviation on the plantar pressure of both the left foot and the right foot

Key words: Spin deformity and foot planter pressure.

INTRODUCTION

The spine is a complex structure composed of a series of bones called vertebrae that are stacked on top of each other. It serves as the main support for the body, protects the spinal cord, and allows for movement and flexibility. However, various conditions can affect the spine, leading to deformities. Here are some common spine deformities as shown in figure 1:[1]

Scoliosis: Scoliosis is a lateral curvature of the spine that often develops during childhood or adolescence. It can vary in severity and may cause the spine to appear "S" or "C" shaped when viewed from the back. Mild scoliosis usually does not cause significant problems, but severe cases can lead to pain, breathing difficulties, and reduced mobility. Treatment options include observation, bracing, and in severe cases, surgery. [2]

Kyphosis: Kyphosis refers to an excessive outward curvature of the upper back, resulting in a rounded or hunched appearance. It can be caused by poor posture, osteoporosis, developmental issues, or certain diseases. Mild kyphosis may not require treatment, but severe cases can cause discomfort and breathing difficulties. Treatment options include physical therapy, exercises, bracing, and in rare cases, surgery.

Lordosis: Lordosis is an excessive inward curvature of the lower back, leading to an exaggerated swayback posture. It can be caused by several factors, including poor posture, obesity, pregnancy, or certain conditions such as spondylolisthesis. Mild cases usually do not require treatment, but severe lordosis can cause back pain and may need interventions such as physical therapy, exercises, and in rare instances, surgery. [3]

Herniated Disc: While not a spinal deformity per se, a herniated disc can cause significant discomfort and affect the alignment of the spine. A herniated disc occurs when the soft cushion-like material between the vertebrae, called the intervertebral disc, protrudes or ruptures. This can result in pressure on nearby nerves, causing pain, tingling, or numbness. Treatment options include rest, pain medication, physical therapy, and in severe cases, surgery. [4]

Spinal Stenosis: Spinal stenosis is a narrowing of the spinal canal, which can put pressure on the spinal cord and nerves. It can occur due to age-related degeneration, spinal injuries, or conditions like arthritis. Symptoms may include pain, numbness, or weakness in the back, neck, or extremities. Treatment options include pain management, physical therapy, exercise, and in severe cases, surgery.

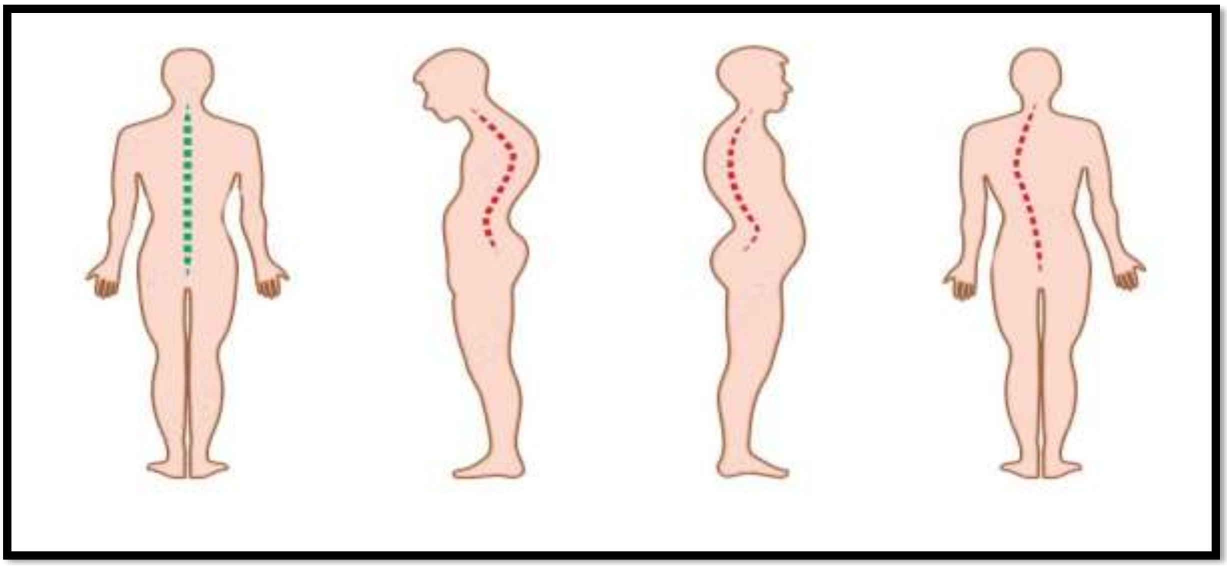


Figure 1: common spine deformities

One of the interest research fields in biomedical engineering study is about the human factor due to the foot pressure distribution while standing, walking even running. This pressure distribution is essential to understand the effect on the human body and balancing criteria. In order to ensure the health is in good condition, advanced technology in biomedical engineering tries to invent something that can help to find the treatment for human illness. [5]

