The influence of a single core muscle workout on the level of static and dynamic balance in adults using the Sigma Balance Platform and the Y-Balance Platform

Patryk Ciężarek[1], Grzegorz Frankowski[2], Małgorzata Kulesa- Mrowiecka[2], Joanna Zyznawska[2], Anna Dębowska[2], Marta Bojanowska[2], Kinga Słojewska[1]

[1] Doctoral School in Medical and Health Sciences, Jagiellonian University, Collegium Medicum, Poland
[2] Physiotherapy Institute, Jagiellonian University, Poland

Correspondence to: Patryk Ciężarek, email: ciezarek.patryk@gmail.com

DOI: https://doi.org/10.5114/phr.2022.114587

Received: 27.05.2021 **Reviewed:** 19.07.2021 **Accepted:** 23.07.2021

Abstract

Background: Dynamic balance enables the body to cope with disturbances that may be caused by the external and internal environment. The tonic activity of the antigravity muscles (also referred to as core muscles) affects the center of gravity shifts. Balance improvement therapy uses exercises to balance the tension and strength of the core muscles, taking into account their concentric and eccentric actions.

Aims: The project aimed to determine whether a single workout that strengthens and stimulates deep core muscles, based on eccentric and concentric exercises, influences static and/or dynamic balance.

Material and methods: A group of 100 students (range of age: 19–26 years old) from the Collegium Medicum of the Jagiellonian University in Kraków (Poland) was qualified for the study based on the conducted survey determining the inclusion criteria. Finally, 50 subjects completed the 15-minute core muscle workout developed by the authors. Static and dynamic balance was tested directly before and after the workout. The control group included 50 individuals tested twice without participating in the training. Tests were conducted using two Y-Balance Test platforms (three planes of movement) and the Sigma balance platform.

Key words

core muscle training,
static balance,
dynamic balance

Results: The analysis of the study revealed a statistically significant difference between the groups in the dynamic balance test for the medial movement of the right limb. No statistically significant differences were found for the results of static balance measurements: path length and point surface area. The analysis of the overall results for the two remaining planes in the dynamic balance test did not reveal any statistically significant differences between the control and the experimental groups.

Conclusion: Single core muscle workout does not influence static balance, but it impacts the dynamic balance, improving the posteromedial direction results, and therefore may be useful as an introduction to coordination exercises in working with patients with balance disorders. This can allow the proper muscles to work more efficiently, increasing their strength and muscle mass.

Introduction

Balance is a specific state of the postural system controlled by the nervous system is ensured by reflexive tension of the antigravity muscles, also known as the postural muscles. Balance is divided into static balance, which occurs during rest, and dynamic balance during physical activity. The dynamic balance enables the body to cope with disturbances that may be caused by the external and internal environment [1]. It is the ability to maintain vertical posture by humans while performing motor tasks and movements. The movement destabilizes the posture of the body, which must return to its typical position. The presented mechanism is referred to as stability. The tension of specific muscle areas allows the body to balance its forces. The factor that determines the stability of the standing position is the location of the overall center of gravity [1, 2, 3]. The center of gravity of the body shifts towards the dominant limb. Population-based studies show that the center of gravity is shifted to the right because right-sided dominance is more common [4]. The motor system is controlled by several central and peripheral mechanisms. Receptors (in muscles, joints, skin, and tendons) transmit information that generates a central representation of the body in the nervous system, which enables vertical orientation and the proper placement of body parts in space. The central body representation is partially genetically determined, but to some extent it can be influenced by the learning process [1, 2, 3, 4, 5].

The analysis of body posture control includes posturographic tests that analyze small, involuntary movements: postural sway of the center of gravity while standing steadily. These tests are performed using special platforms of computerized video systems [5, 6, 7]. When the center of gravity is examined, small oscillation movements are connected with actions such as breathing or blood circulation. The tonic activity of antigravity muscles (also referred to as core muscles) also influences the shifts of the center of gravity [1,2,3,4]. The state of functional balance stability control is verified using functional tests, which consist of performing simple, functional tasks and evaluating them on an accepted scale [8, 9].

