

Article

Effect of a 10-Week Sensomotor Exercise Program on Balance and Agility in Adolescent Football Players: A Randomised Control Trial

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Abstract: The main aim of this study was to evaluate the effects of a 10-week sensomotor exercise programme on body balance and agility in a group of adolescent athletes. Initially, 120 adolescent football players were included in the study. In the final analysis, 90 athletes aged 10–17 years participated. The study was designed as a single-blinded, randomised controlled trial. Healthy athletes who met the inclusion criteria were randomly divided into two comparative groups: experimental and control groups. Sensomotor exercises were conducted twice weekly for 10 weeks in the experimental group. The adolescent footballers were subjected to the following tests: a COP (Centre of Pressure) test on a stabilometric platform, a Y balance test (Y-BT), and an agility test. The experimental group showed improvement with respect to the following variables: COP-based path length, with eyes open, for 30 s duration—improved by 5.3 cm (mean: 20.0; 95% CI 15.3–24.8); area, with eyes open, for 30 s duration—improved by 1 cm² (mean 2.1; 95% CI 0.6–3.5); area, with eyes closed, for 30 s duration—improved by 0.4 cm² (mean 2.2; 95% CI 1.6–2.8). The Y-BT was significantly improved in terms of the final score for the following variables: left leg anterior by 2.1% (mean 73.1; 95% CI 70.7–75.2); right leg posterolateral by 3.8% (mean 112.3; 95% CI 109.3–115.3); right and left leg posteromedial by 5.6% (mean 111.7; 95% CI 108.6–114.9) and 5.7% (mean 112.3; 95% CI 109.7–115.1), respectively; medium posterolateral by 3.2% (mean 111.8; 95% CI 109.0–114.7); medium posteromedial by 6.0% (mean 112.0; 95% CI 109.2–115.0); and Y total score by 3.5% (mean 98.8; 95% CI 96.6–100.9). The agility test in the experimental group was improved by 1.6 s (mean 13.2; 95% CI 12.6–14.0). A 10-week programme of additional sensomotor exercises improved selected parameters determining balance and agility in the young football players.

Keywords: sensomotor exercise programme; balance; agility; adolescent football players



Citation: Sikora, D.; Linek, P. Effect of a 10-Week Sensomotor Exercise Program on Balance and Agility in Adolescent Football Players: A Randomised Control Trial. *Appl. Sci.* **2023**, *13*, 89. <https://doi.org/10.3390/app13010089>

Academic Editors: Marcin Maciejczyk and Przemysław Bujas

Received: 23 November 2022

Revised: 14 December 2022

Accepted: 14 December 2022

Published: 21 December 2022



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1. Introduction

Balance is fundamental in the execution of the complex technical movements performed by football players and is important in order to achieve a high level of performance [1]. Schedler et al. [2] suggested that youths have a great capacity for developing balance (static and dynamic). However, during adolescence, there is a latency period in which a higher degree of postural lability is observed [3]. Thus, the implementation of additional exercise programmes that could improve balance in adolescent individuals seems warranted [4]. Agility is another important physical skill that should be developed during childhood and plays an important role in football [5]. Therefore, agility training should also be included in footballers' training from an early age [6].

Additional balance exercise programmes are mainly applied to enhance athletic performance [7] and bolster injury prevention [8]. In practice, the most commonly implemented exercise programmes are used in order to improve body balance [9], because low levels of balance are associated with an increased risk of injury [10]. In turn, the relationship between body balance and athletic performance is not fully conclusive [11,12].

Sensomotor exercises are designed to improve proprioception. In the literature, several other terms are used, such as proprioception exercises [13,14], neuromuscular exercises [15,16], balance exercises [17,18], and stabilisation exercises [19,20], but, practically speaking, all these terms refer to the same type of exercise. However, it is worth noting that sensomotor exercises contain three exercise components: static, dynamic, and functional components [21,22]. Some studies have suggested that additional balance training is an important part of regular athletic training because it improves athletes' performance [12] and prevents injury [8]. It has been confirmed that balance training reduces the angles and valgus moments of the knee and increases the activity of the hamstring muscles [23]. This is considered beneficial for the stabilisation of the knee joint [24]. Thus, sensomotor exercises have been demonstrated to significantly mitigate knee pain, improve global knee function, and reduce the re-injury of anterior cruciate ligaments [25,26].

There is also some doubt concerning the effects of additional body balance exercises in children and adolescents if the duration of these exercises decreases [27]. A systematic review by Brachman et al. [28] showed that additional exercise improved body balance in a group of athletes when conducted for at least eight weeks. Therefore, we hypothesised that an additional sensomotor exercise programme implemented for a period of 10 weeks should improve body balance and agility in adolescent football players. Thus, the main aim of this study was to evaluate the effects of a 10-week sensomotor exercise programme on body balance and agility in a group of adolescent athletes. In this study, the exercises introduced contain all the elements of sensomotor exercises.

2. Materials and Methods

2.1. Ethics

This study was authorised by the Bioethics Committee for Scientific Studies at the Academy of Physical Education in Katowice on 18 May 2017 (Decision No. 4/2017). All study procedures were performed according to the Helsinki Declaration of Human Rights of 1975, modified in 1983. The clinical trial registration number is ACTRN12616000390482.

