**Original Article**

# Effects of Three Different Programs of Static and Dynamic Balance Training on Agility, Stability, and Balance in Healthy Male University Students: A Quasi-Experimental Study

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**ABSTRACT**

*Objectives:* To determine the effects of three different programs of static and dynamic balance training on agility, stability, and balance in healthy male university students.

*Study design:* A quasi-experimental design.

*Setting:* Walailak University, Nakhon Si Thammarat, Thailand.

*Subjects:* Thirty-six healthy male university students aged 18-25 years with functional ankle disability index score equal to 100 and body mass index between 18.5-22.9 kg/m$^2$.

*Methods:* The participants were allocated by block randomization into three groups. Group A (n = 9) received static balance training for 6 sessions followed by dynamic balance training for 6 sessions. Group B (n = 11) received dynamic balance training for 6 sessions followed by static balance training for 6 sessions. Group C (n = 12) alternated between static and dynamic balance training for 12 sessions. The participants underwent one position for one session every other day. The total time of the training program was 15 minutes for each session. Agility, ankle stability, and balance before training and after completion of the 12$^{th}$ session were analyzed between the three groups by using one-way ANOVA and within the groups by paired simple t-test and with a $p$-value < 0.05.

*Results:* There was no significant difference in agility, ankle stability, and balance between the three groups ($p > 0.05$). When analyzing before training and after completion of the 12$^{th}$ session, a significant difference was found in agility, ankle stability, and balance within Group A, B, and C ($p < 0.05$).

*Conclusions:* The results of the three training programs were not different. Nevertheless, the three different programs of static and dynamic balance training showed an improvement in all variables after completion of the 12$^{th}$ training session. Therefore, a healthy person can use any of the three different training programs for improving agility, ankle stability, and balance.

**Keywords:** agility, balance, exercise program, lower extremities, stability

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## Introduction

Daily movement takes place in the lower limbs, which relies on hip, knee, and foot coordination. Healthy university students aged 18-26 years have experienced 54% of musculoskeletal problems, and the top three problems are with the lower extremities: hip and thigh at 24.9%, ankle and foot at 19.3%, and knee at 17.1%.[1] The causes of the problems in daily life activity have resulted from trauma (26.7%), playing sports (18.8%), running (18.0%), and idiopathic factors (9%).[2] Each stable step in walking indicates effective lower extremity function depending on kinetic and kinematic factors.[3,4] The kinetic factors consist of power of the lower extremities, alignment of the joint forces, and momentum. The kinematic factors consist of stepping speed, lower limb angle, and lower limb velocity.[5] The kinetic and kinematic factors are related to physical function (e.g., muscular strength, lower limb stability, flexibility, cardiovascular endurance, balance, coordination, and neuromuscular control). Effective lower extremity movement will result in increased ability to engage in physical activity.[6,7]

Lower limb exercises are not only crucial for people with health problems but also for athletes with injuries.[8] Athletes with lower extremity problems require a rehabilitation program to effectively return to sports activity. Young athletes need to train their lower extremities to perform sport-specific skills at a high level.[9] In addition, a study in staying healthy found insufficient training to address physical activity problems, especially in adolescents who were unable to reach their goals of moderate to vigorous physical activity.[10] Exercise programs are essential to increasing physical activity and increasing the effectiveness of locomotion in routine activities.[11] A previous study has found that increased exercise prescription through physical activity is related to a better quality of life in healthy people and university students.[11] Some research found that university athletes who undergo

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physical training can prevent lower limb musculoskeletal problems.[9]

Previous studies have found that musculoskeletal problems are associated with physical fitness, such as power, speed, flexibility, balance, and agility.[12,13] In addition, the studies have found that balance, agility, and stability are associated.[14,15] Balance training can improve agility and stability.[16]

