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The Effect of Balance Training on Physical Motor Functions TO 11-12 Year Old Female Football Players

Xiwen Yang, Nea A. Sualog*

ADAMSON UNIVERSITY – MANILA, Philippines

* **Corresponding author:** Nea A. Sualog (Email: nea.sualog@adamson.edu.ph)

Abstract: The aim of this study was to investigate the effect of balance training on the physical motor function of adolescent female football players. Thirty female football players aged 11-12 years were selected from Ausheng Football Club as the study subjects, and they were divided into a test group and a control group of 15 each using experimental testing and mathematical statistics methods. The experimental group received balance training intervention for a period of 5 weeks while the control group did not receive any intervention. The Y-Balance test and FMS test were used as assessment indicators to evaluate the balance and body movement function of the athletes respectively. Differences in performance between the two groups before and after training were compared and the relationship between balance ability and physical motor function was analyzed by methods such as paired samples t-test and independent samples t-test. The results showed that compared with the control group, the experimental group showed significant improvement in all balance indicators, especially in medial back and overall balance. In addition, the experimental group showed significant improvement in hurdle stride, linear lunge, and rotational stability indicators. The overall motor function of the experimental group improved significantly as assessed by the Functional Movement Screen (FMS), which indicated that the balance training was very effective. The Y-balance test further confirmed that the experimental group showed a substantial improvement in balance, while the control group showed little change. In addition, the results of the Y-balance test showed a moderate positive correlation with the results of the FMS test, suggesting a relationship between balance and functional movement. These findings emphasize the positive impact of balance training on the physical motor function of young female footballers, demonstrating the importance of balance training in motor development and injury prevention.

Keywords: Balance, Physical Motor Function, Adolescents, Football.

1. Introduction

Football demands exceptional physical prowess and mental acuity from its players. The physical fitness of athletes significantly influences game performance, especially in high-stakes matches where superior fitness often determines success. However, rigorous physical training can also pose risks, potentially leading to injuries, fatigue, and decreased performance. To mitigate these risks and enhance performance, functional training has emerged as a valuable approach.

Functional training targets specific performance improvements within the context of a sport. It emphasizes multidimensional, multi-joint, and multi-muscle group exercises to enhance athletes' strength, speed, flexibility, coordination, and notably, balance. Despite its importance, balance training has not received ample attention within domestic football functional training programs.

Balance ability, crucial for maintaining stability and preventing injuries, remains understudied in football training. Research indicates that balance training can significantly enhance various football skills and cognitive abilities in elite youth players. However, there's limited understanding of how balance training impacts the physical motor function of youth footballers.

To address this gap, this study aims to investigate the effects of balance training on the physical motor function of adolescent female football players. Through an experimental approach, players will be randomly assigned to either an experimental group, undergoing eight weeks of balance training, or a control group, receiving regular training. Subsequent assessments will compare the physical motor functions of both groups, shedding light on the impact of balance training in this demographic.

2. Research Participants

The sample participants for this study consisted of 30 eligible junior female football players selected from the Pingxiang Ausheng Club. These players were actively involved in football training and matches in their respective clubs. To ensure homogeneity of the sample, the study used specific inclusion criteria such as age range (11-12 years), training experience of more than 2 years and participation in regular football activities.Afer that, they were divided into two groups with 15 members per group- the experimental and control groups.The experimental group underwent the balance training intervention, which involved targeted exercises aimed at improving balance, stability, and overall physical motor function. Meanwhile, the control group maintained their regular training routines without any additional intervention.

3. Statistical Treatment

Descriptive Statistics:Statistical indicators such as mean and standard deviation were used to describe and summarize the basic situation and changes in the indicators of the two groups of adolescent football players in the pre-test and post-test.

Paired samples t-test: This was used to compare the indicators of the two groups of adolescent football players in the pre-test and post-test, in order to test whether there is a significant difference, so as to assess the effect of balance training.

Independent samples t-test: Independent samples t-test was used to compare the indicators in the post-test between the two groups of adolescent female football players to test whether there were significant differences in order to assess the effect of balance training.

Pearson's correlation analysis: Pearson's correlation analysis was used to correlate the Y-balance ability of the adolescent female football plays with the indicators of physical movement function, in order to test whether there is a significant correlation, so as to reveal their intrinsic connection.

4. Results and Discussion

This section focuses on analysing the results of the experimental group and the control in the Y balance test and the FMS test before and after the experiment, as well as the association between the Y balance test and the FMS test.It also discusses the reasons for this.

4.1. Analysis Personal Information between the Experimental and Control Groups

In order to ensure the validity of the experiment, 30 athletes who participated in the experiment were physically examined and their basic information was recorded three days before the experiment started. The basic information of the participating experimental athletes is shown in Table 1.

