Effects of Proprioceptive Training Program on Core Stability and Center of Gravity Control in Sprinters

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Abstract

Romero-Franco N, Martínez-López EJ, Lomas-Vega R, Hita-Contreras F, and Martínez-Amat A. Effects of proprioceptive training program on core stability and center of gravity control in sprinters. *J Strength Cond Res* 26(8): 2071–2077, 2012—The purpose of this study was to determinate the effect of a 6-week specific-sprinter proprioceptive training program on core stability and gravity center control in sprinters. Thirty-three athletes (age = 21.82 ± 4.84 years, height = 1.76 ± 0.07 m, weight = 67.82 ± 08.04 kg, body mass index = 21.89 ± 2.37 kg·m^{-2}) from sprint disciplines were divided into a control (n = 17) and experimental (n = 16) groups. A 30-minute proprioceptive training program was included in the experimental group training sessions, and it was performed for 6 weeks, 3 times each week. This program included 5 exercises with the BOSU and Swiss ball as unstable training tools that were designed to reproduce different moments of the technique of a sprint race. Stability with eyes open (EO) and eyes closed, postural stability, and gravity center control were assessed before and after the training program. Analyses of covariance (α = 0.05) revealed significant differences in stability in the medial-lateral plane with EO, gravity center control in the right direction and gravity center control in the back direction after the exercise intervention in the experimental athletes. Nevertheless, no other significant differences were demonstrated. A sprinter-specific proprioceptive training program provided postural stability with EO and gravity center control measures improvements, although it is not clear if the effect of training would transfer to the general population.

Key Words proprioception, athletics, postural stability, gravity center, Swiss ball

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Introduction

In the last 2 decades, proprioception has been considered an irreplaceable tool in the rehabilitation of muscle injuries. Restoring neuromuscular control after a muscle injury by means of proprioceptive exercises performance is based on the fact that the ligaments have proprioceptors and any damage on these structures would change the afferent information, requiring a neurological restoration to obtain a complete recovery (9). If there is no complete restoration and the sense of proprioception is damaged, it provides wrong information to the central nervous system, which cannot be managed, producing uncontrolled and fast body movements. This situation increases the risk of injury and affects the stability of the subject (26). It has been shown that proprioception is affected by age, gender, injuries, environmental temperature, dehydration conditions, and exhausting exercises (10,17). Fatigue caused by these exhausting exercises is considered as a predisposing factor to muscle injury, and it usually appears in sports competition (20). This situation produces disturbances that displace the gravity center outside the base of support and is necessary to activate the stabilizing muscles to correct these alterations and restore the normal postural balance (14,25). Because of this, in recent years, proprioception has also become one of the most important techniques in the prevention of muscle injuries (2,7).

The effectiveness of proprioceptive exercises has been occasionally studied (8,11,21) providing significant improvements in core stability in athletes of different sports. This training is often included in exercise routines by using unstable platforms. Besides, this stability increase has been confirmed to provide a basis to obtain a higher strength output (27).

According to previous research studies, some controversy exists between the consulted authors, and there is no clear relationship between proprioceptive training and improvement in athletic performance.

To address this problem, the purpose of this study was to demonstrate the effect of a sprinter-specific proprioceptive training program with unstable platforms, using the Swiss ball

