



# Effects of Short-Term Core Stability Training on Dynamic Balance and Trunk Muscle Endurance in Novice Olympic Weightlifters

by

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*Our primary objective was to investigate the effects of short-term core stability training on dynamic balance and trunk muscle endurance in novice weightlifters learning the technique of the Olympic lifts. Our secondary objective was to compare dynamic balance and trunk muscle endurance between novice and experienced weightlifters. Thirty novice (NOV) and five experienced (EXP) weightlifters participated in the study. Mediolateral (ML) and anteroposterior (AP) dynamic balance and trunk muscle endurance testing were performed a week before (Pre) and after (Post) a 4-week core stability training program. In the NOV group, there was an improvement of both dynamic balance (ML and AP,  $p = 0.0002$ ) and trunk muscle endurance ( $p = 0.0002$ ). In the EXP group, there was no significant difference between Pre and Post testing conditions, except an increase in muscle endurance in the right-side plank ( $p = 0.0486$ ). Analysis of the results showed that experienced lifters were characterized by more effective dynamic balance and greater core muscle endurance than their novice peers, not only before the training program but after its completion as well. In conclusion, the applied short-term core stability training improved dynamic balance and trunk muscle endurance in novice weightlifters learning the Olympic lifts. Such an exercise program can be incorporated into a training regime of novice weightlifters to prepare them for technically difficult tasks of the Olympic snatch and clean and jerk.*

**Key words:** resistance training, lifting technique, body balance, balance board.

## Introduction

Olympic weightlifting exercises such as the clean and jerk, and the snatch are commonly incorporated into training programs as they allow athletes to generate high forces at high velocities, thus increasing power (Hori et al., 2005). Yet, the Olympic lifts are very complex and contain a high degree of technical difficulty (Winwood et al., 2015). These exercises require also greater core stability and overall dynamic body balance (Bryanton and Bilodeau, 2019).

The core is important in providing local strength and balance and is central to almost all kinetic chains of athletic activity (Szafraniec et al., 2018a). Core stability exercises activate specific motor patterns of the trunk muscles by challenging spinal stability and trunk postural

control (Kavcic et al., 2004), therefore they have become popular for enhancing sports performance and injury prevention (Kellis et al., 2020). Common core stability exercises include the abdominal drawing-in maneuver and quadruped arm lifts (Akuthota et al., 2008). These exercises recruit deep muscles of the spine such as the lumbar multifidus and abdominal muscles such as the transversus abdominis, obliques and rectus abdominis (McGill, 2001). Strong abdominals and lower back muscles are crucial in providing the most solid position for a weight that is being lifted, and it should be a priority for long-term success and health of the weightlifter (Keogh et al., 2010; Zouita et al., 2019; Maszczyk et al., 2020).

Dynamic balance is one of the most important motor skills and is defined as the

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ability to perform a task while maintaining or regaining a stable position (Maszczyk et al., 2018, 2019), or the ability to maintain or regain balance on an unstable surface with minimal extraneous motion (Hrysomallis, 2011; Szafraniec et al., 2018b). Improving the dynamic balance can improve the overall physical performance in most sports, such as judo, gymnastics, weightlifting, etc. The use of free-weights during resistance training imposes greater mechanical demands on the body due to the center of mass of the total system being further away (higher) from the base of support, and in turn challenge postural stability (Granacher and Gollhofer, 2011). In other words, powerlifters and Olympic weightlifters need to develop skillful control of body posture via contraction of large agonists and stabilizers. In turn, this may improve their ability to control their COP about the base of support, also during dynamic tasks (Bryanton and Bilodeau, 2019).

Although initially used by competitive weightlifters, Olympic-style lifts have become increasingly common in the conditioning programs of athletes from different sport disciplines (Moore and Quintero, 2019). When implementing this type of exercise into the training program, we should be aware, however, that inadequate conditioning, lack of strength or endurance, loss of balance and poor technique can increase the risk of injury, which are most frequently located in the knee, lower back and shoulder (Keogh and Winwood, 2017). That's why, an adequate level of dynamic balance and trunk muscle strength and endurance, seems to be crucial when preparing novice weightlifters for Olympic-style lifts. The question remains, what is the adequate level of fitness to safely perform the Olympic lifts. To the best of our knowledge, there are no guidelines or norms related to the level of core stability sufficient for practicing Olympic weightlifting safely. There are also no specific recommendations on the time necessary to build trunk muscle endurance or dynamic balance before implementing exercises such as the clean or the snatch into a training program.

