International Journal of Internet, Broadcasting and Communication Vol.10 No.2 84-94 (2018)
http://dx.doi.org/10.7236/IJIBC.2018.10.2.14

IJIBC 18-2-14

The Influence of Foot Position on Standing Balance on an Unstable Base of Support

Jun Cheol Lee

Department of Physical Therapy, Kyungnam College of Information & Technology, Korea
*hklee1348@hanmail.net**

Abstract

The purpose of this study was to compare the balance ability at different foot positions using K A T 2000 (Berg, Inc, vista, CA.1994). Thirty (male 15, female 15) normal subjects participated in this study. All subjects were tested at a one leg position or a two leg position that were toe-in 25˚, toe-out 25˚, and 45˚. The starting position was where the subject crossed their arms across the chest and flexed knees slightily. The results of each test were displayed on a screen in a score format, which indicated balance index. These collected data were analyzed by using one way ANOVA, and t-test. The results of this study were as follows: When changing the angle of the foot in the one-foot and two-foot standing positions, there was no statistically significant difference, but the balance performance with the foot rotated by 25˚ was better than that with the foot rotated by 45˚. When changing the direction of the foot in the one-foot and two-foot standing positions, there was no statistically significant difference, but the balance performance with the foot rotated laterally was better - except for the case when the foot was medially rotated by 25˚ in the right-foot static standing position. When the feet were medially rotated by 25˚ in the two-foot static standing position, and were medially rotated by 25˚ and 45˚ in the one-foot static standing position, the balance performance of females was better than that of males.

In this study, it was found that the balance performance of the subjects changed when the position of the foot was shifted on an unstable base of support. However, there was little correlation between balance performance and the height, weight and foot length of the subjects. It is necessary to conduct a follow-up study targeting various age groups and those with various diseases using an unstable platform or applying different physical or visual conditions, such as the length of the legs. Physical therapists need to consider the position of the foot in clinical settings for a better balance training or assessment.

Keywords: *Foot Position, Standing Balance, Unstable Base, Support, Balance performance*

1. Introduction

To successfully perform daily routines, it is necessary to have postural stability in order to maintain postures and move voluntarily, and to retain the ability to balance the body in order to respond to external changes. The ability of balance is the ability to maintain the center of gravity (COG) of the body on the base of support (BOS) by minimizing the sway of the body, or the ability to control the COG on a weight-bearing base in a given environment. [1].

In this process, inputs from the visual, vestibular and somatosensory systems are combined, and

Manuscript Received: Apr. 2, 2018 / Revised: Apr. 18, 2018 / Accepted: May. 1, 2018
Corresponding Author: hklee1348@hanmail.net
Tel:+82-55-246-3131, Fax: +82-55-230-1347
Department of Physical Therapy, Kyungnam College of Information & Technology, Korea

harmonious muscular contraction, an output from the motor control system, is included. When the BOS changes, these sensory systems need to detect the changes, and the motor control system needs to adapt to new requirements in order to change postures. [2]

As a result of these processes, the balance of the body can be maintained. Balance is divided into static balance and dynamic balance. Static balance is the ability to maintain posture and balance against gravity with the head and body in a static position, and dynamic balance is the ability to retain balance by maintaining stability when the head and the body suddenly move or when the BOS changes. [3] [4].

From a functional perspective, balance is divided into several different behaviors: maintaining postures like standing or sitting; controlling the COG when, for example, moving, rotating, or stretching out the arm; and reacting to maintain or restore the COG on the BOS when an unstable force is applied such as making a false step or slipping. [5] [6]

Postural control is defined as the control of the body's position in a given space to achieve the two purposes of the sense of direction that properly maintains stability and the relationship between the body and the environment. [3] By doing so, the equilibrium of the body can be maintained and stability is provided to changing postures caused by changing motor tasks.