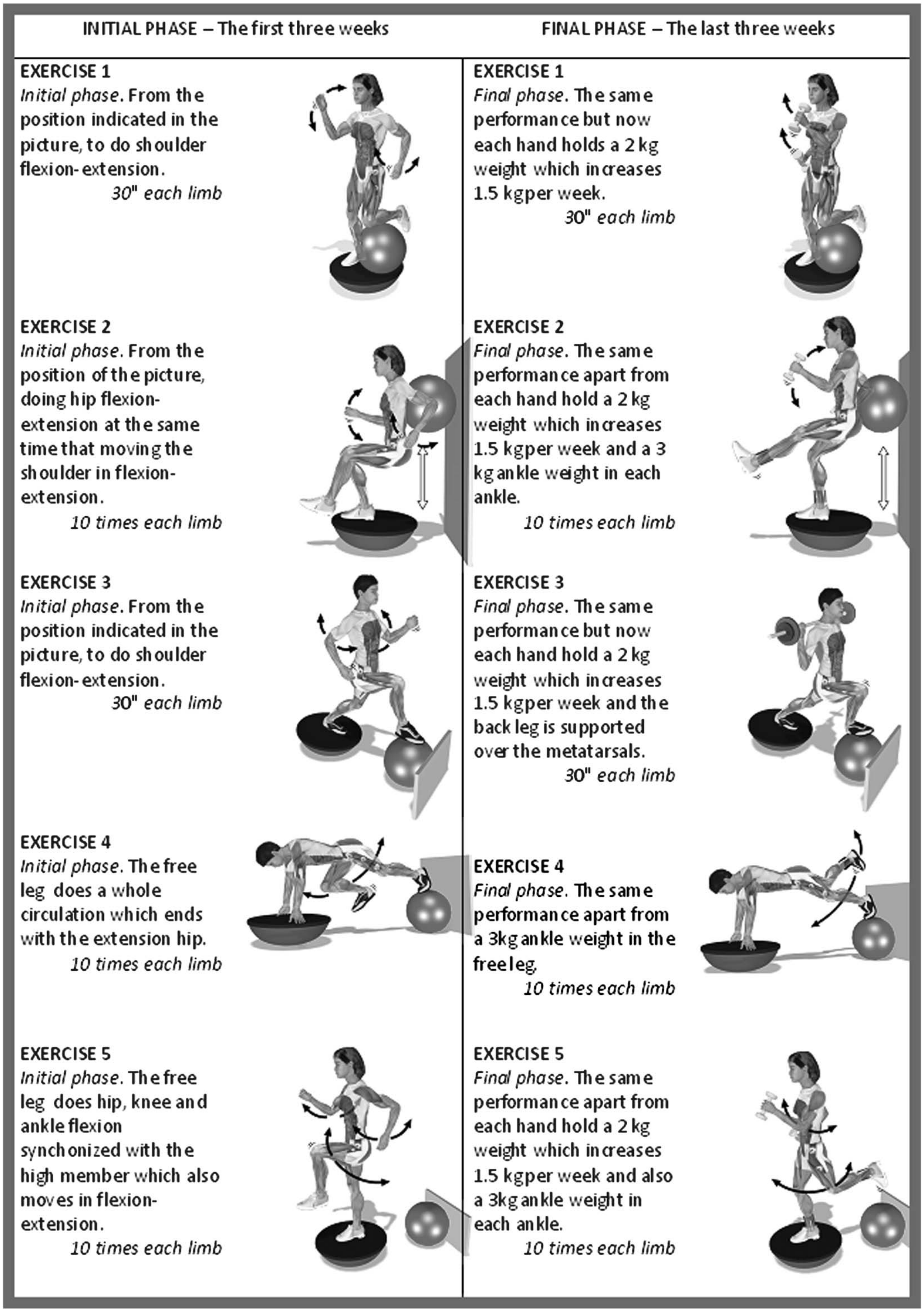

Figure 1. Instructions and exercises to do in the 6-week specific-sprinter proprioceptive training program.

and BOSU as main training tools, on eyes open (EO) and eyes closed (EC) postural stability and sprinters gravity center control. It was hypothesized that a proprioceptive training would improve the stability and the gravity center control of sprinters.

Methods

Experimental Approach to the Problem

A quasiexperimental, pretest-posttest control group design was used in this study. The intervention consisted of the implementation of a sprinter-specific 6-week proprioceptive exercises program in a group of sprinters. These sprinter-specific exercises tried to reproduce the different moments of the technique of a sprint race to perform the propioceptive practice in the same position that the athletes had to compete. Each week, this program was repeated on 3 days, concretely every Monday, Wednesday, and Friday. It was carried out from September to October, which is the preseason period in which none of the athletes were participating in competitions, and all of them were training their aerobic capacity and strength. The training program was divided into 2 different phases of 3 weeks, respectively. The first one was an initial phase, which took place from September 13 to October 3, and the sprinter-specific exercises were performed without additional weight. The last one was the final phase, which took place from October 4 to October 21 and the sprinter-specific exercises were performed with additional weight (Figure 1). The control group had a shorter duration training program because no proprioceptive training was included in it. To avoid influencing the results, the training of the control group and the experimental group took place in the mornings and in the afternoons, respectively. Preintervention and postintervention tests included stabilometric tests with open eyes and closed eyes, postural stability test, and gravity center control test. The dependent variables were all the measures from the 3 tests. The independent variable was the sprinter-specific training program.