According to the simplified classification by V. Janda [2], we can distinguish between tonic, phasic and mixed muscles. Depending on the classification of muscles, they are distinguished by different functional adaptations and functions in the body affecting balance. Tonic muscles that consist of slow-twitch fibers are more resistant to fatigue and regenerate quickly, but they are prone to tightness during dysfunction. On the other hand, phasic muscles, composed of fast-twitch fibers, are prone to fatigue and regenerate slowly. During dysfunctions, they are prone to weakness and atrophy. Instability in the symmetry of tonic and phasic muscle tensions can lead to compensations, overloads, and injuries that affect body balance. Balance improvement therapy uses exercises to balance the tension and strength of the core muscles, considering their concentric and eccentric actions. Implementing these exercises in patients aims to stimulate receptors and recruit a higher number of motor units, thereby stimulating balancing reactions [2].

Aims

This study aimed to analyze the influence of a single core muscle workout on the level of static and dynamic balance in adults using the Sigma Balance Platform and the Y-Balance Platform.

Material and methods

Deep muscle training programs are becoming increasingly popular. The authors aimed to examine whether a single training session can have a significant positive effect on balance. The tested groups were comprised of students of the following faculties of the Collegium Medicum: electroradiology, physiotherapy, emergency medical services, pharmacy, medicine, and medical analytics. Inclusion criteria for the study included: age between 19 and 26 years of age, no balance disorders, neurological disorders, illnesses, or injuries that could impair physical performance. Another inclusion criterion was consent to participate in the study. Tests were conducted at the Department of Physical Education and Sports and Department of Physiotherapy of the Collegium Medicum. A group of 100 participants took part in the study, of which 50 (27 women and 23 men) were assigned to the experimental group that completed the workout, while 50 others (44 women and 6 men) were assigned to the control group. Participants were selected from currently available medical faculty groups. The differences in gender ratios were due to the fact that medical majors at Collegium Medicum are female-dominated (medical majors: medical analytics, pharmacy, physiotherapy), which may be one of the study's limitations. The average age in the experimental group was 20.9 years, and in the control group – 19.5 years. The study was planned in two blocks. First, participants were recruited into a control group in which repeated measures were determined, while recruiting the experimental group in which supervised training was conducted. The two groups were then evaluated for training effectiveness.

The analysis was performed using two instruments: Static balance was analyzed using the Sigma Balance Platform, while the dynamic balance was tested using the Y Balance Test Platform. Two measurements were conducted in the control group, with a break of approximately 15 minutes for rest. In the experimental group, measurements were taken before and after a series of core muscle exercises that lasted approximately 15 minutes. The differences in the experimental and the control group results were then compared.

Subjects performed a 60-second balance test on the Sigma Balance Platform to evaluate the length of the center of gravity path and the surface area of the virtual center of gravity. The XL base was used for the study. The static balance test on the device is presented in **Figure 1**.

The test on the Y Balance platform evaluated the swing of the body in three directions: frontal, posteromedial, and posterolateral. According to the adopted research methodology, three measurements were taken for each direction, and the results were then averaged. The dynamic balance test is presented in **Figures 2A – 2C**.

Figure 1. Static balance test on the Sigma Balance Platform.