Consequently, our primary objective was to investigate the effects of short-term core stability training on dynamic balance and trunk muscle endurance in novice weightlifters preparing for the acquisitions of the technique of the Olympic lifts. Our secondary objective was to

compare dynamic balance and trunk muscle endurance between novice and experienced weightlifters.

## **Methods**

Thirty novice (NOV) and five experienced (EXP) weightlifters at the age of 26–30 years with no balance impairments were recruited to participate in the investigation (Table 1). The EXP group was comprised of weightlifters who train using free-weights for a minimum of three times per week, with a minimum of three years of consistent resistance training experience. The NOV group included healthy male individuals recruited with no prior experience in resistance training with free-weights. The study was approved by the Commission for Ethics of Scientific Research at the University School of Physical Education in Wroclaw. All participants provided their written informed consent after receiving verbal and written information.

### **Procedures**

All participants were required to attend two separate testing sessions. During the initial session (Pre), they signed an informed consent, anthropometric variables (height, mass, age) were collected and dynamic balance and muscle endurance testing was performed. The second session (Post) was conducted 1 week after the completion of the training program. During the second session, the participants performed dynamic balance and muscle endurance testing.

### **Dynamic balance assessment**

Mediolateral (ML) and anteroposterior (AP) dynamic balance was measured using the stabilometric platform (Libra; EasyTech, Salerno, Italy). The Libra platform is an electronic oscillating balance board that measures mediolateral or anteroposterior tilt from  $-15^{\circ}$  to  $+15^{\circ}$  to an accuracy of  $1^{\circ}$ . It was connected to a computer with dedicated software. Testing was performed in a quiet, well-lit, temperature-controlled room to minimize external distractions. The participant stood barefoot on the balance board and was monitored by personnel for safety precautions in case of loss of balance. Feet were parallel and the upper limbs rested freely along the trunk. Also, the participants kept their knees extended throughout the test to exclude the effects of the knee joint on maintaining balance. The task was to maintain balance on the device for

30 s. In each plane (ML and AP in random order) two trials were performed and the better result was considered for further analysis. Rest intervals between successive attempts were set at 60 s.

Dynamic balance was quantified based on the total area of sway registered during the 30-s trial (Figure 1). The total area of sway (TA) is the area created by sway line amplitude that deviated from the centerline (°s) (Szafraniec et al., 2018b).

#### **Trunk muscle endurance assessment**

To assess the global core muscle endurance, a plank test was used. Participants held a basic plank position – a prone bridge supported by the forearms and feet. Elbows were vertically below the shoulders with the forearms and fingers extending straight forward. The neck was kept neutral so that the body remained straight from the head to the heels (Tong et al., 2014).

The assessment of the internal and external oblique muscles was performed by following a side-bridge plank test. The subjects were instructed to lay on one side and place their top foot on top of the lower foot. Subjects were instructed to support themselves with only their elbow, forearm, and foot. Their hips were then raised off the floor and their body held in a straight position. The non-supporting arm was held across their chest with the hand placed on the opposite shoulder. After a 1-min rest interval, the subject repeated the side-bridge plank test on the opposite side (Myrick et al., 2019).

The endurance of the erector spinae (multifidus) muscle was assessed by a trunk extension test (a modified Biering-Sorensen test). Subjects were instructed to lay prone on a padded table with the upper body unsupported and extended off the edge of the table. Their legs and buttocks were fixed to the table with straps. The arms were folded across the chest with each hand resting upon the opposite shoulder. The test commenced when the subject's upper body was parallel to the floor and terminated when the subject was unable to keep their upper body from dropping below the horizontal position (Keogh et al., 2010).

In all tests, time until exhaustion (or failure) was recorded.

