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Laboratory tests and game performance of young soccer players

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Abstract
Introduction. **Results of laboratory tests could be treated as a valuable source of information about players' physical fitness.** Aim of Study. **The purpose of this study was to identify laboratory physical fitness tests that could be useful for predicting competences of 17-year-old soccer players.** Material and Methods. **Selected components of players' physical fitness were assessed and the effectiveness of game performance was evaluated in a group of eighteen young soccer players. The following parameters were measured: anthropometric measurements, anaerobic and aerobic capacity, locomotion speed, explosive strength of the lower limbs, reaction time, and balance.** Results. **The results achieved in laboratory and exercise tests were converted into ranks. An assessment of players' effectiveness in one-on-one games was made using special one-on-one test methodology, and a list of ranked game performances was prepared. On the basis of observations made by three independent experts, the participants were classified according to their "usefulness" for the game using the Game Performance Assessment Instrument (GPAI). The ranking assessment of the effectiveness of one-on-one games and of a classified game was correlated with the results of laboratory tests. It was found that players with the highest scores in locomotion speed tests and in the explosive leg power test were also highly assessed by the experts with regard to the efficiency of their performance in one-on-one games as well as, to a slightly lesser degree, in the classified game. There was no significant relationship between the expert assessment of "usefulness" for the game and other tests.** Conclusions. **On the basis of strength-speed test results we may satisfactorily predict young soccer players' efficiency of game performance.**

KEYWORDS: efficiency of action, physical fitness, soccer, youth, competitive game, one-on-one game.

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What is already known on this topic?
A diagnosis of the player's personal disposition should be conducted within a possibly wide range, since efficient performance in games depends not only on players' sports level but also on their ability to compensate some dispositions with other ones, and on individual performance and cooperation (compensation phenomenon). The previous studies shows that speed skills are the most significant for achieving top results in football.

Introduction

The aim of rationally conducted sport training in team sports games is systematic development of players' situational skills. Effective sport training demands preparation of an ordered sequence of training performances resulting directly from a properly executed performance assessment. Training must be carried out on the basis of systematic, objective and reliable observations of competitions. Only then will setting training tasks for players adequate to their abilities make the improvement of technical-tactical skills and formation of motor skills possible.

In this context, control of the level of selected components of physical fitness is an extremely important issue, and in sports games it is of paramount significance. Regular control and assessment of players' dispositions enable systematic corrections of the training program, and in consequence, decide about the quality of training [1, 2]. Control and assessment of soccer players' performance demand complex research [3, 4]. The aim of this study was to identify laboratory motor tests which could be used for the diagnosis of young soccer players' training.

Material and Methods

Experimental Approach to the Problem

Eighteen young elite soccer players participated in this study. Their mean age was 16.6 ± 0.5 years, and they all had trained systematically for more than seven years (mean training period 8.1 ± 1.5 years). All players participated in a three-year sport training program for talented young soccer players under the auspices of the Polish Football Association.

The experimental procedures took place during the second third of the competitive season (February–March 2012). All the examined soccer players underwent anthropometric measurements and took seven laboratory tests and one field test in two sessions separated by four weeks. The laboratory tests and anthropometric measurements were carried out within three days in the following order: Day 1 – anthropometric measurements, reaction time, balance, anaerobic capacity; Day 2 – anaerobic capacity and explosive strength of the lower limbs with at least two hours' rest interval between both tests; Day 3 – locomotion speed (including endurance speed). The field test was conducted on a grass field during one day, one week after the laboratory tests. All tests and measurements were performed in the morning. The temperature was 20–22°C (lab tests) and 4°–6°C (field test), and relative humidity was no more than 50%. Wind speed on the field did not exceed 0.4 m · s^{-1}. The time interval between the laboratory and field sessions was at least four days. The test–retest reliability for laboratory and field tests was 0.96 and 0.85, respectively. The assessment of performance efficiency in a classified game was made by three independent experts observing the game, and took place during three consecutive matches of the season tournament (within an interval of one week). Inter-observer reliability (ICC) among the examiners was 0.86. Approval of a local IRB and the university scientific board was granted for this study protocol and parental written consent was received prior to all experimental procedures.

