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Relationship between balance and running tests in adolescent football players

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Abstract
Introduction. **Football is a sport that requires a variety of motor skills during both high- and low-intensity efforts. Motor abilities such as speed, endurance and balance are crucial in adolescent football players; it is likely that performance on individual tests assessing each motor ability should show some relationships.** Aim of Study. **The aim of this study was to examine the relationship between balance and running tests in adolescent football players.** Material and Methods. **Fifty adolescent male football players (mean age: 16.6 ± 0.5 years) who had been training football were included in the study. The study was conducted over the period of three consecutive training days. All athletes underwent measurements on the stabilometric platform, Y-Balance Test (Y-BT), speed test, and endurance (beep) test.** Results. **There were significant correlations between the speed test (measured on 5 m, 10 m, 30 m) and the anterior direction reach distance for right limb ($R = -0.45$, $p < 0.001$; $R = -0.59$, $p < 0.001$; $R = -0.44$, $p = 0.001$), left limb ($R = -0.43$, $p = 0.001$; $R = -0.57$, $p < 0.001$; $R = -0.45$, $p = 0.001$) and anterior direction mean score ($R = -0.44$, $p = 0.001$, $R = -0.57$, $p < 0.001$, $R = -0.45$, $p = 0.001$). The following stabilometric measurement track length (eyes open 30 s) was correlated with speed measured at 5 m ($R = 0.78$, $p < 0.001$), at 10 m ($R = 0.68$, $p < 0.001$) and at 30 m ($R = 0.67$, $p < 0.001$). There was also a negative correlation between the total number of completed 20 m repetitions in endurance test and the posteromedial direction in the Y-BT on the left ($R = -0.33$, $p = 0.02$).** Conclusions. **Adolescent football players show moderate to very strong correlations between balance parameters (static and dynamic) and linear speed. The results of the present study point to the need for further research into the role of balance training in the development of some motor skills like endurance or speed.**

Keywords: balance, endurance, speed, adolescent football.

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Introduction

Football requires a variety of motor skills during both high- and low-intensity efforts [35]. Undoubtedly, speed and endurance performance are crucial in football [9]. Speed skills translate into game dynamics, which contributes significantly to goal scoring [31]. The endurance allows players to maintain their efficiency from the first to the last minute of the game, which can directly influence the result of the match [17, 28].

The ability to decelerate and accelerate as well as to change direction during a football match is related to the overall balance of the body [19]. Both static and dynamic balance are important in complex movements in football, allowing adaptation to changing conditions on the pitch as well as to team tactics [2, 14]. Therefore, balance seems to be important in adolescent football players [37, 38], as a high level in professional sport is related to motor skills at a young age [19]. Balance plays a crucial role in the optimal functioning of athletes [13, 32]. The proper functioning of the body's balance system depends on the coordination of multiple sensory inputs, including the vestibular system, vision, and proprioception. Disruptions in any of the systems responsible for maintaining balance can lead to loss of balance and increase the risk of injury in athletes [33]. Additionally, researchers have shown that football players' loss of balance is affected not only by environmental factors such as the type of ground, fatigue, exhaustion [43, 44] but also by psychological aspects accompanying players during sport [40].

Nowadays, researchers attach increasing importance to exercises aimed at improving body balance [6, 39]. Most often, such exercises are thought to reduce the risk of injury [8], because it was shown that poor balance ability is significantly associated with an increased risk of injury such as ankle sprain [20, 30] and anterior cruciate ligament injury [16]. Furthermore, football players with impaired balance are more prone to contact and non-contact injuries due to a lower ability to avoid collisions and absorb impact forces [22]. Adirim and Cheng [1] suggested that the highest risk of balance-related injuries occurs during adolescence (13-18 years), as rapid body growth disrupts postural control and lower limb stabilisation mechanisms. This justifies the need to pay special attention to this age group.