#### **Core stability training**

The planned core stability training aimed to prepare the subjects for incorporating the

Olympic lifts for their training regime. The training program consisted of 8 training sessions (50 min × twice a week × 4 weeks). A single workout included 18 core stability exercises. The applied exercises targeted the abdominal muscles (transversus abdominis, obliques, and rectus abdominis), lumbar multifidus, quadratus lumborum, and gluteal muscles, which are the main stabilizers of the spine and are responsible for controlling the pelvis and trunk positioning (Szafraniec et al., 2018a). The training program included the abdominal drawing-in maneuver, quadruped arm lifts and stability ball exercises.

#### **Statistical analysis**

All data are presented as mean ± SD. Normal distribution of the data was examined using the Kolmogorov-Smirnov normality test. Analyzing dynamic balance, initially mixed-model ANOVA, repeated-measures analysis with one between factor (group) and two within factors (time and plane) was conducted. There was no significant effect for planes and interactions: plane × time, plane × group; plane × time × group. Therefore the following analysis was performed for both planes separately. The same analysis was used for the functional test. We used a mixed-model ANOVA, repeated-measures analysis with one between factor (group; NOV and EXP) and one within factor (time; Pre and Post). Tukey's post-hoc multiple comparison was performed if a significant main effect was observed. For each ANOVA, partial eta-squared was calculated as measures of effect size. Values of 0.01, 0.06, and above 0.14 were considered as small, medium, and large, respectively.

The statistical analyses were performed using Statistica 13.1 software (Dell, Round Rock, TX, USA). The significance level was set at  $p < 0.05$ .

## **Results**

#### **Dynamic balance**

In the ML plane, mixed-model ANOVA showed a significant main effect for groups ( $F = 17.53$ ,  $p = 0.0002$ ,  $\eta_p^2 = 0.35$ , observed power = 0.9) and time ( $F = 18.04$ ,  $p = 0.0002$ ,  $\eta_p^2 = 0.35$ , observed power = 0.9) (Figure 2). Tukey's test established a decrease of TA in the Post condition in the NOV group (Pre  $104.4 \pm 37.3$  °s vs. Post  $72.3 \pm 26.9$  °s;  $p = 0.0002$ ), yet not in the EXP group (Pre  $39.2 \pm 12.1$  °s vs. Post  $23.1 \pm 4.9$  °s;  $p = 0.4295$ ). There was a significant difference in TA between NOV and

EXP both in the Pre ( $p = 0.0005$ ) and Post ( $p = 0.0094$ ) conditions.

In the AP plane, statistical testing showed a significant main effect for groups ( $F = 12.21, p = 0.0014, \eta_p^2 = 0.27, \text{observed power} = 0.9$ ), time ( $F = 11.99, p = 0.0015, \eta_p^2 = 0.27, \text{observed power} = 0.9$ ) and group  $\times$  time interaction ( $F = 5.54, p = 0.0248, \eta_p^2 = 0.14, \text{observed power} = 0.6$ ). In the Post condition TA significantly decreased in the NOV group (Pre  $120.6 \pm 50.5$  °s vs. Post  $67.0 \pm 20.6$  s;  $p = 0.0002$ ), but not in the EXP group (Pre  $46.8 \pm 8.9$  °s vs. Post  $36.6 \pm 8.7$  s;  $p = 0.9316$ ). There was a significant between-groups difference only in the Pre-condition ( $p = 0.0007$ ).