Note: *own source.*

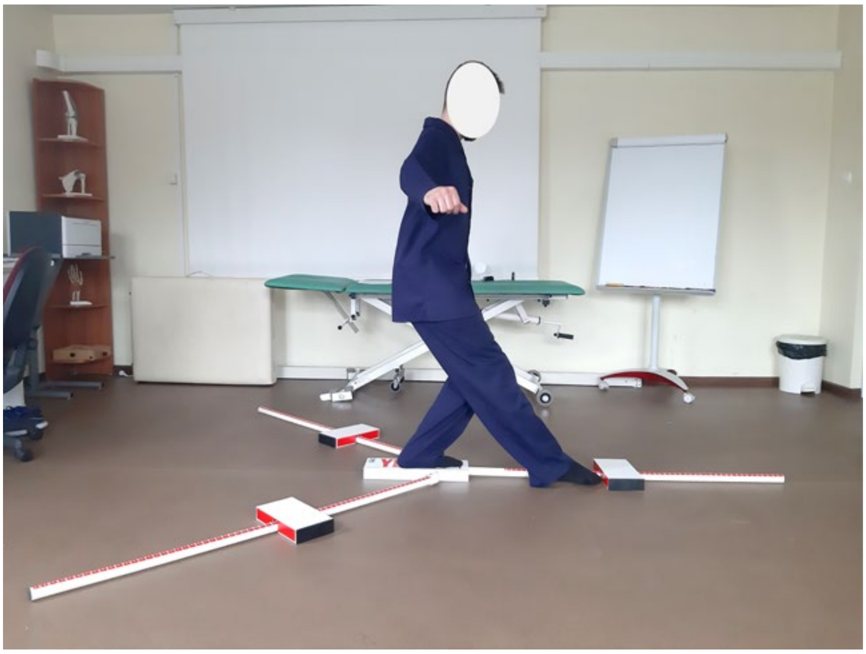

Figure 2A. Dynamic balance test on the Y Balance Test platform for the frontal direction.

Note: *own source.*

Figure 2B. Dynamic balance test on the Y Balance Test platform for the posterolateral direction.

Note: *own source.*

Figure 2C. Dynamic balance test on the Y Balance Test platform for the posteromedial direction.

Note: *own source.*

The relative length of the right lower limb was measured for each of the subjects to average the total result in three analyzed directions, according to the study's methodology. The calculation formula is presented below in **Figure 3**.

$$\text{SCORE} = \frac{\text{(Anterior + Posteromedial +Posterolateral)}}{\text{3 x Right Limb Lenght}} \times 100$$

Figure 3. Calculation formula.

Core muscle workout

The core muscle workout consisted of three exercise series of 10 repetitions each, with a 15-second break between the series and a 30-second break between individual exercises. Students in the experimental group had to perform five exercises that engaged the core muscles during each exercise. The subjects' attention was drawn to proper breathing and isometric tension of the transversus abdominis muscle during the exercises.

Exercises 1-3 were based on eccentric stimulation of the extensors and eccentric work of the abdominal muscles. The first exercise was to raise the torso with the position held for 10 seconds. The most important thing in that exercise was to concentrate on the tension of the transverse abdominal muscle. The next exercise was to raise the lower limbs to 90 degrees and twist the joined limbs to the right and left by 45 degrees (ten repetitions). Another exercise was the forward support position, alternating the right upper limb to the left lower limb and the left upper limb to the right lower limb (ten repetitions). The methodology is shown in **Figures 4A-4C**. The next exercise involved eccentric stimulation of the extensors and eccentric work of the abdominal muscles. Raise the torso from the forward lying position and hold the position (ten repetitions). The methodology is shown in **Figure 4D**. The last exercise was designed to stimulate the hip abductors. Tape around the ankles from the semi-squat position, lateral stride to the right, return to position, and lateral stride to the left (ten repetitions). The methodology is presented in **Figure 4E**.

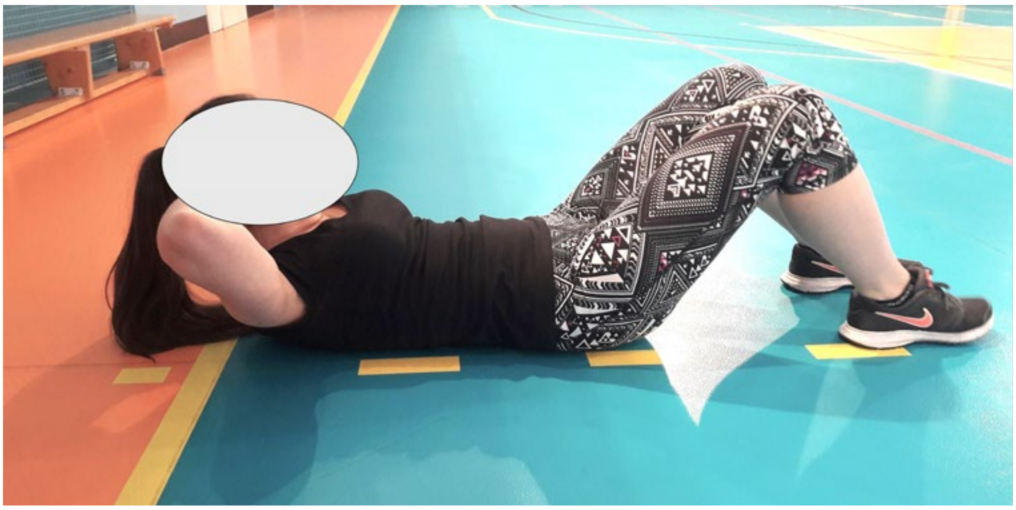

Figure 4A. Exercise 1 – concentric work of the abdominal muscles, eccentric work of the core muscles.