2.2. Study Design

The study was designed as a single-blinded, randomised controlled trial. The study was conducted in Będzin (Silesian region of Poland). Healthy athletes who met the inclusion criteria were randomly divided into two comparative groups: experimental and control groups. Sensomotor exercises were conducted twice weekly for 10 weeks in the experimental group. We decided to use such a protocol based on systematic review by Brachman et al. [28], wherein it was suggested that such a training regimen should be conducted twice a week for at least 8 weeks. All participants and their parents were informed about what the study would involve and were told that they could withdraw at any stage without providing a reason. Written informed consent was obtained from all participants.

2.3. Participants

Initially, 120 adolescent male football players were included in the study. In the final analysis, 90 athletes aged 10–17 years participated. All athletes had been attending football training for a minimum of two years at the Football Academy twice a week. The eligibility criteria for the study were as follows: (a) the achievement of a minimum score for each question from the Oslo Sport Trauma Research Centre Questionnaire, which is equivalent to full participation in training units [29], and (b) the absence of any injury excluding the participants for more than a week from training units in the last four months prior to the study. All study participants began the study by performing a stabilometric platform ALFA and then a Y balance test (Y-BT). The exclusion criteria were (a) a history of previous abdominal surgery and (b) participation in any physiotherapy treatment within six months prior to the study. A detailed scheme is presented in Figure 1, and the participants' characteristics are presented in Table 1. The necessary sample size was estimated using an

alpha of 0.05, a statistical power of 0.80, and an effect size of 0.3. Based on this calculation, the minimum number of participants in each group should be at least 45.

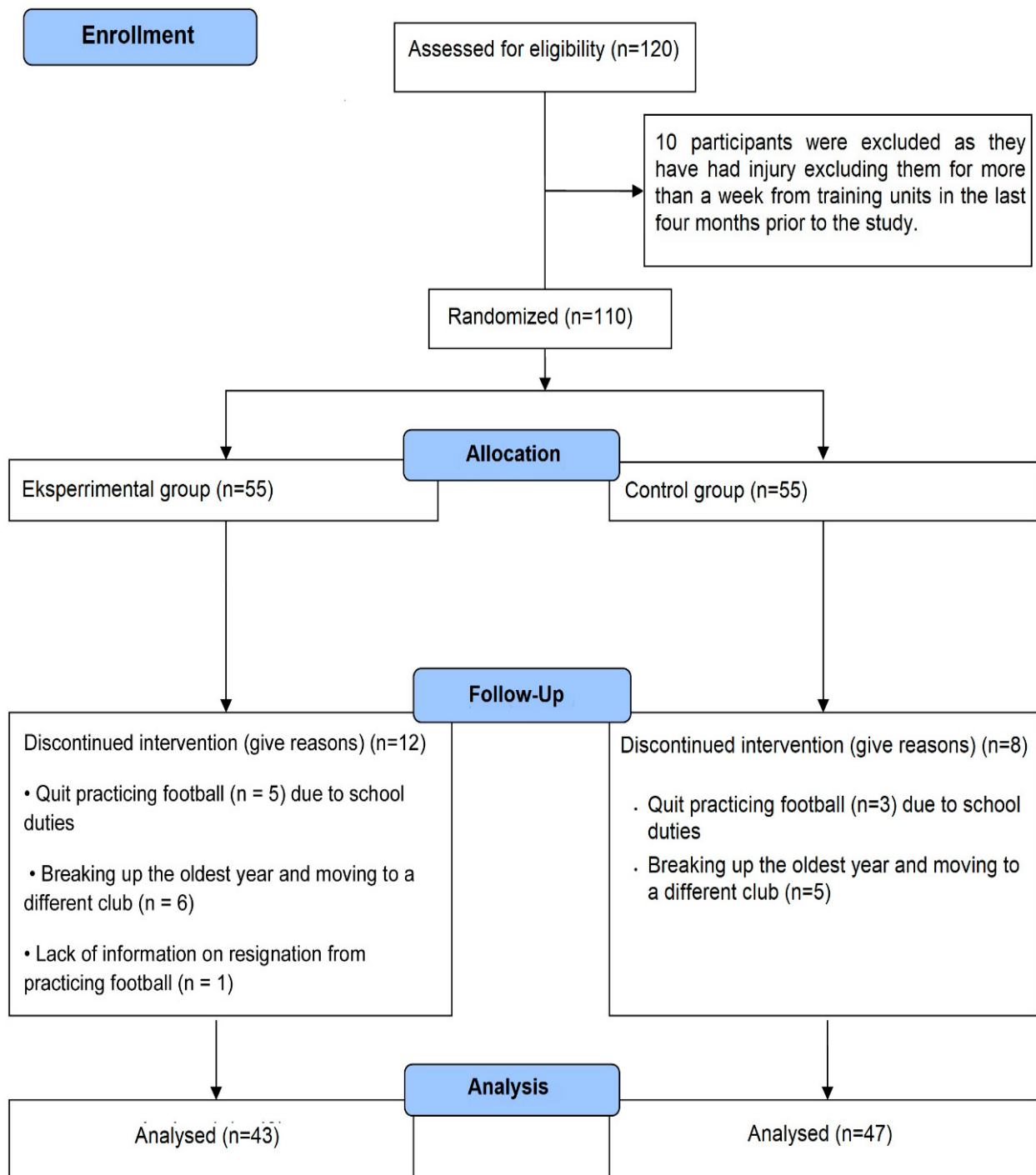


Figure 1. A detailed diagram of the flow of the studied players.

2.4. Randomisation and Allocation

Eligible athletes were randomly allocated into two parallel groups (experimental or control) by drawing lots with group numbers. Individuals who drew the number “1” were assigned to the first group, and those that drew the number “2” were assigned to the second group.