Measurement of foot pressure distribution (FPD) is useful to identify anatomical foot, evaluation of foot and gait pathologies [6]. Feet are the parts of the human body that will sustain the most and highest of pressure during standing. Pressure force distributions that are over the sole of the feet are not even as some forces will be distributed to every other part of the soles. As the foot is having contact with the ground, a reaction force will act upwards towards the human body. When all the forces over every part of the sole are average together, the forces are represented as the center of pressure [7].

There are lots of foot diseases caused by pressure distribution on foot. Such diseases sometimes can be prevented early if the people understand about foot pressures. Therefore, this study is done with the intention of helping people to know their foot pressure distribution during standing. The intention of this study is about understanding the dynamic force distribution behavior on human foot, identifying the pressure and force distribution of human foot at different selected point of foot.

Foot pressure refers to the force exerted on the feet during standing, walking, and other weight-bearing activities. Understanding how to distribute pressure on the human foot is crucial for maintaining proper foot health and preventing discomfort or injuries.

The foot is typically divided into three main regions: the forefoot, midfoot, and hindfoot. Each region plays a specific role in weight-bearing and movement as shown in figure 2: [9]

- Forefoot: The forefoot comprises the toes and the ball of the foot. It is responsible for bearing a significant portion of the body weight during activities like walking and running. Pressure should be evenly distributed across the metatarsal heads (the bony structures at the base of the toes) and the cushioned pads beneath them.

- Midfoot: The midfoot forms the arch of the foot and includes the tarsal bones. It acts as a shock absorber and helps with weight transfer during movement. Pressure should be distributed along the arch evenly, with proper support and stability.

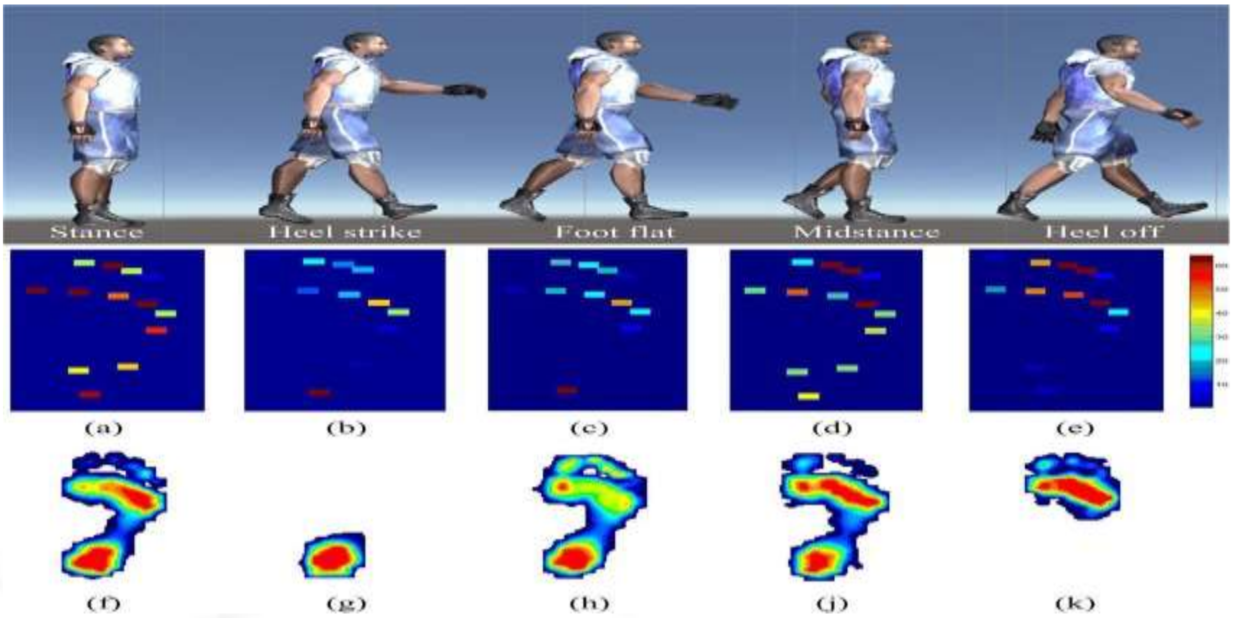
- Hindfoot: The hindfoot consists of the heel bone (calcaneus) and the ankle joint. It provides stability and supports the body's weight. Pressure is concentrated in the central portion of the heel, but it should be distributed evenly to avoid excessive strain on specific areas.

