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Changes of Physical Capacity and Soccer-Related Skills in Young Soccer Players within a One-Year Training Period

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Abstract

Background: The aim of this study was to determine changes in both aerobic and anaerobic physical capacity as well as in sport-specific skills in footballers as a result of the applied training load within a one-year training period. It was assumed that the type of applied training load would have a significant influence on changes in physical capacity indexes and on differences in soccer technical skills. Material/ Methods: The tests applied in the research were: Wingate test 30 sec. version for lower extremities (used to assess anaerobic capacity), PWC170 test (used to assess aerobic capacity) and German Football Association test of soccer technique skills known as DFB test (Deutsche Fussball Bund test). Results: The highest values of maximal power (Pmax=11.2 W·kg-1) and maximal total work volume (W=270.1 J·kg-1) obtained in Wingate test were noted at the end of the preparatory season. Statistically significant differences ($p \leq 0.05$) of mean values of the maximal power occurred between the first and the second test. No differences were stated between mean values of total work volume. However, aerobic capacity index and VO2max determined by an indirect method reached the highest values at the end of the competitive season and amounted to 18.6 kgm·kg-1·min-1 and 51.8 ml·kg-1·min-1 respectively. The best results in soccer technical skills test were registered at the end of the preparatory season (343.6 points) and at the end of the competitive season (340.2 points). Conclusions: It is stated that training load applied had a beneficial influence on changes in physical capacity indexes and results of soccer-related skills.

Keywords

physical capacity, soccer, skills, training period

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Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Key words: *physical capacity, soccer, skills, training period*

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Introduction

According to Bangsbo [1, p. 67], soccer is a very demanding game in terms of physical fitness. Characteristic forms of this activity are: fast running with direction changes, jumps, taking possession of the ball. It is stated that while playing a match a top class player changes intensity of his performance about 1100 times and the total distance covered on the pitch is about 10–12 km [2, 3]. Therefore, fitness training aims at preparing a footballer to manage the task. Simultaneously, it should enable the player to use fully his technical skills during the whole match.

A proper training process determined by the choice of a correct load and means is indispensible to achieve sports mastery. Moreover, certain conditions must be achieved regarding somatic structure, energy and regulation abilities of the body, mental features, profile and the level of physical fitness, technique and tactical skills as well as theoretical knowledge. Some of these factors are determined genetically in a wide range, so their level or possibility of their development should be recognized at the stage of selection and justify the decision to practice sport professionally.

Until the moment of achieving the aim (sports mastery) the players should receive proper training with an appropriate choice of training methods. These methods should take into consideration young players' biological development tempo, especially the periods of favorable conditions for development as a base for future highest achievements in adulthood.

According to Impellizzeri [4], the training process must be precisely monitored in order to provide optimization of physical fitness, and the results obtained from tests should be used to improve the effectiveness of the game play [5, p. 102].

A proper training process needs permanent delivery of information regarding the training effects and adaptive changes in the body as a reaction to a training load. An analysis of the training load and its relation to physical fitness, technique and tactic as well as the aerobic and anaerobic capacity level are a crucial element of the training process control. Team games are a group of sports in which organization of the training process and its realization is extremely difficult. Thanks to the knowledge regarding the theory of sports, training it is possible to program the training cycle freely, but its realization should always consider human and material potential. Constant readiness to introduce training amendments constitutes a significant factor in the training process. However, it is possible only on condition that the program includes recording and controlling the training loads.

Bangsbo [1, p. 84] enumerates factors proving main reasons for testing footballers:

- assessment of the training program effectiveness (or lack of it)
- raising footballers' motivation to training
- providing footballers with the information (feedback) regarding their performance level
- rising the players' awareness regarding the goals of training
- assessment of a player's sports condition (his capability of participation in the match)
- information for short and long-term planning.

Training control applied in football should encompass at least four scopes of the training process:

- selection aiming at an assessment of a young player's inherited and potential sports abilities,
- an assessment of the training effectiveness by testing changes of the performance level,
- registration and analysis of the training load,
- an analysis of the game, mainly its effectiveness.

It is advisable to test the players two to four times a year. The first tests should be done at the beginning of the cycle, after the off-season. Next – at the end of the winter preparatory stage and finally at the end of the competitive season. Based on the tests results, the players are grouped according to each tested factor. In this way, it is easy to track strong and weak aspects of each player's preparation.

Literature on the subject shows a few tests to assess physical capacity of sportsmen. But according to Christopher [6, p. 356], there are no standard protocols to test football players.

Both laboratory and field tests are used to evaluate physical capacity. The test of incremental effort till exhaustion is one of the most commonly used laboratory methods.

PWC_{170} test [7] is an indirect method of estimating the level of aerobic capacity. It is yet reliable as submaximal effort is applied and the result is not dependent on the tested subject's motivation.

Tests involving maximal effort often cannot be applied because they cause training program disturbances. They are not only arduous but pose a problem of technical correctness. Therefore, according to Birch et al. [8], submaximal effort tests are more practical, cheaper, more effective and reliable because they reflect cardio-vascular fitness.

Willmore and Costill [9] claim that there are many methods to state anaerobic capacity but most of them provide only rough assessment. They also claim that Wingate test is one of the best methods to assess anaerobic capacity regardless of some limitations. Based on the results of a few authors [10], it is said to provide a reliable description of both lactic acid and non-lactic acid elements of anaerobic capacity.