Table 1. Basic Information About the Athletes

Index	Experimental group Mean	Experimental group SD	Control group Mean	Control group SD
Height	151.40	1.80	150.73	1.94
Weight	41.73	2.22	42.00	2.23
Training years	2.87	0.64	2.93	0.70

Based on the data provided in Table 1, it can be observed that the mean height of athletes in the experimental group is 151.40 cm with a standard deviation of 1.80 cm, while the mean height in the control group is slightly lower at 150.73 cm with a standard deviation of 1.94 cm, indicating a marginal difference between the two groups. Similarly, the mean weight of athletes in the experimental group is 41.73 kg with a standard deviation of 2.22 kg, whereas in the control group, it is slightly higher at 42.00 kg with a similar standard deviation of 2.23 kg, suggesting a minor distinction in weight between the two groups. Moreover, athletes in the experimental group have been training for an average of 2.87 years with a standard deviation of 0.64 years, whereas athletes in the control group have been training for an average of 2.93 years with a slightly lower standard deviation of 0.70 years, indicating comparable levels of experience in terms of training years.

Overall, while there are slight differences in height and weight between the experimental and control groups, as well as a slightly higher mean training duration in the experimental group, these distinctions are relatively minor and may not significantly influence the outcomes of the intervention.

Background factors such as participants' age range, height, weight, and level of competition may influence the baseline characteristics of athletes and may vary from study to study. The population of this study was 11-12 years old, which is different from the population of Junjie's (2022) study on young Chinese female footballers, so the results shown will be different.

4.2. Analysis of Y-balance Test and FMS Test Results of Two Groups of Experimental Members before the Intervention

Before the intervention, Y-balance test and FMS test were conducted for the two groups of experimental members, and independent sample T test was conducted for the Y-balance test and FMS test results of experimental subjects, which effectively evaluated the lower limb balance ability and the physical motor function of the experimental group and the control group. The results are shown in Table 2, Table 3 and Table 4 below.

Table 2. Y-Balance Test Results (cm) of Two Groups of Experimental Members (N=15) before the Intervention

Support leg	Index	Experimental group Mean	Experimental group SD	Control group Mean	Control group SD
Left leg support	Front	69.40	4.95	71.29	4.81
	Inner behind	83.13	6.16	84.64	6.63
	Outer back	86.67	6.28	88.21	5.81
	Integrated	87.90	5.94	89.77	5.46
Right leg support	Front	68.40	5.93	70.2	5.81
	Inner behind	82.60	8.12	83.87	6.67
	Outer back	84.40	6.92	86.07	6.26
	Integrated	86.43	6.50	88.10	5.41

Table 2 shows the extension distances of the contralateral leg in the three directions during the preexperimental right and left leg supports. Prior to the start of the intervention, baseline Y balance test results were collected to compare the balance and stability of the experimental and control groups.Table 2 reveals that the control group generally exhibits slightly higher mean reach values across both left and right leg supports in various directions compared to the experimental group. Specifically, for left leg support, the control group demonstrates higher mean reach values at the front (71.29 cm vs. 69.40 cm), inner behind (84.64 cm vs. 83.13 cm), outer back (88.21 cm vs. 86.67 cm), and an integrated mean reach of 89.77 cm compared to 87.9 cm in the experimental group. Similarly, for right leg support, the control group also presents higher mean reach values at the front (70.2 cm vs. 68.4 cm), inner behind (83.87 cm vs. 82.6 cm), outer back (86.07 cm vs. 84.4 cm), and an integrated mean reach of 88.10 cm compared to 86.43 cm in the experimental group. However, the differences in mean reach values between the two groups are relatively small, with overlapping standard deviations indicating some degree of variability within each group. Further statistical analysis would be necessary to determine the significance of these differences.

Overall, it provides insights into the baseline Y balance test results for both the experimental and control groups before the intervention. It indicates that the control group generally demonstrates slightly higher mean reach values across various directions compared to the experimental group, suggesting potentially better balance and stability. However, the differences in mean reach values are relatively small, with overlapping standard deviations, indicating variability within each group.

Y balance test can better respond to the dynamic postural control and core control ability of the lower limbs of middle distance runners in multiple directions. The results of this study were all lower than 90% of the composite score compared with Junjie (2022) mentioned in his study that 96.91% of our youth women's football team found that the results of this study were weaker compared with high level women's football team, which may be related to the degree of development and the level of competitiveness. It was also similarly weaker than the volleyball-specific female college students' YBT score of 94.51% in Yan's (2023) study. This may be related to the younger age of the present participants. Besides, it Indicates some risk of lower limb injury to the subject(the composite score is <95%).

