



Efficacy of dynamic Swiss ball training in improving the core stability of collegiate athletes

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Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract

Introduction: The training of core muscles is key in sports training to improve performance and reduce the risk of injuries. However the most effective method to improve core musculature is still controversial. Therefore the objective of this study was aimed at investigating the effectiveness of dynamic Swiss ball training in reinforcing the core stability of collegiate athletes. **Materials and methods:** This two-group, two-factor research involved 67, 18- to 28-year-old collegiate athletes (18 females, 49 males) who were divided into experimental and control groups. The experimental group was provided dynamic Swiss ball training, whereas the control group was instructed to perform floor exercises. The groups underwent training for six weeks (three days per week). Four core stability tests (the Biering-Sorenson trunk extension, Side Bridge, prone bridge, and double leg lowering tests) were administrated pre- and post-training. **Results:** The mean scores of the participants in the core stability tests significantly improved after six weeks of training ($p < 0.05$), but the between-group comparisons revealed that the experimental group significantly outperformed the control group in terms of enhancement in core stability ($p < 0.05$). **Conclusion:** The relatively high improvement in core stability parameters after Swiss ball training suggested that these exercises are favorable alternatives to traditional floor exercises in strengthening the core muscles. The findings are expected to help athletes, coaches, trainers, and other strength and conditioning specialists involved in athletic training decide on appropriate training methods.

Keywords: core training; dynamic exercises; athletic rehabilitation; sports training

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www.physactiv.eu

Received: 30.03.2020; Accepted: 10.05.2020; Published online: 20.01.2021

Cite this article as: Nuhmani S. Efficacy of dynamic Swiss ball training in improving the core stability of collegiate athletes. Phys Activ Rev 2021; 9(1): 9-15. doi: 10.16926/par.2021.09.02

INTRODUCTION

The muscles around the pelvis, low back, and hip regions constitute what is referred to as the “core,” and they play a principal role in the transfer of forces between the trunk and extremities [1]. A strong core allows athletes to effectively execute swift coordinated movements that help them improve their athletic performance [2]. A weak core paired with strong extremity muscles may lead to altered biomechanics and prevent sufficient force generation and transfer, thereby ultimately impairing athletic performance and causing musculoskeletal injuries. Sports performance and core strength are strongly correlated, as reported in previous studies [3-5]. Thus, the training of core muscles as part of sports training is central to improving sports performance and reducing the risk of injuries. However the most effective method to improve core musculature is still controversial.

A stability ball or Swiss ball is used in both athletic rehabilitation and conditioning, with exercises involving this tool believed to activate the core muscles to a greater extent than that achieved with traditional core training activities. Proponents of Swiss ball training claimed that it can stimulate neuromuscular pathways and hence reinforce strength, balance, and coordination [6]. The more rigorous challenge presented by such training to the core muscles can be attributed to the unstable surface of a Swiss ball. The effectiveness of exercises performed on an unstable surface in strengthening core stability has been validated in previous studies [7-9], but minimal empirical data have been derived as to the use of Swiss balls in athletic rehabilitation and training. Most studies focused on static Swiss ball-based exercises intended to boost the facilitation and activation of the core muscles despite the fact that sports and athletic training requires stronger levels of force and muscle activation to develop the considerable strength and endurance necessary for athletes to perform various sports-specific skills. To address this deficiency, the current work was directed toward investigating the effectiveness of dynamic Swiss ball training on the core stability of collegiate athletes.

METHODS

Experimental approach to the problem

The study adopted a two-group, two-factor design in carrying out laboratory-based core stability tests to determine whether Swiss ball training or floor exercises improve core stability. The first factor were tests administered before and after the intervention, and the second factor were two categories of training, namely, Swiss ball training (experimental group) and floor exercises (control group). The core stability tests, which were set as the dependent variables, were the Biering-Sorenson trunk extension, Side bridge, Prone bridge, and double leg lowering tests.

Participants

The volunteer participants were 67 collegiate athletes (18 females, 49 males) with a mean age of 24.32 ± 3.53 years, a height of 162 ± 5.73 cm, a body mass of 64.41 ± 8.80 kg, and a weekly training of 8.92 ± 1.78 hours at the Indira Gandhi Physical Education Center in New Delhi. The sample size was calculated as 26 per group to estimate a difference of 2.53 seconds in performance of 25.65 ± 2.62 (mean \pm SD) among amateur athletes with 80% power and 5% significance level based on a previous study [10]. The participants were free from injuries at the period of testing and intervention. Individuals were excluded from the study if they had abdominal, low back, or lower limb injuries/pain and those who were unable to perform the core training exercises without pain. The participants were familiar with traditional resistance training, but none of them knew about Swiss ball training. They were advised to carry on with their normal diet and daily activities.