Note: *own source.*

Figure 4B. Exercise 2 – concentric work of the abdominal muscles, eccentric work of the core muscles.

Note: *own source.*

Figure 4C. Exercise 3 – concentric work of the abdominal muscles, eccentric work of the core muscles.

Note: *own source.*

Figure 4D. Exercise 4 – concentric work of the core muscles, eccentric work of the abdominal muscles.

Note: *own source.*

Figure 4E. Exercise 5 – stimulating hip abductor muscles.

Note: *own source.*

Results

Center of gravity path length

In the experimental group, an improvement of a 0.7-centimeter reduction in the center of gravity path length was noted. Path length results were analyzed using a student's t-test. The accepted level of statistical significance was $p < 0.05$, and the obtained result was 0.86. These differences were not statistically significant. The results are shown in **Figure 5**.

Center of gravity surface area

A slight improvement was observed in the experimental group, consisting of 0.02 cm^2 reduction of the point surface area. The path length results were analyzed using Welch's t-test. The accepted level of statistical significance was $p < 0.05$, and the obtained result was 0.46. These differences were not statistically significant. The results are presented in **Figure 6**.

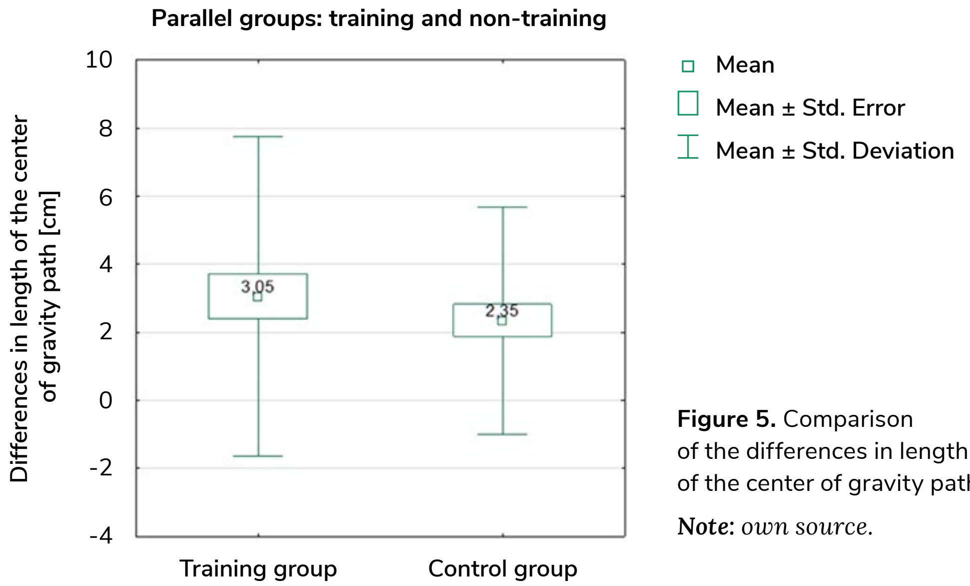

Figure 5. Comparison of the differences in length of the center of gravity path.