Proper footwear plays a crucial role in distributing pressure on the foot. Shoes with adequate arch support, cushioning, and a good fit can help evenly distribute pressure and reduce the risk of foot problems. Additionally, orthotic inserts or custom-made insoles may be recommended to provide additional support and improve pressure distribution for individuals with specific foot conditions or imbalances [10].

Figure 2: The foot region

Material and methods

The analysis of the posture will be conducted by using Photographs of bipedalism in the frontal plane. The foot plantar pressure will be measured by using Tactilus platform. The test subject will be two females do not suffer from any spine injuries. Photos for the test surject will be taken by using digital camera. The camera will be mounted on stand to elevate it to the mid height of the test subject. The distance between the camera and the test subject was 4 m to insure photographing the full length of the subject and the reference pastor.



Apparatus

The test was conducted by using the following devices:

1. Digital camera canon with 3 mega pixels.
2. Reference screen
3. Tactilus foot plantar pressure.
4. Laptop
5. Jimage software.
6. Biomech software.

Procedure

The experiment was conducted by using the following procedure as shown in figure (5):

1. Marks were made on the shoulders and the hip. To make them visual during the photographing.
2. The test subject was directed to stand on the foot plantar pressure platform.
3. The instructor asks the him to stand still and look at the mark on the reference screen.
4. Three photos will be captured taken from the back.

5. The foot pressure will be recorded during the photo taking.
6. The photos will be analyzed by using j image software.
7. The foot pressure will be analyzed using the biotech software.
8. The test subject will instruct to lean to the left and the steps from 4-7 will be repeated.
9. The test subject will instruct to lean to the right and the steps from 4-7 will be repeated.

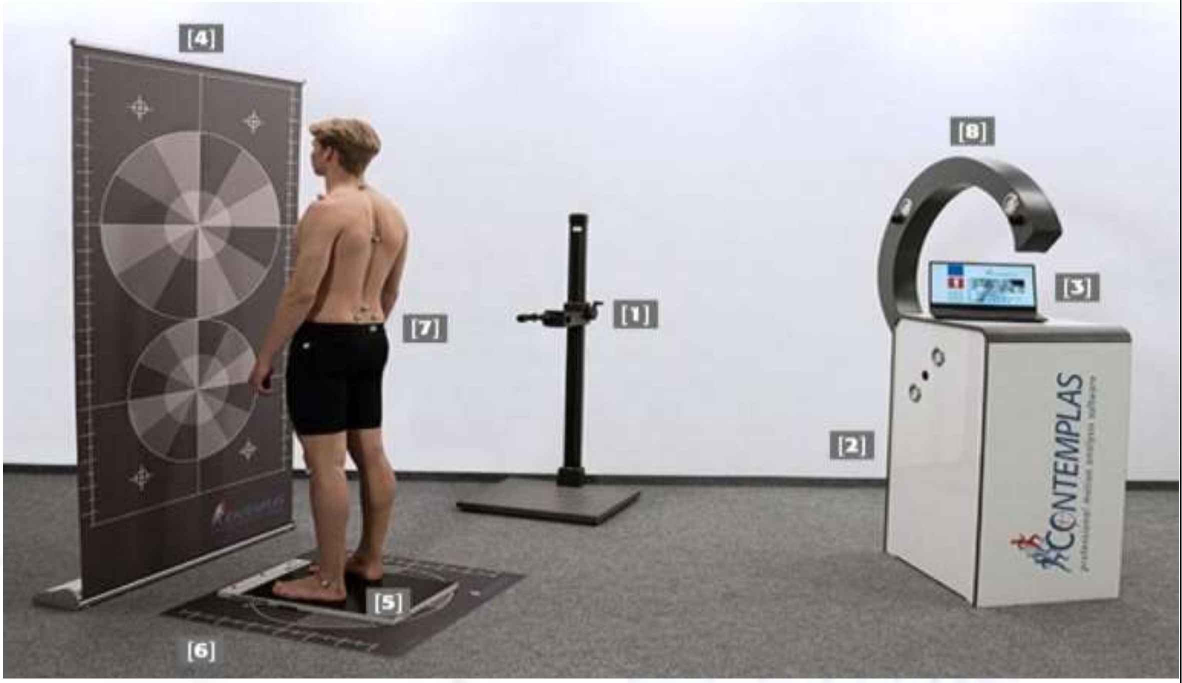


Figure 3: Experiment layout

The results obtained from the analysis of the photos and the respective foot plantar pressure will be investigated to found the relationship between the posture deviation and the foot plantar pressure.

