

Effects of Physioball and Conventional Floor Exercises on Early Phase Adaptations in Back and Abdominal Core Stability and Balance in Women

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ABSTRACT

The purpose of this study was to compare the effects of 5 weeks of physioball core stability and balance exercises with conventional floor exercises in women. The experimental group ($n = 15$) performed curl-ups and back extensions on the physioball while the control group ($n = 15$) performed the same exercises on the floor. Baseline and post-training tests included electromyography (EMG) recordings of the rectus abdominus and erector spinae muscles; abdominal, back, and knee strength measurements with the Cybex Norm System; and 2 unilateral stance balance tests. The physioball group was found to have significantly greater mean change in EMG flexion and extension activity ($p = 0.04$ and $p = 0.01$, respectively) and greater balance scores ($p < 0.01$) than the floor exercise group. No significant changes ($p > 0.05$) were observed for heart rate or Cybex strength measurements. Early adaptations in a short-term core exercise program using the physioball resulted in greater gains in torso balance and EMG neuronal activity in previously untrained women when compared to performing exercises on the floor.

Key Words: functional training, EMG, unilateral stance

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Introduction

Functional training is the ability of the neuromuscular system to perform dynamic concentric, eccentric, and isometric stabilization contractions in response to gravity, ground-reaction forces, and momentum. The central nervous system and body proprioceptors work together to refine patterns of movement (4, 5). Performing exercises on the physioball may increase proprioceptive demands and stress the core

muscles that are important for balance and stability in sports (6).

Abdominal muscular endurance and strength and torso balance are important for trunk stability, appropriate posture, and body movements during sports (6). The floor curl-up and back extensions are often used to evaluate and develop abdominal muscular endurance and strength (8, 9, 16). However, these floor exercises primarily strengthen the hip flexors and only minimally affect the core abdominal muscles since they are performed on a linear plane (9–11). Performing curl-ups and back extensions on the physioball may be a better method of strengthening core muscles since exercises are performed on an unstable surface. Also, this type of functional training could enhance the body's ability to improve stability and balance since the core muscles stabilize the axial skeleton (5–7).

The purpose of this study was to examine the effects of a 5-week physioball functional training program on abdominal and back isokinetic measurements, myoelectric activity, and balance scores. The results were then compared with a 5-week conventional floor-training program. The investigators hypothesized that the group that performed the abdominal and back exercises on the physioball would show greater stability and balance gains than the control group who performed the same exercises on the floor. Using the physioball would provide an unstable surface, which stresses the core muscles more than a linear plane, such as the floor, to improve trunk stability and balance (1, 6).

Methods

Experimental Approach to the Problem

The women engaged in a 5-week training program designed to compare the effects of performing sit-up and back extension exercises on a physioball (experimental program) vs. a floor (control program) on core muscle



Figure 1. Physioball sit-up.



Figure 2. Physioball back extension.

stability and balance. Early neural adaptations occur after approximately 4 weeks of training. Several researchers have reported that neural adaptations are the physiologic mechanisms by which torso strength and balance adaptations occur in the early phases of a conditioning training program (1, 2, 14). Therefore, a 5-week program is adequate as a preconditioning program in individuals seeking to participate in a regular exercise program or competitive sports.

At the beginning of the study, all women completed a questionnaire that inquired about their exercise histories. Abdominal and back isokinetic measurements, myoelectric activity recordings, and balance scores were conducted pre and post training to document and compare any significant changes between the experimental and control groups.

Participants

Participants were 30 female students at Springfield College. All women were selected based on no prior experience with physioball exercises, individual or team sports, or routine exercise programs. They volunteered for the Springfield College Institute Review Board (IRB) approved investigation after a briefing by the study staff about the purposes and risks of the study. The women signed a volunteer agreement affidavit in accordance with the Springfield College IRB regulations.

Training Program

The women were randomly assigned to either the control group or the experimental group. The control group performed the modified curl-up by Robertson (13) and back extension exercises on the floor. The experimental group performed the same sit-up and back extension exercises using the Gymnic Plus Stability physioballs (55 and 65 cm) (Figures 1 and 2).

At the beginning of the study, a session was conducted to show the women the proper mechanics and

technique in performing the exercises either on the physioball or the floor (13). The women were instructed separately to avoid subject communication and cheating by performing the other exercise program. Each woman had to plan her training around her individual class schedule. The investigator took valid steps to monitor the training sessions in this "free living" training environment. The investigator visited the training site throughout the day to observe whether all of the women adhered to the training program that they were given. The investigator would intervene during the training and explain the correct procedures if the woman was not performing the exercise program correctly whether or not they were floor or physioball exercises. The investigator interviewed all women telephonically at the end of the week to address any questions about their training program. The women kept a daily training record that was reviewed weekly by the investigator.