Static balance training promotes the body's ability to maintain its center of gravity on a support base.[17] Static balance training increases awareness of the joints or joint proprioceptive sense, balance, and muscle onset latency.[17,18] In contrast, dynamic balance training promotes the body's ability to maintain its center of gravity on a support base with a constantly changing center of gravity and base.[17] Dynamic balance training increases the awareness of joints, strength of tendon muscle and ligaments, kinesthesia joints motion, balance, and coordination.[17,19] Both types of training increase agility while playing sports and engaging in various activities that depend on balance.[20] Furthermore, both types of training consist of static and dynamic balance combined with body movements that help work with the neuromuscular, musculoskeletal, and proprioceptive systems; and both trainings reduce the incidence of injuries in the ankle and lower extremities.[17,21] Literature reviews have shown that there has not been a study to compare the effects of static and dynamic balance training on agility, stability, and balance. Our pilot study found that static, dynamic, and alternating balance trainings seem to improve agility, stability, and balance. However, the effects of training still need to be investigated further.

The primary purpose of this study was to compare the effects of three different programs (static followed by dynamic balance training, dynamic followed by static balance training, and alternating between static and dynamic balance training) after 12 training sessions to determine their suitability for increasing agility, stability, and balance in a short period. The secondary purpose of this study was to compare the effects before and after the completion of the 12th training session within the groups that showed an improvement in the results in our pilot study. The study was conducted among healthy male university student volunteers without a history of musculoskeletal injury.

## Methods

### Study design

This research was approved for ethical consideration by the Ethics Committee of Human Research, Walailak University. It was performed under the Declaration of Helsinki (Ethic of WUEC No. 14/095). This study was a quasi-experimental design among male students from Walailak University.

### Participants

The number of participants in this study was calculated by G-Power Version 3.1.9.4 after the pilot study in a sample of 10 people and by performing testing according to the research procedures. The values of the balance test were used in the calculations because they covered the number of participants of all variables in this study. The mean and standard deviation value of the balance test was 31.25 and 25.10, respectively. The participants were divided into three groups, with 12 persons per group (36 male volunteers).

For the inclusion criteria, the participants had to meet the following requirements: (1) right leg dominance, (2) age between 18-25 years old, (3) body mass index between 18.5-22.9 kg/m$^2$, and (4) functional ankle disability index (FADI) score equal to 100. The exclusion criteria included the following conditions affecting balance: (1) history of accidents or disorders of the musculoskeletal system, (2) disorders of the nervous system, (3) disorders of the cardiovascular system, (4) disorders of the respiratory system, (5) drinking alcoholic beverages within 24 hours before the test, and (6) taking drugs (e.g., muscle relaxant, antidepressants, and anti-seizure drugs) within 24 hours before the test. The enrollment method is shown in Figure 1.

### Research equipment

The research tools included the following: (1) functional ankle disability index (FADI) test, (2) an ankle disk (PhysioRoom® Air Stability Wobble Balance, Model AB305107, Physioroom Company, Burnley, UK), (3) a mini trampoline (Contrix® Trampoline, Model 68559, CONTRIX INC., New York, USA), (4) a metal measuring tape, (5) a metronome, (6) six cones, (7) a football, (8) three tripod canes, (9) marking tape, and (10) a stopwatch.

### Research procedure

After passing the inclusion-exclusion screening criteria, the volunteers signed an informed consent form and were allocated by block randomization into three groups. Before and after training, stretching was performed to prevent soft tissue injury.

The static balance training program with an ankle disk was divided into six positions and the dynamic balance training program with a mini trampoline was divided into six positions that were arranged from easy to hard. The participants underwent one position for one session every other day. The participants performed 3 repetitions/set within 2 minutes/repetition, 2 sets/session with 30 seconds of rest between repetitions, and 1 minute of rest between sets. The total time of the training program was 15 minutes for each session.

Group A received static balance training for 6 sessions followed by dynamic balance training for 6 sessions. The training program was arranged as follows: Session 1 practiced Static 1, Session 2 practiced Static 2, Session 3 practiced Static 3, Session 4 practiced Static 4, Session 5 practiced Static 5, Session 6 practiced Static 6, Session 7 practiced Dynamic 1, Session 8 practiced Dynamic 2, Session 9 practiced Dynamic 3, Session 10 practiced Dynamic 4, Session 11 practiced Dynamic 5, and Session 12 practiced Dynamic 6 (Figure 2).