All players underwent anthropometric measurements, including body fat assessment. Body height was measured to the nearest 0.1 cm with a portable stadiometer (Model 214, Seca Corp, Hannover, MD, USA), and body mass (including fat mass and percentage) to the nearest 0.1 kg with Tanita scales (model BC-418, Tanita Corp, Tokyo, Japan). Body height ranged from 1.72 to 1.87 m (mean: 1.77 m ± 4.8) and body mass from 52.5 to 73.3 kg (mean: 65.6 kg ± 6.2). The mean BMI for the whole group of participants was 20.9; the percentage of body fat ranged from 2.8% to 12.3% (mean: 7.11% ± 2.6). All players had a slender body build (Rohrer's Index between 1.00 and 1.26).

The examined soccer players performed a battery of tests of general physical fitness in the following areas:

Anaerobic capacity using the Wingate test [5]: Prior to the test the players performed a 10-minute warm-up on a bicycle ergometer (894 E Monark, Sweden) and stretching exercises. A relative load during the 30-second test was equal to 7.5% of body weight. During the tests the participants were verbally encouraged to exercise as much as possible. The maximum power was expressed in W/kg, while the total work was expressed in J/kg of the level of anaerobic capacity. Additionally, the time to reach maximum power (s), duration of maximum power (s), and the rate of power reduction (%) were estimated.

Aerobic capacity [6]: All soccer players performed the maximal exercise test on a treadmill (TM 400 Trackmaster, Carrollton, Texas, USA). The test used a continuous protocol (Table 1). Players warmed-up on the treadmill for three minutes at 8.0 km · h^{-1}.

Table 1. Continuous treadmill protocol

Stage	Speed [km/h]	Grade [%]	Time [min]
1.	8.0	1.0	3
2.	10.0	1.0	3
3.	12.0	1.0	3
4.	14.0	2.0	3
4.	16.0	2.0	3
5.	18.0	2.0	3
6.	20.0	2.0	3

Maximal oxygen uptake and lung ventilation were measured using a breath-by-breath gas analyzing system (Quarkb2, Cosmed Co., Rome, Italy). Before each test, the gas analyzer was calibrated. The following parameters were evaluated: resting heart rate (HR), maximum heart rate (HRmax), exercise duration, maximal oxygen uptake (VO_2max), maximum ventilation (VEmax), the Veto VO_2 ratio, and respiratory frequency (Rf). The VO_2max was considered to be the highest VO_2 measured, when a plateau in O_2 consumption was reported despite an increase in workload. Time to the point of exhaustion was recorded as the test result.

Explosive strength of the lower limbs (countermovement jump) – measurements were carried out on a square mat (0.69 × 0.69 m) connected to a hand-held computer (Globus Ergo Tester, Codognè, Italy). The mat calculates vertical jump height by measuring the time the feet are not in contact with the mat, and from this it calculates explosive leg power. The hand-held computer displays the height and duration of a jump, mean height plus ground time for 10 jumps, and it calculates explosive leg power. The jumps were performed according to the Bosco Protocol (BOSCO), which recommends that a single jump begins with straight legs and with 90° flexion before take-off. Participants were instructed to hold their hands on their hips during all jump assessments and to assume a self-selected foot position. Each participant performed a series of 10 vertical jumps. The mean time of contact with the ground (s), mean time of flight (s), mean jump height (h) and mean mechanical power (W) were determined.

Reaction time with the use of computer tests [7]. This computer test battery is used to study changes in reaction time and the speed of information process. The tasks are designed to be self-explanatory and require the examiner's minimal supervision. This program takes the participant though six different reaction time tests, each of increasing complexity. In its abridged version, four reaction time tests were used: simple reaction time measurement to a visual stimulus, choice reaction time measurement, complex reaction time measurement, and anticipation time measurement. The players performed 10 repetitions of each test for the total of 40 measurements; the average of every 10 measurements was taken into account. Each test involved a participant responding to a random display of visual symbols on the screen and then responding with specified keystrokes based on the type of symbol, relative position and ultimate color. As the task got more complicated, there was a possibility to enter an incorrect keystroke sequence. In such a case the time for the given individual test was disregarded and the test was repeated until 10 successful attempts had been made. The program keeps track of the number of errors and the decision-reaction time for each test error. The computer scores each task using age and sports-specific norms. The complete procedure took approximately 10–15 minutes.