RESULTS AND DISCUSSION

Photographic Analysis

The photo graphic analysis was conducted on test subject in three cases (standing, lean to the right, and lean to the left). The angles between the midline, right shoulder, left shoulder, right hip, left hip, and shoulder deviation were measure as shown in figure 6.

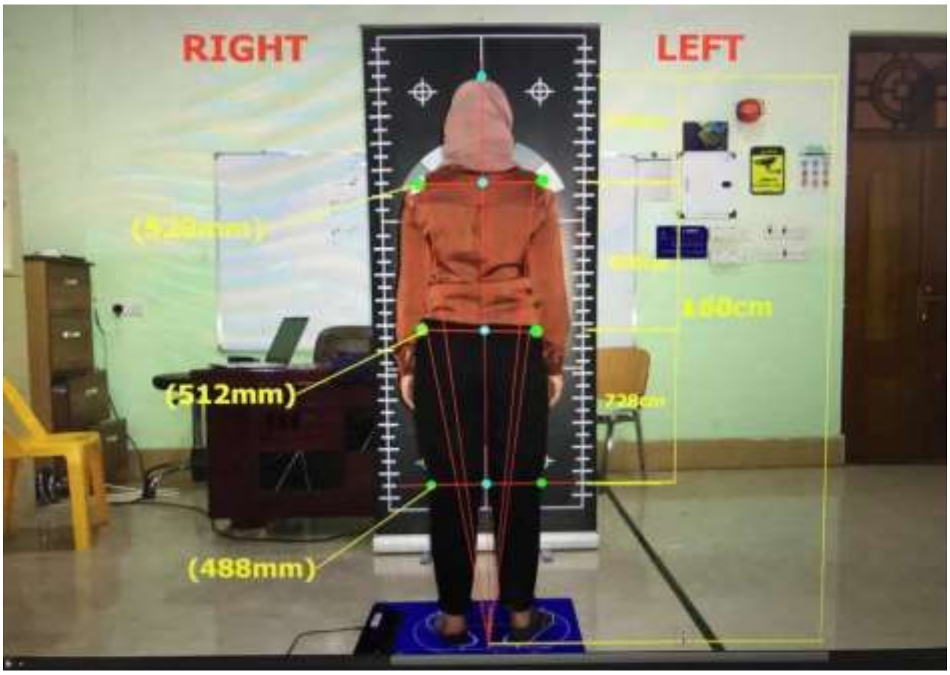


Figure 4: Photographic analysis for the test subject in standing position.

The test subject was directed to lean to the right and the values on the above angles were also measured to address the changes in the body posture as shown in figure 7.

Figure 5: Photographic analysis for the test subject leaning to the right.

Figure 6: Photographic analysis for the test subject leaning to the left.

The test subject was directed to lean to the right and the values on the above angles were also measured to address the changes in the body posture as shown in figure 8.

A slight difference in the values of the left and right shoulder angles in standing was noticed. While, the variation between the left and right hip angles was equal to 14%.

When the test subject lean to the right the values of the angles were severely changed. The value of the right hip shoulder increased to be almost 3 times the left shoulder angle. While, the deviation between the left and right hip angles still very small because the hip here is the fulcrum of the spine rotation. Therefore, the values of the left and right hip angles will be affected slightly during the leaning process. The shoulder deviation angle changed greatly from 0 to 11.74 degree due to the body leaning to the right.

The same behavior seen when the test subject lean to the right. The left shoulder angle increases greatly and its value become four times the right shoulder angle. While, the values of the left and right hip changes slightly. The shoulder deviation angle changed greatly from 0 to 15.094 degree due to the body leaning to the left.

From above we manage to address the changes of the body posture to the right and left in terms of the shoulder, hip, and shoulder deviation angles.

Foot Plantar Pressure

The foot plantar pressure was measured in three cases (standing, leaning to the right, leaning to the left). The analysis of the foot plantar pressure was analyzed by using biotech software.

The foot plantar pressure of the test subject during standing is shown in figure (9), The test subject is applying higher pressure on the right foot. The difference in pressure distribution between the left and the right foot is 7.8%. The maximum pressure is located at the heel site on both foots due the habits of wearing high heel shoes. The bray center is located in fourth quarter. That location reflects the un uniform distribution of the body weight on both feet. The bray center shifted down due to the high plantar pressure on the heels and to the right to due to the higher pressure influencing the right foot. Also, the foot stamp shown that the heavy high arc of the left foot and light high arc of the right foot.