Table 3. FMS Test Rresults of Two Groups of Experimental Members (N=15) Before the Intervention

Index	Experimental group Mean	Experimental group SD	Control group Mean	Control group SD
Squats	2.13	0.35	2.40	0.50
Hurdle step	1.93	0.46	2.13	0.35
Inline lunge	2.20	0.56	2.20	0.40
Shoulder mobility	2.20	0.68	2.07	0.57
Active leg raises	2.13	0.52	2.20	0.40
Trunk Stability Push-Ups	2.20	0.67	1.80	0.65
Rotary stability	1.93	0.46	1.73	0.44
FMS total score	14.73	1.28	14.53	1.02

Table 3 shows the scores and between-group differences in the pre-experimental subjects' functional movement screen. All subjects were pain free on the test and no items scored 0. The results of the baseline FMS test prior to the intervention showed that prior to the experiment, the mean total FMS test score of the 15 subjects in the experimental group was 14.73 and the mean total FMS test score of the 15 subjects in the control group was 14.53. The mean total score of the experimental group and the control group exceeded 14, indicating that the experimental group and the control group as a whole did not have a greater risk of sports injuries, but should be vigilant in preventing the risk of injuries.The experimental group displays a mean score of 2.13 with a standard deviation of 0.35 for squats, 1.93 (±0.46) for hurdle step, 2.20 (±0.56) for inline lunge, 2.20 (±0.68) for shoulder mobility, 2.13 (±0.52) for active leg raises, 2.20 (±0.67) for trunk stability push-ups, and 1.93 (±0.46) for rotary stability, resulting in a total FMS score of 14.73 (±1.28). In contrast, the control group demonstrates slightly higher mean scores for most tests, including squats (2.40 ± 0.50), hurdle step (2.13 ± 0.35), inline lunge (2.20 ± 0.40), shoulder mobility (2.07 ± 0.57), active leg raises (2.20 ± 0.40), trunk stability push-ups (1.80 ± 0.65), and rotary stability (1.73 ± 0.44), resulting in a total FMS score of 14.53 (±1.02). While the control group tends to have slightly higher mean scores across most FMS tests, the differences between the two groups are generally small. Notably, the control group has a lower mean score for trunk stability push-ups compared to the experimental group.

The results of this study showed that the total FMS test scores of the experimental group and the control group were 14.73 and 14.53, respectively, which were not much different from the results of Ruidong(2018) mentioned in his study that FMS test of adolescents in general secondary school students, which was 15.10 points. Compared to the initial levels mentioned in Ping's (2023) study, the results of the present study were higher than the female members with injuries 13.57 and lower than the members without injuries 15.86.It was also found that with a dividing line of 14, the rate of injuries was significantly higher in the low-scoring members of the FMS than in the high-scoring members.It can be seen that the motor function of the subjects in this study is at a normal level.

The comparison of Y-balance and Functional Movement Screen (FMS) test results between the experimental and control groups before the experiment, as presented in Table 4, reveals several key findings. The Y-balance test results for both left and right legs, across various directions (front, inner behind, outer back, and integrated), do not exhibit significant differences between the groups. Furthermore, while there is a slight variation in mean scores for specific FMS tests such as squats, hurdle step, and trunk stability push-ups, these differences are not statistically significant, as evidenced by t-test results with p-values exceeding 0.05.

Overall, the data suggest that there are no significant disparities in Y-balance, or FMS test results between the experimental and control groups before the experiment, indicating that they are reasonably well-matched at baseline.

Differences in baseline characteristics between groups may be due to differences in recruitment criteria. Differences in Y balance scores, and FMS scores between athletes in the experimental and control groups were relatively small and may not have had a substantial impact on the results of the study. These baseline characteristics may serve as reference points for assessing the impact of the intervention on athletic performance.

Table 4. Comparison of the Results of Y-balance and FMS Tests between the Experimental and Control Groups Before the Intervention

Index	Experimental Group Mean	Control Group Mean	t	Sig.	Interpretation
YBT/(left)Front	69.40	71.29	1.04	0.15	Not significant
Inner behind	83.13	84.64	-0.37	0.35	Not significant
Outer back	86.67	88.21	-0.69	0.25	Not significant
Integrated	87.9	89.77	0.91	0.19	Not significant
(right)Front	68.40	70.2	-0.84	0.21	Not significant
Inner behind	82.60	83.87	-0.46	0.32	Not significant
Outer back	84.40	86.07	-0.69	0.25	Not significant
Integrated	86.43	88.10	0.79	0.22	Not significant
FMS/Squats	2.13	2.40	-1.67	0.05	Not significant
Hurdle step	1.93	2.13	-1.34	0.10	Not significant
Inline lunge	2.20	2.20	0	0.50	Not significant
Shoulder mobility	2.20	2.07	0.57	0.28	Not significant
Active leg raises	2.13	2.20	-0.39	0.35	Not significant
Trunk Stability Push-Ups	2.20	1.80	1.51	0.07	Not significant
Rotary stability	1.93	1.73	1.19	0.12	Not significant
FMS total score	14.73	14.53	0.46	0.32	Not significant

4.3. Analysis of Y-Balance Test and FMS Test Results of the Two Groups after the Intervention

After the intervention, Y-balance test and FMS test were conducted again for the members of the two groups respectively, and independent samples t-tests were conducted on the results of Y-balance test and FMS test of the experimental subjects, which effectively evaluated the balance ability of the lower limbs and the body movement function of the experimental group and the control group. The results are shown in Tables 5 ,6 and 7 below.