*Trunk muscle endurance*

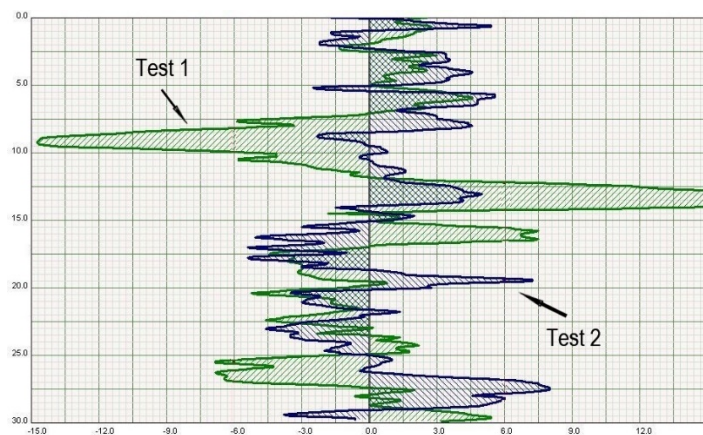
A significant group  $\times$  time interaction was present for all functional tests (Figure 3). In the plank test ( $F = 22.43, p < 0.0001, \eta_p^2 = 0.41, \text{observed power} = 1.0$ ), muscle endurance increased only in the NOV group (Pre  $56.4 \pm 23.4$  s vs. Post  $115.4 \pm 25.2$  s;  $p = 0.0002$ ). Participants in the EXP group were characterized by higher muscle endurance than subjects in the NOV group in Pre and Post conditions ( $p = 0.0002$  and  $p = 0.0002$ , respectively). In the left-side plank ( $F =$

$11.45, p = 0.0019, \eta_p^2 = 0.26, \text{observed power} = 0.9$ ), the endurance was enhanced in the NOV group only (Pre  $43.6 \pm 20.6$  s vs. Post  $101.7 \pm 27.8$  s;  $p = 0.0002$ ). The experienced weightlifters maintained a stable position during the left-side plank longer than the novice both in the Pre and Post condition ( $p = 0.0002$  and  $p = 0.0002$ , respectively). In the right-side plank ( $F = 9.94, p = 0.0035, \eta_p^2 = 0.24, \text{observed power} = 0.9$ ), muscle endurance improved in the NOV (Pre  $47.2 \pm 17.4$  s vs. Post  $104.9 \pm 23.3$  s;  $p = 0.0002$ ) and EXP group (Pre  $170.0 \pm 17.9$  s vs. Post  $195.6 \pm 13.3$  s;  $p = 0.0486$ ). The experienced lifters reached better results in the right-side plank test than the novice ones in the Pre and Post condition ( $p = 0.0002$  and  $p = 0.0002$ , respectively). In the trunk extension test ( $F = 10.56, p = 0.0027, \eta_p^2 = 0.25, \text{observed power} = 0.9$ ), muscle endurance increased only in the NOV group (Pre  $60.0 \pm 22.2$  s vs. Post  $115.9 \pm 25.2$  s;  $p = 0.0002$ ). The participants from the EXP group were characterized by greater trunk erector endurance than subjects from the NOV group in the Pre and Post condition ( $p = 0.0002$  and  $p = 0.0002$ , respectively).

**Table 1**

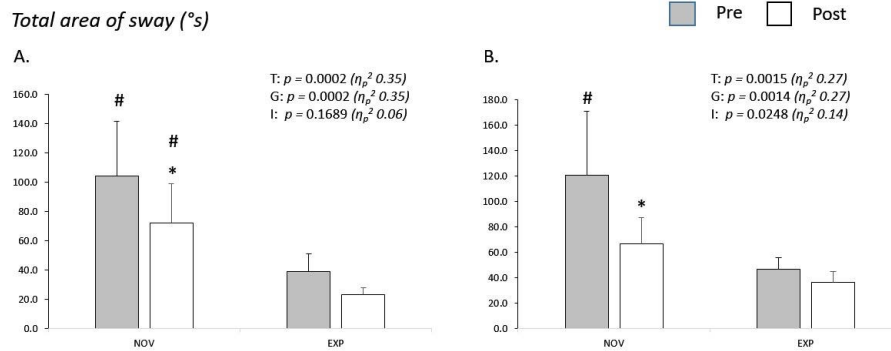
*Participants characteristics.*

	NOV ( $n = 30$ )	EXP ( $n = 5$ )	Groups comparison ( $p$ value)
Age (years)	$31.5 \pm 1.7$	$30.4 \pm 4.7$	0.5244
Body mass (kg)	$77.9 \pm 10.2$	$83.6 \pm 6.8$	0.2417
Height (cm)	$178.9 \pm 6.1$	$181.0 \pm 4.6$	0.4695
BMI	$24.4 \pm 2.9$	$25.5 \pm 1.0$	0.3994