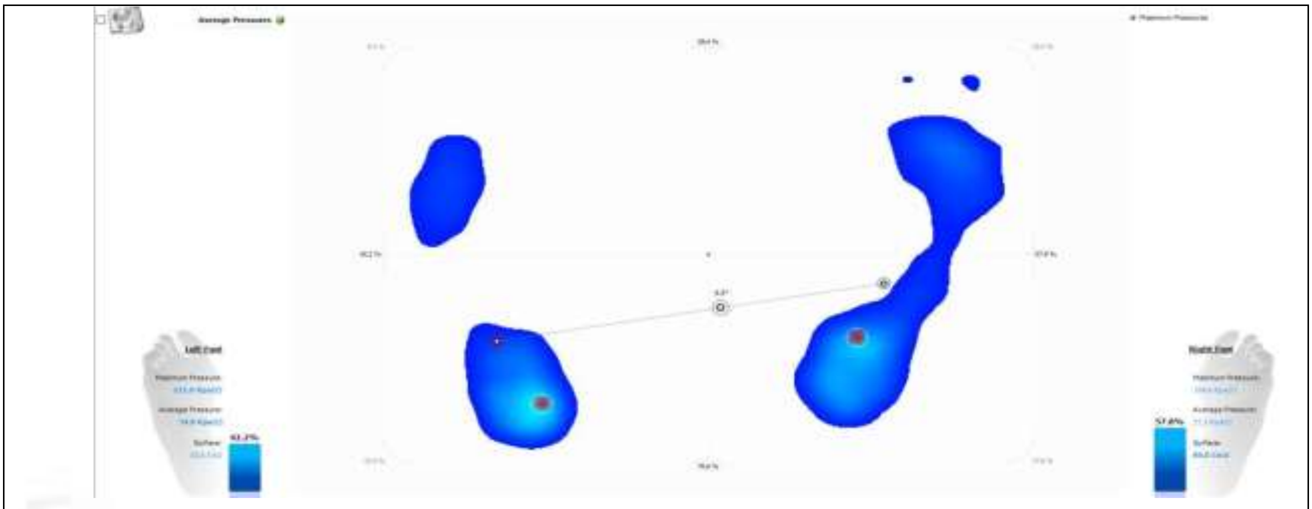


Figure 7: Foot plantar pressure during standing

The oscillation in the movements of the bray center during the test is shown in figure (10). The oscillation of the bray center was measured during the 5 second test in the lateral and anteroposterior planes. The oscillation in the latral direction is almost negligible. While, we found high oscillation in the anteroposterior direction.

That's mean that the test subject body was leaning to posterior direction at the beginning of the test and in the end, she was leaning to the anterior direction.

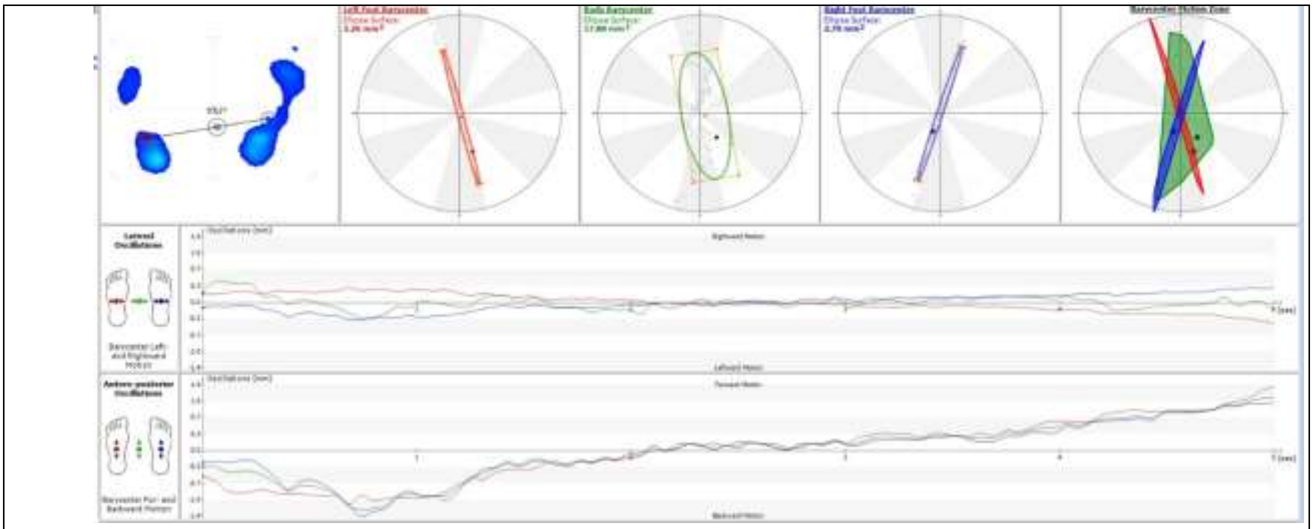


Figure8: Bray center oscillation during standing.