The 5-week program for the experimental and control groups are shown in Table 1. The program consisted of training 5 days per week, with each session lasting 15 minutes. During the first week, all women performed 3 sets of 15 repetitions of each exercise, alternating the sit-up with the back extension exercises. During the second week, the training routine consisted of 4 sets of 15 repetitions of each exercise. During the third and fourth weeks, the training routine included 4 sets of 20 repetitions of each exercise. During the fifth week, participants performed 4 sets of 25 repetitions of each exercise. No rest periods were taken between all sets of repetitions.

All women in both training groups successfully completed the entire 5-week program. There was 100% compliance among the women.

Testing Battery

Before the start of the study, all testing instruments were calibrated. Intraclass reliability tests were con-

Table 1. Training log.*

	Monday Set/reps	Tuesday Set/reps	Thursday Set/reps	Friday Set/reps	Saturday Set/reps
Week 1					
Curl-up	3/15	3/15	3/15	3/15	3/15
Back extension	3/15	3/15	3/15	3/15	3/15
Week 2					
Curl-up	4/15	4/15	4/15	4/15	4/15
Back extension	4/15	4/15	4/15	4/15	4/15
Week 3					
Curl-up	4/20	4/20	4/20	4/20	4/20
Back extension	4/20	4/20	4/20	4/20	4/20
Week 4					
Curl-up	4/20	4/20	4/20	4/20	4/20
Back extension	4/20	4/20	4/20	4/20	4/20
Week 5					
Curl-up	4/25	4/25	4/25	4/25	4/25
Back extension	4/25	4/25	4/25	4/25	4/25

* Experimental group performed the exercises on the physioball and the control group did them on the floor.

Table 2. Intraclass reliability data on testing battery.

Measures and apparatus	<i>r</i>	<i>P</i>
EMG trunk flexion	1.00	<0.01
EMG trunk extension	0.99	<0.01
Balance test 1	0.94	<0.01
Cybex trunk flexion	0.99	<0.01
Cybex trunk extension	0.98	<0.01
Cybex knee flexion	0.94	<0.01
Cybex knee extension	0.97	<0.01

ducted on all dependent measures and results are shown in Table 2.

Core muscle strength was measured with the CYBEX Norm machine before the 5-week training program and at the end of training. Abdominal and lower back strength were determined with a 5 maximal repetition test at 60 degrees per second. Leg strength was measured with a 5 maximal repetition test at 60 degrees per second. The right leg was used throughout the testing period because all women reported right leg dominance.

Electromyogram recordings of the rectus abdominis and erector spinae muscles were taken during the exercises before beginning and at the completion of the training program. Heart rate was taken immediately after the completion of each curl-up and back extension exercise. These measurements were also obtained before and after completion of the training program.

The unilateral stance balance test with both eyes closed and a unilateral stance balance test with knee flexed 60 degrees and both eyes closed were used to

estimate balance during these tests; the time an individual maintained balance on one leg (7) was recorded. The subject used the right leg to execute the balance test since this was the self-reported dominant leg for each subject. Both balance tests were administered prior to beginning the training program and at the end of the training program.

Statistical Analyses

The dependent variables included the change values of: (a) Cybex Norm System abdominal, erector spinae, and leg muscles; (b) unilateral stance; (c) maximal EMG values of rectus abdominis and erector spinae muscles during the 4 exercise modes; and (d) average heart rates measurements of each group. Change values were computed based on each subject's pre- and post-test values. The independent variable was the group (experimental and control). Independent *t*-tests (2-tailed) were used to compare mean change values of the measurements taken for experimental and control groups. The SPSS software program (15) was used to compute the statistical analyses. The level of significance was set at $p \leq 0.05$ for hypothesis testing.

Results

The average age (mean \pm SD) of the women was 23 \pm 5.80 years (range: 18.0–45.0 years), with average height (mean \pm SD) 165.27cm \pm 4.18 (range: 150.0–185.0 cm), and average weight (mean + SD) 58.8 kg \pm 5.63.

Table 3 shows the average (mean \pm SD) age and body measurements of the individuals in the experimental and control groups. The control group was

Table 3. Descriptive statistics for women participating in a 5-week training session ($N = 30$).

Group dependent variables	Experimental ($n = 15$)		Control ($n = 15$)	
	Mean	SD	Mean	SD
Age (years)	19.47	5.80	22.87	5.87
Weight (kg)	55.60	5.45	57.13	5.13
Height (cm)	155.47	3.18	163.47	4.22

slightly older, heavier, and taller than the experimental group. However, differences were not significant.