Subjects

Thirty-three male sprinters (age = 21.82 ± 4.84 years, height = 1.76 ± 0.07 m, weight = 67.82 ± 08.04 kg, body mass index = 21.89 ± 2.37 kg·m^{-2}) from sprint disciplines (100-, 200-, 400-, and 110- and 400-m hurdles) voluntarily participated in the study. The athletes were divided into 2 groups by means of a simple random probability sampling: group 1 (control) consisted of 17 subjects (age = 21.18 ± 4.47 years, height = 1.75 ± 0.02 m, weight = 65.3 ± 9.79 kg, body mass index = 21.27 ± 2.65 kg·m^{-2}). This group simply continued with their daily workout routine. Group 2 (experimental) consisted of 16 subjects (age = 22.5 ± 5.12 years, height = 1.77 ± 0.06 m, weight = 70.5 ± 4.44 kg, body mass index = 22.33 ± 3.15 kg·m^{-2}). This group added a sprinter-specific proprioceptive exercise protocol to their routine training. No athlete had ever performed any proprioceptive training before. All the subjects were informed of the risks and signed the informed consent form. According to the standards of the Declaration of Helsinki, parents or legal guardian signed the informed consent form in the case of underaged athletes (rev. 2008).

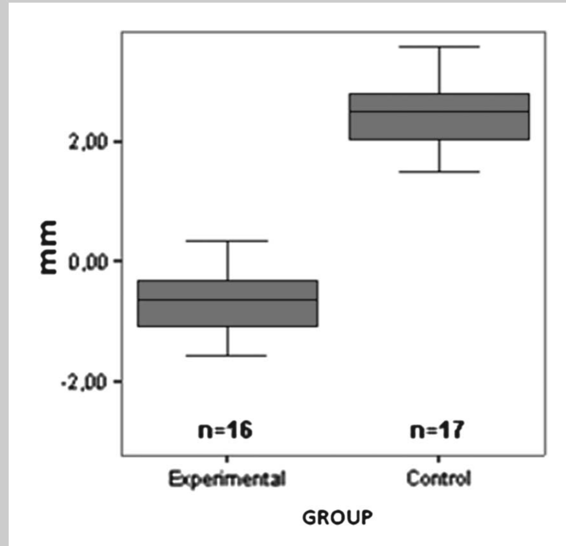

Figure 2. Real picture of exercise 2–initial phase.

Procedures

Stability Test with Eyes Open and Closed. An EPS Baropodometric platform was used (Bologna, Italy). Reliability of this test has been shown in earlier studies (4). All the athletes were asked to stand on both feet on the baropodometric platform with EO and ECEC for 52 seconds each one to allow the study of visual and vestibular influences on sway parameters. This test measures the mean center of pressure position in

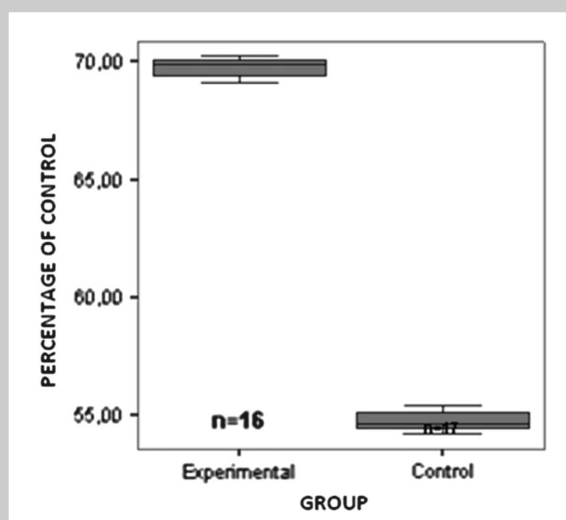

Figure 3. Real picture of exercise 1–final phase.

TABLE 1. Summary of eyes open results after 6 weeks of the proprioceptive training program in both groups.*

Variable	Experimental ($N = 16$)	Control ($N = 17$)	Significance	Eta square
XEO (mm)	−0.78 ± 4.31	2.30 ± 2.75	0.010†	0.203
DEO (mm)	90.04 ± 19.71	105.82 ± 23.12	0.073	0.103
SpEO (mm·s^{-1})	1.79 ± 0.39	2.14 ± 0.52	0.065	0.109
YEO (mm)	−1.12 ± 6.79	2.88 ± 4.76	0.151	0.067
SEO (cm^2)	0.62 ± 0.35	0.90 ± 0.62	0.216	0.051
RombergS	1.05 ± 0.59	0.74 ± 0.46	0.099	0.088
RombergSp	0.89 ± 0.09	0.93 ± 0.09	0.249	0.044
RombergD	1.23 ± 0.30	1.26 ± 0.22	0.891	0.001

*XEO = mean position center of pressure in the medial-lateral plane with eyes open; YEO = mean position center of pressure in the anterior-posterior plane with eyes open; DEO = distance covered by the center of pressure with eyes open; SpEO = speed of center of pressure movement with eyes open; SEO = surface covered by the center of pressure with eyes open; RombergS = Romberg index about surface; RombergSp = Romberg index about speed; RombergD = Romberg index about distance.
†Statistical significance ($\alpha > 0.05$).

the medial-lateral plane (*X*) and posteroanterior plane (*Y*). It also measures the surface covered by the center of pressure (S), the speed of the center of pressure movement (Sp), the distance covered by the center of pressure (D) and the Romberg index about surface (RombergS), about speed (RombergSp), and about distance (RombergD).