Balance exercises are also thought to improve sports performance [39]. However, the available literature shows conflicting results regarding the association between speed, endurance and balance in football players. Çakmak et al. [7] showed no relationship between speed, endurance and balance in adolescent female football players. In contrast, such a relationship was confirmed in adult football players [27]. However, it is worth noting that some movement patterns are different between male and female athletes, which ultimately translates into cross-gender differences in the degree of association between selected motor abilities [26, 41]. From this perspective, it can be assumed that the relationship between speed, endurance and balance may be related to the gender of the examined athletes. Given that there are no studies in the literature identifying the degree of association between speed, endurance and balance in adolescent male football players (to date, studies have only included adolescent female football players), it has been decided to investigate this in the present study. Such analysis may contribute to designing more adequate forms of training, as well as enhancing the skills needed adolescent football players. If we assume that motor abilities such as speed, endurance and balance are crucial in adolescent football players, it is likely that performance on individual tests assessing each motor ability should show some relationships.

Aim of Study

The aim of this study was to evaluate the relationship between speed, endurance and balance in adolescent football players.

Material and Methods

Participants and venue

The study was conducted at the Sports and Recreation Centre in Będzin. The study was approved by the local ethics committee (Decision No. 3/2015); all parents/legal guardians were informed verbally as well as in writing about the entire study procedure and gave written consent to the study. Fifty teenage male football players aged 16-17 who had been training football for a minimum of five years at the Zagłębie Sosnowiec Football Academy and the Sports and Recreation Centre in Będzin, were qualified for the study (Table 1). The primary eligibility criteria for the study were: a) obtaining a minimum score on each question in the Oslo Sport Trauma Research Centre Questionnaire (OSTRC), which was tantamount to full participation in training units [11], and b) no injury excluding for more than one week from the training units in the last four months prior to the study.

The study was conducted over three consecutive training days. On the first day, all participants started

Table 1. Basic data of the population studied

	Football players (n = 50)			
	Mean ± SD	Median	Min.	Max.
Age [years]	16.6 ± 0.5	17.0	16.0	17.0
Weight [kg]	63.6 ± 12.2	64.2	37.2	86.0
Height [cm]	175.8 ± 9.1	176.0	144.0	194.0
BMI [kg/m^2]	20.4 ± 2.7	20.4	14.5	26.5
Years of training	8.0 ± 1.3	8.0	5.0	12.0

Note: BMI – body mass index, n – number of participants, min. – minimum, max. – maximum, SD – standard deviation with measurements on the stabilometric platform and then performed the Y-Balance Test (Y-BT). On the next day, the participants performed a speed test; and on the last day of the study, an endurance test (beep test) was conducted. Before each test, the participants performed a 20-minute warm-up on a Kettler recumbent exercise bike (S line 7682).

Stabilometric platform

The test was carried out on an Alfa stabilometric platform (Technomex) consisting of an immobile stand measuring 55 × 55 cm. The platform has four strain gauge sensors, and its sampling frequency is 62 Hz (hertz). The Alfa is PC-compatible and has software for data capture and processing. Its software receives the raw signal and then converts it into a digital form which is displayed on the screen. Each of the players started the test by placing their bare feet parallel on the platform with a distance of 10 cm measured from the head of the first metatarsal bone to the midline of the platform; the player's upper limbs were kept by their side. During the static balance assessment, the participant assumed an upright position, gaze directed straight ahead (a point marked on the wall) and stood still. An open-eye test with a duration of 30 seconds was performed. The length of the path taken by the centre of pressure (COP) and the area in which the COP moved were assessed.

Y-Balance Test

The Y-BT [25] was used in the study. The Y-BT consists of a central stand made of plastic and three tubes placed in the anterior, posterolateral and posteromedial directions. A movable indicator is placed on each tube to indicate the accuracy of the measurement to 0.5 cm. Each player started the test with their dominant lower limb with the upper limbs placed on the alas of the ilia. The study subjects performed four test trials followed by five measurement trials, always in the same order (anterior, posterolateral and posteromedial direction), as recommended by Linek et al. [25], this procedure was developed for adolescent football players and showed acceptable reliability ($ICC_{3.1}$ 0.66–0.82 in all directions). A score was not recorded if the player touched the ground during the test, pulled the foot away from the central stand, lost balance, or pulled the upper limbs away from the alas of the ilia. After the test was completed on the therapy table, the relative length of the lower limb (anterior superior iliac spine – medial ankle) was measured in each player using a tape measure. The normalised score of each player, calculated according to the formula (distance achieved in the test/relative length of the lower limb)*100 [25], was considered for further analysis. Composite reach distance was also calculated as the sum of the three reach directions divided by three times limb length, and then multiplied by 100 [34].