However, since the body is an organism, no matter how much the body tries to maintain a certain form of balance, the trunk is swayed to some extent. Therefore, good balance can be maintained when the sway of the trunk is minimized, and the COG of the body is located within the BOS. [7] If the COG is beyond the limit of stability and proper motor reactions are not applied, the body takes a step to maintain balance or the body falls. [6]

In particular, the equilibrium of the bipedal human body can be easily broken. When walking, the phenomenon of going back to the equilibrium state happens repeatedly. The posture of the heel of the lower extremity is loosened as the body moves forward. When the sole touches the ground and the center line of the body is located within a new BOS created by the two soles, the body restores the state of equilibrium, and, in this process, the size of the BOS and the stability of the ground are important factors in maintaining balance while walking. [8]

The feet, as an important means for walking mobility, play roles such as properly adapting to the environment and circumstances surrounding the body between the body and the ground and providing momentum and direction required for the movement of the trunk while walking, and the feet also absorb physical impacts created in the process, support the weight of the body, and adapt to the ground and respond to the changing center of the body, maintaining the balance of the body and the stability of the feet. [9]

Gait balance is closely related to the length of a step and the position of a foot, and the length of a step is known to affect the varus and valgus stress of the ankle joint. In particular, the alignment of the ankle joint in the early stance phase affects impact absorption and gait stability, and thus it is very meaningful to examine it. It was also reported that the position of the feet affects standing balance[10] [11], and earlier studies on standing balance depending on the angle of the foot showed that the angle of the foot affects standing balance, and, thus, suggested that the angle of the foot needs to be considered in balance assessment and training. [12] [13]

Several studies have been recently conducted on gait assessment depending on the angle and position of the foot, but they adopted different approaches such as simply examining changes in the position of the foot, selecting certain positions of the foot that can affect the balance of the body, and putting the foot in certain positions. [12] [14] This study aimed to examine the effects of the position of the foot in one-foot and two-foot standing positions on balance performance in maintaining static balance, that is, a stable balance in the standing position which is the most basic precondition for walking. [3] [4]

To do so, KAT (kinesthetic ability trainer) 2000 that has recently started to be used and is expected to be widely adopted to assess the balance of the body was applied to compare balance performance depending on the medial and lateral angles of the foot on an unstable platform in the one-foot and two-foot standing positions, and to compare balance performance depending on the direction of the ankle in the one-foot and two-foot standing positions. Based on the results, differences in balance performance depending on the gender of subjects were examined.

2. Methods

1. Subjects and duration

This experiment was conducted on a total of 30 students (15 males and 15 females) of Masan University who consented to participate in this experiment and met the requirements of this study. The subjects were selected among those who did not have any neurosurgical disease, any orthopedic disorder in the lower extremities and the trunk, any damage to the vestibular system, any after effect stemming from their medical history or any disorder related to balance performance. This experiment was conducted for 7 days from December 7 to December 14, 2017.

1) Tools

In this study, KAT 2000, a kinesthetic ability trainer, was used to assess the balance performance of the subjects, and the angle of the foot was measured using the shape of a foot (Figure 1) that was prepared based on the position of the foot used in the study of Kirby et al. (1987) [10] with some adhesive tape deployed.

KAT 2000 uses an unstable platform that is supported at its central point by a small axis, and the platform can be tilted forward, backward or sideways. The stability of the platform can be controlled by changing the air pressure inside an air bag between the bottom of the equipment and the platform. The sum of the Q1, Q2, Q3 and Q4 on the screen is a balance index(BI).

2) Procedure

A warm (28˚) and quiet indoor environment was maintained in this experiment, and the subjects were instructed to dress comfortably. Prior to this experiment, education on the theoretical background of this study including the purpose and methods of this experiment and training were provided for 3 assistants. One assistant was in charge of recording the general characteristics of subjects and operating a computer, and another assistant checked the preparedness of the subjects and attached the shape of the foot on the platform. The last assistant was in charge of demonstrating the method of this experiment.

The balance performance of each subject was tested for 20 seconds after the assistant demonstrated balance performance. To prevent the fatigue of the subjects, they were allowed to have a one-minute break between tests. The air pressure of the platform used in this study was maintained at 3.0 psi (pound per square inch), and, after that, one assistant put the shape of the foot on the platform according to the angle marked using adhesive tape. Another assistant made a new chart using a computer, and the last assistant gave a brief explanation on the purpose of this experiment to each subject. A certain angle of the ankle was selected and the balance performance of the subject was assessed.