Figure 11 shown the results of the foot plantar pressure when the test subject lean to the right. The distribution of the foot planter pressure was strongly affected when the person leans to the right. The difference in the distribution between the left and right feet become 47.4%. this change can be reflected to the movement of greater mass of the body to the right when he leans to the right. The type of the feet did not change due to the leaning and we still have heavy high arc in the left and light high arc in the right feet. The bray center shifted its location to the right due the very high-pressure concentration of the right foot.

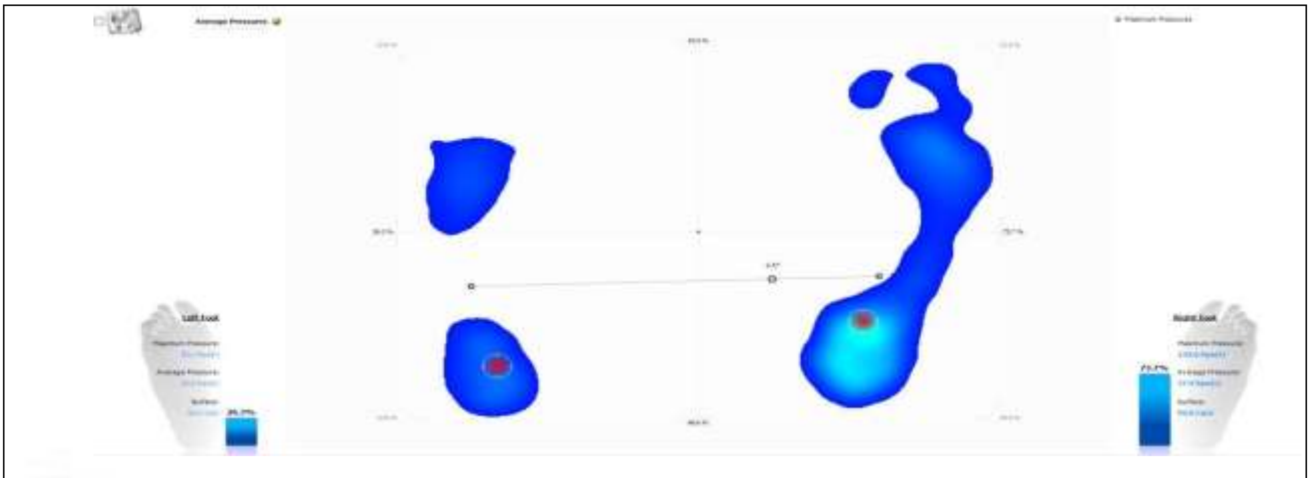


Figure 9: Foot plantar pressure during leaning to the right

The bray center oscillation during leaning is shown in figure 12. The bray center oscillation in the lateral direction is not affected by the body leaning to the right. While, the bray center oscillation changed due to the leaning to the right in the anteroposterior direction. The body was leaning to the anterior direction in the beginning of the test and the test subject lean to the back slightly in the end of the test.