Balance – assessment of functional balance using a posturography system [8]. The test measured the movement of players' center of pressure (COP) within 30 seconds. The assessment of the balance level was carried out with the use of a computer posturographic platform with four tensometric force transducers (model PE 90, Military Institute of Aviation Medicine, Warsaw, Poland). Every player was precisely informed about the kind and performance of the test prior to the experiment, and took part in two trials which varied in difficulty and performance conditions. Both trials consisted of sustaining a relaxed, upright position, with the arms down: with eyes open and then with eyes closed, for 30 seconds.

Locomotion speed – runs at distances of 5 m, 15 m, 30 m from a standing position and from a flying start [9]. These tests were carried out in a gym on a tartan surface. Before the test participants performed a 20-minute warm-up. Running times were measured using photocells (TAG Heuer, Switzerland, HL model 2-31, consisting of two photocells; results were exported using Msports Pro, version 2.05) positioned at the start line and the finish line of each of the analyzed distances. Players began running from a standing position with one foot on the start line (first test), and from a flying start (2 meter distance). Two runs were performed in each test, separated by a four-minute break. Better (shorter) time at 5, 15 and 30 meters was chosen for a detailed analysis.

Endurance speed measured with a shuttle run test (150 meter shuttle endurance test with 10 returns) [10]. This test (Figure 1) is a useful indicator of speed endurance and was measured immediately after testing the speed

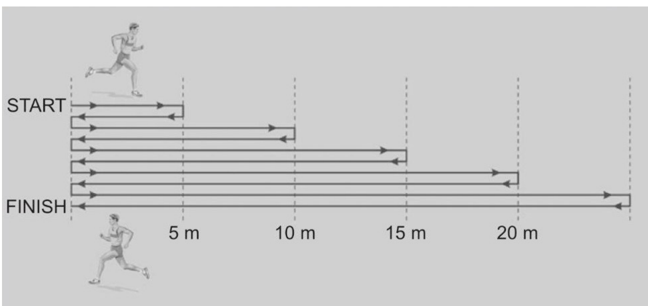

Figure 1. Shuttle run test – endurance speed measurement

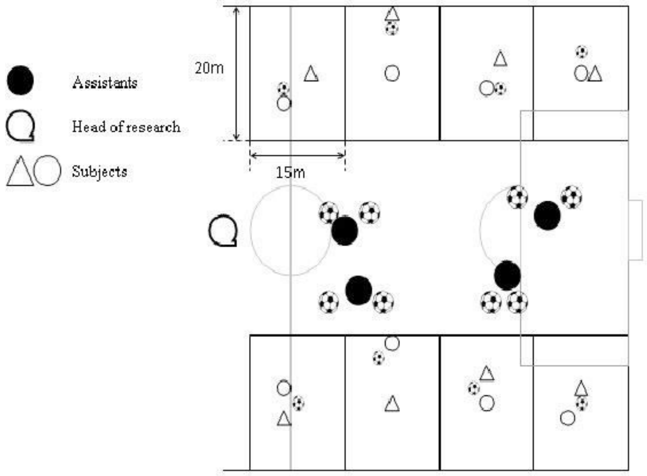

Figure 2. One-on-one games – performance efficiency estimation

of locomotion on the same surface. While making a return participants had to step on the line or cross it.

The participants' performance efficiency in one-on-one games was also assessed on a grass soccer pitch [11]. One-on-one games were organized in a match–rematch system (a total of 34 games for each player; game time 90 s, with an interval of 2–3 minutes; 15 × 20 m playing area with two mini goals 0.4 × 0.65 m made by Energoexport-Silesia, Poland). The aim of the game was to attain the maximal number of points by scoring goals (including hitting a goal post or the crossbar) and to prevent the opponent from scoring points (losing goals, also by hitting the crossbar or a goal post).