3) Measurement methods

The position of the foot in a one-foot or two-foot standing position was maintained with the medial and lateral angle set at 45˚ and 25˚, and the balance performance of a subject was measured for 20 seconds.

Static balance performance was assessed using the following method.

Each subject was instructed to cross their arms on the breast and to slightly bend the knees to hold a stable beginning posture. To ensure the cursor is maintained on the base point displayed on a computer screen, the test process was practiced several times. To eliminate the visual feedback effects from the screen, the screen was turned around, and upon the oral instruction of “start” the subject stared at a sticker attached on the wall located 1m in front of the subject and maintained a balance for 20 seconds.

3. Definitions of terms

The terms used in this study can be defined as follows:

1) BI (balance index): The BI is the sum of 9 partial balance indices (PBIs). When the platform of KAT 2000 is divided into 4 sections, the 9 PBIs include Q1, Q2, Q3 and Q4, +X axis, -X axis, +Y axis and –Y axis, and the base point. The lower the BI, the better the balance performance of a subject.

2) SBI (static balance index): When the circular platform that was leveled at the base point for 20 seconds

is tilted by 1˚, the cursor on the computer screen moves by 3.5mm, and the sum of the distance is the SBI.

3) Foot angle (angle change): Based on the method suggested by Kirby et al. (1987), the angle from the center of each foot to the sagittal line from the heel was recognized as the foot angle, and an angle that changed the position of the foot was called "angle change."

4. Analysis methods

Each item on the assessment recording paper was encoded and entered into a computer, and the data were statistically analyzed using SPSS/PC+ (ver 10.0). To examine balance performance and differences in the performance depending on the foot angle, an independent sample t-test was conducted. To examine differences in balance performance depending on the gender of the subjects and the position of the foot, an independent sample t-test was conducted. The significant level was set at α=0.05 to verify the statistical significance of the data.

5. Limitations

Since the process was practiced one time prior to the main experiment, it was difficult to completely exclude the effect of learning. Due to the limited size of the platform used in this study, it was difficult to diversify the position of the foot. This experiment was conducted on 30 students in their 20s who major in physical therapy in Masan University, and thus it is difficult to generalize the results of this study to other age groups.

6. Results

1) General characteristics of subjects

The top and bottom 2 subjects in the male and female groups respectively in terms of balance index (BI) were excluded, and the data of 22 subjects (11 males and 11 females) were analyzed. The average age of males and females was 25.91±2.12 and 23.00±0.63 years respectively. The average height of males and females was 173.55±3.93 ㎝ and 162.64±4.39cm. The average weight of males and females was 66.82±8.28kg and 55.45±5.28kg respectively.

The average length of the left foot of males and females was 250.09±8.73mm and 228.36±11.66mm respectively, and that of the right foot of males and females was 250.45±6.65mm and 228.73±10.81mm respectively. The right foot of all the 22 subjects was the dominant foot (Table 1).

Table 1. General characteristics of subjects

	Male	Female	t	P
Age (year)	25.91±2.12	23.00±0.63	4.363	0.001
Height (cm)	173.55±3.93	162.64±4.39	3.838	0.001
Weight (kg)	66.82±8.28	55.45±5.28	6.140	0.000
Left foot (mm)	250.09±8.73	228.36±11.66	4.945	0.000
Right foot (mm)	250.45±6.65	228.73±10.81	5.678	0.000

Average±SD

2) Impact of foot angle on balance performance

Balance performance depending on the angle of the foot was compared. When the feet were medially rotated by 45˚ and 25˚ in the two-foot static standing position, balance performance was 1735.41±947.53, and 1444.23±816.67 respectively. There was no statistically significant difference, but the balance performance with the feet medially rotated by 25˚ was better.

In addition, when the feet were laterally rotated by 45˚ and 25˚, balance performance was 1282.36±649.80 and 1252.00±646.75 respectively, showing no statistically significant difference.

