Research Paper

Hong Kong Physiotherapy Journal
Vol. 42, No. 1 (2022) 23–30
DOI: 10.1142/S1013702522500032

Hong Kong Physiotherapy Journal
https://www.worldscientific.com/worldscinet/hkpj

Immediate effect of stabilization exercises versus conventional exercises of the trunk on dynamic balance among trained soccer players

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Received 9 September 2020; Accepted 17 November 2021; Published 31 December 2021

Background: Trunk stability is key in controlling body balance and movements. Trunk Stabilization Exercises (TSE) and Conventional Trunk Exercises (CTE) are performed to improve dynamic balance. The authors have previously reported that dynamic balance was improved by a 12-week and 6-week TSE program. However, there is a dearth of research on its immediate effect on dynamic balance in trained soccer players.
Objective: To compare the immediate effect of TSE with that of CTE on dynamic balance in trained soccer players.
Methods: Forty-eight male soccer players (24.60 ffi 1.38 years) participated in this crossover study, wherein each participant took part in three exercise sessions: TSE, CTE, and No Exercise control (NE), each consisting of three steps: pre-test, intervention and post-test, with an interval of one week between each exercise condition. To assess dynamic balance, the Y Balance Test-Lower Quarter (YBT-LQ) score in the anterior, posteromedial, and posterolateral directions was measured before and 5 minutes after each intervention.
Results: The YBT-LQ composite score was significantly improved after TSE (0.51) as compared to CTE (0.22) and NE (0.04) ($p < 0.05$). Furthermore, in TSE and CTE conditions, YBT-LQ scores of the posterolateral and posteromedial directions significantly improved at the post-test ($p < 0.05$).
Conclusion: Both TSE and CTE are effective in immediately improving dynamic balance; however, TSE showed greater improvement as compared to the latter. Immediate improvements in the posteromedial and posterolateral directions of the YBT-LQ were demonstrated after performing the TSE and CTE.

Keywords: Core training; balance; trunk exercises; sit-ups.

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Introduction

The trunk acts at the center of the kinetic chain and essentially helps to maximize the athletic function.[1,2] Function is produced primarily by sequenced and coordinated activation of body segments that station the distal segment in optimum position at the optimum velocity with the optimum timing in order to produce the desired athletic task.[2] In sports such as soccer, besides its local functions of generating optimum force and providing stability, the trunk is also involved in most activities of the lower limbs such as kicking, running, throwing, and jumping.[3]

A common approach, for coaches or athletes, while designing a strength and conditioning regime, is to primarily focus on the body segment that is most seemingly required to succeed in the game.[4] If the sport demands high impact activities such as jumping, sprinting, or kicking, like in soccer, training is conventionally focused on the lower segments, followed by the upper body. Trunk training is given least attention or is performed towards the end of the workout regime. However, Gambetta *et al.* claim that without adequate strength and stability of the trunk, the athlete shall not be able to apply sufficient extremity strength necessary for optimal strength development.[5]

A well strengthened core allows for improved force output, increased neuromuscular efficiency, and decreased incidence of overuse injuries which transfers to variety of sports related activities.[6] Strengthening the core can enhance the ability to accurately utilize the musculature of upper and lower body segments leading to powerful and efficient movements.[6] Conventional Trunk Exercises (CTE) such as sit-ups, abdominal crunches or back extensions are traditionally performed to strengthen the trunk muscles and include repeated flexion and extension movements of the trunk.[7] Since the only resistance to core muscle activity is the body weight, these exercises do not provide sufficient levels of muscle activity to strengthen the trunk.[8,9] Hence, substantial repetitions of these exercises may be required to achieve optimum performance.[10]

Alternatively, Trunk Stabilization Exercises (TSE) like side and back bridges are performed by adjusting the functional postures such as keeping the lumbar spine in a neutral position with little or no trunk movements. The chief goal of the TSE is to enhance and restore co-contraction and coordination of local and global muscles to improve the control of the pelvis and the lumbar spine.[11,12] Besides, it also aims to restore the capacity of the trunk muscles to meet the demands of postural control.[13,14] Previous studies have demonstrated significant improvement in trunk stability and athletic performance after training with TSE[15,16] and have also proved its efficacy in rehabilitating patients with low back pain.[17,18] Moreover, it has been reported that the warm-up programs including TSE reduced the incidence of anterior cruciate ligament injury.[19]