Before the start of each game of the first round the players drew lots using a coin. The winning player started the game from his goal, and his opponent from the centerline. After losing the point the game was resumed from the goal, and the player had to retreat to defend the centerline. The player could start again only when the opponent in ball possession, touched it for the first time on his half of the pitch. In other cases (putting the ball off the field, player's error, hand ball, etc.) the opponent resumed the game. The defender was obliged to remain at a distance of at least 3 m from the player with the ball and start his actions only after the ball was on the field of play. In case a goal was defended with the hands, a penalty kick was administered (from the middle of the field at an empty goal). It was performed at the end of the match. Using a playing effectiveness index (points scored in all games in attack subtracted from all the lost points in defense) a ranking of the players' one-on-one game effectiveness was determined.

The games were supervised by five officials: the head researcher and four assistants. The assistants followed closely the players' actions and, if necessary, served the ball to the players resuming the game. The head researcher wrote down results of each game after each round (Figure 2). Before the first round of games the players became familiarized with the objective of the study, rules of the game, and were well-motivated. A regular 15-minute warm-up with one-on-one game elements was carried out before the start of the experiment.

In the last stage of research the assessment of players' performance efficiency in a classified game was performed. Three independent experts (licensed coaches) made direct observations of the players' performance in three matches using the Game Performance Assessment Instrument (GPAI), according to the criteria in Table 2 [12]. After each game the experts filled in an evaluation sheet (Appendix 1) with actions of individual players scored from 0 to 5 points: 5 = very effective performance – always; 4 = effective performance – usually; 3 = moderately effective performance – sometimes; 2 = weak performance – rarely; 1 = very weak performance, hardly ever; 0 = never). On the basis of the average of experts' rating a ranking list of players was drawn up complying with the level of players' game efficiency.

STATISTICA version 10 (StatSoft, Inc.) was used for all statistical analyses. Ranking assessments of

Table 2. GPAI Component definitions and assessment criteria [Griffin, Mitchell, Oslin 1997]

Component	Definition	Criteria
Base	Appropriate return of performer to a home or recovery position between skill attempts	The student recovers to a base position at the baseline (or at the net) on her/his side of the "doubles" court after striking the ball
Decision-making	Making appropriate decisions about what to do with the ball (or projectile) during a game	The student appropriately remains in her/his base position or moves forward to net when there is a perceived opportunity for an upcoming offensive shot or retreats backward from baseline when there is a perceived need for an upcoming defensive shot
Skill execution	Efficient performance of selected skills	The student strikes the ball such that it lands in bounds

Appendix 1. Player evaluation sheet

The total number of points	Elements of evaluation / Player	Decisions made			Skill execution						Adjustment				
		Made pass to open player	First time pass	Used target player	Crossing	Control of the ball	Head playing	Shooting	Shielding ball	Tackling	Moved to open space	Moved out of space for another player to come into	Support the ball carrier	Made overlapping run	Setting in the defense and opponent's coverage

effectiveness in one-on-one games and the classified game were correlated with the results of laboratory tests. Spearman's, gamma and Kendall's tau rank correlation coefficients were applied (Spearman's rank correlation coefficient higher than 0.47 for a two-tailed test was assumed as statistically significant). Intraclass correlation (ICC) and analysis of variance (ANOVA) of rating were used for test–retest and inter-observer reliability. In all cases the level of statistical significance was set at $p \leq 0.05$. All the results were reported as means ± standard deviation (SD).

Results

It was found that the players with the highest results in speed tests were also highly assessed by experts on their one-on-one game effectiveness. The two locomotion speed tests in question were a 15 m run and a 30 m run from a flying start (Spearman's correlation: 0.609 and 0.566, respectively). As for the 15 m run a confirmation of the strength of correlation was also obtained in stricter statistical tests (gamma and Kendall's tau correlation). No statistically significant correlation between expert assessment of performance efficiency in the classified game and results of speed tests was noted. It was also found that the power of the correlation between all indicators of explosive leg power and the ranking list of one-on-one game effectiveness was statistically significant. Spearman's correlation between all indicators of explosive strength of the lower limbs and the ranking of effectiveness in one-on-one games was statistically significant (Spearman's coefficient from 0.605 to 0.630 for all indicators of the test). This was not noted with reference to expert assessment of the efficiency of performance in the classified game. Moreover, no essential correlation was found between expert assessment of game efficiency, effectiveness in one-on-one games, and anaerobic capacity, aerobic capacity, reaction time, and balance. However, a high correlation ($p \leq 0.01$) was noted between indicators of anaerobic and aerobic efficiency, at least an indicator of medium power (W/kg) and total work (J/kg) (Wingate test) with VO_2max (Spearman correlation coefficient 0.72 and 0.72, respectively).