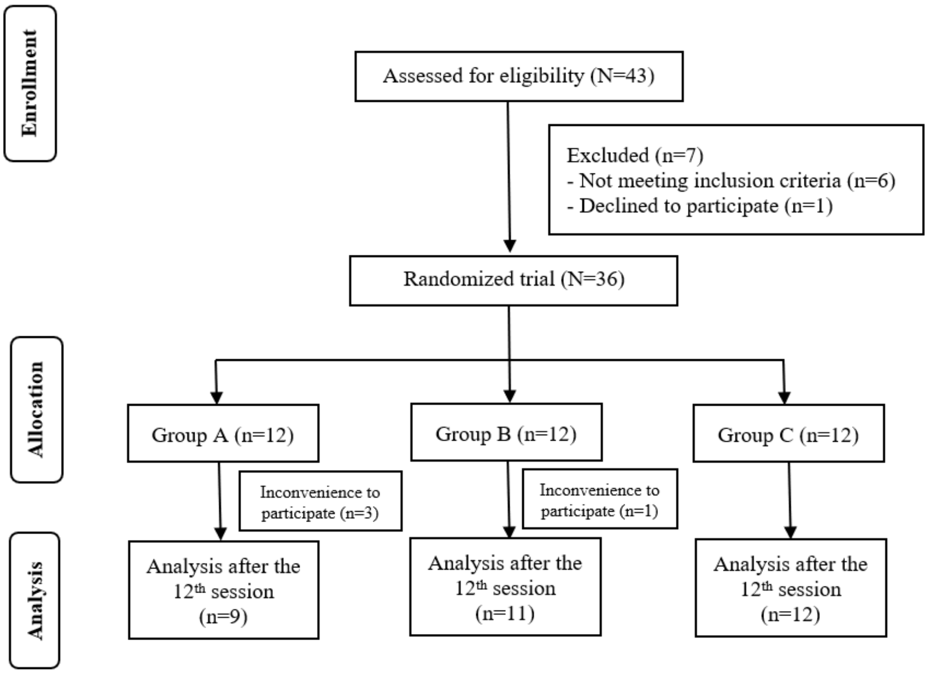


**Figure 1.** Flow diagram

| Number | Position | Exercise descriptions |
|---|---|---|
| Static 1 |  | Standing with both knees bending and eyes opened |
| Static 2 |  | Standing with one knee bending and eyes opened |
| Static 3 |  | Standing with both knees bending and eyes closed |
| Static 4 |  | Standing with one knee bending and eyes closed |
| Static 5 |  | Standing with one knee bending with eyes opened and arm raised to touch the target within the base of the support according to a metronome (55 beats/minute) |
| Static 6 |  | Standing with one knee bending with eyes opened and taking a ball within the base of the support according to a metronome (55 beats/minute) |

| Number | Position | Exercise descriptions |
|---|---|---|
| Dynamic 1 |  | Standing and reaching out to touch the target outside the base of the support with eyes opened according to a metronome (55 beats/minute) |
| Dynamic 2 |  | Jumping and alternating legs to the front and back with eyes opened according to a metronome (55 beats/minute) |
| Dynamic 3 |  | Jumping by both legs with eyes opened according to a metronome (55 beats/minute) |
| Dynamic 4 |  | Jumping and alternating legs to the front and back with eyes closed according to a metronome (55 beats/minute) |
| Dynamic 5 |  | Jumping with both legs in a stationary position for five repetitions with eyes opened and taking a ball outside the base of the support |
| Dynamic 6 |  | Jumping with both legs in a stationary position with eyes opened and kicking a ball after completing five repetitions |

**Group A** received static balance training for 6 sessions followed by dynamic balance training for 6 sessions.
**Group B** received dynamic balance training for 6 sessions followed by static balance training for 6 sessions.
**Group C** alternated between static and dynamic balance training for 12 sessions.

**Protocol:** Training program was practiced every other day with one position for one session.
A total training period was 15 minutes/session, 2 minutes/repetition, 3 repetitions/set,
2 sets/day with 30 seconds of rest between repetitions and 1 minute rest between sets.