Table 5. Y-balance Test Results between Two groups of Experimental Members (N=15) After the Intervention(cm)

Support leg	Index	Experimental group Mean	Experimental group SD	Control group Mean	Control group SD
Left leg support	Front	75.40	5.00	72.33	4.66
	Inner behind	89.27	5.67	84.93	6.51
	Outer back	92.20	5.43	89.13	5.62
	Integrated	94.39	5.45	90.85	5.31
Right leg support	Front	74.73	5.23	71.13	5.60
	Inner behind	89.07	6.54	84.80	6.49
	Outer back	89.93	5.13	87.00	6.04
	Integrated	93.17	5.03	89.13	5.23

As can be seen in Table 5, the Y-balance test results between two groups of experimental members after the experiment, with each group consisting of 15 participants. The data show the mean reach distances in centimeters (cm) for both the experimental and control groups, along with their respective standard deviations (SD), across various directions and support legs. For the left leg support, the experimental group exhibits higher mean reach distances compared to the control group in all directions, including front (75.4 cm vs. 72.33 cm), inner behind (89.27 cm vs. 84.93 cm), outer back (92.20 cm vs. 89.13 cm), and integrated (94.39 cm vs. 90.85 cm). Similarly, for the right leg support, the experimental group demonstrates greater mean reach distances than the control group in all directions, with notable differences in front (74.73 cm vs. 71.13 cm) and integrated (93.17 cm vs. 89.13 cm). Additionally, the standard deviations for both groups generally indicate similar variability in reach distances across different directions and support legs.

Overall, these findings suggest that the experimental group shows improved balance performance compared to the control group after the experiment, as evidenced by greater mean reach distances across various Y-balance test directions and support legs.

The Y balance score of the experimental group was nearly 94% which was similar to the result of Junjie (2022) the composite score of 96.91% of China's youth women's football team, while the score of the control group was nearly 90%, which was also a relative improvement, which indicated that there was a certain relationship between the Y balance and the degree of growth and development, and at the same time, the balance training could effectively improve the balance of the lower limbs.However, they are still lower than 95%. Ping (2023) mentioned in his study that the impairment rate of 81.8% for YBT composite scores lower than 95% is much higher than the impairment rate of 44.4% for YBT composite scores higher than 95%. Therefore. the experimental group still needs to continue to extend the balance training, which is expected to make the Y balance score more than 95% and reduce the risk of lower limb injury.

As can be seen from Table 6,it provides the post-experiment Functional Movement Screen (FMS) test results between two groups of experimental members, each comprising 15 participants. The data present the mean scores for various FMS test components, along with their respective standard deviations (SD), for both the experimental and control groups. In terms of specific FMS test scores, the experimental group demonstrates higher mean scores compared to the control group across most indices. Notably, the experimental group shows improvements in hurdle step (2.87 vs. 2.13), inline lunge (2.80 vs. 2.20), shoulder mobility (2.27 vs. 2.07), trunk stability push-ups (2.40 vs. 2.47), and rotary stability (2.17 vs. 1.73), indicating enhanced functional movement patterns and core stability. Moreover, the experimental group exhibits a higher mean total FMS score

(17.00) compared to the control group (15.13), suggesting an overall improvement in movement quality and functional fitness after the experiment. While both groups demonstrate relatively low variability in FMS test scores, the experimental group consistently outperforms the control group across multiple FMS components, indicating the effectiveness of the intervention in enhancing functional movement capabilities.Overall, the experimental group displays higher scores across FMS components, indicating improved movement patterns and core stability.

Table 6. FMS Test Results between Two Groups of Experimental Members (N=15) After the Experiment

Index	Experimental group Mean	Experimental group SD	Control group Mean	Control group SD
Squats	2.13	0.34	2.40	0.49
Hurdle step	2.87	0.34	2.13	0.34
Inline lunge	2.80	0.40	2.20	0.54
Shoulder mobility	2.27	0.44	2.07	0.44
Active leg raises	2.20	0.40	2.13	0.34
Trunk Stability Push-Ups	2.40	0.61	2.47	0.50
Rotary stability	2.17	0.37	1.73	0.44
FMS total score	17.00	0.73	15.13	0.72

After 5 weeks of balance training intervention,the experimental group achieved a total FMS score of 17, which is similar to the total FMS score of 16.9 ± 3.0 found by Kiesel et al.(2021) in 46 professional football players before the start of the season, suggesting that the members of the experimental group of the present study have body movement functions comparable to those of professional football players, and have attained the stabilisin. The FMS score of 17 after the experiment in this study was even higher than the high level of wrestling exercise of 15.08 investigated by Hui (2024), And she often uses FMS to effectively screen and identify movement patterns that good Chinese wrestlers need to be warned about. Therefore, screening is necessary even if the FMS score is high. In addition, the score of 2.8 for the hurdle stride was the highest among the seven items tested, which could be attributed to the good stability of the supporting leg or the flexibility of the hip, knee, and ankle joints of the striding leg to achieve such a good quality of movement completion. It may be due to the better stability of the supporting leg or the flexibility of the hip and ankle joints to achieve such a good quality of movement forces that football players need to possess.