Table 1. Intergroup comparison of players in terms of basic statistics.

	Experimental Group (n = 43)	Min.	Max.	Control Group (n = 47)	Min.	Max.	p-Value
Age [years]	12.5 ± 2.2	10.0	17.0	12.4 ± 2.1	10.0	17.0	0.8
Weight [kg]	44.4 ± 9.5	27.3	61.9	43.8 ± 12.4	26.3	78.1	0.8
Height [cm]	155.3 ± 11.5	135.0	176.0	155.8 ± 14.2	125.0	185.0	0.9
BMI [kg/m ²]	18.2 ± 2.3	14.7	24.4	17.6 ± 2.5	13.6	24.9	0.3
Years of training [years]	4.9 ± 2.2	2.0	10.0	4.9 ± 1.9	2.0	9.0	0.9
Number of training days per week [days]	2.5 ± 0.5	2.0	3.0	2.5 ± 0.5	2.0	3.0	1.0

Legend: n—number of competitors in a given group, Min—minimum, Max—maximum, BMI—body mass index, and p—statistical significance $p < 0.05$.

2.5. Blinding Procedures

The experiment involved four independent physiotherapists who were responsible for conducting a full set of tests before and after the 10-week experimental period. The physiotherapist who performed tests at the baseline also performed the same tests after a period of 10 weeks. After 10 weeks, all participants were tested in the same order as at baseline. Thus, the people assessing the outcomes were blinded to the athlete's allocation (experimental or control) and had no knowledge regarding the purpose of the study.

2.6. Outcome Measures

2.6.1. Y Balance Test (Y-BT)

The Y-BT involves the use of a central plastic stand, wherein three tubes are placed in three directions (anterior, posterolateral, and posteromedial directions) [30]. Each tube has a movable pointer indicating the measurement's accuracy to 0.5 cm. Each subject started the test with their dominant lower limb, always in the same order (direction): anterior, posterolateral, and then posteromedial. The recommendations of Linek et al. [31] were followed (the completion of four training trials and then five measurement trials). This procedure's reliability (ICC_{3,1}) was between 0.66 and 0.82 for all directions in adolescent footballers. The result was not recorded if the subject lost their balance during the trial, pulled a lower limb away from the central stance, pulled their hands away from the hip plates, or touched the ground while returning to the starting position. The relative length of the lower limb (anterior superior iliac crest–medial ankle) was also measured using centimetre tape to calculate the distance value according to the following formula: (distance obtained in the test/relative length of the lower limb) × 100 [25].

2.6.2. Stabilometric Platform—ALFA

The balance test was performed on a stabilometric platform—ALFA (Technomex)—consisting of a stationary base measuring 55 × 55 cm. The platform has four load cells with a sampling rate of 62 Hz. The platform software collects a raw signal and subsequently converts it into a digital format, displaying it on the screen. A static test with a duration of 30 s was performed with the participants' eyes open and closed. Each subject began the test by placing their bare feet parallel to the platform with a distance of 10 cm measured from the head of the metatarsal bone to the midline of the platform, while the lateral ankles were placed on a perpendicular line dividing the platform into two halves, running 15 cm from the posterior edge of the platform; each subject's arms were kept down along the body.

For the static balance assessment, the subjects were instructed to hold an upright position, with their eyes directed straight ahead (focusing on a point marked on the wall) and remaining standing still. An open-eye test was performed; then, at the examiner's instruction, the athlete would close their eyes and the closed-eye test was performed. After the tests (with the participants' eyes open and closed) were conducted for a duration of 30 s

each, the subject left the platform. The following parameters were used for further analysis: path length (eyes open and closed) and surface area (eyes open and closed).

2.6.3. Agility Test

Each athlete completed an obstacle course (Figure 2), which was used to assess the athletes' agility. Each athlete was required to complete the obstacle course as fast as possible. Time began when the athlete crossed the starting line and stopped when they crossed the finishing line and was measured to the nearest 0.01 s [32]. Each subject completed the obstacle course twice; the average score from both trials was recorded and used for further analysis. The interval between attempts to complete the obstacle course was two minutes.