Note: *own source.*

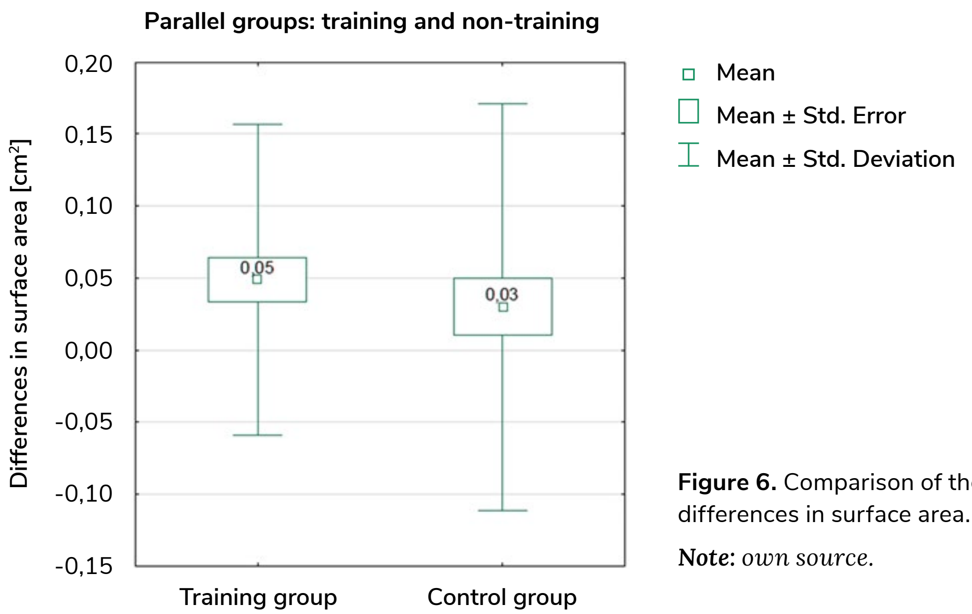

Figure 6. Comparison of the differences in surface area.

Note: *own source.*

Y Balance Test

Normal distribution results were analyzed using Student's t-tests and Welch's t-tests. In addition, forward movement of the left limb was analyzed using Student's t-test, and other values were analyzed using Welch's t-test. No statistically significant differences between the mean scores of the experimental and the control group were found.

Results whose distribution was not compliant with normal distribution were analyzed using the Mann-Whitney U test. A statistically significant difference was found for the posteromedial measurement for the right limb. The difference in medians was 2.33 centimeters. The analysis of the left limb results, according to the model, showed no statistically significant differences.

Posteromedial direction for right leg

In the experimental group, improvement was observed in increasing the range of measurement in the posteromedial direction. The difference between medians was 2.33. The results were analyzed using the Mann-Whitney U test. The accepted level of statistical significance was $p < 0.05$, and the obtained result was 0.046. These differences were statistically significant. The results are provided in **Figure 7** and **Table 1**.

Result from the formula for the right leg

Moreover, there was an improvement in the experimental group in terms of an increase in the results of measurements in all directions for the right limb, calculated according to the formula. The difference in means was 0.74. The results were analyzed using Welch's t-test. The accepted level of statistical significance was $p < 0.05$, and the obtained result was 0.37. These differences were not statistically significant. The results are shown in **Figure 8** and **Table 2**.

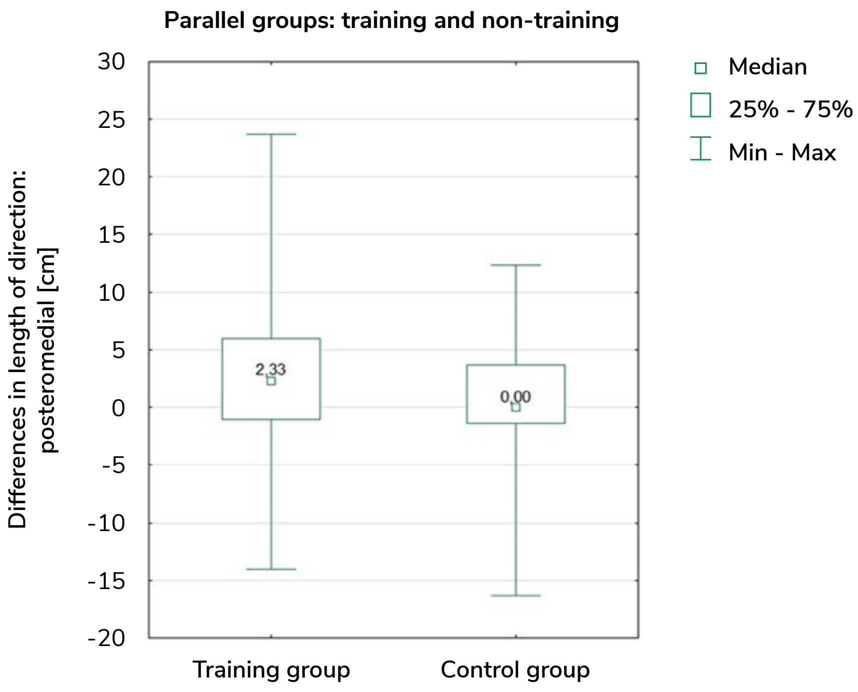

Figure 7. Comparison of the differences for the right limb, posteromedial direction.