Table 7. Comparison of the Results of Y-balance and FMS Tests Between the Experimental and the Control Groups after the Intervention

(Continuation on page 8)

Index	Experimental group Mean	Control group Mean	t	Sig.	Interpretation
YBT/(left)Front	75.4	72.33	1.67	0.05	Not significant
Inner behind	89.27	84.93	1.87	0.04	Significant
Outer back	92.20	89.13	1.46	0.08	Not significant
Integrated	94.39	90.85	1.72	0.048	Significant
(right)Front	74.73	71.13	1.76	0.04	Significant
Inner behind	89.07	84.80	1.73	0.04	Significant
Outer back	89.93	87.00	1.24	0.12	Not significant
Integrated	93.17	89.13	2.05	0.02	Significant
FMS/Squats	2.13	2.40	-1.67	0.05	Not significant
Hurdle step	2.87	2.13	5.71	0.00	Significant
Inline lunge	2.80	2.20	3.33	0.01	Significant
Shoulder mobility	2.27	2.07	1.20	0.12	Not significant
Active leg raises	2.20	2.13	0.48	0.32	Not significant
Trunk Stability Push-Ups	2.40	2.47	0.32	0.38	Not significant
Rotary stability	2.17	1.73	3.47	0.00	Significant
FMS total score	17.00	15.13	6.82	0.00	Significant

Table 7 provides a comprehensive comparison of Y-balance and Functional Movement Screen (FMS) test results between the experimental and control groups after the intervention, with each group consisting of 15 participants. The data show the mean scores for various Y-balance indices, including left and right leg support in different directions, as well as specific FMS test components, along with their respective t-statistics and significance levels. In terms of Y-balance test results, the experimental group exhibits significantly higher mean reach distances compared to the control group in multiple directions, including front (left: $t = 1.67$, $p = 0.05$; right: $t = 1.76$, $p = 0.04$), inner behind (left: $t = 1.87$, $p = 0.04$; right: $t = 1.73$, $p = 0.04$), and integrated (left: $t = 1.72$, $p = 0.048$; right: $t = 2.05$, $p = 0.02$), indicating improved balance and stability post-intervention. Similarly, for FMS test components, the experimental group demonstrates significantly higher mean scores compared to the control group in hurdle step ($t = 5.71$, $p < 0.01$), inline lunge ($t = 3.33$, $p = 0.01$), and rotary stability ($t = 3.47$, $p < 0.01$), highlighting enhanced movement quality and core stability. Additionally, the experimental group achieves a significantly higher mean total FMS score (17.00) compared to the control group (15.13) ($t = 6.82$, $p < 0.01$), indicating an overall improvement in functional movement patterns and fitness levels following the intervention.

Overall, the experimental group demonstrates improved balance and stability with significantly higher reach distances and better FMS scores, indicating enhanced movement quality and core stability compared to the control group.

These findings underscore the effectiveness of the intervention in enhancing both balance and functional movement capabilities in the experimental group compared to the control group.The results of Y balance test after the experiment of this study are consistent with the results of Gengzhi(2018), which shows that the dynamic balance ability of lower limbs of youth football speciality students can be effectively improved by core strength training. The balance training in this study included some core strength training content.The FMS test results were consistent with the results of He(2019), which showed that the functional movement ability of high school boys' football sports teams was effectively improved through physical movement function intervention, and the total score of FMS was improved.

4.4. Comparison of Y-balance test and FMS test results in the control group before and after the intervention

Table 8. Comparison of Y-balance Test Results of the Control Group Before and After the Intervention

(Continuation on page 9)

Support leg	Index	Pre-experiment Mean	Post-experiment Mean	t	Sig.	Interpretation
Left leg support	Front	71.29	72.33	-0.57	0.29	Not significant
	Inner behind	84.64	84.93	-0.12	0.45	Not significant
	Outer back	88.21	89.13	-0.42	0.34	Not significant
	Integrated	89.77	90.85	-0.53	0.3	Not significant
Right leg support	Front	70.20	71.13	-0.48	0.32	Not significant
	Inner behind	83.87	84.8	-0.26	0.39	Not significant
	Outer back	86.07	87.00	-0.42	0.34	Not significant
	Integrated	88.10	89.13	-0.5	0.31	Not significant

Table 8 compares the Y-balance test results of the control group before and after the experiment, with each group consisting of participants. The data present the mean reach distances in centimeters (cm) for various Y-balance indices, including left and right leg support in different directions, along with their respective t-statistics and significance levels. Across all directions and support legs, the control group demonstrates slight improvements in mean reach distances post-experiment compared to pre-experiment values. However, these improvements are not statistically significant, with p-values greater than 0.05 for all indicators, indicating no significant change in balance and stability in the control group without the balance training intervention.