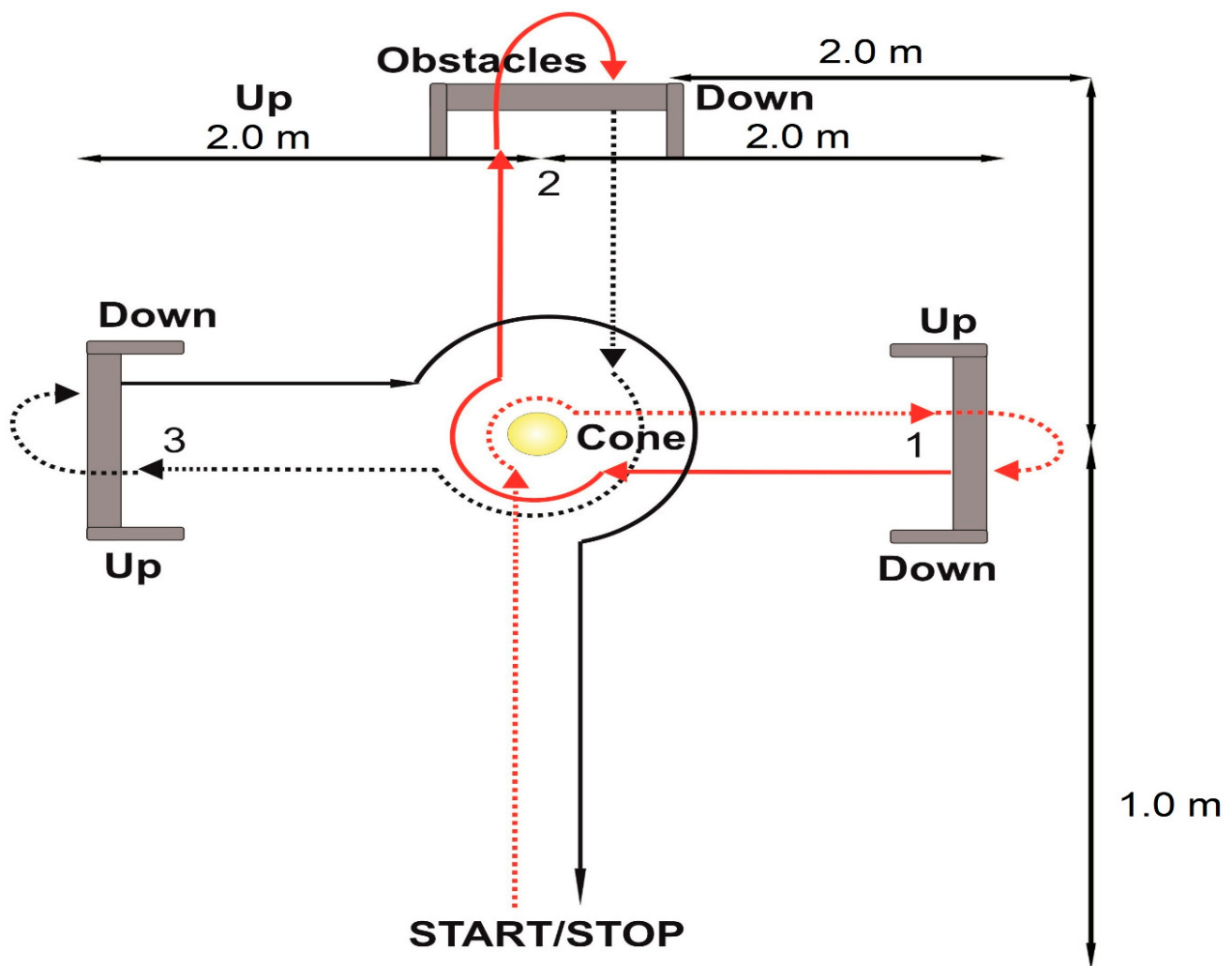


Figure 2. Agility test—the track used in the study.

2.7. Intervention

Subjects in the experimental group were required to adhere to a strict schedule of engaging in the test two days per week and 45 min before the regular football-training session conducted at the local sports club. The experienced physiotherapist monitored attendance at sessions by collecting information regarding participation in exercises and correctness of the exercises performed. Participants in the experimental group were divided into subgroups of five participants before the first session (at a given time or on a given day). Within a single exercise unit, each subgroup performed five body-balance exercises, with each exercise performed in four series of eight repetitions (the break between series was 10 s). The exercises took place in a separate room ("the gym"). Each day, a member of

each group drew lots to determine which exercise (from which station) they would conduct on a given day (Figure 3). Each time before starting the sensomotor exercises, the subjects in the experimental group performed a 10 min warm-up on a Kettler stationary bike (S line 7682).