Registration of the training load was carried out in the form proposed by Jastrzębski [11]. This version uses a simplified registration form of information zone and energy system involved in the exercise as well as the classification of exercise applied during football training. Thanks to the simplified way of registration this form makes a clear, less time consuming option. Moreover, the use of Excel program allows analysing easily and correcting possible faults of training process.

The aim of the study was to determine the changes of aerobic and anaerobic capacity level as well as soccer-related skills in young soccer players in response to the training load in a one-year long training cycle.

It is assumed that the quantity and quality of the training load applied in young football players has a direct influence on the development of their physical capacity as well as on football skills. Therefore, research questions were posed as follows:

1. What are the changes of aerobic and anaerobic capacity in young football players during a one-year training cycle?
2. What is the influence of the training load applied within a one-year training period on the footballers' special fitness?

Material and methods

16 young soccer players from Football Academy in Malbork took part in the study. A biometric characteristic of the subjects is presented in Table 1. A typical training microcycle (1 week) consisted of 5 training units and 4 PE lessons (including 1 hour of swimming). One-year training cycle started on 4th August 2008 and finished on 17th June 2009. During this time 274 training units were conducted.

One-year training cycle included three series of tests:

1. September 2008 (the beginning of the competitive season – the first tournament round)
2. March 2009 (the end of the preparatory season – the second tournament round)
3. June 2009 (the end of the competitive season - the second tournament round)

Tab.1. Mean values of biometric indices of soccer players in subsequent tests

Test	Statistical value	Height [cm]	Weight [kg]	Age [yrs]
1. 09.2008	$\overline{X}$	**173.6**	**60.5**	**15.4**
	SD	7.44	9.25	0.29
2. 03.2009	$\overline{X}$	**175.3**	**63.4**	**15.9**
	SD	6.59	8.58	0.29
3. 06.2009	$\overline{X}$	**177.6**	**64.4**	**16.1**
	SD	6.39	8.51	0.29

The training load was registered according to Jastrzębski's method [11]. Excel spreadsheet, Microsoft Office 2007, was used for data collecting and calculating.

In order to control the players' physical capacity two tests were used: test PWC_{170}, [7] and Wingate test 30 seconds version with lower extremities burden: 75 g/kg^{-1} of body mass [10]. The maximal oxygen uptake was calculated from Karpman formula:

$$\mathbf{VO_{2max}=1.7 \times PWC_{170} + 1240}$$

The tested players were submitted to DFB test (sport-specific skills test of Deutscher Fussball Bund) to assess football skills. In 2001 German Football Association prepared a set of skill tests. Depending on the amount of scored points the participants are awarded a badge. The aim of testing is to select football-talented youth. The test consists of 7 technical tasks and is applicable to children 10 and more years old. The subject can score 60 points in each task, 420 in total. A certain amount of points evidenced and confirmed by a coach then sent to DFB entitles the subject to receive a gold, silver or brown badge. As suggested, the gold level players should be subjected to close attention. The test norms are shown in Table 2.

Tab. 2. Norms of points for age spans

Children (10–13 yrs)	Youth (14–16 yrs)	Adult (from 17 yrs)	Badge
260 and more	300 and more	340 and more	Gold
220	260	300	Silver
180	220	260	Brown

Football skills test comprises 7 tasks [12]:
Task 1: Rotation kick from the corner of the penalty area at the goal line
Task 2: Dribble
Task 3: Juggling
Task 4: Pass the ball against the bench ("master of pass")
Task 5: Pass the ball to the goal with a head
Task 6: Centre the ball to the point
Task 7: Long pass from the penalty kick point