These findings suggest that the control group did not experience notable improvements in Y-balance performance over the observation period, highlighting the importance of the balance training intervention in facilitating significant enhancements in balance and stability among participants in the experimental group.

After 5 weeks of regular training, the Y balance scores of the control group all increased to a certain extent compared with the pre-experimental period, but the difference was not significant, which may be due to the critical period of growth and development, or the increase in the scores due to the cumulative effect of the technical training, because football are all lower limb sports, with more single-leg support. However, it is far from the YBT scores of the integrated athletes in the results of the study by Qiao (2019); and since the integrated left and right support scores of the control group were still below 95% after the experiment, it indicates that the dynamic stability of the lower limbs is poor, and there is a risk of lower limb injuries. Therefore, there is an urgent need for corrective YBT training for the 30 football players of this club.

Table 9. Comparison of FMS Test Results of the Control Group Before and After the Intervention

Index	Pre-experiment Mean	Post-experiment Mean	t	Sig.	Interpretation
Squats	2.40	2.40	0	0.50	Not significant
Hurdle step	2.13	2.13	0	0.50	Not significant
Inline lunge	2.20	2.20	0	0.50	Not significant
Shoulder mobility	2.07	2.07	0	0.50	Not significant
Active leg raises	2.20	2.13	0.48	0.32	Not significant
Trunk Stability Push-Ups	1.80	2.47	-3.03	0.00	Significant
Rotary stability	1.73	1.73	0	0.50	Not significant
FMS total score	14.53	15.13	-1.79	0.04	Significant

As can be seen in Table 9, it provides a comprehensive comparison of Functional Movement Screen (FMS) test results of the control group before and after the intervention, with each group comprising participants. The data outline the mean scores for various FMS test components, including squats, hurdle step, inline lunge, shoulder mobility, active leg raises, trunk stability push-ups, rotary stability, and the total FMS score, alongside their respective t-statistics and significance levels. Notably, the control group demonstrates no significant changes in mean scores for most FMS test components, as indicated by t-tests with p-values greater than 0.05. However, there was a significant increase in the mean score for trunk stabilisation push-ups post-intervention compared to pre-intervention ($t = -3.03$, $p < 0.01$), suggesting that participants' core stability improved. Additionally, total FMS scores increased post-intervention and the difference was statistically significant ($t = -1.79$, $p = 0.04$).

Overall, most components show no significant changes, except trunk stability push-ups, indicating improved core stability post-intervention. The total FMS score significantly increased, reflecting improved movement quality.

The results of these studies showed that although the control group did not improve significantly on most FMS test components, there was a significant improvement in trunk stability support and total scores, suggesting that the control group performed well in terms of trunk neural control, highlighting the potential impact of routine training on specific aspects of functional movement in control participants, contrary to the findings of Yingxiu (2022), a mother, who referred to juvenile middle distance runners scored less than 2 for trunk stability, which may be related to the programme characteristics of distance runners, who do not focus on upper body strength exercises. Notably, few of the control group were able to accurately perform ipsilateral trunk rotational stabilization movements, which may be due to the inconsistent growth and developmental rates of the trunk and limbs, as well as an imbalance in upper and lower limb strength resulting from the predominance of lower limb training; therefore, the training of adolescent athletes needs to be focused on the development of the whole person.

4.5. Comparison of Y-balance Test and FMS Test Results of the Experimental Group Before and after the Intervention

Table 10. Comparison of Y-Balance Test Results of the Experimental Group Before and After the Intervention

Support leg	Index	Pre-experiment Mean	Post-experiment Mean	t	Sig.	Interpretation
Left leg support	Front	69.40	75.40	2.81	0.00	Significant
	Inner behind	83.13	89.27	-2.79	0.00	Significant
	Outer back	86.67	92.20	-2.54	0.01	Significant
	Integrated	87.9	94.39	-3.06	0.00	Significant
Right leg support	Front	68.4	74.73	3.05	0.00	Significant
	Inner behind	82.6	89.07	-2.37	0.01	Significant
	Outer back	84.4	89.93	-2.45	0.01	Significant
	Integrated	86.43	93.17	-3.13	0.00	Significant