Postural Stability. Postural stability measurement was carried out in the Biodex Balance System (BBS; Biodex Medical Systems, Shirley, NY, USA). The BSS is a multiaxial tilting platform that allows the examiner to objectively measure the ability of a subject to maintain dynamic postural stance on a platform through the use of stabilometry (1,19). Schmitz and Arnold (19) examined the intrarater reliability of the Biodex Stability System and reported an intraclass correlation coefficient value of 0.82 for total stability, using a stability test. The variables measured are General Stability (Gs), medial-lateral stability (Ml), and anteroposterior stability (Ap). Measures were obtained from three 20-second trials where participants were asked to maintain an upright standing position on the surface of BBS.

Gravity Center Control. The BBS was used for this test. This test is designed to challenge the user to move through a movement pattern consistent with the sway envelope. The sway envelope is that area a person can move their gravity center within their base of support. It is approximated from vertical as 8° to one side, 8° to the other and 8° forward and 4° back. Scoring is shown as a percentage and reflects the directional accuracy of the movement to the blinking targets time counts up. The variables obtained are general gravity center control (ControlGC) and this control in the right

TABLE 2. Summary of control gravity center results after 6 weeks of proprioceptive training in both groups.*

Variable	Experimental ($N = 16$)	Control ($N = 17$)	Significance	Eta square
CG control (%)	53.63 ± 14.40	48.18 ± 13.38	0.270	0.103
Front (%)	52.44 ± 17.81	57.88 ± 13.98	0.339	0.031
Back (%)	69.75 ± 18.20	54.71 ± 17.68	0.026†	0.154
Right (%)	63.31 ± 17.15	49.71 ± 23.87	0.041†	0.132
Left (%)	56.31 ± 21.36	61.00 ± 22.63	0.545	0.002
Front right (%)	58.94 ± 21.83	52.06 ± 20.34	0.357	0.015
Front left (%)	60.31 ± 18.17	50.88 ± 20.65	0.173	0.054
Back right (%)	51.75 ± 16.47	53.71 ± 17.55	0.743	0.000
Back left (%)	52.19 ± 24.12	46.24 ± 18.74	0.437	0.047

*CG control = general gravity center control; front = gravity center control in the front direction; back = gravity center control in the back direction; right = gravity center control in the right direction; left = gravity center control in the left direction; front right = gravity center control in the front-right direction; front left = gravity center control in the front-left direction; back right = gravity center control in the front-right direction; back left = gravity center control in back-left direction.
†Statistical significance ($\alpha > 0.05$).

(Right), left (Left), back (Back), front (Front), front-left (Front-left), front-right (Front-right), back-left (Back-left), and back-right (Back-right) directions.

Training Program. The training protocol was performed 3 d·wk^{-1} and for 30 minutes each session. The training program consisted of 5 sprinter-specific proprioceptive exercises (Figure 1). Some real pictures of these exercises are shown in Figures 2 and 3.

Statistical Analyses

Data were analyzed using SPSS for Windows, version 17; SPSS, Inc., Chicago, IL, USA. Analyses of covariance were used to study the influence of a proprioceptive program in the stability of athletes, using basal measurement values (pretreatment) as a covariate. Eta square was used to measure the effect sizes. Significance was determined at $p < 0.05$.

Results

A descriptive study of all the variables throughout absolute frequency distribution (*N*) and basic measures summarized as mean, *SD*, and *SEM* was performed. All the variables showed a normal distribution and were comparable at baseline.

Variables of the Stability Test with Eyes Open and Closed

Table 1 shows the mean of the variables measured in the stability test with EO. In the medial-lateral plane of the center of pressure with EO (XEO) mean position (Figure 2), -1.1 ± 4.3 mm was obtained by the experimental group compared with the control group value of 2.6 ± 2.8 mm, showing statistical differences ($p = 0.010$).

The remaining variables showed nonstatistically significant differences though the center of pressure distance with EO (DEO), the center of pressure speed with EO (SpEO), and the Romberg index about the surface oscillation (RombergS) differences were of borderline significance.