When the foot was medially rotated by 45˚ and 25˚ in the right-foot static standing position, balance performance was 1775.59±816.91 and 1371.05±666.75 respectively. There was no statistically significant difference, but the balance performance with the foot medially rotated by 25˚ was better.

In addition, when the foot was laterally rotated by 45˚ and 25˚ in the right-foot static standing position, balance performance was 1727.05±801.34 and 1668.41±1196.42 respectively. There was no statistically significant difference, but the balance performance with the foot laterally rotated by 25˚ was better (Table 2).

Table 2. Impact of foot angle on balance performance

Foot support state \ Foot angle	45˚	25˚	t	P
Two-foot medial static standing	1735.14±947.53	1444.23±816.67	1.092	0.281
Two-foot lateral static standing	1282.36±649.80	1252.00±646.75	0.155	0.877
Right-foot medial static standing	1775.59±816.91	1371.05±666.75	1.799	0.079
Right-foot lateral static standing	1727.05±801.34	1668.41±1196.42	0.191	0.850

Average±SD

3) Impact of foot angle on balance performance in the case of males

Balance performance depending on the angle of the foot in the case of males was compared. When the feet were medially rotated by 45˚ and 25˚ in the two-foot static standing position, balance performance was 1659.00±894.01 and 1824.36±916.02 respectively. There was no statistically significant difference, but the balance performance with the feet medially rotated by 45˚ was better.

In addition, when the feet were laterally rotated by 45˚ and 25˚ in the two-foot static standing position, balance performance was 1304.82±650.53 and 1357.73±427.93 respectively, showing no statistically significant difference.

When the foot was medially rotated by 45˚ and 25˚ in the right-foot static standing position, balance performance was 2179.55±765.76 and 1699.64±643.43 respectively. There was no statistically significant difference, but the balance performance with the foot medially rotated by 25˚ was better.

In addition, when the foot was laterally rotated by 45˚ and 25˚ in the right-foot static standing position, balance performance was 2029.18±876.35 and 2147.27±1265.18 respectively, showing no statistically significant difference (Table 3).

Table 3. Impact of foot angle on balance performance in the case of males

Foot support state \ Foot angle	45˚	25˚	t	P
Two-foot medial static standing	1659.00±894.01	1824.36±916.02	-0.428	0.673
Two-foot lateral static standing	1304.82±650.53	1357.73±427.93	-0.225	0.824
Right-foot medial static standing	2179.55±765.76	1699.64±643.43	1.591	0.127
Right-foot lateral static standing	2029.18±876.35	2147.27±1265.18	-0.254	0.802

Average±SD

4) Impact of foot angle on balance performance in the case of females

Balance performance depending on the angle of the foot in the case of females was compared. When the feet were medially rotated by 45˚ and 25˚ in the two-foot static standing position, balance performance was 1811.82±1036.01 and 1064.09±493.56 respectively. There was a statistically significant difference, and the balance performance with the feet medially rotated by 25˚ was better.

In addition, when the feet were laterally rotated by 45˚ and 25˚ in the two-foot static standing position, balance performance was 1259.91±679.99 and 1146.27±818.14 respectively, showing no statistically significant difference.

When the foot was medially rotated by 45˚ and 25˚ in the right-foot static standing position, balance performance was 1371.64±675.31 and 1042.45±531.07 respectively. There was no statistically significant difference, but the balance performance with the foot medially rotated by 25˚ was better.

In addition, when the foot was laterally rotated by 45˚ and 25˚ in the right-foot static standing position, balance performance was 1424.91±616.18 and 1189.55±949.13 respectively. There was no statistically significant difference, but the balance performance with the foot laterally rotated by 25˚ was better (Table 4).