Table 10 presents a detailed comparison of Y-balance test results of the experimental group before and after the experiment, with each group comprising participants. The data depict the mean reach distances in centimeters (cm) for various Y-balance indices, including left and right leg support in different directions, along with their respective t-statistics and significance levels. Across all directions and support legs, the experimental group demonstrates significant improvements in mean reach distances post-experiment compared to pre-experiment values. Specifically, for left leg support, significant increases are observed in mean reach distances for front ($t = 2.81$, $p < 0.01$), inner behind ($t = -2.79$, $p < 0.01$), outer back ($t = -2.54$, $p < 0.05$), and integrated ($t = -3.06$, $p < 0.01$) directions. Similarly, for right leg support, significant enhancements are noted in mean reach distances for front ($t = 3.05$, $p < 0.01$), inner behind ($t = -2.37$, $p < 0.05$), outer back ($t = -2.45$, $p < 0.05$), and integrated ($t = -3.13$, $p < 0.01$) directions.

These findings indicate a marked improvement in balance and stability among participants in the experimental group following the intervention, underscoring the effectiveness of the intervention in enhancing Y-balance performance.

This may have something to do with the fact that a lot of balance training is done with single leg supports doing dynamic movements that improve the flexibility and extension of the opposite leg. So the experimental group's Y balance scores improved more after the intervention compared to the pre-intervention, but the left leg support in the posterior-internal direction (89.27%) and posterior-external direction (92.20%) was significantly lower than BHAT R, MOIZ J A(2023)mentioned in his study that of the combined sports athletes in the posterior-internal direction (123%) and posterior-external direction (120%), which may be due to the fact that the training of adolescent girls' football players is mostly based on prolonged aerobic exercise for the sake of exercise economy, limiting the stride length.

Table 11. Comparison of FMS Test Results of the Experimental Group Before and After the Intervention

Index	Pre-experiment Mean	Post-experiment Mean	t	Sig.	Interpretation
Squats	2.13	2.13	0	0.5	Not significant
Hurdle step	1.93	2.87	-6.26	0.00	Significant
Inline lunge	2.20	2.80	-3.33	0.00	Significant
Shoulder mobility	2.20	2.27	-0.32	0.38	Not significant
Active leg raises	2.13	2.20	0.39	0.35	Not significant
Trunk Stability Push-Ups	2.20	2.40	-0.84	0.20	Not significant
Rotary stability	1.93	2.17	-2.32	0.01	Significant
FMS total score	14.73±0.32	17±0.19	-5.9	0.00	Significant

As can be seen in Table 11, it presents a detailed comparison of Functional Movement Screen (FMS) test results of the experimental group before and after the intervention, with each group comprising participants. The data outline the mean scores for various FMS test components, including squats, hurdle step, inline lunge, shoulder mobility, active leg raises, trunk stability push-ups, rotary stability, and the total FMS score, alongside their respective t-statistics and significance levels. The experimental group demonstrates significant improvements in several FMS test components post-intervention compared to pre-intervention values. Particularly noteworthy are the substantial increases in mean scores for hurdle step ($t = -6.26$, $p < 0.01$) and inline lunge ($t = -3.33$, $p < 0.01$), indicating marked enhancements in movement quality and lower limb function. Additionally, there is a significant improvement in rotary stability post-intervention ($t = -2.32$, $p < 0.05$), highlighting enhanced core stability among participants. Moreover, the total FMS score shows a significant increase post-intervention ($t = -5.9$, $p < 0.01$), indicating an overall improvement in functional movement patterns and fitness levels following the intervention.

Overall, the total FMS score significantly increases, reflecting improved functional movement patterns and fitness levels.

These results suggest that the intervention effectively targeted specific aspects of functional movement, resulting in significant improvements in movement quality and total FMS scores for participants in the experimental group. This is in line with Xiaoming (2019) who mentioned in his study that trunk strength, lower limb strength, and stability on both sides of the body were effectively improved through a somatic movement functional intervention, which in turn improved FMS scores, but the main items that were improved were the three tests of squatting, active leg lifting, and rotational stability of the body, whereas in the present study, apart from the squatting and trunk stability support which did not have a significant improvement, all the other five In this study there was significant improvement in all five tests except deep squat and trunk stability push-up, which may be related to gender, which is consistent with the study by Kramer, Taylor A et al. (2019) that females performed better in deep squat and trunk stability push-up. Females performed better on the FMS test compared to males.

In addition, research has shown that an athlete's initial skill level affects the degree of improvement after training. Athletes with lower pre-training scores showed greater improvement in tests such as the hurdle step and the straight split-leg squat, whereas athletes with higher initial scores showed little to no improvement in areas such as shoulder flexibility and trunk stabilisation push-ups. This suggests that balance training is particularly effective in addressing deficits in motor function. This idea is supported by the research of Damian Sikora(2021) et al, who showed that those at lower risk showed less improvement compared to those at higher risk, suggesting that the efficacy of balance training may reach a saturation point.