Task 1: Rotation kick from the corner of penalty area at the goal line

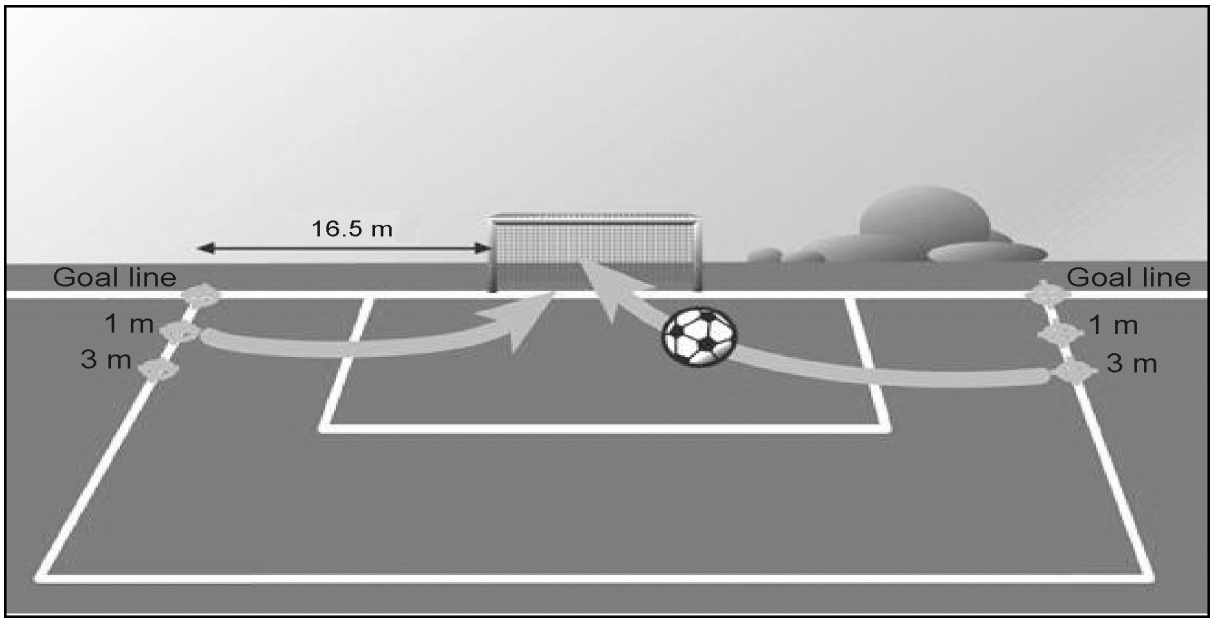

Fig. 1. Rotation kick from the corner of penalty area at the goal line [12]

The player kicks the ball 4 times from one of the three places:

A. The point where penalty area meets the boundary line.
B. The point on a line of the penalty area 1 m far from the boundary line.
C. The point on a line of the penalty area 3 m far from the boundary line.

The player chooses the side and place of kicks. He scores 20 points if he performs successful kicks from place A, 15 points from place B and 10 points from place C. The total score is a sum of three best results. The maximal total score is 60 points.

Task 2: Dribble

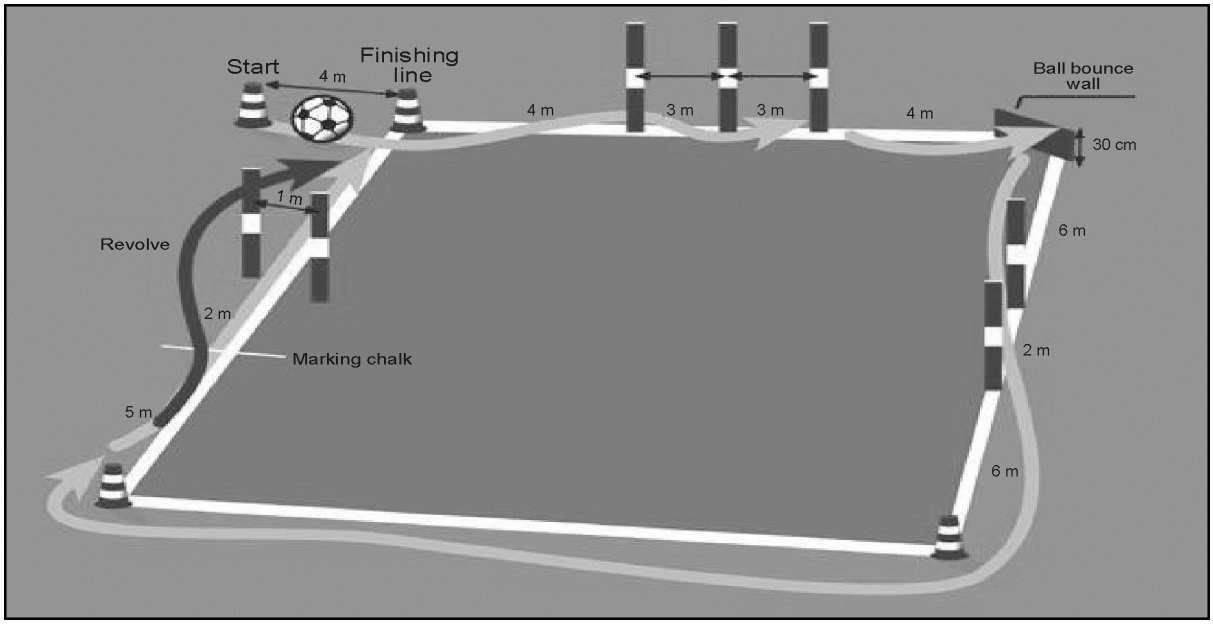

Fig. 2. Dribble [12]

The player's task is to cover the obstacle course (square 14 x 14 m) with a ball in the possible shortest time. The task is performed twice. The best result is accepted. Time measurement starts with the first movement of the player and finishes when he crosses the finishing line with the ball. Maximal 60 points can be scored.

Scoring:
Less than 18 seconds – 60 points
18–20 seconds – 50 points
21–23 seconds – 40 points
24–26 seconds – 30 points
27–30 seconds – 20 points
More than 30 seconds – 0 points

Task 3: Juggling

Free juggling in the square of 10 m x 10m. The test starts with the hand throw of the ball by the player. The test is performed twice. Scoring is stopped when the ball touches the ground or leaves the square with its entire circumference. The best result is the final score. The player is allowed to perform two juggle trials out of the square before the test. Every ball touch is granted one point. Maximal score is 60 points.