**Figure 2.** Training program

Group B received dynamic balance training for 6 sessions followed by static balance training for 6 sessions. The training program was arranged as follows: Session 1 practiced Dynamic 1, Session 2 practiced Dynamic 2, Session 3 practiced Dynamic 3, Session 4 practiced Dynamic 4, Session 5 practiced Dynamic 5, Session 6 practiced Dynamic 6, Session 7 practiced Static 1, Session 8 practiced Static 2, Session 9 practiced Static 3, Session 10 practiced Static 4, Session 11 practiced Static 5, and Session 12 practiced Static 6 (Figure 2).

Group C alternated between static and dynamic balance training for 12 sessions. The training program was arranged as follows: Session 1 practiced Static 1, Session 2 practiced Dynamic 1, Session 3 practiced Static 2, Session 4 practiced Dynamic 2, Session 5 practiced Static 3, Session 6 practiced Dynamic 3, Session 7 practiced Static 4, Session 8 practiced Dynamic 4, Session 9 practiced Static 5, Session 10 practiced Dynamic 5, Session 11 practiced Static 6, and Session 12 practiced Dynamic 6 (Figure 2).

### Outcome measures

All participants received the Side Hop Test for measuring stability, the Illinois Agility Test for measuring agility, and the Balance Test for measuring balance before the first day of training and after completion of the 12$^{th}$ session (on the 24$^{th}$ day after participants underwent the program).

Illinois Agility Test:[22] This test was performed to assess agility performance. The reliability (ICC) was between 0.85-0.98.[22] There was a total of 8 cones, 4 of which was used to form a rectangle that was 5 meters wide and 10 meters long, and the other 4 cones were placed down the center of the rectangle at 3.3 meters apart.[23] When testing, the participants must run as quickly as possible through a specified path (Figure 3). A total of three cycles were conducted, and the shortest time representing the best agility performance was chosen and recorded in seconds.

Side Hop Test:[24] This test was performed to assess ankle stability. The reliability (ICC) was between 0.84-0.98.[24,25] The test method involved the participants jumping to the right and left as quickly as possible, consisting of 10 hops over a 30-centimeter line. The test was performed three times with one minute of rest between each time, and the shortest time representing the best stability performance was chosen and recorded in seconds.

Balance Test (on an ankle disk):[26] This test was performed to assess balance performance, which is affected by the perception of joints in different ways including controlling the posture of the body and modifying the contraction of the muscles around the ankle. The reliability (ICC) was between 0.79-0.95.[27] The test method involved the participants standing with one leg on the ankle disk and arms crossed. If the raised foot touched the floor at any time, the time was immediately stopped and recorded in seconds. The longest time represented the best balance performance. The test was

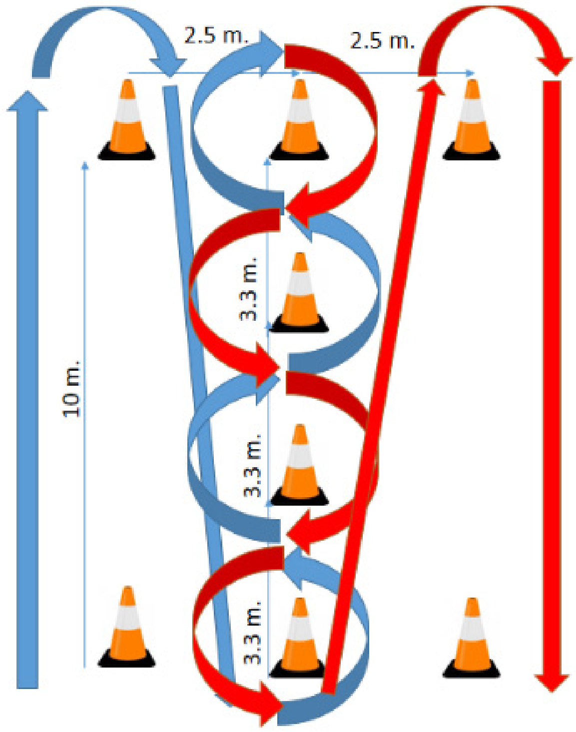


**Figure 3.** Illinois Agility Test Pathway

performed on both sides for each leg.