Discussion

The better results young soccer players achieve in locomotion speed tests, the higher their usefulness is assessed in one-on-one games. This conclusion [13] is only partially confirmed in this study. It concerns results achieved by the examined 17-year-old soccer players in locomotion speed tests, i.e. 15 m and 30 m runs, measured from a run-up start, excluding the time of starting reaction. It may mean that the time of starting reaction was not of significance for the assessment of game effectiveness. Reaction time tests, by some means, confirm this hypothesis because no statistically significant correlation was noted between experts' assessments of the classified game and the players' performance effectiveness in one-on-one games and results of these tests. Most probably this results from the fact that the participants differed slightly from one another in their reaction results. It is proven by variability coefficients in the tests (simple reaction: 14.5%; choice reaction: 10.0%; complex reaction: 18.3%; anticipation reaction: 2.9%). The participants were thus a homogeneous group in terms of the examined skills, particularly with reference to anticipation reaction. It is worth noting that the abilities of reaction and spatial orientation are ascribed essential significance for young players' efficient game performance [14]. The above interpretation of research results leads to a belief that locomotion speed and similar abilities connected with reaction time measured independently (from a flying start) indicates soccer players' individual abilities in this respect. It is an essential assertion especially because the correlation of effectiveness ranking in one-on-one games, in particular in the case of speed tests, is statistically highly significant. Therefore, independently from tasks set for players in games, locomotion speed over typical 15 or 30 meter distances remains a leading ability of competitors' physical fitness, which was also confirmed by Reilly et al. [15], Cometti et al. [16], Little and Williams [17], Gissis and Papadopoulos [18] and Di Salvo et al. [19], and Jastrzębski et al. [20].

An essential relationship between young players' effectiveness in one-on-one games and indicators of explosive strength of the lower limbs defined in our research was also shown by Ostojic [21] and Kalaportharakos et al. [22]. It is this power to which the most progressive character of development in adolescent soccer players is ascribed [23]. It should be added that the level of this ability is conditioned by speed potential, i.e. ability to develop strength in a short time (that is a high gradient of force). This was confirmed by Arnason et al. [24], Buchheit et al. [25], Chamari et al. [26] and Wisloff et al. [27] and by results of our participants in respect of the preferred high level of speed (locomotion speed, speed of movements, and their frequency). On the other hand, lack of a statistically significant correlation between experts' assessment of effectiveness in the classified game and physical fitness components in the players constitutes a surprise. Szwarc [28] contradicted this conclusion [11, 29] and the positive correlation found by him between one-on-one game efficiency and competence in the classified game gives credibility to his observation.

In summary, the conducted laboratory tests of locomotion speed measurement and explosive strength of the lower limbs are strongly correlated with the assessment of effectiveness of young players in one-on-one games and, as indicated in some other reports [30], also with the assessment of performance efficiency in the classified game.

Conclusions

The results of tests of 15-m and 30-m runs and vertical jump height could be a valuable source of information about players' potential. Thanks to the ease and accessibility of their application, these tests can constitute a permanent and basic control tool for training young players.

What this study adds?

Tests of locomotion speed and explosive strength of the lower limbs (15-m and 30-m runs and vertical jump height) are perfect tools of control of motor skills in 17-year-old soccer players. The level of strength–speed skills affects (usually positively) the effectiveness of a player's performance in a one-on-one game and indicates a player's potential to compete in a classified game. The better results young soccer players achieve in locomotion speed tests, the higher their usefulness is assessed in one-on-one games.

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