Before the study commenced, two familiarization sessions were conducted to ensure that all the subjects were comfortable with the procedures. They were randomly assigned to experimental and control groups by a blinded researcher who was unassociated with the study and advised to guarantee equal group assignment in terms of gender (Figure 1). The purpose and procedures of the research were explained to the participants, and informed consent was obtained from them. They also completed a physical activity readiness questionnaire. The study, which was approved by the

Institutional Ethical Committee of Jamia Hamdard (IRB No: JH/DRSC/IRB/113/10), was conducted in accordance with the Declaration of Helsinki.

Procedures

The baseline core stability of the experimental and control participants was measured two days before the initiation of the six-week intervention, and a post-test was administered two days after the final intervention. The test was randomized for each participant to avoid learning effects.

Biering-Sorenson trunk extension test: The test begins with a subject lying prone on an examination couch, with the upper edge of the anterior superior iliac spine aligned with the edge of the couch and the lower body fixed onto the couch with straps. Arms are folded across the chest as the subject keeps his/her upper body in a horizontal position. An inclinometer is attached onto the interscapular area of the subject's body to ensure constancy in position. The duration of performance is recorded using a stop watch, and the test is discontinued once the subject fails to maintain the horizontal position [2].

Side bridge test: A subject assumes a sideling position, with the upper body supported by the elbow and forearm. The lower limbs are kept straight with the top foot positioned slightly frontward. The hip is lifted off the ground, and the subject maintains a straight line, with his/her entire body supported by the elbow and foot. Once the subject commences with this position, the stop watch is activated. The test is terminated upon failure to carry on with the stance [11].

Prone bridge test: In this test, only the toes and forearm of a subject are in contact with the floor as he/she keeps the head, neck, back, and hip in a neutral position. The subject is required to hold this posture for as long an interval as possible. The test is discontinued upon the inability to maintain the assumed position [12].

Double leg lowering test: A subject is supine, with his/her hip flexed to 90°. An inflated biofeedback cuff (40 mm Hg) is placed under the lower back region (L4–L5 level) to monitor posterior pelvic tilting. The subject's leg is raised passively, with the knee extended, and then he/she is instructed to perform an abdominal bracing procedure. Subsequently, the subject is asked to lower his/her leg while maintaining abdominal contraction. At the point at which a fluctuation of 10 mm Hg registers in the biofeedback apparatus, the test is terminated, and the range of motion of the hip joint is measured [2].

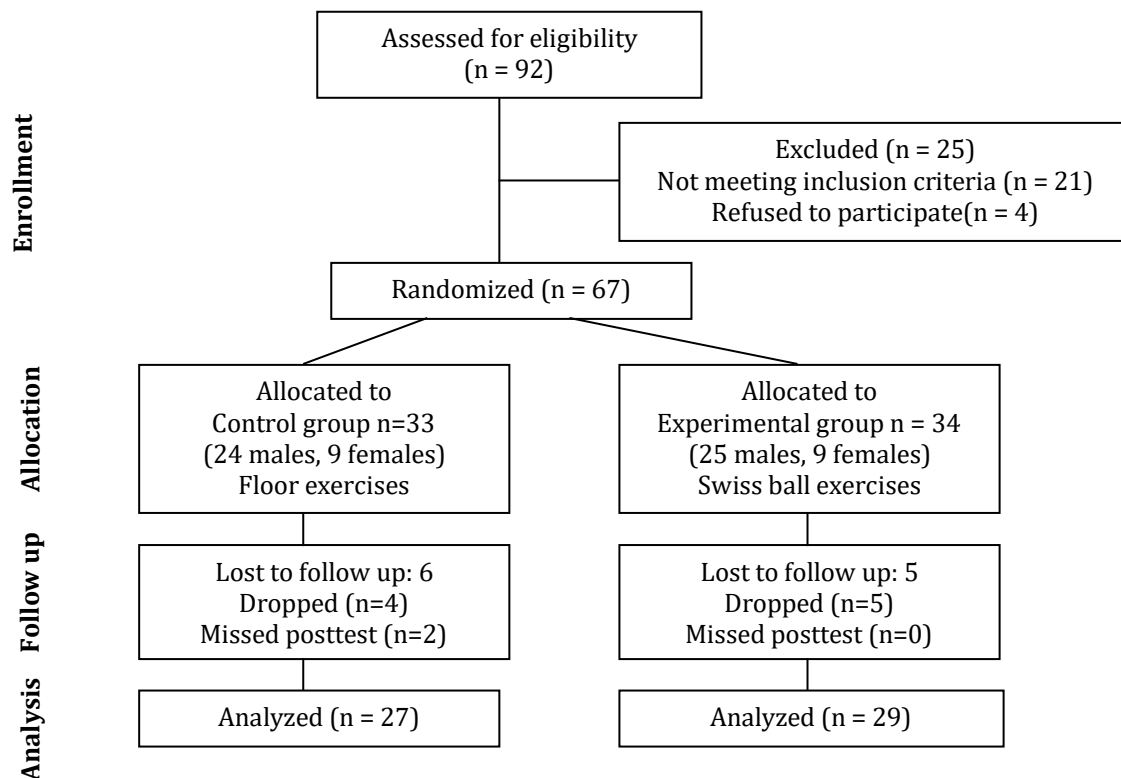


Figure 1. Consort Diagram showing the flow of the participants through each stage of randomized trial.