Figure 4. Mean position of the center of pressure in the medial-lateral plane for the eyes open test (XEO) after 6 weeks of proprioceptive training program in both groups.

Figure 5. Gravity center control in the back direction after 6 weeks of proprioceptive program in both groups.

Postural Stability Variables

None of this test variables revealed significant differences.

Variables of Gravity Center Control

Table 2 shows the mean scores of the test variables after 6 weeks of the proprioceptive training program. The control of the position of the gravity center in the posterior direction presented significant differences ($p = 0.026$) with a score of $69.5 \pm 18.2\%$ from the experimental group and $54.7 \pm 17.7\%$ obtained by the control group. Statistically significant differences appeared ($p = 0.041$) controlling the position of the gravity center in the right direction (Right) when comparing both experimental and control groups (63.3 ± 17.2 vs. $49.7 \pm 23.9\%$, respectively). Nonsignificant differences were observed in the remaining variables.

Discussion

The purpose of this study was to analyze in sprinters the effect of a proprioceptive training program with a Swiss ball and BOSU on postural stability with open and closed eyes and gravity center control. This training program was performed for 6 weeks, from September 13 to October 21, 2010, 3 d·wk^{-1}. The training program was divided into 2 phases: an initial phase, which took place the first 3 weeks where the sprinter-specific exercises were performed without additional weight, and a final phase, which took place the last 3 weeks where the sprinter-specific exercises were performed with additional weight (Figure 1). The training program was divided into these 2 phases in keeping with the training principle of progression, which says that only the gradual increase of the loads improves the physical capacity (13). Previous research studies have shown that proprioceptive training produced stability improvements with 6- to 10-week programs, with 10- to 20-minute sessions, 3–5 d·wk^{-1} (3,11,16,22–24). With this methodology, some interesting findings have been observed in our study. First of all, some improvements on open eyes stability tests were observed, in keeping with Stanton et al. (21) and Schibeck et al. (18) who found that proprioceptive training improved core stability in sportsmen. In this study, as shown in Figure 4, the stability with EO in the medial-lateral plane (XEO) showed that reaching statistical significance because of the mean position of the center of pressure is more centrally situated in the experimental group than in the control group. Second, because in the present investigation the differences shown in the medial-lateral plane were not found in the anterior-posterior plane (YEO), these data support the notion of the priority of the medio-lateral plane in stability strengthening as was suggested by Bieć and Kuczynski (5) whose study produced similar results with young soccer players, with an important medial-lateral plane improvement, which was not observed in the anterior-posterior plane (YOE). On the other hand, in this study favorable tendencies were observed in most of the variables of this same test: The distance from the center of pressure with EO (DEO) and the speed in covering this distance (SpEO) was improved in the experimental group, and these differences were very close to statistical significance as shown in Table 1. This finding supports those of other studies in which the wrong proprioceptive information could lead to purposeless body movements with a postural instability increase, which could explain these differences (27).

Another interesting finding pertained to the use of vision to stabilize as done in the experimental group compared with in the control group; however, no significant differences were determined. According to one study that stated that the Romberg index was useful for identifying damaged proprioception, in this study, this finding determined the proprioceptive system conditions to be in favor of the experimental group (6).

In this study, we observed that gravity center control improvements in the back and right directions in the experimental group resulted from a 6-week proprioceptive training program, as shown in Table 2. This improvement in the back direction in the experimental group compared with that in the control group is shown in Figure 5. These differences support the earlier work of Mattacola et al. (12), who reported gravity center control improvements as measures of dynamic balance thanks to a proprioceptive training over the Freeman balance board. No significant changes were observed in the rest of the gravity center control measures in the present investigation.

In summary, the results of this study suggest that a 6-week sprinter-specific proprioceptive training program using the Swiss ball and BOSU unstable platforms as the main training tools slightly improves core stability and some dynamic parameters such as gravity center control.

Practical Applications

These data denote that specific BOSU and Swiss ball proprioceptive training programs provide postural stability and certain gravity center control improvements. Although these results are applicable to this specific study population (sprinters), previous research studies have shown stability improvements that result from BOSU and Swiss ball training and the guarantee that these training tools can contribute to sports injury prevention (9,11).

According to the results observed in this research, this kind of specific-sprinter exercises under instability could be incorporated as a part of warming-up activities in the athlete specific training sessions to achieve a better postural stability and gravity center control, which could improve the efficiency in the athlete's running technique as a long-term objective.

For further research, a larger sample size and more experience are recommended. Different age ranges and competitive levels and female sample population inclusion should be an interesting option to consider.

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