### Statistical analysis

Statistical analysis was calculated before training and after completion of the 12$^{th}$ session. The statistical significance was set at *p*-value < 0.05. The selected statistics were analyzed as follows: (1) the Kolmogorov–Smirnov goodness of fit test was used to analyze the normal distribution; (2) the one-way ANOVA and Bonferroni tests were used to test differences in the mean values for agility, ankle stability, and balance of the three training programs; and (3) the paired sample t-test was used before training and after completion of the 12$^{th}$ session within the groups. Statistical calculations were performed using IBM SPSS, Version 26 for Windows.

## Results

All participants were allocated into three groups, which consisted of 12 people per group. A total of four participants (three in Group A and one in Group B) requested to withdraw due to inconvenience in continuing with the training. The number of participants in each group was consequently equal to 9, 11, and 12 in Group A, B, and C, respectively. There were no significant differences in the general characteristics between the three groups ($p > 0.05$) (Table 1). There were no significant differences in the Illinois Agility Test, Side Hop Test for both legs, and Balance Test for both legs at baseline between the three groups.

### Illinois Agility test

The mean differences in agility by the Illinois Agility Test among the three groups showed no significant differences

**Table 1.** General characteristics of participants

| Demographic | Mean (SD) Group A (n = 9) | Group B (n = 11) | Group C (n = 12) | *p*-value |
|---|---|---|---|---|
| Age (years) | 20.0 (1.66) | 20.27 (1.49) | 19.50 (0.80) | 0.897 |
| Weight (kg) | 62.52 (9.85) | 60.45 (4.66) | 60.75 (6.76) | 0.650 |
| Height (cm) | 173.80 (3.59) | 170.75 (5.07) | 171.82 (5.12) | 0.175 |
| BMI (kg/m$^2$) | 22.07 (2.87) | 21.07 (1.58) | 20.84 (2.67) | 0.393 |

*Significant level; *p*-value < 0.05

**Table 2.** Comparison of the difference in stability, balance, and agility between the three groups

| Outcome | Mean difference (sec) Group A (n = 9) | Group B (n = 11) | Group C (n = 12) | *p*-value |
|---|---|---|---|---|
| Agility | | | | |
| Both legs | 0.80 | 0.50 | 0.96 | 0.079 |
| Stability | | | | |
| Right leg | 0.80 | 0.90 | 0.87 | 0.870 |
| Left leg | 0.88 | 0.88 | 0.85 | 0.992 |
| Balance | | | | |
| Right leg | -68.19 | -63.55 | -65.70 | 0.995 |
| Left leg | -62.73 | -65.46 | -83.83 | 0.389 |

*Significant level; *p*-value < 0.05

Note: Negative value for balance shows an improvement in balance.

when comparing between Group A, B, and C ($p = 0.079$). The results are presented in Table 2.

However, a comparison of the agility values before training and after completion of the 12th session showed a statistically significant difference within Group A ($p = 0.006$), B ($p < 0.001$), and C ($p < 0.001$). The results are presented in Table 3.

### Side Hop Test

The mean differences in ankle stability by the Side Hop Test among the three groups showed no significant differences when comparing between Group A, B, and C of the right leg ($p = 0.870$) and the left leg ($p = 0.992$). The results are presented in Table 2.

However, a comparison of the Side Hop Test representing ankle stability before training and after completion of the 12th session of the right leg showed a statistically significant difference within Group A ($p = 0.001$), B ($p < 0.001$), and C ($p < 0.001$). In addition, the Side Hop Test of the left leg showed a statistically significant difference within Group A ($p = 0.023$), B ($p < 0.001$), and C ($p = 0.001$). The results are presented in Table 3.

### Balance Test

The mean differences in the Balance Test among the three groups showed no significant difference when comparing between Group A, B, and C of the right leg ($p = 0.995$) and the left leg ($p = 0.389$). The results are presented in Table 2.

However, a comparison of the balance values before training and after completion of the 12th session of the right leg showed a statistically significant difference within Group A ($p < 0.001$), B ($p < 0.001$), and C ($p < 0.001$). In addition, the balance test of the left leg showed a statistically significant difference within Group A ($p = 0.001$), B ($p < 0.001$), and C ($p < 0.001$). The results are presented in Table 3.