Table 1. Detail of the core stability exercise performed by both groups.

Exercise	Week 1 Instruction Sets x repetition	Week II Instruction Sets x repetition	Week III Instruction Sets x repetition	Week IV Instruction Sets x repetition	Week V Instruction Sets x repetition	Week VI Instruction Sets x repetition
Jack knife	Hands wide Knee on ball 2 X 8	Hands wide Knee on ball 2 X 12	Hands narrow Knee on ball 2 X 12	Hands narrow Toe on ball 2 X 8	Hands narrow Toe on ball 2 X 12	Hands narrow Toe on ball 2 X 16
Russian twist	Hands together, wide feet 2 X 8	Hands together, wide feet 2 X 10	Narrow feet 2 X 10	Narrow feet 2 X 112	Add weight plate 2 X 10	Add weight plate 2 X 12
Reverse hyper extension	Arm by side 2 X 25	Arm by side 2 X 35	Hands on chest 2 X 35	Hands on chest 2 X 45	Arms in front 2 X 40	Arms in front 2 X 45
Supine lateral roll	Wide feet 2 X 8	Wide feet 2 X 12	Narrow feet 2 X 8	Narrow feet 2 X 12	Lift one leg 2 X 8	Lift one leg 2 X 12
Hip crossover	Arm by side 2 X 8	Arm by side 2 X 10	Arm by side 2 X 12	Hands on chest 2 X 8	Hands on chest 2 X 10	Hands on chest 2 X 12
Reverse crunch	Arms on knees 2 X 20	Arms on knees 2 X 30	Arms on chest 2 X 25	Arms on chest 2 X 35	Hands by temples 2 X 30	Hands by temples 2 X 40

Training procedures

After the baseline measurements, the experimental group was subjected to a six-week core training program (three session per week) that involved the use of a Swiss ball, whereas the control group executed the same exercises on the floor (Table 1). Each training session lasted approximately 45 minutes. Prior to each training session, the participants completed 10 minutes of warm-up that entailed jogging, side stepping, butt kicks, and whole-body stretching. The participants in the experimental group were provided with a Swiss ball sized such that when they were sitting over the ball the thighs are above horizontal [10]. They were provided training cards that explained the number of sets and repetitions for each exercise and brief instructions on how the exercises should be performed. The overload was given by increasing the frequency, duration, complexity, decreasing base of support and adding external weight [10]. The training was performed three times a week at the college gymnasium in the morning, and all the sessions were supervised by the primary investigator.

Statistical analysis

The Statistical Package for the Social Sciences (version 21.0, SPSS Inc.) was used to analyze the data. Data normality was verified using the Shapiro–Wilk test ($p < 0.05$). The pre- and post-test data from each group were compared via paired sample t-tests, and the mean values and standard deviations of the experimental and control groups were compared through an independent t-test. Statistical significance was set at $p \leq 0.05$.

RESULTS

Out of the 67 collegiate athletes, 11 were excluded because they missed more than three intervention sessions and failed to attend the post-test measurements (two participants). Table 2 presents the demographic data of the participants in both groups. No significant difference in age, weight, height, training time per week, and baseline levels of core stability was found between the experimental and control groups ($p > 0.05$). Table 3 presents the results of the core stability tests before and after six weeks of training. The mean scores of the participants in the tests improved significantly in both groups following training ($p < 0.05$), but between-group comparisons revealed that the experimental group significantly outperformed the control group in respect of improvements to core stability ($p < 0.05$).

Table 2. Demographic characteristics of participants in both groups (mean±SD).

Variables	Experimental Group	Control Group	p
Age [years]	24.1±3.3	24.55 ±3.9	0.54
Height [cm]	161.12±8.2	163.6±7.9	0.18
Body mass [kg]	63.78±7.7	64.92±9.2	0.63
Training per week [hours]	8.68±1.73	9.59±0.17	0.13

Table 3. Pre and post intervention data for all core stability tests in both experimental and control group (mean±SD).