Task 4: Pass the ball against the bench ("master of pass")

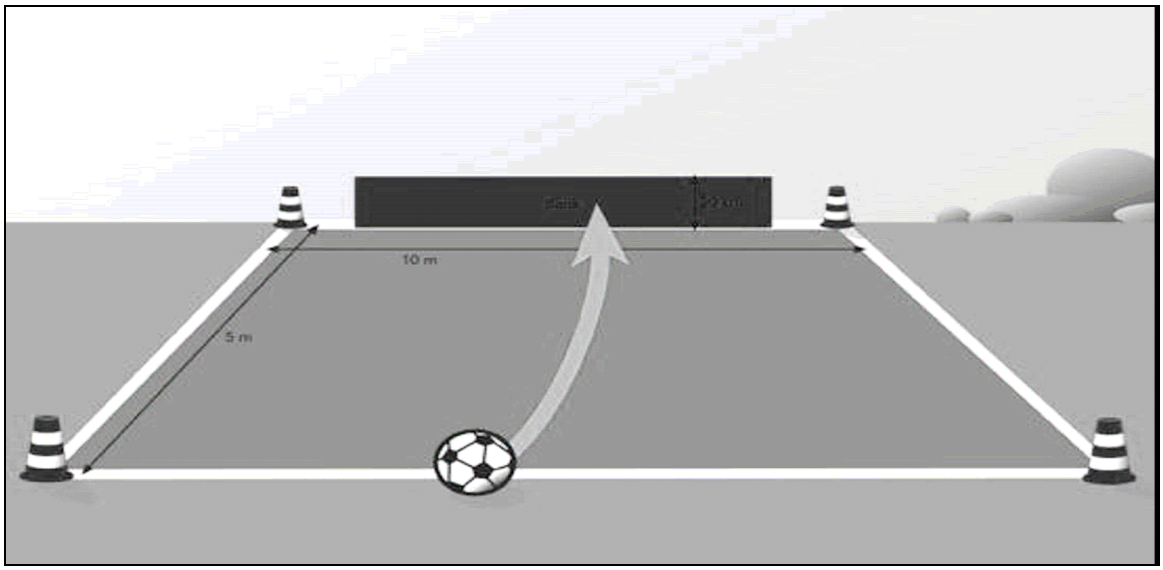

Fig. 3. Pass the ball against the bench ("master of pass") [12]

The player must pass the ball only with the internal part of his foot against a 30cm high bench. The distance between the player and the bench cannot be shorter than 5 m. The ball can be passed directly or after reception. The test is performed only once within 30 sec. time. Each bench bounce is awarded 3 points. The subject is allowed to use a spare ball (placed at one of the two cones) once without stopping the time measurement. Maximal score is 60 points.

Task 5: Head pass to the goal

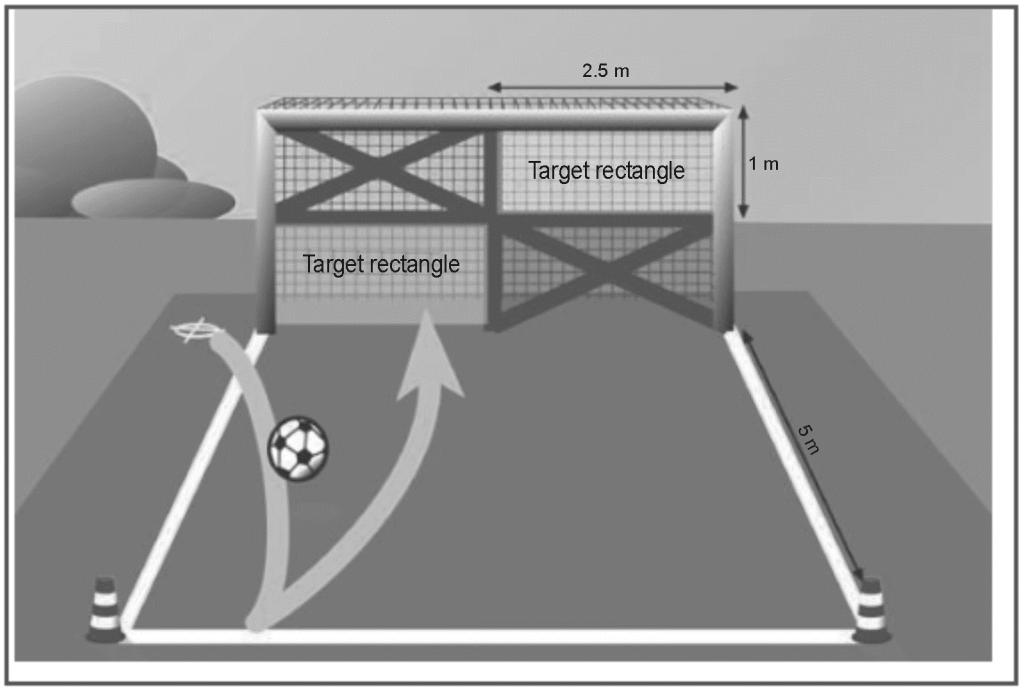

Fig. 4. Head pass to the goal [12]

First the ball is passed with two hands by a partner standing near the goal post to the player. The player being in move performs head pass to one of the sectors of the goal size 5 m x 2 m.

After the pass the ball can touch the ground only once. Points are also awarded if the ball touches the sectors' lines and gets into the goal. The player performs three passes to any upper sector and three passes to any lower sector from a 5 m distance. Each goal is awarded 10 points. Maximal score is 60 points.