Previously, the effect of trunk exercises on static and dynamic balance was studied in healthy adults including college athletes. Kahle *et al.*[20] reported that TSE improved the dynamic balance in healthy individuals. Although the training effects of trunk exercises have been reported, there are limited studies comparing the effect of the TSE and CTE. Previous investigations indicate that the TSE had a specific effect in immediately improving the static balance.[21,22] Atsushi *et al.*[23] and Kahle *et al.*[20] reported that dynamic balance was improved by a 12-week and 6-week stabilization exercise program, respectively. On the other hand, Imai *et al.* illustrated that TSE brings about immediate improvements in the posteromedial and posterolateral directions of the star excursion balance test in adolescents.[24] However, there is a lack of evidence to decisively prove the immediate effect of TSE and CTE on dynamic balance.

Therefore, this study aimed to compare the immediate effect of CTE on dynamic balance with that of TSE. The program that proves to bring about instantaneous trunk stability may further benefit players to prevent injuries and enhance performance.

Materials and Methods

In this prospective interventional study, a total of 83 male soccer players between ages 20–30 years were screened for the eligibility criteria. Zonal and University healthy soccer players, with three or more years of competitive experience, practicing regularly for minimum two hours/day for at least three days/week and not involved in any balance training program apart from their typical sports training were included in the study. The criteria for exclusion were recreational soccer players, those who reported vestibular problems, low back pain or lower limb injuries that required treatment or that may have impeded performance in the past year and those who had undergone lumbar spine or any lower extremity surgery in the past six months. Finally, 55 individuals (mean age 24.60 years and BMI 23.93 ± 1.083) were included between March 2018 to March 2019. A written informed consent was obtained from each participant. The study was approved by the ethics committee of A J Institute of Medical Sciences, Mangalore.

A crossover design was employed in this study in which every subject participated in three conditions i.e., TSE, CTE, and No Exercise (NE) control. Each participant was investigated during a course of three weeks with an interval of one week between three exercise conditions to preclude the impact of exercises performed previously. Every testing condition comprised of three stages: Pretest, intervention, and posttest. Performance on the Y Balance Test – Lower Quater was noted before and five minutes after each intervention. The TSE and CTE programs lasted five minutes each and were supervised and directed by a physical therapist. During the NE session, the subject rested for five minutes on a chair. Using the online randomization http://www.graphpad.com/quickcalcs/index.cfm, the physical therapist generated the randomized order of the three conditions to be performed by the participants, wherein they underwent TSE, CTE, and NE sessions in arbitrary order. Consequently, 19 subjects performed in the order of TSE, CTE, and NE; 18 subjects in the order of CTE, NE, and TSE; and 18 subjects in order of NE, TSE, and CTE. Seven participants could not complete all sessions due to personal reasons.

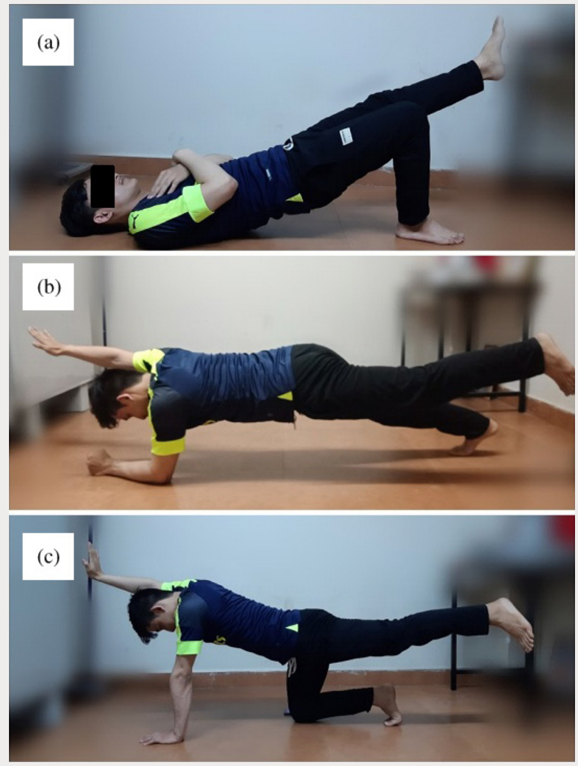

Fig. 1. Trunk stabilization exercises. (a) Back Bridge; (b) Front Plank; (c) Quadruped Exercise.