Core stability tests	Experimental Group				Control Group			
	Pre	Post	D	p	Pre	Post	D	p
Biering-Sorenson test [s]	63.7 ±7.9	76.2± 5.3	19.06	0.01	65.9±6.7	72.8±4.4	10.05	0.05
Side bridge test [s]	57.4±8.4	71.1±6.5	23.08	0.00	60.4±6.3	67.8±7.2	12.02	0.01
Prone bridge test [s]	62.9±7.2	75.4±5.8	19.08	0.02	60.6±4.6	66.3±5.7	09.04	0.04
Double leg lowering test [°]	29.1±8.5	35.5±6.8	21.09	0.01	27±7.82	31.2±5.3	15.01	0.01

D - % of difference

DISCUSSION

The data suggested that both exercise programs improved the participants' core stability parameters ($p < 0.05$). At the same time, however, the group that trained with a Swiss ball for six weeks outperformed the floor exercise group ($p < 0.05$). Researchers reported that the osteoligamentous lumbar spine gives way at an excess load of more than 90 N [13,14]. In this situation, the core muscles act as guy wires around the lumbar spine, stabilizing the spinal region and preventing buckling. Correspondingly, improved core muscle strength can decrease the risk of injuries [15] and enhance athletic performance [16,17].

The improvement in the core stability parameters of the experimental group may be due to their execution of exercises on a relatively unstable surface, which might have induced increased muscular activity in the core and elevated the recruitment pattern of the muscles [18-22]. Even though the groups performed similar exercises, those carried out on unstable surface can stimulate neural adaptation, improve neuro-muscular recruitment, enable the effective synchronization of motor units, lower neuro-inhibitory reflexes, and facilitate effective proprioceptive feedback [23,24]. These effects ultimately enhance core stability. Previous research confirmed that increased instability can cause a proportional rise in muscle activity and motor unit recruitment [18,24,25]. Core training with a Swiss ball was also found to elevate the activity of the transverse abdominis, unlike similar exercises performed on a mat [7]. Adding to these insights, Vera-Garcia, Grenier and McGill [8] indicated that curl-up exercises done on an unstable surface increases muscle activity as the muscles coactivate to stabilize the spine and the entire body. The results of the current study agree with those derived in some previous works. Stanton, Reaburn and Humphries [9], for example, discovered a significant improvement in core stability following short-term training using a Swiss ball. However, the protocol and outcome measures differ from those used in the current research. Aksen-Cengizhan, Onay, Sever and Doğan [26] also found enhanced core stability after Swiss ball training, and Marshall and Murphy [27] declared that Swiss ball exercises more strongly activate core muscles than do exercises performed on stable surfaces. The same results were obtained by Vera-Garcia, Grenier and McGill [8], Anderson and Behm [28], and Behm, Leonard, Young, Bonsey and MacKinnon [29]. Even though both groups showed an improvement in in outcome measures there was no difference noticed between both modalities in improving core stability. Despite of the differences in protocols and exercises used, the findings of the former studies and current study reported a statistically significant improvement in core stability parameters. This appears that the concept of Swiss ball training can improve core stability despite of the exercise and outcome measures used.

One of the most important benefits of Swiss ball training is that a wide variety of exercises can be performed. Difficulty levels can also be modified by changing lever length, base of support, and load distribution. Various resistance modalities, such as TheraBand, dumbbells, and barbells, can be

employed in conjunction with a Swiss ball. The appropriate selection of exercises is based on the type of adaptation required, the proficiency level of athletes, and the stage of rehabilitation, among other factors.

As with any other work, the current research has limitations, one of which is that the post-test body mass and BMI values were not measured after the intervention, thus potentially acting as confounding factors. Previous studies reported [9,26] a variation in BMI and body mass following five to six weeks of core training and Swiss ball training. In light of the current findings, the use of a Swiss ball alone or its combination with other exercises and modalities is promising. However, whether improvements in core stability translate to physical performance was unanswered in this work. Another shortcoming is that speed and energy expenditure during training was not monitored. The relatively high improvement in core stability parameters owing to Swiss ball exercises suggested that these activities are good alternatives to traditional floor exercises, but this result may be applicable only to the population involved in this research. Further exploration is warranted for the adoption of Swiss ball training in non-athletic groups and professional athletes. Studies should also be devoted to determining appropriate protocols and mechanisms for Swiss ball training.

CONCLUSION

The result of this study indicate that both floor and Swiss ball exercises can leads to significant improvement in core stability in collegiate athletes. At the same time Swiss ball exercises produced a significant improvement in core stability compared to floor exercises. These results are expected to help athletes, coaches, trainers, and other strength and conditioning specialists who are involved in athletic training make decisions on appropriate training methods. Exercises can be gradually modified depending on needs and individual differences, but adequate safety and precautionary measures should be taken given that execution is carried out on unstable surfaces. A progressive training method should also be adopted to gain maximum benefits from training.

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