Table 4. Impact of foot angle on balance performance in the case of females

Foot support state \ Foot angle	45˚	25˚	t	P
Two-foot medial static standing	1811.82±1036.01	1064.09±493.56	2.161	0.048
Two-foot lateral static standing	1259.91±679.99	1146.27±818.14	0.354	0.727
Right-foot medial static standing	1371.64±675.31	1042.45±531.07	1.271	0.218
Right-foot lateral static standing	1424.91±616.18	1189.55±949.13	0.690	0.498

Average±SD

5) Impact of foot direction on balance performance

Balance performance depending on the direction of the foot was compared. When the feet were medially and laterally rotated by 45˚ in the two-foot static standing position, balance performance was 1735.14±947.53 and 1282.36±649.80 respectively. There was no statistically significant difference, but the balance performance with the feet laterally rotated by 45˚ was better.

In addition, when the feet were medially and laterally rotated by 25˚ in the two-foot static standing position, balance performance was 1444.23±816.67 and 1252.00±646.26 respectively. There was no statistically

significant difference, but the balance performance with the feet laterally rotated by 25˚ was better.

In addition, when the foot was medially and laterally rotated by 25˚ in the right-foot static standing position, balance performance was 1371.05±666.75 and 1668.41±1196.42 respectively. There was no statistically significant difference, but the balance performance with the foot medially rotated by 25˚ was better (Table 5).

Table 5. Impact of foot direction on balance performance

Foot support state \ Foot direction	Medial	Lateral	t	P
Two-foot 45˚ static standing	1735.14±947.53	1282.36±649.80	1.850	0.071
Two-foot 25˚ static standing	1444.23±816.67	1252.00±646.26	0.866	0.392
Right-foot 45˚ static standing	1775.59±816.91	1727.05±801.34	0.199	0.843
Right-foot 25˚ static standing	1371.05±666.75	1668.41±1196.42	-1.018	0.316

Average±SD

6) Impact of foot direction on balance performance in the case of males

Balance performance depending on the direction of the foot in the case of males was compared. When the feet were medially and laterally rotated by 45˚ in the two-foot static standing position, balance performance was 1659.00±8940.01 and 13404.82±650.53 respectively. There was no statistically significant difference, but the balance performance with the feet laterally rotated by 45˚ was better.

In addition, when the feet were medially and laterally rotated by 25˚ in the two-foot static standing position, balance performance was 1824.36±916.02 and 1357.73±427.93 respectively. There was no statistically significant difference, but the balance performance with the feet laterally rotated by 25˚ was better.

When the foot was medially and laterally rotated by 45˚ in the right-foot static standing position, balance performance was 2179055±7765.76 and 2029.18±876.35 respectively, showing no statistically significant difference.

In addition, when the foot was medially and laterally rotated by 25˚ in the right-foot static standing position, balance performance was 1699.64±643.43 and 2147.27±1265.18 respectively. There was no statistically significant difference, but the balance performance with the foot medially rotated by 25˚ was better (Table 6).

Table 6. Impact of foot direction on balance performance in the case of males

Foot support state \ Foot direction	Medial	Lateral	t	P
Two-foot 45˚ static standing	1659.00±8940.01	13404.82±650.53	1.062	0.301
Two-foot 25˚ static standing	1824.36±916.02	1357.73±427.93	1.531	0.141
Right-foot 45˚ static standing	2179055±7765.76	2029.18±876.35	0.429	0.673
Right-foot 25˚ static standing	1699.64±643.43	2147.27±1265.18	-1.46	0.312

Average±SD

7) Impact of foot direction on balance performance in the case of females

Balance performance depending on the direction of the foot in the case of females was compared. When the feet were medially and laterally rotated by 45˚ in the two-foot static standing position, balance performance was 1811.82±1036.01 and 1259.91±679.99 respectively. There was no statistically significant difference, but the balance performance with the feet laterally rotated by 45˚ was better.

In addition, when the feet were medially and laterally rotated by 25˚ in the two-foot static standing position, balance performance was 1064.09±493.56 and 1146.27±818.14 respectively, showing no statistically significant difference.

When the foot was medially and laterally rotated by 45˚ in the right-foot static standing position, balance performance was 1371.64±675.31 and 1424.91±616.18 respectively, showing no statistically significant difference.

In addition, when the foot was medially and laterally rotated by 25˚ in the right-foot static standing position, balance performance was 104245±531.07 and 1189.55±749.13 respectively, showing no statistically significant difference (Table 7).