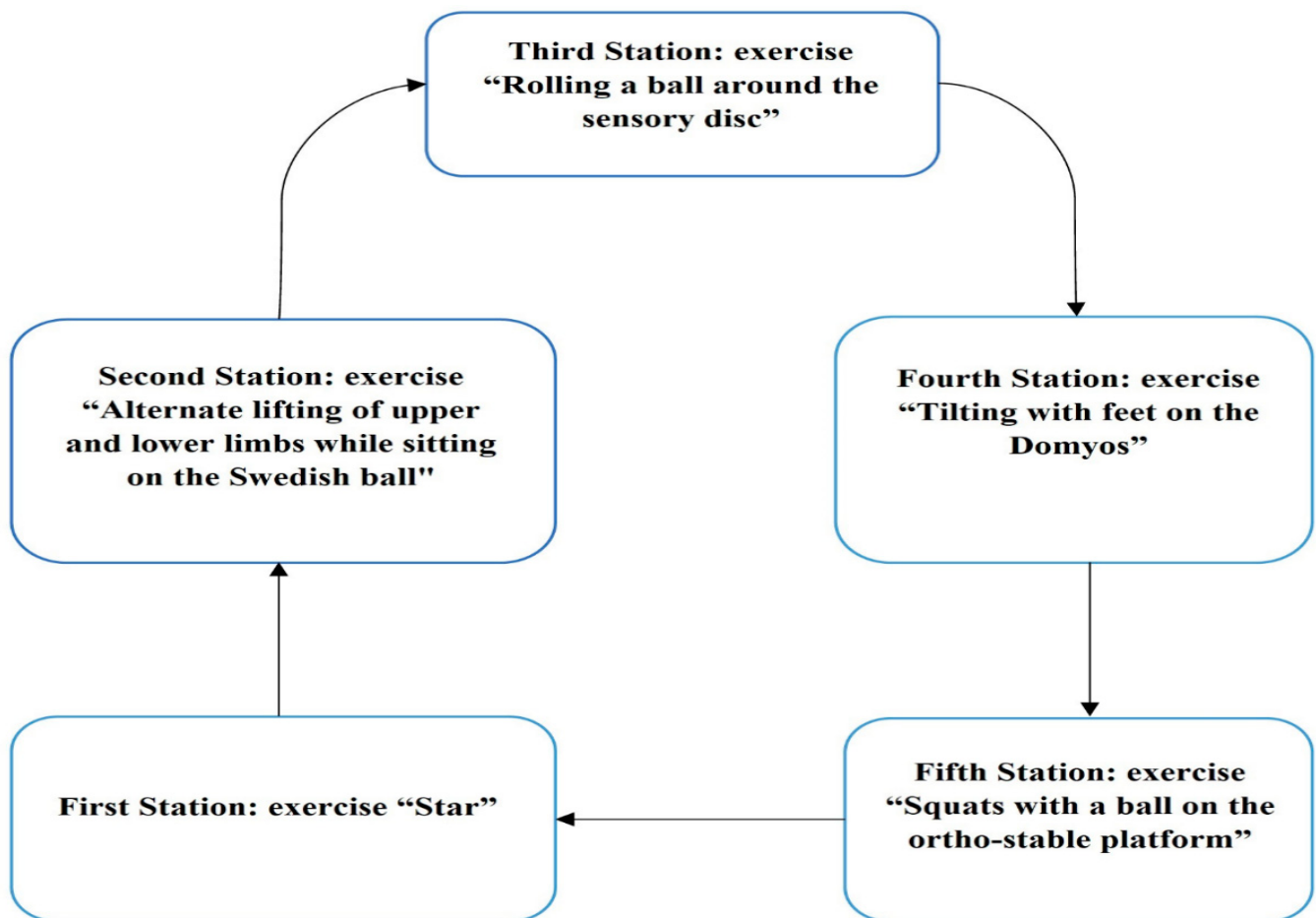


Figure 3. Diagram showing the location of the stations and the direction of movement of the exercising participants.

In contrast, participants in the control group arrived at times agreed upon with the trainer and participated along with the experimental group in regular football training conducted at a sports club. The athletes in the control and experimental groups were asked to abstain from performing any additional movements or engaging in any sport or training activities that they did not habitually carry out in the period up to the beginning of the experiment (in order to conduct the baseline measurements). The following sensomotor exercises were introduced:

(1) First exercise—"star" (Figure 4A):

Starting position: First, the exerciser stands first with their right (with their left later on) foot in the middle of the four lines connecting and marking the "star"; in this starting position, the arms are left to hang alongside the torso.

Exercise action: While performing the exercise, the exerciser's arms are on their hip plates and the exerciser moves the other lower limb as far as possible along the eight individual vertices of the star (forward, and then back to the centre; diagonally forward without crossing the body, and then back to the centre; sideways without crossing the body, and then back to the centre; backwards diagonally without crossing the body, and then back to the centre; backwards diagonally crossing the body, and back to the

centre; sideways behind the supporting limb by bringing it outside the body's centre line, and back to the centre; and forward diagonally in front of the supporting limb, and then returning to the centre). While performing the exercise, the exerciser could not detach their lower limb from the apex of the star or place their lower limb performing the movement on the ground.

- (2) Second exercise—alternate lifting of upper and lower limbs while sitting on a Swedish ball (Figure 4B):

Starting position: The exerciser sits on the Swedish ball and maintains their balance; there are sensory cushions under the exerciser's feet, their arms are positioned alongside the torso, and the exerciser's back is straight.

Exercise: The exerciser lifts their right arm and simultaneously raises their left foot off the cushion to a height of approximately 20–30 cm. The exerciser then changes limbs each time (alternate movements). The exerciser must not lose body balance while performing the exercise and must position their other leg on the ground (next to the sensory disc).

- (3) Third exercise—rolling a ball around a sensory disc (Figure 4C):

Starting position: The exerciser stands with their right foot (the left afterwards) on the sensory disc, with their arms are on the hip plates, their left leg (later the right) in an abducted position (20–30 degrees), gazing forward, and keeping their back straight, while a ball is placed under the left foot.

Exercise: The exerciser performs a slow movement consisting of rolling the ball around the disc while keeping their foot on top of the ball. The task of the exerciser is to maintain body balance during the exercise and to control the movement of the ball around the sensory disc.

- (4) Fourth exercise—tilting with feet on the Domyos (Figure 4D):

Starting position: The exerciser lies on their back, their arms are positioned alongside the torso, the knees are bent 90 degrees, the feet are placed on the "Domyos" balance platform, and the back is against the ground.

Exercise: The exerciser lifts their hips and bends their disc with their feet forward, maintaining this position for 3 s; then, the exerciser performs the same exercise on the left and right sides for 3 s each side. The exerciser must maintain body balance while performing the exercise and is not allowed to take their feet off the balance platform.

- (5) Fifth exercise—squats with a ball on the ortho-stable platform (Figure 4E):

Starting position: The exerciser stands on the ortho-stable platform with their feet slightly apart while holding a ball in their hands. The exerciser's arms are bent at the shoulders at 90 degrees, and their elbows are straightened.

Exercise: The participant performs a series of "squats" while keeping their body balanced and maintaining an arm angle at 90 degrees with their elbows straight. While performing the exercise, the exerciser may not leave the platform or release the ball from their hands.