## Discussion

This study aimed to compare 12 sessions of static and dynamic balance training from three different programs that are suitable for increasing agility, stability, and balance in a short period. Comparisons were made between the three groups and within the groups before and after the completion of the 12th training session among healthy male university student volunteers.

Ankle stability by the Side Hop Test showed no difference between the three groups (static followed by dynamic balance training, dynamic followed by static balance training, and alternating between static and dynamic balance training programs) after completion of the 12th session. The programs for all three groups may have resulted in muscle contraction. Muscle onset latency of the peroneus longus and tibialis anterior muscles after a balance training program thereby improves the mechanoreceptor function, where both muscles are related to the postural control and medial longitudinal arch of foot stability.[28] Therefore, the participants from all three groups demonstrated an increase in ankle stability after completing the training programs in this study.

However, after completion of the 12th session, ankle stability by the Side Hop Test within each group increased when comparing before and after training. Consistent with a

**Table 3.** Comparison of the difference in stability, balance, and agility before and after training within the three groups

| Outcome | Mean (SD) (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Group A (n = 9) | | | Group B (n = 11) | | | Group C (n = 12) | | |
| | Before training | After training | *p*-value | Before training | After training | *p*-value | Before training | After training | *p*-value |
| Agility | | | | | | | | | |
| Both legs | 18.25 (1.24) | 17.45 (0.87) | 0.006* | 18.25 (0.89) | 17.75 (0.75) | < 0.001* | 18.58 (0.77) | 17.63 (0.73) | < 0.001* |
| Stability | | | | | | | | | |
| Right leg | 3.95 (0.58) | 3.16 (0.29) | 0.001* | 4.34 (0.71) | 3.43 (0.39) | < 0.001* | 4.10 (0.59) | 3.23 (0.30) | < 0.001* |
| Left leg | 4.13 (1.07) | 3.25 (0.30) | 0.023* | 4.40 (0.58) | 3.51 (0.50) | < 0.001* | 4.23 (0.62) | 3.38 (0.31) | 0.001* |
| Balance | | | | | | | | | |
| Right leg | 19.55 (15.39) | 87.75 (38.33) | < 0.001* | 6.11 (5.30) | 69.66 (36.76) | < 0.001* | 16.68 (17.70) | 82.38 (39.12) | < 0.001* |
| Left leg | 12.46 (10.30) | 75.19 (44.36) | 0.001* | 4.74 (2.99) | 70.19 (32.29) | < 0.001* | 8.71 (6.12) | 91.54 (42.08) | < 0.001* |

previous study, lower extremity training can improve muscle strength, balance, and proprioception, which are the components of ankle stability.[29,30] A previous study showed that balance training on a balance board for an appropriate amount of time of more than three weeks can effectively increase ankle stability and the medial-lateral center of pressure of the foot, thus improving foot stability.[31] Consistent with a period program, this study used over three weeks for balance training on an ankle disk and a mini trampoline, in which the results showed an improvement in stability in all training programs. Dynamic training by using a mini trampoline involved movements that occurred when the body's position changed from one location to another, which caused a disturbance in the balance of the body.[32] In contrast, static balance training by using an ankle disk involved a small pivot movement at a central point where the postural adjustment was controlled by a platform and the base of the unit.[17] The effects of static and dynamic balance training increased body movement and stability of the lower limbs, which can improve muscle strength and maintain balance resulting in muscles working harder to achieve a certain posture and improvement in ankle stability.[17,32] The minimal detectable change (MDC) of the Side Hop Test ranged from 1.4 to 1.9 seconds in male children and adolescents aged 10-16 years.[25] The average stability time values in this study were 0.8, 0.9, and 0.9 seconds in Group A, B, and C, respectively, in regard to improvement after completion of the 12th session on the dominant side of participants aged 18-22 years. The reason for the difference in improvement value might be due to the difference in age.