Comparisons between the experimental and control groups of mean changes in values pre- and post-training for trunk EMG recording activity, CYBEX trunk/knee measures, balance scores, and heart rates are presented in Table 4. The mean positive changes were significantly higher for EMG trunk flexion ($p = 0.04$) and extension ($p = 0.01$) activity in the experimental group than in the control group. Positive mean changes in trunk balance time for the 2 tests after training were significantly higher in the experimental group than in the control group ($p = 0.00$). No significant ($p > 0.05$) differences in mean changes in values were found for CYBEX trunk flexion and extension, CYBEX knee extension and flexion, and heart rate when comparing the 2 groups.

Discussion

The 5-week functional training program in this study resulted in significant increases in abdominal and erector spinae muscle EMG activity and duration of static balance times when compared to floor exercises. Therefore, it is evident that performing abdominal and

back exercises on unstable surfaces stressed the musculature and activated the neuroadaptive mechanisms that led to the early phase gains in stability and proprioceptor activity in this study (1, 4–6). Whether these exercises provide the specific training adaptations that could be used by trained athletes demands further research. However, individuals beginning a regular exercise program or athletes performing early season conditioning could incorporate this short phase physioball training program that enhances trunk stability and may help the individual to progress to the next phase of their training program (3, 4, 17). Wolfson et al. (17) demonstrated that short-term exposure to alter sensory input resulted in significant improvement in sway control and inhibition of inappropriate motor responses and improved core stability.

No significant strength gains were seen in Cybex trunk flexion and extension with the functional training program when compared to the conventional floor exercises. However, it must be emphasized that Behm, et al. (1), stated that the primary purpose of instability training is to improve core stability rather than strength. The primary purpose of a training program with the physioball should not be to gain strength but to gain stability, improve balance, and improve proprioceptive capabilities (1). The neural adaptation includes more efficient neural recruitment patterns, increased nervous system activation, improved synchronization of motor units, and a lowering of neural inhibitory reflexes (14).

No differences were observed in isometric knee flexor and extensor strength between the physioball and control group before and after training. Some authors have correlated unilateral static balance scores with isometric knee flexor and strength measures (3). Investigators in the present study measured limb

Table 4. Independent groups t -ratio comparing mean change values for experimental and control groups.

Group dependent variables	Experimental ($n = 15$)		Control ($n = 15$)		p
	Mean	SD	Mean	SD	
EMG trunk flexion (mVs)	170.80	123.21	-55.53	373.68	0.04
EMG trunk extension (mVs)	83.07	79.68	-30.87	136.97	0.01
Balance test 1 (s)	10.73	4.48	0.33	6.26	0.00
Balance test 2 (s)	9.13	4.37	2.40	4.55	0.00
Heart rate (bpm)	-8.00	17.91	-1.33	18.07	0.32
Cybex trunk flexion (ft/lb)	7.67	36.92	17.93	33.08	0.43
Cybex trunk extension (ft/lb)	24.53	35.68	19.67	33.40	0.70
Cybex knee flexion (ft/lb)	3.13	11.78	1.27	7.07	0.60
Cybex knee extension (ft/lb)	-5.67	33.04	11.73	24.05	0.11

strength to demonstrate that the physioball group was able to balance on a single leg longer than the control group because of improved trunk balance and stability and not because of greater limb strength. Also, the training program was geared towards gain in core trunk muscle stability and proprioceptive capabilities rather than leg strength training.

Although not significant, mean change in heart rate was higher for the group performing exercises on the physioball (-8.00 bpm) than the group performing floor exercises (-1.33 bpm). It is plausible that the physioball group had to work at a higher intensity to perform exercises on an uneven surface. However, this warrants further research since various investigators reported that a minimum of 20 minutes of continuous aerobic exercise 3 times a week is required for any improvements in fitness level (2).

Practical Applications

The present study has shown that significant gains in trunk stability and balance can occur in untrained women even when a well-designed core stability and balance training program is conducted on a short-term basis. Perhaps, individuals beginning an exercise program, such as walking, should perform these simple exercises that stress the core muscles since the torso is important for any movements. Moreover, an individual may be less likely to be injured if there was more efficient control of upper and lower body muscles by having a better body balance.

It is beyond the scope of the design of this study to make conclusions about the benefits of a short-term program in highly trained athletes who perform traditional strengthening programs; however, it is plausible that the traditional strengthening programs may not stress the core musculature of the torso so further research on core stability training in these athletes is warranted. Also, individuals starting a sport requiring complex skills such as tennis might require a more complex and longer core stability and balance program that mimics specific movements in that sport.

The present study provides groundwork for future study on the topic of core balance and stability training. This type of training may be more beneficial than traditional strength training exercises in maintaining

body stability and imitating the dynamic movements of sport activity.

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