Task 6: Centre the ball to the point

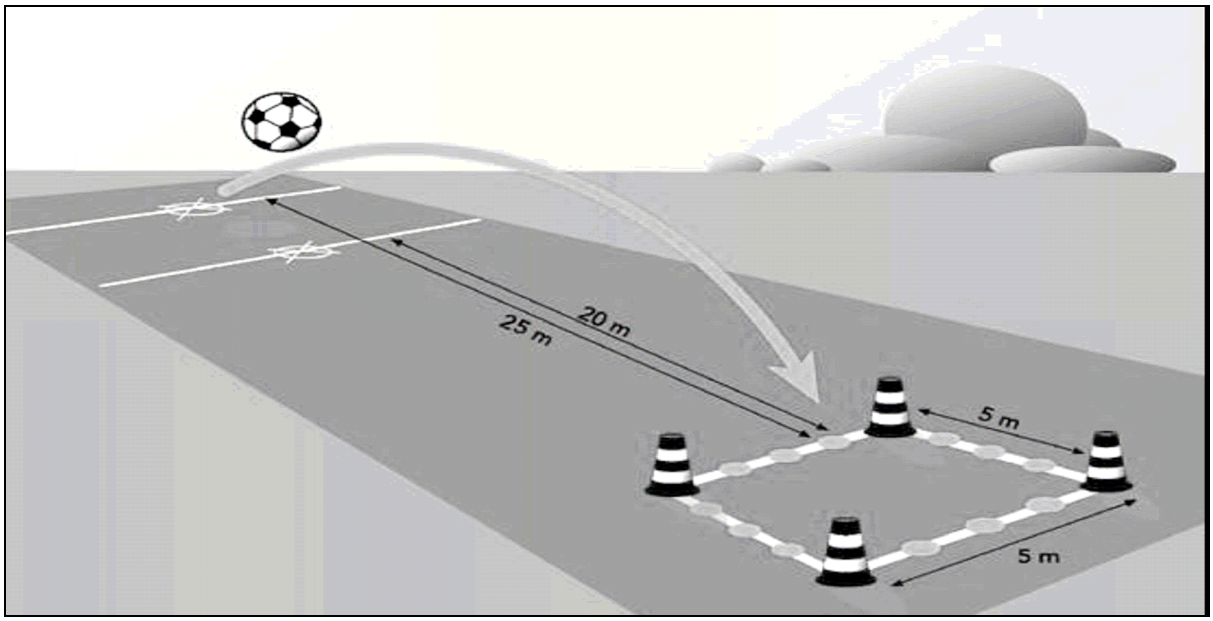

Fig. 5. Centre the ball to the target point [12]

The player kicks the ball with the internal part of either of his feet in order to place the ball in the square size 5 m x 5 m. The nearer square side is 20 m (up to 13 yrs) or 25 m (over 14 yrs) far from the shooting line. The player performs the task three times, each target pass scores 20 points, 60 points in total.

Task 7: Long pass from the penalty kick point

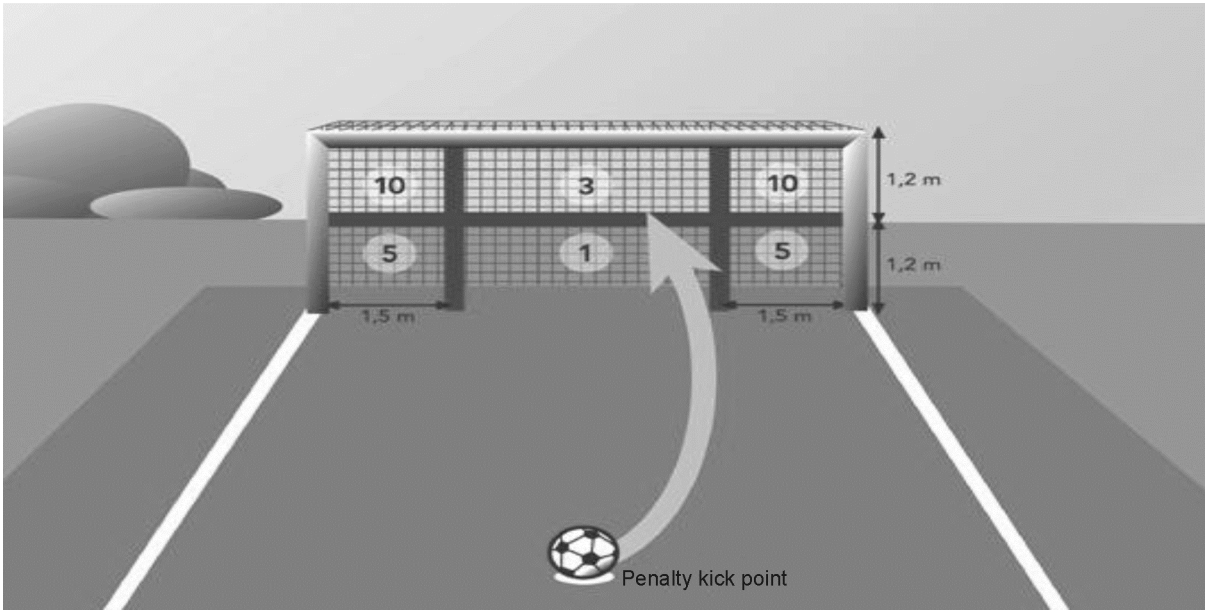

Fig. 6. Precise long pass from the penalty kick point [12]

The player passes the ball to the goal from the penalty kick point 6 times. The goal is divided into six sectors, reaching each one gives a certain number of points. Maximal score in the task is 60 points.

Total values of the training load within one-year training cycle applied to young footballers in 2008/2009 at Football Academy in Malbork are shown in Table 3. The total value of the training load (TR) within the period concerned equals 225h 7min and was accomplished during 274 training units. General performance encompasses 92h 4min (40% TR) and football-specific exercise – 133h 3min (59.1% TR). Footballers performed aerobically 129h 59min (57.7% TR), mixed energy system (aerobic-anaerobic) was used during 89h 51min. (40% TR), anaerobic lactic acid performance – 2 h19min. (1% TR), and anaerobic performance took 2h 58min (1.3% TR).