2.8. Statistical Analysis

Statistical analysis was performed using Statistica (ver. 13.3) and MS Excel (Microsoft Office 2016). Descriptive statistics included calculating the mean and standard deviation for each quantitative variable with independent samples *t*-test. The other outcomes were verified using the Shapiro–Wilk test. Due to the lack of normality for all variables, median, standard error (SE), and interquartile range (Q) with non-parametric statistics were used. The non-parametric Mann–Whitney U and the Wilcoxon pairwise rank tests were used for independent and dependent samples, respectively (*p*-values <0.05 were considered significant).



Figure 4. Introduced sensorimotor exercises: (A)—exercise one: “star”, (B)—exercise two: alternate lifts of upper and lower limbs while sitting on a Swedish ball, (C)—exercise three: rolling a ball around the sensory disc, (D)—exercise four: tilting with lower limbs on Domyos, and (E)—exercise five: squats with a ball on an ortho-stable platform.

3. Results

3.1. Participants

Initially, the experimental and control groups consisted of an equal number of participants ($n = 55$). The reasons behind the participants' inclusion and exclusion are shown

in Figure 1. In the final analysis, 43 and 47 athletes were used in the experimental and control groups, respectively. Thus, 21.8% and 14.5% participants were excluded during the experiment in the experimental and control groups, respectively. The groups showed no statistically significant difference in terms of the baseline anthropometric data (Table 1). The experimental group performed 20 additional sensomotor exercise sessions, 40 athletes participated in all sensomotor exercise sessions, and 3 athletes missed one exercise session each due to school obligations.

3.2. Stabilometric Platform

The data in Table 2 show statistically significant differences in the final test between the experimental and control groups for the following variables: path length, eyes open, 30 s; area, eyes open, 30 s. There was a statistically significant difference with respect to all the variables between the first and second tests in the group participating in sensomotor exercises. The experimental group showed improvement in terms of the following variables: path length—eyes open for 30 s improved by 5.3 cm (mean: 20.0; 95% CI 15.3–24.8); area—eyes open for 30 s improved by 1 cm² (mean 2.1; 95% CI 0.6–3.5); and area—eyes closed for 30 s improved by 0.4 cm² (mean 2.2; 95% CI 1.6–2.8). In addition, both groups showed improvement in performance on the final examination for the following variables: path length—eyes closed for 30 s by 8.4 cm (mean 27.2 95% CI 23.0–31.4) for the experimental group and by 4.8 cm (mean 30.2 95% CI 27.0–33.4) for the control group. There was no statistically significant improvement in any other variables in the control group.

3.3. Y-BT

Analysis of the data in Table 3 revealed statistically significant differences in the final examination between the experimental and control groups with respect to the following variables: left leg anterior; right and left leg anterior; left leg posteromedial; and total Y test score. Both groups showed improvement between the first and final scores regarding the posteromedial variable (experimental by 6.0% (mean 112.0; 95% CI 96.7–100.9) and control by 1.7% (mean 107.2 95% CI 104.2–110.3)). Additionally, the experimental group achieved statistically significant improvement in the final score for the following variables: left leg anterior by 2.1% (mean 73.1; 95% CI 70.7–75.2); right leg posterolateral by 3.8% (mean 112.3; 95% CI 109.3–115.3); right and left leg posteromedial by 5.6% (mean 111.7; 95% CI 108.6–114.9) and 5.7% (mean 112.3; 95% CI 109.7–115.1), respectively; medium posterolateral by 3.2% (mean 111.8; 95% CI 109.0–114.7); medium posteromedial by 6.0% (mean 112.0; 95% CI 109.2–115.0); and Y total score by 3.5% (mean 98.8; 95% CI 96.6–100.9).

3.4. Agility Test

The data in Table 4 show a statistically significant difference between the groups in the final examination. In addition, the participants in the experimental group improved their scores on the final test by 1.6 s (mean 13.2; 95% CI 12.6–14.0).

Table 2. Effects of a 10-week program of sensorimotor exercises on the results of the static test—stabilometric platform.

		Experimental Group (n = 43)		Control Group (n = 47)		Experimental Group Pre/Post Training <i>p</i> -Value	Control Group Pre/Post Training <i>p</i> -Value	Experimental/Control Group Pre-Training <i>p</i> -Value	Experimental/Control Group Post-Training <i>p</i> -Value
		Me ± SE	Q	Me ± SE	Q				
Track Length— eyes open 30 s [cm]	Pre-training	22.8 ± 0.4	16.3–30.0	25.4 ± 0.2	16.5–31.9	0.001 ***	0.1	0.2	0.003 **
	Post-training	15.8 ± 0.4	13.4–20.6	20.7 ± 0.2	16.5–26.4				
Surface Area—eyes open 30 s [cm ²]	Pre-training	1.5 ± 0.2	0.8–2.9	1.4 ± 0.1	0.9–2.6	0.001 ***	0.6	0.8	0.02 *
	Post-training	1.0 ± 0.1	0.7–1.7	1.6 ± 0.1	1.0–2.6				
Track Length— eyes closed 30 s [cm]	Pre-training	32.2 ± 0.5	22.6–43.5	33.1 ± 0.3	24.2–42.7	0.001 ***	0.001 **	0.8	0.1
	Post-training	24.9 ± 0.4	19.4–32.5	29.4 ± 0.3	22.4–38.7				
Surface area—eyes closed 30 s [cm ²]	Pre-training	1.8 ± 0.3	1.2–3.0	2.1 ± 0.1	1.4–4.1	0.01 **	0.1	0.3	0.2
	Post-training	1.7 ± 0.1	0.9–3.1	2.2 ± 0.1	1.3–3.9				

Legend: n—number of players in a given group, *—statistical significance $p < 0.05$, **—statistical significance $p < 0.01$, ***—statistical significance $p < 0.001$, Me—median, SE—standard error, and Q—interquartile range.