Note: *own source.*

Table 1. Results characterizing the differences in Y Balance Test values measured by parametric tests.

Variable	Value differences' analysis			
	N	M	SD	p
Right leg, frontal, experimental group	50	-1.04	3.87	0.16
Right leg, frontal, control group	50	-0.01	3.50	
Right leg, posterolateral, experimental group	50	3.77	5.50	0.84
Right leg, posterolateral, control group	50	4.01	6.36	
Left leg, frontal, experimental group	50	0.19	4.25	0.67
Left leg frontal, control group	50	0.51	3.18	
Left leg, posteromedial, experimental group	50	1.67	5.76	0.96
Left leg, posteromedial, control group	50	1.72	4.94	
Left leg, posterolateral, experimental group	50	4.17	5.56	0.75
Left leg, posterolateral, control group	50	3.79	6.31	
Result from the formula for right leg, experimental group	50	1.94	4.53	0.37
Result from the formula for right leg, control group	50	1.20	3.66	

Abbreviations: N – *number of participants*; M – *mean*; SD – *standard deviation*; p – *level of statistical significance*.

Note: *own source.*

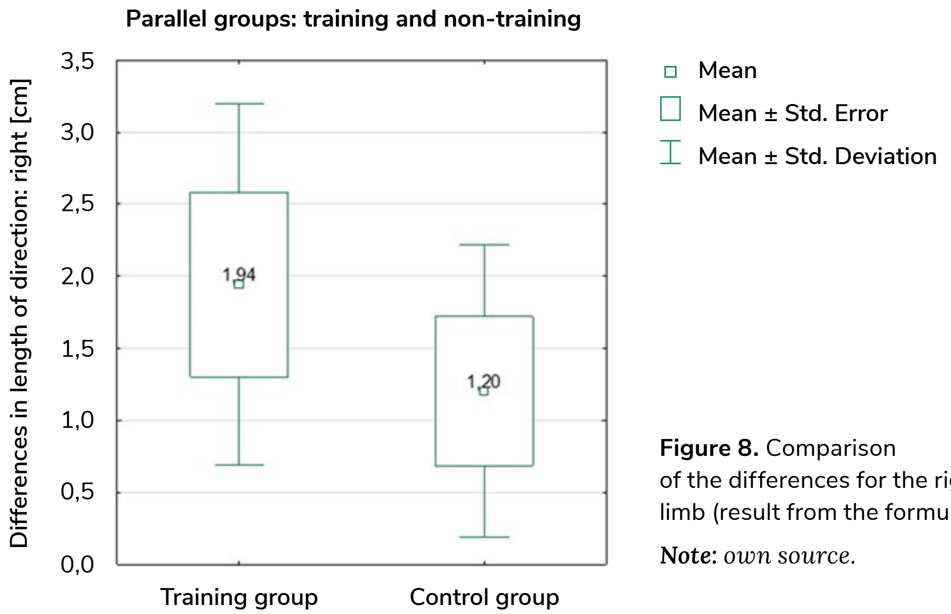

Figure 8. Comparison of the differences for the right limb (result from the formula).

Note: *own source.*

Table 1. Results characterizing the differences in Y Balance Test values measured by the non-parametric test.

Variable	Value differences' analysis				
	N	Me	Upper	Lower	p
Right leg, posteromedial, experimental group	50	2.33	-1.00	6.00	0.046
Right leg, posteromedial, control group	50	0.00	-1.33	3.67	
Result from the formula for left leg, experimental group	50	0.90	-0.70	4.60	0.72
Result from the formula for left leg, control group	50	2.00	-0.70	4.70	

Abbreviations: *N – number of participants; Me – median; p – level of statistical significance.*

Note: *own source.*

Result from the formula for the left leg

Furthermore, the experimental group also showed improvement in the increase of measurements in all directions for the left limb, calculated according to the formula. The difference in medians was 1.1. The results were analyzed using the Mann-Whitney U test. The accepted level of statistical significance was p <0.05, and the obtained result was 0.72. The differences were not statistically significant. The results are presented in **Figure 9** and **Table 1**.