Table 7. Impact of foot direction on balance performance in the case of females

Foot support state \ Foot direction	Medial	Lateral	t	P
Two-foot 45˚ static standing	1811.82±1036.01	1259.91±679.99	1.477	0.155
Two-foot 25˚ static standing	1064.09±493.56	1146.27±818.14	-0.285	0.778
Right-foot 45˚ static standing	1371.64±675.31	1424.91±616.18	-0.193	0.849
Right-foot 25˚ static standing	104245±531.07	1189.55±749.13	-0.449	0.659

Average±SD

8) Comparison of the balance performance of males and females

Balance performance depending on the gender of subjects was compared. When the feet were medially rotated by 45˚, the balance performance of males and females was 1659.00±8940.01 and 1811.82±1036.01 respectively. There was no statistically significant difference, but the balance performance of females was better than that of males.

When the feet were medially rotated by 25˚, the balance performance of males and females was 1824.36±916.02 and 1064.09±493.56 respectively, showing a statistically significant difference ($p<0.005$).

When the feet were laterally rotated by 45˚, the balance performance of males and females was 1659.00±8940.01 and 1259.91±679.99 respectively, showing no statistically significant difference.

When the feet were laterally rotated by 25˚, the balance performance of males and females was 1357.73±427.93 and 1146.27±818.14 respectively. There was no statistically significant difference, but the balance performance of females was better than that of males.

When the right foot was medially rotated by 45˚, the balance performance of males and females was 2179055±7765.76 and 1371.64±675.31 respectively, showing a statistically significant difference ($p<0.005$).

When the right foot was medially rotated by 25˚, the balance performance of males and females was 1699.64±643.43 and 104245±531.07. There was a statistically significant difference, and the balance performance of females was better than that of males.

When the right foot was laterally rotated by 45˚, the balance performance of males and females was 2029.18±876.35 and 1424.91±616.18 respectively. There was no statistically significant difference, but the balance performance of females was better than that of males.

When the right foot was laterally rotated by 25˚, the balance performance of males and females was 2147.27±1265.18 and 1189.55±749.13 respectively. There was no statistically significant difference, but the

balance performance of females was better than that of males (Table 8).

Table 8. Comparison of the balance performance of males and females

Foot support state \ Gender	Male	Female	t	P
Two-foot medial 45˚ static standing	1659.00±8940.01	1811.82±1036.01	-0.370	0.715
Two-foot medial 25˚ static standing	1824.36±916.02	1064.09±493.56	2.423	0.025
Two-foot lateral 45˚ static standing	1659.00±8940.01	1259.91±679.99	0.518	0.876
Two-foot lateral 25˚ static standing	1357.73±427.93	1146.27±818.14	0.760	0.456
Right-food medial 45˚ static standing	2179055±7765.76	1371.64±675.31	2.624	0.016
Right-food medial 25˚ static standing	1699.64±643.43	104245±531.07	2.613	0.017
Right-food lateral 45˚ static standing	2029.18±876.35	1424.91±616.18	1.871	0.076
Right-food lateral 25˚ static standing	147.27±1265.18	1189.55±749.13	2.008	0.058

Average±SD

9. Discussion

Balance is a special neurophysiological process of maintaining the stability of the body, and the sway of the body needs to be minimized with the center of gravity (COG) located within the base of support (BOS) in order to maintain a proper balance. The COG is a point of the body that is considered in gravity activities and it is vertically above the BOS. [1]

Factors that affect the balance of the body can be divided into musculoskeletal factors and neurological factors. Musculoskeletal factors are factors that are involved in the effects of postural alignment or musculoskeletal flexibility on the balance of the body, and neurological factors are factors that make the body move by integrating the sensory processing process and the central nervous system, and creating motor programs, and factors that are involved in the effects of muscular strength and endurance on balance control. The sensory processing process is a process of controlling the visual, vestibular and somatosensory systems. [3]

Standing balance is known to be closely related to gait performance [16] [17], and some earlier studies also reported that standing balance is significantly correlated with gait performance. [18] [19] [20] Normal walking means moving the COG forward in a smooth and effective way through the well-balanced movement of the four limbs while consuming the minimum energy. [21]

In other words, a proper gait speed is required for an independent social life. In this regard, this study was conducted on 30 subjects in their 20s to assess their static balance performance, the most basic precondition for walking. Their balance performance on an unstable platform was measured, and changes in balance performance depending on the stability of the BOS and the support feet were examined.