Table 3. Effect of a 10-week sensorimotor exercise program on the results of Y-BT.

		Experimental Group(n = 43)		Control Group (n = 47)		Experimental Group Pre/Post Training <i>p</i> -Value	Control Group Pre/Post Training <i>p</i> -Value	Experimental/Control Group Pre-Training <i>p</i> -Value	Experimental/Control Group Post-Training <i>p</i> -Value
		Me ± SE	Q	Me ± SE	Q				
Y-Anterior Right [%]	Pre-training	72.5 ± 0.2	66.3–76.6	71.8 ± 0.1	67.9–75.6	0.5	0.6	0.7	0.5
	Post-training	71.5 ± 0.2	69.5–76.4	71.2 ± 0.2	67.1–76.2				
Y-Anterior Left [%]	Pre-training	71.3 ± 0.1	65.7–76.5	70.9 ± 0.1	67.4–75.4	0.02 *	0.2	0.9	0.04 *
	Post-training	72.6 ± 0.2	68.3–78.6	69.9 ± 0.2	65.9–75.2				
Y-Posterolateral Right [%]	Pre-training	109.9 ± 0.3	100.6–115.0	109.3 ± 0.3	102.0–114.7	0.01 *	0.5	1.0	0.1
	Post-training	111.2 ± 0.3	107.2–116.0	108.3 ± 0.3	102.1–114.8				
Y-Posterolateral Left [%]	Pre-training	108.6 ± 0.3	101.2–118.0	107.9 ± 0.2	102.8–113.2	0.1	0.8	0.6	0.3
	Post-training	111.4 ± 0.3	104.6–115.6	108.6 ± 0.3	101.6–115.1				

Table 3. Cont.

		Experimental Group(n = 43)		Control Group (n = 47)		Experimental Group Pre/Post Training <i>p</i> -Value	Control Group Pre/Post Training <i>p</i> -Value	Experimental /Control Group Pre-Training <i>p</i> -Value	Experimental /Control Group Post-Training <i>p</i> -Value
		Me ± SE	Q	Me ± SE	Q				
Y-Posteromedial Right [%]	Pre-training	105.0 ± 0.3	99.6–113.5	107.1 ± 0.2	98.6–110.6	0.001 **	0.1	0.7	0.04 *
	Post-training	111.8 ± 0.3	107.0–116.1	107.3 ± 0.3	99.6–114.2				
Y-Posteromedial Left [%]	Pre-training	107.1 ± 0.2	99.6–112.9	106.4 ± 0.2	99.3–111.7	0.0001 ***	0.1	0.7	0.001 **
	Post-training	110.3 ± 0.3	108.1–116.7	108.5 ± 0.3	100.6–114.2				
Y-Anterior—Medium [%]	Pre-training	71.7 ± 0.1	66.2–75.5	71.3 ± 0.1	67.6–75.1	0.4	0.2	0.7	0.2
	Post-training	72.0 ± 0.2	68.4–76.2	70.8 ± 0.2	67.0–74.5				
Y-Posterolateral Medium [%]	Pre-training	109.2 ± 0.2	102.8–113.4	107.9 ± 0.2	101.8–113.5	0.02 *	0.8	0.8	0.2
	Post-training	110.1 ± 0.2	106.0–115.8	108.4 ± 0.3	102.2–114.8				
Y-Posteromedial Medium [%]	Pre-training	106.7 ± 0.2	99.4–113.1	105.4 ± 0.2	98.5–110.6	0.0001 ***	0.03 *	0.6	0.02 *
	Post-training	111.6 ± 0.2	106.1–116.9	106.6 ± 0.3	99.5–113.9				
Y-Total Score [%]	Pre-training	95.9 ± 0.2	89.9–101.5	94.8 ± 0.2	91.3–98.9	0.0003 ***	0.3	0.7	0.04 *
	Post-training	98.3 ± 0.2	94.7–101.6	95.4 ± 0.2	88.9–100.9				

Legend: n—number of players in a given group, *—statistical significance $p < 0.05$, **—statistical significance $p < 0.01$, ***—statistical significance $p < 0.001$, Me—median, SE—standard error, and Q—interquartile range.

Table 4. Effect of a 10-week sensorimotor exercise program on agility.

		Experimental Group (n = 43)		Control Group (n = 47)		Experimental Group Pre/Post Training <i>p</i> -Value	Control Group Pre/Post Training <i>p</i> -Value	Experimental /Control Group Pre-Training <i>p</i> -Value	Experimental/Control Group Post-Training <i>p</i> -Value
		Me ± SE	Q	Me ± SE	Q				
Agility test (s)	Pre-training	14.2 ± 0.1	13.5–16.6	14.4 ± 0.1	13.2–15.5	0.001 ***	0.2	0.7	0.04 *
	Post-training	13.0 ± 0.1	11.5–15.2	14.2 ± 0.1	12.5–15.3				

Legend: n—number of players in a given group, *—statistical significance $p < 0.05$, ***—statistical significance $p < 0.001$, Me—median, SE—standard error, and Q—interquartile range.

4. Discussion

The main aim of this study was to evaluate the effects of a 10-week sensomotor exercise programme on the body balance and agility of adolescent football players. The results showed that additional sensomotor exercises improved body balance and agility. Therefore, it seems reasonable to implement such exercises as a part of training.