Tab. 3. Training loads during a one-year training cycle

Information zone	Intensity zone				Sum 1–4 (min.)
	1. Aerobic performance (min.)	2. Mixed (aerobic and anaerobic) performance (min.)	3. Anaerobic lactic acid performance (min.)	4. Anaerobic non-lactic acid performance (min.)	
1. General	**4807**	**624**	**78**	**15**	**5524** (92 h 4 min.)
2. Specific	**2992**	**4767**	**61**	**163**	**7983** (133 h 3 min.)
Sum 1–2 (min.)	**7799** (129 h 59 min.)	**5391** (89 h 51 min.)	**139** (2 h 19 min.)	**178** (2 h 58 min.)	**13507** (225 h 7 min.)

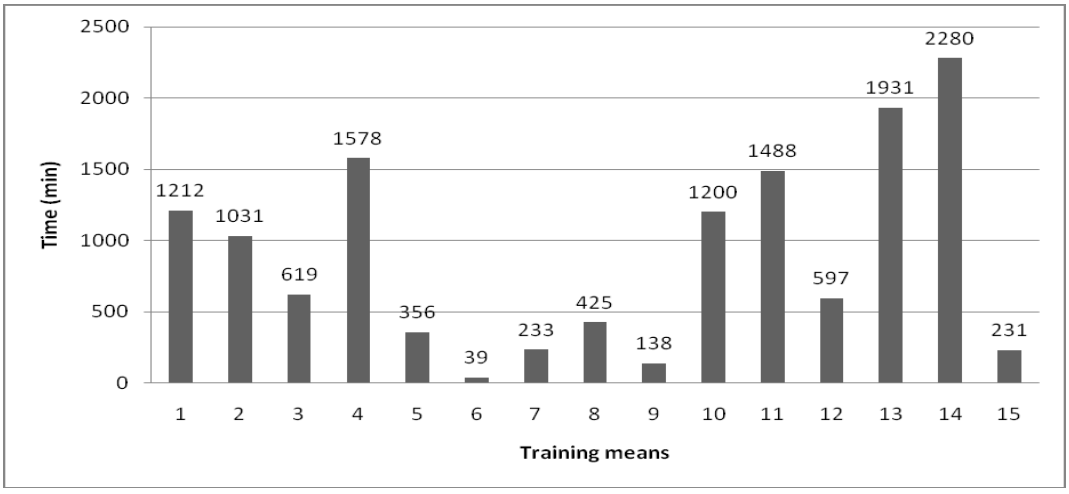

Fig. 7. Characteristic of training means applied to young football players from Football Academy in Malbork within a one-year training cycle. 1-general warm-ups; 2-specialist warm-ups; 3-flexibility and stretching exercise; 4-continuous running; 5-middle-length distance running; 6-sprints; 7-general fitness drills; 8-coordination drills; 9-strength exercise; 10-general fitness in the form of games and additional sports; 11-individual and group technical skills; 12-technical-tactical exercise in defense and attack; 13-small-sided games; 14-league, cup and control games; 15-physical and specific soccer tests

During the period concerned, most training means applied are considered as football-specific ones. They are: control games, cup and final matches (14), small-sided games in different forms (13), individual or group technical exercise (11), technical-tactical exercise in defense and attack (12). A lot of time was allocated to specialist warm-ups in form of deliberately chosen exercise with balls or in form of simplified games (2) (Fig. 7).

Among the general training means, continuous run was used most often (4). It was performed in form of jogging after the match or running exercises developing aerobic endurance. Other general means commonly used were general warm-ups (1), general fitness exercise in form of different games and additional sports (10). Training means supporting football training were: relaxing and flexibility exercise and stretching (3), coordination (8) and general fitness drills (7). Performance time of sprints (6) or middle length distance run (5) was relatively short in comparison to aerobic performance due to high intensity of these tasks.

Data obtained were shown as mean values and standard deviation. To analyze physical capacity and football-specific skills tests results firstly Shapiro-Wilk test was used to check if variables distribution in subsequent tests are in accordance with normal distribution with 95% confidence interval. Normal distribution of variables confirmed in all three trials occurred in: DFB test, strength to speed index and work performed in Wingate test. Next the assumption of homogenous variance was checked in all results by Levene's test. Then the results were analyzed by one-way Analysis of Variance for repeated tests. Moreover, ANOVA Friedman test stated no statistically significant differences between PWC_{170} and VO_{2max} results. The results of DFB subsequent tests happened to differ, so Tukey test of honest significant difference (HSD) was applied to determine statistically significant differences. All the statistical calculations were done with use of computer program Statistica 8.0 Polish version.

Results

Figures 8 and 9 show changes of mean values of PWC_{170} index and directly calculated values of VO_{2max}. Based on this data footballers' aerobic capacity was determined. Variations of the indices values were stated. The highest value of VO_{2max} was registered in the third test.

PWC_{170} index value increased constantly in subsequent three tests (1, 2, 3). In the third test – at the end of one-year training cycle, the players showed the highest value of this index.