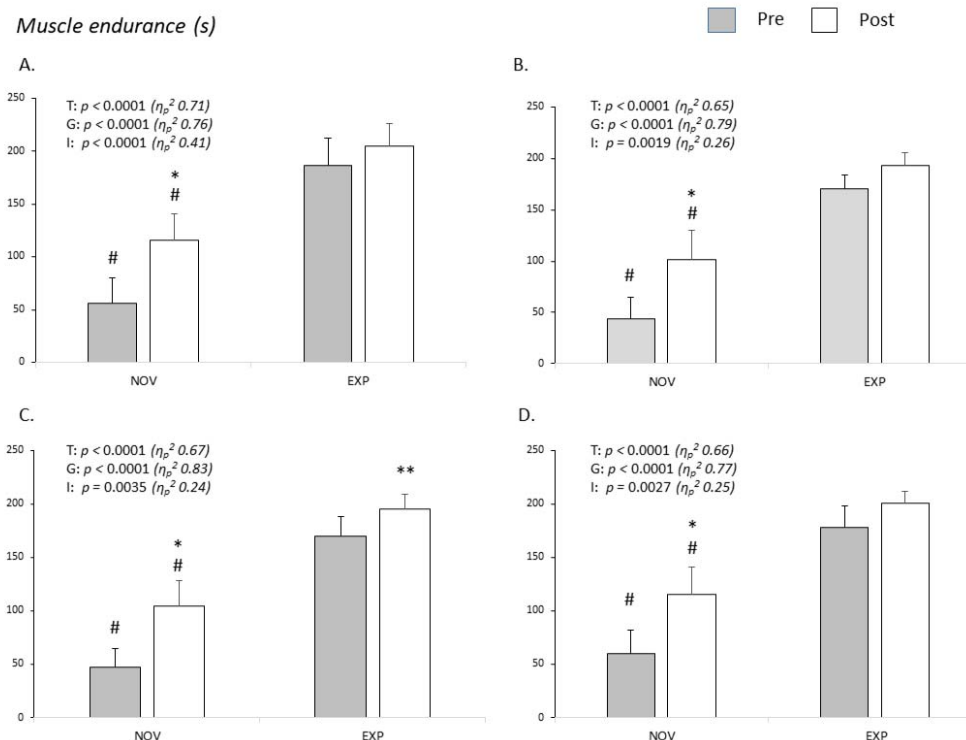
**Figure 1**

*Sample comparison chart of two balance tests.*



**Figure 2**

Total area of sway in the mediolateral (A) and anteroposterior plane (B) measured before (Pre) and after (Post) the training program. T, time effects; G, group effects; I, interaction effects. \*  $p < 0.001$ , significantly different from Pre. #  $p < 0.01$ , significantly different from EXP.



**Figure 3**

Muscle endurance before (Pre) and after (Post) the training intervention measured with functional tests: plank (A), left-side plank (B), right-side plank (C) and trunk extension (D). T, time effects; G, group effects; I, interaction effects. \*  $p < 0.001$ , \*\*  $p < 0.05$  significantly different from Pre. #  $p < 0.001$ , significantly different from EXP.

## Discussion

The primary objective of our study was to investigate the effects of short-term core stability training on dynamic balance and trunk muscle endurance in novice weightlifters preparing for Olympic lifts. The main findings are that the applied training program, which consisted of 8 training sessions, significantly improved both trunk muscle endurance and dynamic balance in the mediolateral and anteroposterior plane.

Our secondary objective was to compare dynamic balance and trunk muscle endurance between novice and experienced weightlifters. The results showed that experienced lifters were characterized by more effective dynamic balance and greater core muscle endurance than their novice peers, not only before the training intervention, but also after its completion.