The agility values from the Illinois Agility Test showed no difference between the three groups in improvement due to the static and dynamic balance exercises, which were used to improve agility and functional movement in daily life consistent with a previous study.[33]

However, comparing the agility values before and after completion of the 12th training session showed an increase in agility performance within each group. The results of the Illinois Agility Test were consistent with a previous study, which determined that static and dynamic balance training should be practiced appropriately to increase agility.[34] Static balance training using an ankle disk resulted in an increase in proprioceptive senses, balance, and coordination. Dynamic balance training using a mini trampoline resulted in an increase in stability, balance, proprioceptive senses, muscle power, muscle strength, and coordination. The results of alternating between the static and dynamic balance training showed an increase in agility performance, the same as in the other groups. In addition, a previous study on football players determined that agility training combined with balance training could increase athletic performance.[35] Another study has also determined that agility and coordination were highly correlated with the ability to maintain balance.[36] The Illinois Agility Test's minimal detectable change (MDC) was equal to 0.52 seconds in male athletes of team sports.[22] This study showed improvement of agility time values, which were 0.8, 0.5, and 1.0 seconds in Group A, B, and C, respectively, after completion of the 12th session.

The balance test showed no difference between the three groups of training program. Several studies have suggested using static and dynamic exercise for improving balance.[32,37] The results of the static balance training on an unstable surface were related to the center of pressure excursion, surface pressure, and degree of sway, while the results of the dynamic balance training were related to leg movements and landing from a jump.[37] As a result, all three groups in this study exhibited good balance.

When comparing within each group for the Balance Test, an increase in balance was found after completion of the 12th training session. Consistent with a previous study, the improvement of balance was due to the function of the internal movement of the joints, sensory organization, musculoskeletal system, motor coordination, weight balance adjustment, and environment adaptation.[38] The training program in this study was comprised of static and dynamic balance training to improve joint awareness and balance related to closed and opened kinetic chains. A previous study among healthy adults who had no exercise habits found that both closed and opened kinetic chains increased balance. Moreover, closed kinetic chain training affected joint compression, proprioceptive feedback from the foot, muscle activity, and neuromuscular control during exercise with a posture similar in real life.[39] A previous study found that static balance training involved standing still on both feet and causing the body to sway from the base of the support. The measurement indicated the average of the center of pressure and the variance of the position by the function of the nervous system and muscles.[32] A static balance training program with an ankle disk can prevent ankle sprain by stimulating proprioception and helping to slow down the activation of the tibialis anterior and tibialis posterior muscles, which twist the ankle inward to prevent excessive ankle inversion.[40] During training on an ankle disk, the difficulty level can be increased by decreasing the base of the support. An ankle disk training program was used as a learning mechanism. Proprioceptive activity can help improve postural control and physical movements in ordinary people.[27] Some research on ankle disk training focused on the contraction of the muscles around the ankle in healthy individuals. The training program with an ankle disk helped prevent the occurrence of ankle sprain and prevent functional instability in terms of acute ankle sprains for people with first-time ankle sprains.[41] Dynamic training involved movement that occurred when the body's position changed from one location to another, which caused disturbance in the balance of the body.[32] This research used a mini trampoline because it can increase body movement outside the base of the support to improve muscle strength and maintain balance. A mini trampoline is a device that has an unstable surface, which makes the muscles work harder to achieve a certain posture and induces postural control after training.[42] The minimal detectable change (MDC) of the balance test on an ankle disk is needed for further study.

The benefits of this study included the development of effective training programs and the option to select a training pattern that is appropriate for specific problems. The strengths of this study included easy training and minimal equipment. The limitation of this study was in the limited time available to collect data. If the training period was longer, the results might be more evident due to the period of training. Further studies should identify training programs for each sport and study the long-term effects of training to determine how to improve ankle stability, balance, and agility.

## Conclusions

The effects of three different programs (static balance training for 6 sessions followed by dynamic balance training for 6 sessions, dynamic balance training for 6 sessions followed by static balance training for 6 sessions, and alternating between static and dynamic balance training for 12 sessions) on agility, stability, and balance in healthy male university students demonstrated improvement after completion of the 12$^{th}$ session in all training programs. However, no significant differences were found between the three groups because the three exercise programs induced body movement that led to maintaining position. Therefore, a healthy person who aims to improve agility, stability, and balance can use any of the three training programs within a short training period to increase physical performance.

## Disclosure

No potential conflict of interest relevant to this article was reported.

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