Sports tests

The tests were carried out on an artificial turf pitch; the measurements were taken using the Witty System photocells (Microgate Bolzano, Italy). The wireless technology allows measurement with an accuracy of 0.01 seconds. To enable data collection and presentation of the results, the Witty System utilises the Witty Manager software (version 1.14.32 Microgate Bolzano, Italy), which is compatible with PCs [3].

Speed test

Each player covered a distance of 30 metres (from the start line to the finish line) between the photocells in a straight line. The player's start was from the run-up; the distance between the start line and the first measuring gate was 5 metres. The player's task was to cover the distance in the shortest possible time. The time was switched on when the player passed the start line and further measurements were taken at 5 m, 10 m and 30 m. The time was stopped when they passed the finish line (30 m). Each player covered the 30 m distance twice, and the average score from both trials was recorded [3, 5].

Progressive multi-stage 20 m shuttle run (beep) test

The protocol used for the progressive, multi-stage 20 m shuttle run (beep) test was a commonly used modification of this test [4, 15, 36] developed from the original presented by Léger and Lambert [23]. The players ran back and forth ("shuttle") between photocells placed 20 metres apart. The initial speed was 2.22 $m\text{-}s^{-1}$ for 1 minute. At the end of the first minute, the speed increased to 2.5 $m\text{-}s^{-1}$ and progressively increased by 0.14 $m\text{-}s^{-1}$ each subsequent minute. The speed was dictated by the audible beeps from the pre-recorded audio, which was checked for accuracy prior to testing. Each minute stage (level) consisted of multiple "shuttles", the number of which depended on the speed of the test stage. The players were instructed to run at the speed of the sound signals for as long as possible. When the player could no longer keep pace with the beeps (i.e., did not complete two consecutive shuttles in time), the test was terminated. VO_2max (maximal oxygen uptake) was calculated from the maximum speed achieved during the test using the formula

−24.4 + 6.0 × maximal aerobic speed (MAS) [24]. For the purpose of the study, the parameter Total was calculated as the total number of completed 20 m repetitions (during the entire test). A further analysis used the parameters of VO_2max and Total.

Statistical analysis
All statistical analyses were calculated using the statistical package Statistica 13.1 (StatSoft). Basic anthropometric data (mean ± standard deviation, median, minimum and maximum values) were presented for the entire study group. It was decided to assess in the study group the correlations between balance (static and dynamic) and speed (5 m, 10 m and 30 m) and endurance beep tests (Total – number of distances covered, VO_2max). Due to the non-normal distribution in the Shapiro–Wilk test, it was decided to use a nonparametric test (Spearman's rank sum correlation test) where statistical significance was assumed to be $p < 0.05$. Spearman's rank correlation coefficient (R) was interpreted according to Hopkins et al. [18]. An R value of 0 to 0.30 or 0 to −0.30 was considered a weak correlation; 0.31 to 0.50 or −0.31 to −0.50 was a moderate correlation; 0.51 to 0.70 or −0.51 to −0.70 a strong correlation; and 0.71 to 1 or −0.71 to −1 a very strong correlation.

Results

Speed test and balance
The data in Table 2 show that there was a negative moderate correlation between the 5 m and 30 m speed test and the Y-BT anterior direction right, left limb, anterior direction mean score. Moreover, there was a negative strong correlation between the 10 m speed test and the Y-BT anterior direction right, left limb, anterior direction mean score. The other data in Table 2 show no correlation between speed tests and Y-BT results. Table 3 includes data from the stabilometric platform and speed tests: a very strong correlation occurred between track length [cm] – eyes open 30 s and speed measurement at 5 m; a strong correlation between track length [cm] – eyes open 30 s and measurement at 10 m and 30 m. Further analysis of the data in Table 4 indicates that there was a moderate correlation between surface area [cm^2] – eyes open 30 s and speed measurements at 5 m, 10 m and 30 m.