In our previous study (Szafraniec et al., 2018a), we observed that a single bout of core stability exercises improved the control of body balance during closed-eyes quiet standing. This effect was evident at 30 minutes after exercise and remained for at least 24 hours later. Improvement of postural stability was limited to the ML plane, with no effects in the AP plane. Although the results may justify the use of core stability exercises in training, in general, many questions are still unanswered. It was difficult to explain why balance in the AP plane was unaffected by core stability exercises. We suspected that the single bout of exercises could be an insufficient training stimuli, or the balance task (quiet standing) was not sensitive enough to capture the changes. In the current study, we decided to apply a more difficult balance task (a balance board) and a short training program. The results indicate that in the NOV group the dynamic balance was improved in both planes. The results of our research are difficult to compare directly with the results of other authors, due to different methods of dynamic balance assessment. In our study, we used an electronic oscillating balance board, while other authors most often used the Star Excursion Balance Test (SEBT). However, Sandrey and Mitzel (2013) stated that the 6-week core-stabilization-training program (30 min × three times per week) resulted in a significant improvement in dynamic balance of high school track and field athletes. Similar results were obtained in high school soccer players after a 12-

week training program (3 times per week) of trunk stabilization exercises (Imai et al., 2014b). Also, badminton players improved their dynamic balance, measured with the SEBT, after the 8-week core stability training (Hassan, 2017; Ozmen and Aydogmus, 2016). In turn, a 9-week core stability program (30 min × three times per week) improved dynamic balance measures in competitive collegiate dancers (Watson et al., 2017). The training program we used was the shortest of those presented above, but sufficient to provoke the improvement of dynamic balance in the group of NOV lifters. However, no improvement was registered in the EXP group. This may probably be due to two things. First of all, the training program was too short to observe adaptive changes in already trained athletes. Secondly, although these subjects have not previously performed exercises typically focused on core stability, the use of free weights during many years of training shaped this ability. This thesis can be confirmed by the research of Willardson et al. (2009), who compared core muscle activity during resistance exercises performed on stable ground vs. the BOSU Balance Trainer. Twelve trained weightlifters performed the back squat, deadlift, overhead press, and curl lifts on a stable and unstable surface with a load of 50% 1RM. The activity of the rectus abdominis, external oblique abdominis, transversus abdominis/internal oblique abdominis, and erector spinae muscles was assessed. There were no significant differences between the BOSU and stable conditions across all muscles and lifts examined. The authors concluded that each of the aforementioned lifts can be performed while standing on stable ground without losing the potential core muscle training benefits.

This conclusion may also explain the lack of improvement of trunk muscle endurance in the EXP group in our research. Only in case of the right-side plank, the endurance increased but the increment was on the verge of statistical significance ( $p = 0.0486$ ). In such a small sample, statistical significance at this level should be considered uncertain. In the NOV group, trunk muscle endurance increased in all tests performed. Our results are in line with the findings of other authors (Hassan, 2017; Sandrey and Mitzel, 2013). Sandrey and Mitzel (2013) found a 160-250 % increase in trunk muscle

endurance after a 6-week (18 sessions) core-stabilization training program in high school track and field athletes. In turn, Hassan (2017) noticed only a 22-33% improvement in trunk endurance after an 8-week (16 sessions) core stability training program in young male badminton players. In our study, we observed an increase in core endurance in the NOV group in the range of 93-103%.

Our results show a significant difference in dynamic balance and core endurance between the NOV and the EXP group, both before and after the applied training program. This indicates that the 4-week (8 sessions) program was too short for the novices to approach experienced colleagues in respect to the examined abilities. Therefore, it seems reasonable to use core stability exercises for a longer time before starting Olympic weightlifting exercises. By improving dynamic balance and trunk muscle endurance, we can reduce the risk of injury when implementing technically difficult exercises with free weights, such as the clean or the snatch.

Limitations of the study are based mainly on the number of subjects enrolled in the EXP

group and the selection of very experienced weightlifters to be compared with the novices. Currently, it seems to us more rational to choose into the EXP group subjects with a significantly shorter experience in Olympic weightlifting, e.g. 6 or 12 months (we qualified people with at least 3 years of experience). It would be worth adding to our research a group that performs other types of resistance exercises. This should be the direction of future research, which would allow to determine the possible priority of core stability training over other forms of strength training in shaping trunk muscle endurance and dynamic balance.

### Conclusions

The applied short-term core stability training improved dynamic balance and trunk muscle endurance in novice weightlifters attempting to learn the Olympic lifts. Such a training program can be incorporated into a training regime of novice weightlifters to prepare them for technically difficult exercises using free weights.

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