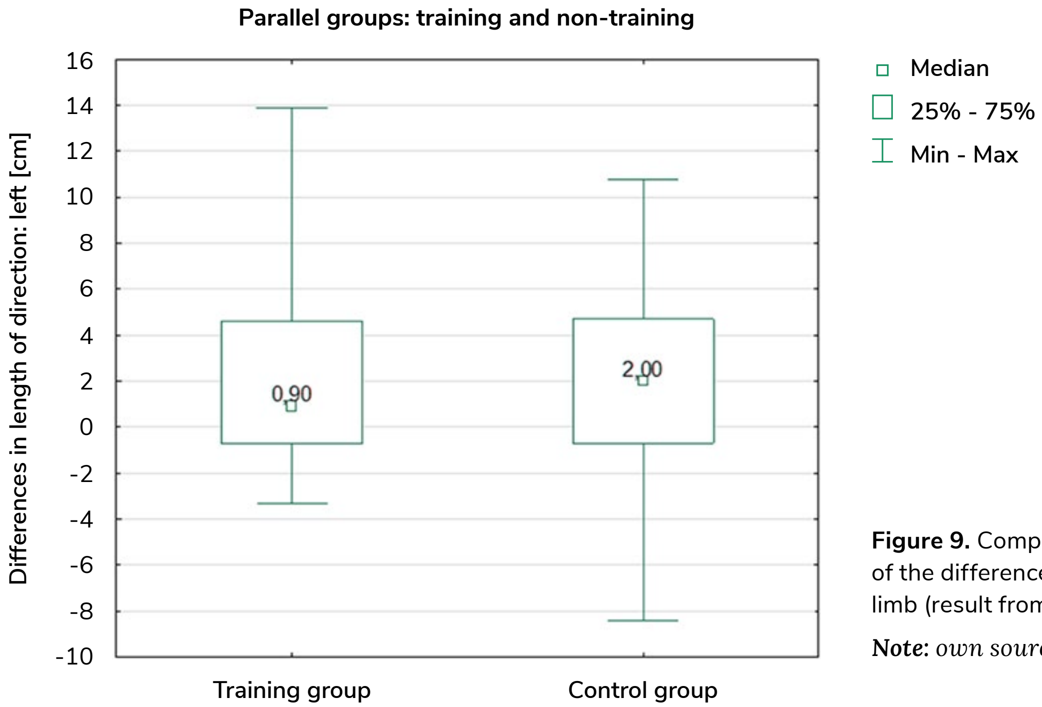

Figure 9. Comparison of the differences for the left limb (result from the formula).

Note: *own source.*

Discussion

No similar studies of single stimulus core muscle training have been reported in the literature. Study conducted by Podbielska et al. [10] on balance in individuals training full-contact martial arts compared people who did not exercise and demonstrated that those who trained had better dynamic balance. However, no statistically significant differences in static balance were found. On the other hand, a study by Benis et al. [11] compared neuromuscular bodyweight exercises with standard tactical-technical exercises performed twice a week for an 8-week period and demonstrated a statistically significant improvement in dynamic balance tested with the Y Balance Test platform. The improvement referred to the posteromedial and posterolateral directions. No improvement was reported in the frontal direction.

Our study revealed that single-core muscle training did not influence static balance, although it slightly affected the dynamic balance, improving the performance in the posteromedial direction. A study conducted by Iizuka et al. [12] showed significant improvement in the values recorded in swimmers after antigravity muscle training for nine weeks. A study by Szczygieł et al. [13] found statistically significant improvement in 19 subjects, measured using photogrammetric method and respiratory inductive plethysmography after core muscle training. These exercises improved body posture in the sagittal plane and increased respiratory amplitude. It should be noted that so far, there are no studies that evaluated static and dynamic balance values after therapy engaging the core muscles in a larger population.