Table 2. Correlation between the Y-Balance Test and speed test results

	5 [m]	p value	10 [m]	p value	30 [m]	p value
Y – Anterior – Right [%]	−0.45*	<0.001	−0.59*	<0.001	−0.44*	0.001
Y – Anterior – Left [%]	−0.43*	0.001	−0.57*	<0.001	−0.45*	0.001
Y – Anterior – Mean [%]	−0.44*	0.001	−0.57*	<0.001	−0.45*	0.001
Y – Posterolateral – Right [%]	−0.02	0.9	−0.03	0.8	−0.15	0.3
Y – Posterolateral – Left [%]	−0.10	0.5	−0.13	0.4	−0.13	0.4
Y – Posterolateral – Mean [%]	−0.03	0.8	−0.06	0.7	−0.14	0.3
Y – Posteromedial − Right [%]	−0.08	0.6	−0.15	0.3	−0.11	0.5
Y – Posteromedial – Left [%]	−0.09	0.5	−0.14	0.3	−0.12	0.4
Y – Posteromedial – Mean [%]	−0.04	0.8	−0.10	0.5	−0.12	0.4
Y – Composite Score [%]	−0.18	0.8	−0.27	0.06	−0.26	0.07

* statistically significant p < 0.05

Table 3. Correlation between the stabilometric platform and speed test results

	5 [m]	p value	10 [m]	p value	30 [m]	p value
Track length [cm] – eyes open 30 [s]	0.78*	<0.001	0.68*	<0.001	0.67*	<0.001
Surface area [cm2] – eyes open 30 [s]	0.41*	0.003	0.33*	0.02	0.38*	0.007

* statistically significant p < 0.05

Table 4. Correlation between the Y-Balance Test and endurance test (multistage 20 m shuttle run) results

	Total	p value	VO_2max	p value
Y – Anterior – Right [%]	0.05	0.7	−0.04	0.8
Y – Anterior – Left [%]	0.02	0.9	−0.04	0.8
Y – Anterior – Mean [%]	0.05	0.7	−0.04	0.8
Y – Posterolateral – Right [%]	−0.09	0.6	−0.13	0.4
Y – Posterolateral – Left [%]	−0.07	0.7	−0.06	0.7
Y – Posterolateral – Mean [%]	−0.07	0.6	−0.09	0.5
Y – Posteromedial – Right [%]	0.02	0.9	0.11	0.4
Y – Posteromedial – Left [%]	−0.33*	0.02	−0.16	0.3
Y – Posteromedial – Mean [%]	−0.15	0.3	−0.02	0.9
Y – Composite Score [%]	−0.11	0.4	−0.09	0.5

* statistically significant $p < 0.05$

Endurance test and balance

The data in Table 4 show that a moderate negative correlation occurred only between the total number of completed 20 m repetitions (Total parameter) and the Y-BT left limb posteromedial direction. The analysis of the data in Table 5 shows that there was no statistically significant correlation between the results of the stabilometric platform and the endurance test.

Table 5. Correlation between the stabilometric platform and endurance test (multistage 20 m shuttle run) results

	Total	p value	VO_2max	p value
Track length [cm] – eyes open 30 [s]	−0.12	0.4	−0.07	0.7
Surface area [cm^2] – eyes open 30 [s]	−0.04	0.8	−0.16	0.3

* statistically significant $p < 0.05$

Discussion

The present study analysed the relationship between balance (static and dynamic) and speed and endurance in adolescent football players. The results showed that there was a moderate to strong correlation between speed tests and dynamic balance. Furthermore, there was a moderate to very strong correlation between static balance and speed tests. Between endurance and balance, a moderate negative correlation occurred only between the total number of completed 20 m repetitions and the posteromedial direction of the Y-BT (left lower limb). The results have shown that adolescent football players presented a relationship only between balance and speed. Thus, there is reason to claim that adolescent football players use slightly different (unrelated) motor skills for balance and endurance assessment tests.

Results of other studies evaluating the relationship between static balance and speed are inconclusive. Çakmak et al. [7] found no significant correlation between static balance and speed in adolescent female football players. The different results obtained between the present study and the results of Çakmak et al. [7] may be related to the gender of the players, as the present study qualified adolescent male football players. Although both groups played the same sport, some studies have suggested that gender may affect the balance test results [26, 41].