Interventions

The TSE and CTE exercise programs were adapted from a crossover design conducted by Imai *et al.* in adolescent soccer players.[24] The TSE regime comprised of the back bridge, front plank and quadruped exercise (Fig. 1). The first exercise was performed in a back bridge position by raising the pelvis so that a neutral hip flexion angle was maintained and then raised on one leg with complete knee extension. This position was held for 5 s before raising the opposite leg followed by 10 s rest. In the front plank position, the participant was asked to simultaneously raise the left arm and right leg and hold it straight up for 5 s. This was immediately followed by raising the right arm and left leg simultaneously for 5 s after which he was asked to lower his body and rest for 10 s. In a similar manner, the last exercise was performed in a quadruped position. Each exercise was performed five times. Okubo *et al.*[25] reported that the given TSE involve activity of trunk muscles higher than that of other conventional exercises of the trunk. The TSE was completed within an average of three minutes. The YBT-LQ was recorded immediately thereafter.

For the CTE program, subjects performed back extensions, sit-ups, and sit-ups with trunk rotation (Fig. 2). Each exercise was repeated 30 times. The YBT-LQ was recorded immediately thereafter.

Outcome measure

The Y Balance Test – Lower Quarter: The participants performed the YBT-LQ in the anterior, posterolateral, and posteromedial directions.[26–28] Verbal instructions and visual demonstration of the test were given by the therapist before performing the test. During the test, both hands were held at the iliac crest. The leg used for kicking the ball during game was used as the stance limb, with the distal most part of the great toe set

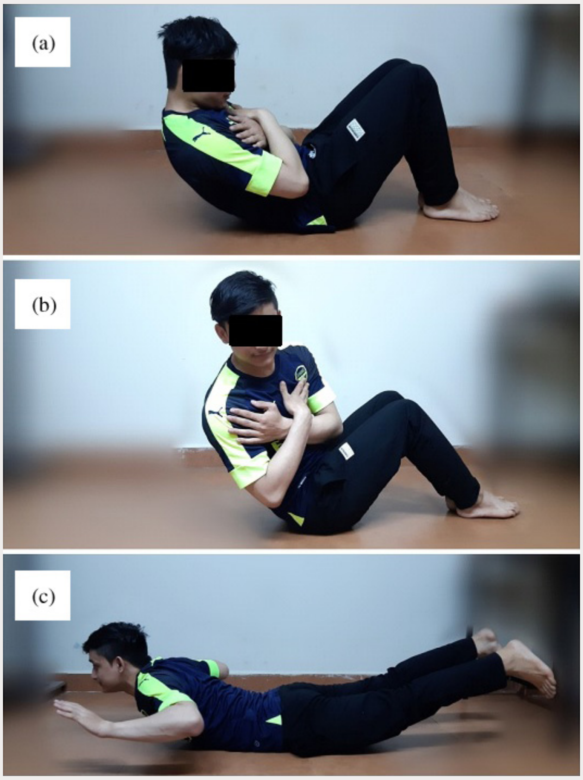

Fig. 2. Conventional trunk exercises. (a) Sit-ups; (b) Sit-ups with trunk rotation; (c) Back Extensions.

at the intersection of the three measuring tapes taped to on the floor (Fig. 3). While they maintained the single-leg stance, they were to use the opposite leg to reach on the line along the respective directions, touch the ground at the farthest point possible with the distal most part of the great toe and return to the starting position. In order to rule out the influence of shoes, the test was performed barefoot. After three practice trials, the subjects were asked to rest for 2 min and thereafter three test trials were performed in each direction. At each test trial, the order of the reaching directions was randomized. If a subject failed to maintain the stance leg or in returning the reaching foot to the starting position, the test was discarded and repeated over again. In each direction, the longest reach distance was used for further analysis. To exclude the influence of limb length, it was normalized with the reach distances of the subject.[29,30] The limb length was measured from the anterior superior iliac spine to the center of the ipsilateral medial malleolus.[30] The composite score was calculated using the following formula[26]:

$$\frac{\text{sum of three directions}}{\text{limb length} \times 3} \times 100.$$

Sample size and sampling

A sample size was estimated with 95% confidence level and 80% test power based on the parameters of Imai *et al.*[24] where the mean difference (d) between pre and post intervention was 2.8. This showed that the ideal sample size for the study would be 46. The study subjects were recruited

Fig. 3. Directions of the Y Balance Test - Lower Quarter. (a) Anterior; (b) Posterolateral; (c) Posteromedial.

using convenience sampling on the basis of the inclusion and exclusion criteria.