Prior to conducting this experiment, a warm and quiet indoor environment was maintained to minimize environmental and physiological factors that can affect balance performance, and the subjects were instructed to dress comfortably. In addition, to ensure the subjects fully understood the entire procedure required for balance assessment, they were given the opportunity to practice the procedure sufficiently. They were instructed to keep the head straight and stare at the wall located 2m in front of the subject. The vestibular and visual feedback effects were controlled, and the subjects were instructed to cross their arms on the breast to minimize the impact of moving the arms on their balance performance.

Since the stability of the BOS can become 0 psi, and affect the balance index (BI) [22] [23], the stability of the platform used in this study was maintained at 3 psi during the experiment. In addition, the higher the

value of psi, the more stable and solid the base. Thus, when the stability of the platform is 0 psi, the platform is too unstable to examine changes in balance performance depending on the position of the foot. When it is 6 psi, the platform is too solid to test dynamic balance performance. Considering this, the air pressure of the platform was maintained at 3 psi to assess balance performance in an objective way, and KIT 2000, the validity of which was already confirmed, was used in this study. [23]

In an earlier study on differences in balance performance between the dominant and non-dominant feet in the one-foot standing position, it was found that when the dominant foot supported the body in a standing position, the BI was statistically significantly low. [22] Based on the results, the balance performance of the dominant foot of the subjects was measured in this study.

Changes in postural sway depending on the angle of the foot were measured. When the foot was laterally rotated by 25˚, the value was the lowest, and when the foot was medially rotated by 45˚, the value was the highest. [10] There was no statistically significant difference between different angles of the foot in the one-foot and two-foot static standing positions, but the balance performance with the foot rotated by 25˚ both medially and laterally was higher than that with the foot rotated by 45˚. There was also no statistically significant difference between different foot directions in the two-foot static standing position, but the balance performance with the foot rotated laterally was better.

There was no statistically significant difference between the medial and lateral directions with the foot rotated by 25˚ in the one-foot static standing position, but the balance performance with the foot medially rotated was better. Differences in balance performance depending on the gender of the subjects were also compared, and it was found that the balance performance of females was better than that of males.

In this study, it was found that the balance performance of the subjects changed when the position of the foot was shifted on an unstable base of support. However, there was little correlation between balance performance and the height, weight and foot length of the subjects. It is necessary to conduct a follow-up study targeting various age groups and those with various diseases using an unstable platform or applying different physical or visual conditions, such as the length of the legs. Physical therapists need to consider the position of the foot in clinical settings for a better balance training or assessment.

10. Conclusions

This study aimed to examine the effects of the angle of the foot, the direction of the ankle, and the gender of subjects on standing balance in the one-foot and two-foot static standing positions on an unstable base of support, targeting normal persons in their 20s. Among those who consented to participate in this study and met the requirements of this study, the data of a total of 22 persons (11 males and 11 females) who were tested for balance performance using KAT 2000 by rotating the angle of the ankle by 25˚ and 45˚ medially and laterally were analyzed. Based on the results, the following conclusions were obtained.

1. When changing the angle of the foot in the one-foot and two-foot standing positions, there was no statistically significant difference, but the balance performance with the foot rotated by 25˚ was better than that with the foot rotated by 45˚.
2. When changing the direction of the foot in the one-foot and two-foot standing positions, there was no statistically significant difference, but the balance performance with the foot rotated laterally was better - except for the case when the foot was medially rotated by 25˚ in the right-foot static standing position.
3. When the feet were medially rotated by 25˚ in the two-foot static standing position, and were medially rotated by 25˚ and 45˚ in the one-foot static standing position, the balance performance of females was better than that of males.