The results of this study have also shown a moderate to strong relationship between linear speed and the anterior direction of the Y-BT. Lockie et al. [27] also obtained a strong relationship between dynamic balance and linear speed in adult athletes representing football and rugby. However, some differences in the results between our and the Lockie et al.'s [27] study are worth mentioning at this point. Footballers in the present study have obtained a significant relationship between the anterior direction in Y-BT and speed, whereas in Lockie et al.'s [27] study, a strong relationship occurred between speed and medial and posteromedial directions in Y-BT. This between-study difference may undoubtedly be related to the study tool used. Lockie et al. [27] used the modified Star Excursion Balance Test (SEBT), whereas in this study Y-BT was used. It is known that there are differences in the results obtained between the SEBT and the Y-BT [12], which could have contributed to the difference in the obtained significant correlations.

Analysing the correlation between balance and endurance, it can be seen that there was no statistically significant correlation between the results from the stabilometric platform and the endurance parameters tested. A negative correlation occurred only between the posteromedial direction of the left lower limb and the total number of completed 20 m repetitions in endurance test. Thus, the results obtained show that adolescent football players do not manifest a relationship between balance and endurance. In turn, the negative correlation obtained for the left lower limb in the posteromedial direction of the Y-BT may have at least several reasons. The players were not divided into groups based on the dominant (right or left) lower limb, which may have translated into a negative correlation for one lower limb. The results obtained in the present study are in line with the findings of other researchers who have attempted to assess the relationship between balance and endurance. Marciniak et al. [29] and Çinar-Medeni et al. [10] did not obtain a correlation between balance and VO_2max parameters. It also seems relevant that in the study by Marciniak et al. [29], the subjects were professional firefighters, and in the study by Çinar-Medeni et al. [10] the subjects were orienteering athletes. Thus, it can be assumed that regardless of the type of physical activity or sport practised, there is no relationship between aerobic fitness and balance parameters.

Football is a sport that requires high technical skills, reflected on the pitch in the execution of elements such as passing, aerial duels, dribbling, agility, and shots on goal. All these activities are performed very often on the move at high speed, with contact with the opponent, as well as under changing conditions on the football pitch. Thus, footballers must have the ability to maintain their body position in balance (static balance), to maintain balance during a given movement task, and to regain balance after a given movement task (dynamic balance). While balance is often perceived as maintaining a stable posture, in football, the ability to dynamically shift and regain balance is equally crucial. Motor training coaches are therefore increasingly implementing training programmes that improve postural stability and proprioception and that focus on balance exercises, core muscle strengthening and neuromuscular control. This allows footballers to gain the ability to swing their centre of gravity in a controlled manner and to position their upper and lower limbs accurately during a given movement task [21, 42]. High balance levels consequently allow footballers to control the ball effectively, make quick changes of direction and maintain stability during difficult passes. All of these mechanisms help to reduce injury and improve sports performance.

At this point, the limitations that occurred in this study should also be noted. Male adolescents footballers were only included in the study; thus, the results obtained should not be freely transferable to a group of women or children and adolescents practising other sports or no sport at all. In the group qualified for the study, the dominant and non-dominant limb division was omitted, as well as the position on the pitch, which should be taken into account in future studies. The assessment of static balance took place on a stabilometric platform in a standing position on both lower limbs (open-eye test). In future studies of adolescent football players it is worth considering stabilometric tests on one lower limb and using closed-eye test. In addition, the athletes' endurance was determined indirectly on the basis of a 20 m multistage shuttle run test. Therefore, the result should not be interpreted as a direct measurement of endurance but as an indirect determination of VO_2max. Linear speed was measured, although multidirectional speed is more important in football. Thus, the results should not be comparable to other methods of assessing balance, speed and endurance.

Conclusions

Adolescent football players show moderate to very strong correlations between balance parameters (static and dynamic) and speed. Endurance shows weak correlation with the balance parameters studied in the group of adolescent footballers. The results of the present study point to the need for further research into the role of balance training in the development of motor skills like endurance or speed. At this stage, it is crucial for coaches to integrate balance training into player development programs, as it plays a fundamental role in enhancing motor skills, particularly during the adolescent growth phase.

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Conflict of Interest

The authors declare no conflict of interest.

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