Statistical analyses

Statistical package SPSS (IBM SPSS Statistics for Windows, ver. 21.0. Armonk, NY: IBM Corp.) was used to analyze the data. The Kolmogorov–Smirnov test and Levene test were used to test normality and equal variance assumptions, respectively. The baseline data of the YBT-LQ between groups were compared by using a one-way ANOVA. A two-way (group $\times$ time) repeated measures ANOVA was used to assess the changes over time and the between-group difference. Further, a Tukey's HSD *post hoc* test was done when a statistically significant interaction effect was found. Statistical significance was inferred at $p < 0.05$. Effect size (ES) was calculated using Cohen's d to compare the results of the pre-test and the post-test. ESs were interpreted as large (> 0.81), moderate (0.51–0.80), or small (0.21–0.50).

Results

There were no significant differences in the baseline data of the composite scores and each direction of the YBT-LQ between groups ($p < 0.05$). Significant condition-by-time interactions existed for the YBT-LQ composite score ($F = 13.82$; $p = 0.023$). The composite score improved following both regimes however, the Tukey's HSD *post hoc* test detected that the composite score was greater post TSE ($p = 0.010$, ES $= 0.51$) as compared to CTE ($p = 0.012$; ES $= 22$). Moderate to small ESs were associated with these relations. There was no significant change in the composite score after NE ($p = 0.131$; ES $= 0.04$) (Table 1).

Table 1. Changes in normalized composite scores of the *Y* balance test — Lower quarter.

	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Tukey's HSD (p value)	ES	% change
Composite[a]					
TSE	109.86 ± 4.27	112.07 ± 4.27*	0.010	0.51	2.01
CTE	109.83 ± 4.30	110.78 ± 4.34*	0.012	0.22	0.86
NE	109.78 ± 4.28	109.98 ± 4.33	0.131	0.04	0.18

Notes: [a]Significant group-by-time interaction ($p < 0.05$).
*Significant difference between the pre and post scores ($p < 0.05$).
CTE: Conventional Trunk Exercises; ES: Effect size; NE: No Exercise; TSE: Trunk Stabilization Exercises.

When scores of each direction were analyzed, there were significant condition-by-time interactions in the posteromedial direction ($F = 16.275$, $p = 0.001$) and posterolateral direction ($F = 16.852$, $p = 0.001$), with no effect in the anterior direction ($F = 8.654$, $p = 0.693$). The Tukey's HSD *post hoc* test revealed significantly greater scores in the posteromedial and posterolateral directions at the post-test than at the pretest in the TSE and CTE conditions. Moderate to small ESs were associated with these relations (Table 2).

Discussion

This investigation aimed to compare the immediate effect of two different types of trunk exercise programs on dynamic balance in professional soccer players. It was observed that the YBT-LQ composite score significantly improved after TSE and CTE. However, the former had greater effect concerning immediate improvement in dynamic balance as compared to CTE. Imai *et al.* in a similar study in adolescent soccer players[24] noted that the YBT-LQ composite score improved only after the TSE but not after CTE or NE. Although previous researchers have established that 6 weeks or 12 weeks of the SE improved dynamic balance,[20,23] this study provides evidence that compares the acute effects of stabilization and conventional exercises on dynamic balance in young trained athletes.

Compared to the CTE and NE conditions, participants displayed improved reach distance scores of the YBT-LQ in the TSE condition as compared to CTE. The two exercise programs vary in terms of the stresses acting on specific body segments.[24] To derive the optimal effects of physical training basic principles, such as the Specific Adaptation to Imposed Demands (SAID), must be followed, stating that the body adapts specifically in response to the demands and stresses placed on it.[31] In CTE, stress to flexors and extensors of the lumbar spine is applied in a dynamic bilateral manner. SE program, to the contrary, maintain and control closed kinetic chain positions placing unilateral stresses on muscles involved in hip extension, in resemblance to stresses in the posterolateral and posteromedial directions of the YBT-LQ.[24] Consequently, in terms of SAID, the

Table 2. Changes in normalized reach distance scores of the Y balance test — Lower quarter.