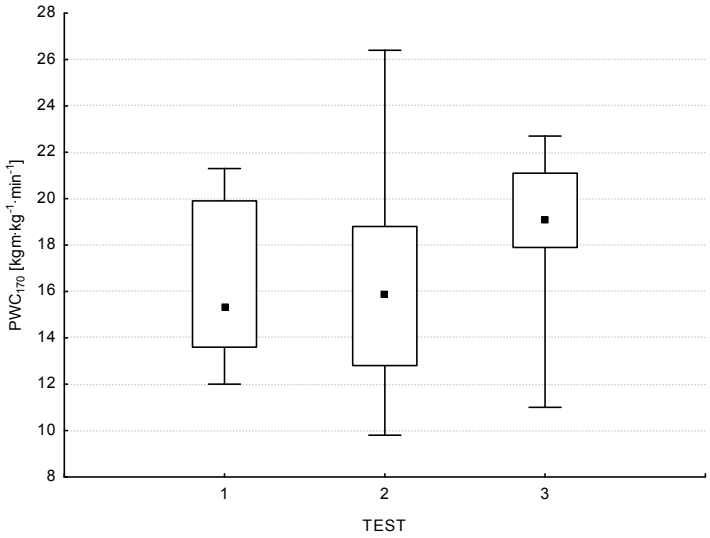

Fig. 8. Median, quarter deviation, minimal and maximal values of PWC_{170} test in subsequent tests (1, 2, 3)

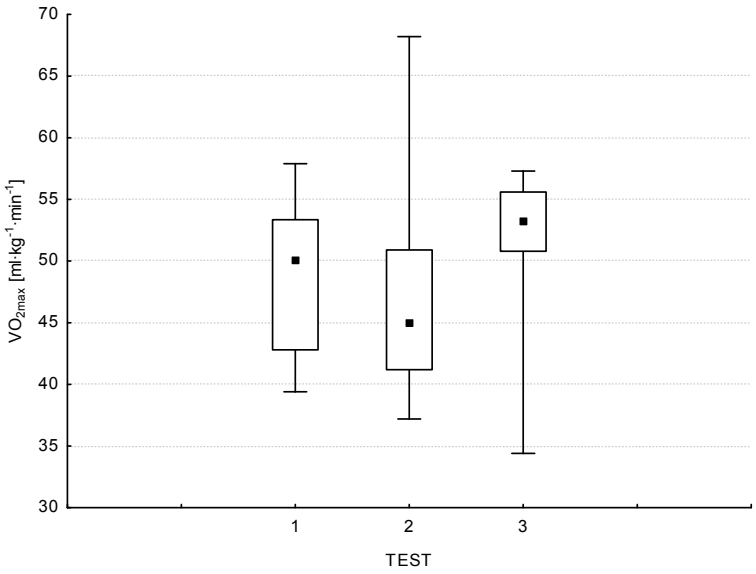

Fig. 9. Median, quarter deviations, minimal and maximal values of VO_{2max} test in subsequent tests (1, 2, 3)

Tab. 4. Mean values of anaerobic performance indexes in Wingate test in Football Academy in Malbork players within a one-year training cycle

Test	Statistical value	Wingate test	
		Maximum power (W · kg^{-1})	Performance work (J · kg^{-1})
1.	$\overline{X}$ ± SD	10.7 ± 0.84*1-2	254.3 ± 18.98
2.	$\overline{X}$ ± SD	11.2 ± 0.76	270.1 ± 18.68
3.	$\overline{X}$ ± SD	10.9 ± 0.68	263.0 ± 16.63

** Differences statistically significant at p ≤ 0.05*

Table 4 shows variability of maximal power and total work volume mean values obtained by the footballers in 30 second version Wingate test. This data allows determining players' anaerobic capacity. The highest value of maximal power was registered in the second test – at the end of the preparatory season before league matches (the time of building sports condition). The lowest values of the tested indices were noticed in the first test. Statistically significant differences between the maximal power mean values were stated between the first and second test.

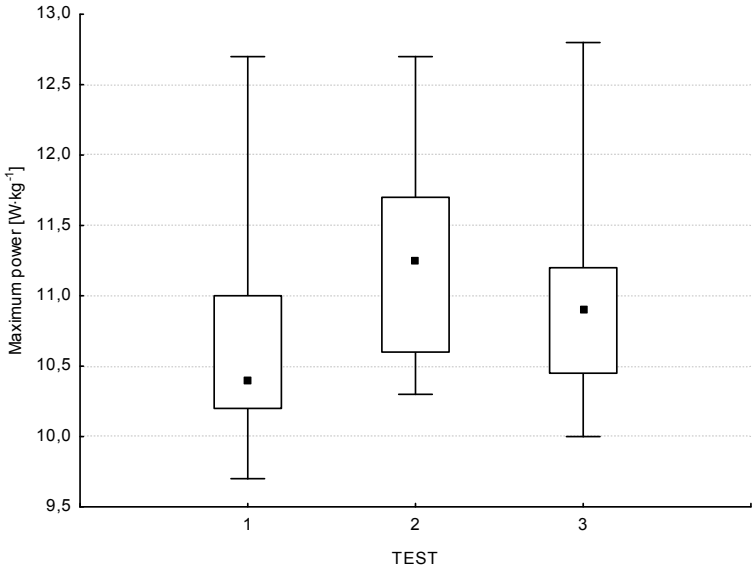

Fig. 10. Quarter deviations, maximal and minimal values of maximal power in subsequent tests

Tab. 5. Mean values of football-specific skills indices in DFB test in chosen periods of a 1-year training cycle

Test	1	2	3
Test DFB [points]	321.7 ± 16.77 *1-2, 1-3	343.6 ± 21.88	340.2 ± 20.15

** Differences statistically significant at p ≤ 0.05*

The results of DFB test (football-specific skills tests used to monitor footballers' technical skills prepared by German Football Association – DFB) are shown in Table 5. The result of 300 points out of 400 scored in the test is considered good for the players aged 14–16. Mean value of the players tested was the lowest in the first test – at the beginning of the training cycle. The highest result was registered in test two – at the end of the preparatory season.