Improving balance is an important part of training among people with destabilization in this area. It is a therapeutic tool used in the rehabilitation of numerous illnesses. Quite often, during rehabilitation holidays of limited duration, the improvement of this parameter requires difficult, long-term measures. Thus, it seems important to investigate whether even a single workout stimulating core muscles may result in improved functioning in this area. Furthermore, the exercises used in training can be useful as an introduction to coordination exercises when working with patients with balance disorders. This allows the relevant muscles to work more efficiently, increasing their strength and muscle mass.

Conclusions

Dynamic balance tests revealed a statistically significant improvement in the posteromedial direction for the right limb. No statistically significant differences were found in static balance tests, although a certain trend in correlations was observed. In the remaining directions, the differences were not statistically significant. Single workout stimulating the core muscles did not influence the static balance in a significant way. However, it improved the range of one of the directions analyzed on the Y Balance Test platform, so it can be used to introduce balance exercises for patients with related disorders. It seems necessary to repeat the study with a larger number of patients and to conduct research evaluating long-term core muscle training, lasting, e.g., two weeks or more, in a large group of patients.

References

1. Błaszczyk JW. Biomechanika Kliniczna. Wydawnictwo Akademii Wychowania Fizycznego w Katowicach, 2014.
2. Olczak A, Równowaga ciała człowieka - ćwiczenia. Wydawnictwo Lekarskie PZWL, Warszawa 2016.
3. Kostiukow A, Rostkowska E, Samborski W, Badanie zdolności zachowania równowagi ciała. Ann Acad Med Stetin. 2009;55(3):102-9.
4. Orendorz-Frączkowska K, Wybrane aspekty oceny kontroli posturalnej u dzieci zdrowych i z idiopatycznym zespołem nerczycowym. Akademia Medyczna we Wrocławiu, Wrocław 2011.
5. Błacha R., Powtarzalność napięć izometrycznych mięśni jako miara zdolności różnicowania kinestetycznego. Wydawnictwo Akademii Wychowania Fizycznego we Wrocławiu, Wrocław 2013.
6. Ocetkiewicz T, Skalska A, Grodzicki T, Balance estimation by using the computer balance platform: repeatability of the measurements. Gerontol Pol. 2006;14(1):144-8.
7. Kuczyński M, Podbielska M, Bieć D, Paluszak A, Kręcisz K. The basics of postural control assessment: what, how and why do we need to measure? Acta Bio-Opt Inf Med Biomed Eng. 2012;4(18):243-9.
8. Paszko-Patej G, Terlikowski R, Kułak W, Sienkiewicz D, Okurowska-Zawada B. Factors affecting the process of balance development of child and the possibility of objective evaluation. Child Neurol. 2011; 20(41):121-7.
9. Szostek-Rogula S, Zamysłowska-Szmytke E, A review of scales and tests for functional assessment of patients with vertigo and balance disorder. Otolaryngol. 2015;14(3):141-9.
10. Podbielska M, Senhadri H, Kuczyński M, Static and dynamic tests of postural control in taekwondo contenders. Acta Bio-Opt Inf Med Biomed Eng. 2013;19(2):79-84.
11. Benis R, Bonato M, La Torre A. Elite Female Basketball Players' Body-Weight Neuromuscular Training and Performance on the Y-Balance Test. J Athl Train. 2016;51(9):688-95.
12. Iizuka S, Imai A, Koizumi K, Okuno K, Kaneoka K. Immediate effects of deep trunk muscle training on swimming start performance. Int J Sports Phys Ther. 2016;11(7):1048-53.
13. Szczygieł E, Blaut J, Zielonka-Pycka K, Tomaszewski K, Golec J, Czechowska D, Masłoń A, Golec E. The Impact of Deep Muscle Training on the Quality of Posture and Breathing. J Mot Behav. 2018;50(2):219-27.
14. Kaczmarczyk P, Ringier P. Evaluation of the Effect of Training on Unstable Ground on Dynamic Stability in Soccer Players Using the Y-Balance Test. Physiotherapy Review, 2021, 25(1), 38-44.

    http://physiotherapy.review/Evaluation-of-the-Effect-of-Training-on-Unstable-Ground-on-Dynamic-Stability-in-Soccer-Players-Using-the-Y-Balance-Test,161,43553,0,1.html