Analyses of other studies evaluating the effects of additional sensomotor exercises (described as neuromuscular) on the Y-BT showed similar conclusions [33,34]. Some similarities regarding the intervention are seen between the present experiment and other works, which likely contribute to their similar results: the intervention was implemented twice per week before the regular training session and included exercises on one foot using an unstable surface. In studies by Benis et al. [33] and Alyson et al. [34], female basketball (mean age 20.1 years) [33] and football (mean age 15.1 years) [34] players were selected for the experiment, and additional neuromuscular exercises were introduced for eight weeks. Nevertheless, these authors obtained similar results to the present study, for which the intervention lasted two weeks longer.

Opposite results to those in the present study were obtained by Sato and Moka [35], where no improvement in SEBT test scores (an earlier version of the Y-BT) was observed after the introduction of a six-week stabilisation exercise programme in a group of adult runners. This may be due to one of several reasons. Sato and Moka [35] studied runners, whereas in the present experiment the examined group was football players. Each sport discipline is characterised by typical movement patterns [36,37]. Thus, it can be assumed that the effect of specific exercises on athletes' performance will vary based on the represented discipline.

With regard to the stabilometric parameters, the additional sensomotor exercises introduced in the present experiment for a period of 10 weeks improved the COP (Center of Pressure) value in the 30 s open-eye test. Such results are consistent with other reports [38,39]. Imai et al. [38] and Gioftsidou et al. [39] found improved COP values after 12-week programmes of additional stabilisation [38] and balance [39] exercises prior to regular training in a group of adolescent football players. In the current experiment, no significant improvement in the COP parameter with the closed-eye trial was achieved. Opposite results were obtained by Pau et al. [40] in a study on adolescent volleyball players (mean age 13.2). Unfortunately, we did not find any studies assessing the effects of sensomotor exercises on the COP value in a 30 s closed-eye test in adolescent footballers.

Interestingly, in the present study, the sensomotor exercises only improved the COP value for the footballers in the 30 s open-eye test. The exclusion of visual control (closed-eye test) as one of the main senses contributes to changes in the central nervous system's precision and postural control (after visual exclusion) [41]. Thus, the area of sway with a participant's eyes opened is unlikely to reflect the postural control mechanisms that were improved after sensomotor exercises [42]. Improvements in neuromuscular and sensomotor function associated with sensomotor exercises help to reduce postural sway to a smaller area and with a lower speed of movement and, subsequently, reduce the need for large postural corrections. The sensomotor exercises introduced were performed without closed-eye tests, which may have indirectly contributed to the lack of improvement in the COP parameters achieved with closed eyes. It may be that the sensomotor exercises excluding visual control would trigger greater compensatory components of the other organs affecting body balance among the young football players and enable improvements in the COP parameters during the closed-eye tests.

In the present study, the athletes who underwent 10 weeks of sensomotor training showed significant improvements in track time on the agility test. Makhoul et al. [6] implemented plyometric exercises combined with balance exercises and plyometric exercises combined with agility exercises for a period of eight weeks (twice per week) in a group of young football players, and they obtained improvements in agility in both groups. Other researchers have replaced the routine warm-up among adolescent football players with programmes based on the FIFA 11 programme [43] and neuromuscular exercises [44].

Although these programmes varied in terms of the duration and form of the exercises applied, they all improved agility within the groups of adolescent football players. All these reports [6,43,44] are consistent with our study results.

It is also worth mentioning the limitations of the present study. The experiment involved individuals who had been practicing football for a minimum of two years. Furthermore, they were recruited from a single football academy, and, despite their assurance, there was no control of their participation in other activities (with the exception of sensomotor exercises and regular football training). Additional sensomotor exercises (due to the specificity of the sport and the number of participants) were applied in a “station” form, and the number of repetitions was the same for each age group. The exercises did not include an age (younger vs. older athlete) classification and did not include a gradation from easy to difficult. This could affect the correctness of the exercises performed. Puberty age was not assessed in the study group, and the wide age range of 10–17 years suggests that the participants were at different stages of puberty (before, after, and during). The study included only young male football players; therefore, the results obtained should not be freely applied to women or adolescents practicing other sports.

5. Conclusions

A 10-week programme of additional sensomotor exercises improved selected parameters determining balance and agility in young football players. It worth noting that the intervention used in the present study is easily accessible and does not require any sophisticated devices. Additionally, this intervention allows for applications of these exercises to a large group of athletes simultaneously.

Author Contributions: Conceptualization, D.S. and P.L.; methodology, D.S. and P.L.; software, D.S. and P.L.; validation, D.S., P.L. and formal analysis, D.S.; investigation, D.S. and P.L.; resources, D.S. and P.L.; data curation, D.S.; writing—original draft preparation, D.S. and P.L.; writing—review and editing, D.S. and P.L.; visualization, D.S.; supervision, D.S. and P.L.; project administration, D.S. and P.L.; funding acquisition, D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. The study was fully funded by the Team of Biomedical Basis of Physiotherapy, The Jerzy Kukuczka Academy of Physical Education in Katowice.

Institutional Review Board Statement: The study was designed in accordance with the Declaration of Helsinki and approved by the local medical ethics committee (Ethics Approval number: 4/2017).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors thank the participants for their time, and the coaches and staff at their clubs for helping with the recruitment of players and logistics in carrying out the project.

Conflicts of Interest: There are no conflict of interest in the present study and the study was not funded by any external bodies.

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