	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Tukey's HSD (p value)	ES	% change
Anterior					
TSE	78.88 ± 5.00	79.30 ± 5.04	—	0.08	0.53
CTE	78.89 ± 4.68	79.37 ± 4.68	—	0.10	0.60
NE	78.87 ± 4.80	79.30 ± 4.79	—	0.06	0.54
Posteromedial[a]					
TSE	108.43 ± 4.82	113.04 ± 4.71*	0.000	0.96	4.25
CTE	108.64 ± 4.62	110.17 ± 4.45*	0.012	0.33	1.40
NE	108.65 ± 5.12	109.41 ± 5.16	0.437	0.14	0.70
Posterolateral[a]					
TSE	106.90 ± 4.95	108.78 ± 5.85*	0.000	0.34	1.75
CTE	106.84 ± 4.72	107.35 ± 4.73*	0.009	0.12	0.48
NE	106.85 ± 4.98	107.19 ± 4.86	0.502	0.07	0.31

Notes: [a]Significant group-by-time interaction ($p < 0.05$).
*Significant difference between the pre and post scores ($p < 0.05$).
CTE: Conventional Trunk Exercises; ES: Effect size; NE: No Exercise; and TSE: Trunk Stabilization Exercises.

SE may be more capable than the CTE as a training program in improving the dynamic balance.

Concerning the YBT-LQ maximum reach distance scores, the results demonstrated the improvements in the posterolateral and posteromedial reach distances with no change in the anterior reach direction. Imai *et al.* in their crossover study also demonstrated similar findings.[24] The local and global trunk muscles are recruited and adjusted maintaining the trunk in position during the TSE program.[25] The range of motion of hip flexion of the stance leg has a fundamental contribution while moving the contralateral limb in the posterior direction.[32] Eccentric muscle contraction of the erector spinae, multifidus, and hamstrings is essential to maintain balance as the trunk leans forward in the YBT-LQ position.[33,34] Consequently, participants may possibly have improved control over trunk position during the posterior directions of the YBT-LQ after the TSE due to the contribution of both local and global muscles, with trunk motion controlled by the latter.[24] In addition, enhancing the control of the trunk rotation may have helped in control of the lower extremity during the posteromedial direction since the TSE involved both upper and lower limb excursions that has previously shown to involve increased external oblique activity.[28]

The anterior direction maximum reach scores, on the other hand, did not change post exercise in any of the exercise conditions. Previous studies that investigated both immediate and long term effects of training on dynamic balance, support these findings.[24,26] It is probable that the anterior direction is sensitive to changes affected by distal segments than proximal as it is reported that dorsiflexion range influences the anterior direction to a greater extent than posterior directions.[30]

There are few limitations in this study, first being a limited sample size with all young male soccer players. Further, confirmation of these results must be carried out in larger and diverse populations, including female athletes and older individuals. The results apply only to the TSE and CTE programs used in this study. The existing literature consists of various trunk exercises and methods to enhance the strength of trunk muscles and trunk control. However, this investigation studied the effect on the YBT-LQ of the TSE and CTE programs comprising three exercises. This study also could not prove how long the immediate effect on the YBT-LQ lasts and will need to be investigated in the future to elucidate the efficacy of trunk exercises. Finally, this study could not prove if the exercises could play a role in terms of injury prevention in soccer players.

Conclusion

Posterolateral and posteromedial directions of the YBT-LQ improved immediately after the TSE as compared to the CTE. Since an immediate effect on YBT-LQ was demonstrated, a trunk exercise program may enhance the dynamic balance, vital for almost all athletic activities. Strength and conditioning professionals use various exercises as part of warm-up programs to improve the performance and the simple TSE program used in this study can be easily incorporated into a warm-up routine. Therefore, it is recommended that the coaches and trainers consider altering their warm-up sessions to include trunk strengthening exercises, with the hope of enhancing the athlete's dynamic balance.

Acknowledgment

We would like to express our gratitude to the study participants and are thankful to the statistician, Mr. M. S. Kotian for his invaluable contribution to the study and also to the Principal and teaching staff of our institute for their support and guidance.

Conflict of Interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding/Support

The authors received no financial support for the research and/or authorship of this paper.

Author Contributions

Conception and design of study: C.J. D'souza, H. Santhakumar; Acquisition of data: C.J. D'souza, B. Bhandary, A. Rokaya; Analysis and/or interpretation of data: C.J. D'souza, H. Santhakumar, A. Rokaya. Drafting the manuscript: C.J. D'souza, A. Rokaya; Revising the manuscript critically for important intellectual content: H. Santhakumar, B. Bhandary. Approval of the version of the manuscript to be published: C.J. D'souza, H. Santhakumar, B. Bhandary, A. Rokaya.

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