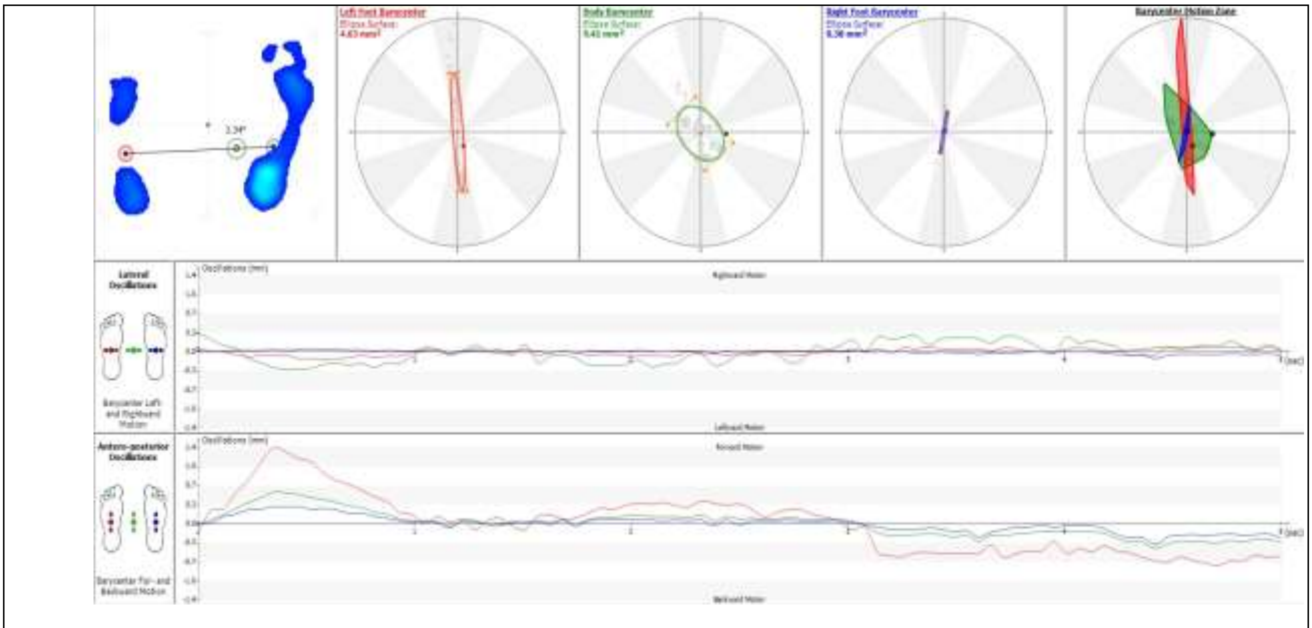


Figure 10: Bray center oscillation during leaning to the right.

Figure 11 shown the results of the foot plantar pressure when the test subject lean to the left. The distribution of the foot planter pressure changed significantly and the left foot holds higher planter pressure than the right foot. The difference in the pressure distribution become 9.6% between the left and right feet. The maximum pressure location was not affected by the leaning process and it location remain in the heel area. The location of the bray center moved from the fourth to the third quarter due to the movement of the upper body mass to the left. The type of feet changed from heavy high arc in the left foot to light high arc due to the increases in the surface area of the foot required to hold the increases in the body weight on this foot.

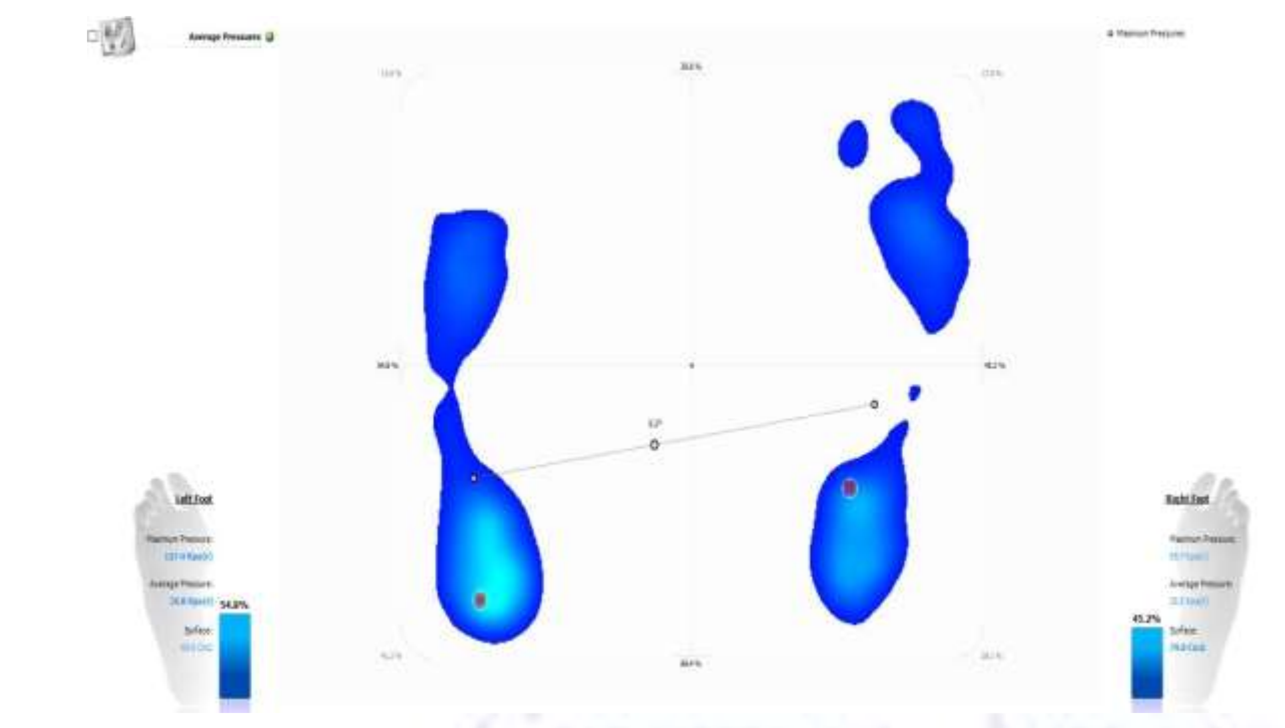


Figure 11: Foot plantar pressure during leaning to the left

The bray center oscillation during leaning is shown in figure 12. The oscillation of the bray center in the lateral direction increased due to the high angle of leaning to the left which affected the balance of the whole body. The bray center oscillation in the anteroposterior direction also increases but, the body was leaning to the anterior direction in the beginning of the test and lean slightly to the posterior direction at the end of the test.