References

[1] Nichols DS. Balance retraining after stroke using force platform biofeedback. Phys Ther. 77(5);553-558, 1997.

[2] Lebiedowska, M. K. , Wente, T. M. , Dufour, M. The influence of foot position on body dynamics. Journal of biomechanics. 42(6):762-766. 2009.

[3] Shurnway-Cook A, Horak FB: Assessing influence of sensory interaction on balance. Suggestion from field Phys ther 156;1548-1550. 1986.
[4] Lee YT, Kim H, Shin HS. The Effect of Training Program for the Balance on the Gait Stability. Korea Society of Sports Biomethanics. Korean Journal of Sport Biomechanics. 20(4):373-380. 2010.
[5] Berg K. Balaance and its measure in elderly: A review. Physiother Can. 41;240-246. 1989.
[6] King MB Judge JO, Wolfson L. Functional base of support decreases with age. J Gerontol Med Sci. 49;258-263. 1994.
[7] Bae SS, Kim HS, Lee HO, Park JH, Hong WS. The body's movement. Hyunmoonsa. 182-190. 1992.
[8] Kwon JC. A Study of Various Factors Influencing Standing Balance of Independent Ambulatory Hemiparetic Patients. J. of Korean society of physical therapy. 1(1):14-25. 1989.
[9] Seong IH. The Biomechanics and Diabetes of the Foot. In Lee TG. The Diabetic Foot Diseases. The New Medical Journal. 43(3):56-62. 2000.
[10] Kirby RL,Price NA, Macleod DA. The influence of foot position on standing balance J Biomechanics. 20;423-427. 1987.
[11] Lee WA, Deming L, Sahgal V. Quantitative and clinical measure of static standing balance in hemiparetic and normal subject. Physical Therapy Korea. 9;70-976. 1988.
[12] Lee HS, Kwon HC. The Influence of Foot Angle on Standing Balance Upon the Unstable Platform. Physical Therapy Korea. 4(3):34-44. 1997.
[13] Wang, Z. , Molenaar, P. C. , Newell, K. M. Erratum to: The effects of foot position and orientation on inter- and intra-foot coordination in standing postures: a frequency domain PCA analysis. Experimental brain research. 230(1):29. 2013.
[14] Narayanan, R.M. Putting your best foot forward: Applying for a faculty position. IEEE potentials. 32(3):22-25.2013.
[15] Rosenbaum D, hautmann S, Gold L, et al. Effects of walking speed on plantar pressure pattern and hindfoot angular motion. Gait posture. 2:191-197. 1994.
[16] Hamrin E, Eklund F, Hillgren AK, et al. Muscle strenth and balance in post stroke patient. Ups J Med Sci. 87;11-26. 1982.
[17] Dettmann MA, Linder MT, Sepic SB. Relationships among walking performance, postural stability, and functional assessment of the hemiplegic patient. Am J Phys Med. 66;77-90. 1987.
[18] Bohannon RW, Leary KM. Standin balance and function over the course of acute rehabiltation. Arch Phys med Rehabil. 76;994-996. 1995.
[19] Park JS, Choi HS, Kim TH, Noh JS. Effects of the foot position on standing balance in patients with hemiplegia. Physical Therapy Korea. 2001;8(2):73-85. 2001.
[20] Peacock, Don. Effect of foot and ankle position on tarsal tunnel compartment volume. Foot & Ankle Quarterly. 25(3):189-171. 2014.
[21] Kim MJ, Lee SA, Kim SG, Seong IY. The Study for Gait Speed of Stroke Patients : Comfortable versus Maximum Safe Speed. Annals of Rehabilitation Medicine. 18(4):736-741. 1994.
[22] Kwon HS, Kwon OY. Evaluation of the Balance Ability for 20 to 29 Years Old on the Unstable Platform. Physical Therapy Korea. 3(3):1-11. 1996.
[23] Howard ME, Cawley PW, Losse GM, et al. Correlation of static and dynamic balance indices to injury history, performance criteria, and physical finding in 595 elite college football players. 8th annual AOSSM Specialty Day. Orlando. FI. 19;1-30. 1995.