4.6. Correlation Analysis between Y-balance Test and FMS Test Results after the Experiment for the Experimental Group

Table 12. Correlation Analysis between Y-Balance Test and FMS Test Results after the Experiment for the Experimental group

R and P	Left leg support Integrated	Right leg support Integrated
FMS total score	r = 0.554, p = 0.032	r = 0.478, p = 0.071

As can be seen in Table 12, independent variable is Y-Balance Test results, dependent variable is FMS Test Results. The results indicated a moderate positive correlation between the Y-balance test and the FMS test results. The Pearson's correlation coefficients (r) for left and right leg support were 0.554 and 0.478, respectively, indicating a moderate positive correlation. However, the p-values associated with the correlation coefficients of FMS total score and left leg support were 0.032, respectively, which is less than 0.05, implying that the relationship is statistically significant at the 0.05 level. This suggests that the observed correlation is unlikely to have occurred randomly, providing evidence of a true relationship between the Y-balance test and the FMS test. The p-value associated with the correlation coefficient between the FMS total score and the right leg support is 0.071, which is greater than the typical significance level of 0.05. This means that there is not enough evidence to conclude that the observed correlation is different from zero and that it may have occurred randomly.

It shows a moderate positive correlation between the Y-balance and FMS tests. Pearson's correlation coefficients indicate significant correlation for the FMS total score and left leg support ($p < 0.05$), suggesting a meaningful relationship. However, the correlation with right leg support lacks significance ($p > 0.05$), indicating inconclusive evidence of correlation.

The results of the present study are in agreement with the findings of Ziyu and Xuesi et al((2022)). which confirmed a moderate positive correlation between the FMS total score and the YBT lower limb composite values, similarly to Kramer, Taylor A(2019) et al. where the FMS composite scores were positively related to the YBT composite scores with left side support. However, Damian Sikora and Pawel Linek(2021) concluded that the YBT and FMS should not be used interchangeably as they assess different motor deficits in a population of youth footballers. The use of either screening tool cannot successfully predict injury risk in youth footballers. Ping (2023) similarly argued that assessment using a combination of FMS and YBT was better than assessment using a single method, and that assessment using a combination of FMS scores and YBT scores was the most effective.

On the contrary, a cross-sectional investigation by Armstrong R (2019) found that the total FMS score was positively correlated with the mSEBT score, which is similar to the results of this study. In their study, Li et al. (2018) found that balance and body movement functions of different ball players were assessed using the mSEBT and FMS tests, and found that balance training significantly improved the athletes' body movement functions. However, their study also noted that the correlation between the mSEBT and the FMS test was not high, which may be due to the wide variety of ball sports involved in the study, which have different requirements for balance and motor function, highlighting the importance of sport-specific balance training. Therefore, it is recommended that coaches should always use a combination of both FMS and YBT testing tools in the future.

5. Conclusion

In conclusion, this study investigated the effects of balance training on the physical motor function of adolescent female football players from the Pingxiang Ausheng Football Club. The research addressed several key questions related to the participants' personal information, Y-Balance Test scores, and Functional Movement Screen (FMS) scores before and after the intervention.

The results of the study showed that the experimental group that received balance training had greater improvements in both Y balance test scores and FMS scores compared to the control group. This indicates that the experimental group had improved balance, stability and overall quality of movement.

This study underscored the importance of incorporating balance training programs into the training regimens of 11-12 years old female football players to enhance their physical motor functions, including balance, stability, and functional movement. By improving these fundamental aspects of athleticism, balance training not only contributes to the development of well-rounded athletes but also holds potential implications for injury prevention and long-term athletic success. Further research in this area could explore the long-term effects of balance training and its potential benefits across different age groups and athletic populations.

6. Recommendations

This study investigates the impact of balance training on the physical motor functions of 11-12-year-old female football players, addressing a critical aspect of their athletic development. The findings hold significant implications for coaches, trainers, and stakeholders invested in optimizing the performance and well-being of young athletes. Recommendations stemming from this study include:

1) Incorporation of Balance Training: Based on the positive outcomes observed, it is recommended that balance training be incorporated into the regular training regimen for young female football players to enhance their physical motor functions.

2) Long-Term Training Programs: In order to maximize the benefits of balance training, it is recommended that such programmes be implemented over a longer period of time and that interventions should not be implemented for less than 5 weeks, with regular assessments to monitor progress and adjust the intensity of training as required.

3) Supplementary training: balance training is not the main training element, but a supplementary training in cycle training, which does not have to be too long in terms of training duration and helps to improve the quality of movements of young female athletes.

4) Integration with Skill Training and Increase Strength Training: Coaches and trainers should consider combining balance training with specific skills training and appropriate base strength enhancements to create an overall training environment that promotes the overall development of the athlete.

5)Injury Prevention Focus: Balancing the positive effects of training on functional movement patterns with an emphasis on recovery.

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