When we link the photographic analysis with the foot planter pressure, we can find a strong correlation between the deviation in the posture. The angles of deviation can be linked with the values of the foot plantar pressure to find a mathematical model have the ability to predict the deviation in the spin from the values of foot planter pressure distribution on the left and right feet.

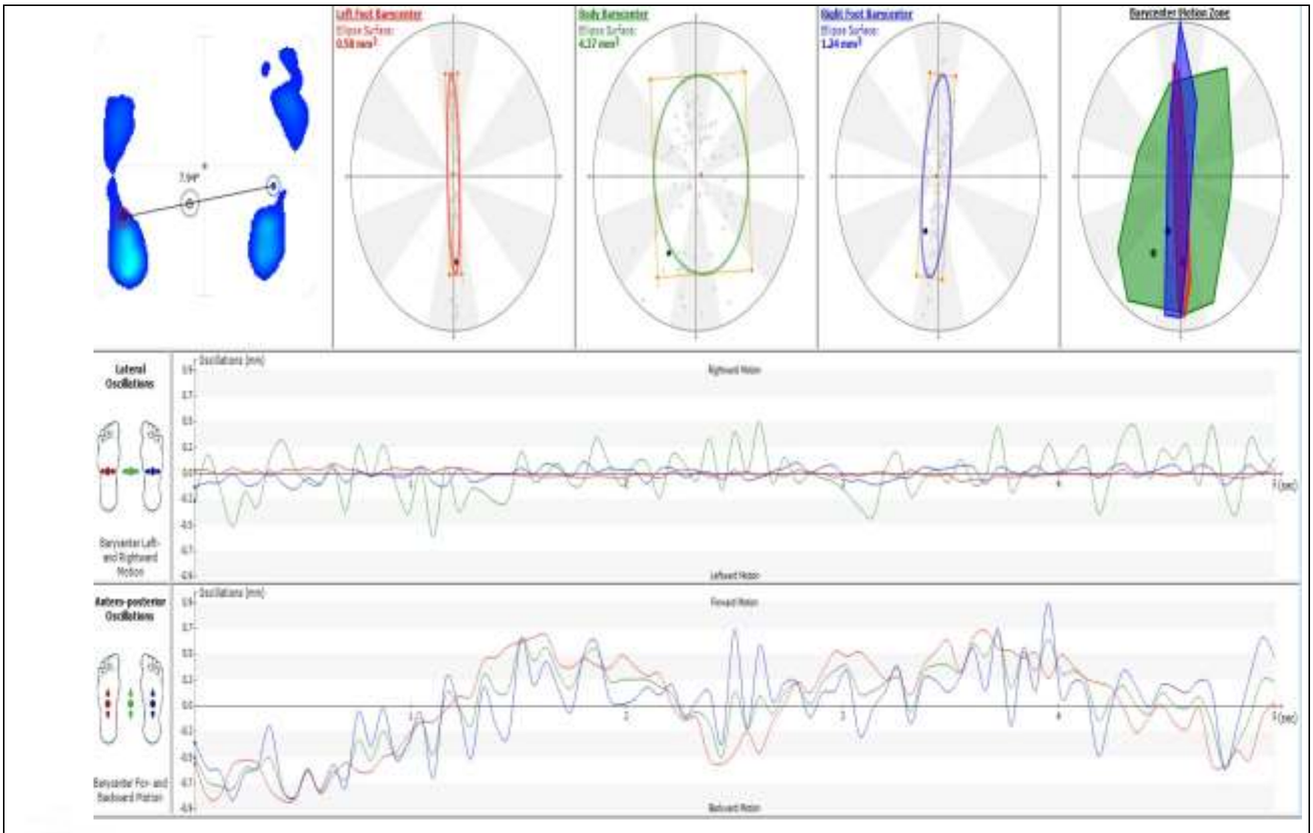


Figure 12: Bray center oscillation during leaning to the left.

Conclusion

This project presents a study of the relationship between the foot plantar pressure and the spine deformity (posture assessment). The resalts shows very high correlation between the foot planter and body posture deviation. The posture deviation can affect the shape of the foot, pressure distribution, bray center location, and over all body balance. The posture deviation does not affect the maximum pressure location and lateral bray center oscillation.

The mathematical model could not be derived because of the number of samples used. Therefore, we encourage increasing the number of samples to find an accurate mathematical model to find the posture deviations from the bray center values.

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