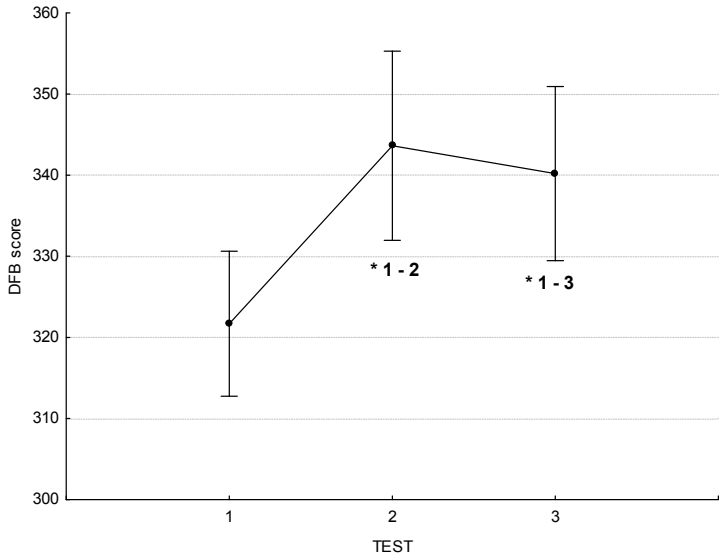

Fig. 11. Mean values and confidence intervals of DFB tests results in subsequent trials

Figure 11 shows existing statistically significant differences between mean values of DFB test scores. The differences are recognizable between the first and the second test as well as between the first and the third test.

Discussion

The most important factor which can effectively and comprehensively influence the level of sports condition of the player and the whole team is the training load. There is evidence to support this theory. Helgerud proved in his studies [13] that proper training can increase VO_{2max} by 11%. In consequence, the total distance covered during the game increased by 20%, the amount of contacts with the ball increased by 23% and number of sprints increased by 100%.

The number of training sessions in a typical week-long microcycle as well as in a year-long macrocycle applied to Football Academy in Malbork players are similar to those stated by Szwarc [14] as model ones for young footballers' training. In his opinion, a typical microcycle should consist of 7–8 training units and during one-year training cycle there should be conducted approximately 250 sessions.

In percentage terms (%), the relation of sport-specific effort to general exercise in a year-long training cycle is similar to those recommended by many authors. Przybylski [15, pp. 122 and 137] stated that the proper percentage relation between specific and other training loads at the beginning of the specialization stage should constitute from 60% to 40%. Furthermore, Bompa [16] recommends a similar distribution of specific and general parts for young sportsmen aged 15–16.

Based on the presented results, it can be assumed that aerobic and anaerobic capacity as well as sport-specific skills developed as a consequence of the applied training load. The results are comparable to the same age group or other, more advanced footballers.

In comparison of PWC_{170} index with data obtained by other authors, it can be stated that aerobic capacity of Football Academy in Malbork players reach a high level, which, according to Vaeyens et al.[17], conditions success in youth football.

Indirect methods of determining VO_{2max} are commonly used as they do not require an exhaust gases analyser. It is especially important for amateur players or children and youth. Nevertheless, they are not fully reliable. The margin of error constitutes 10-15%. The same method used repeatedly in order to monitor progress in training results in the fact that the discrepancies are repeated for the certain person [18]. Despite the fact that direct methods do not ensure high precision required in physical capacity assessment and therefore in sports progress of qualified players, there is another aspect to be considered. The advantage of an indirect method over a direct one lies in the fact that in the indirect method the tested person is submitted to a lower load, which increases its safety. Therefore, it is justified to apply indirect methods of $VO_{2\ max}$ assessment among children and youth.

The values of VO_{2max} obtained by Academy players are lower than those registered in American representatives aged up to 15 – 54.5 $ml \cdot kg^{-1} \cdot min^{-1}$ and up to 16 – 56.2 $ml \cdot kg^{-1} \cdot min^{-1}$, [19] or Finish representatives U-18 plus U-17/Finland – 56.0 $ml \cdot kg^{-1} \cdot min^{-1}$, U-16/Finland – 58.0 $ml \cdot kg^{-1} \cdot min^{-1}$, U-15/Finland – 57.0 $ml \cdot kg^{-1} \cdot min^{-1}$ [20], Belgian first league players – 56.5 $ml \cdot kg^{-1} \cdot min^{-1}$ [21], Serbian first league players – 53.5 $ml \cdot kg^{-1} \cdot min^{-1}$ and Italian 17-year-old footballers – 53.3 $ml \cdot kg^{-1} \cdot min^{-1}$ [22]. Slightly higher values of VO_{2max} were stated in Croatian first league – 52.1 $ml \cdot kg^{-1} \cdot min^{-1}$ [23], Portugal first league – 52.7 $ml \cdot kg^{-1} \cdot min^{-1}$, [24] and American representatives up to 14 years old – 52.9 $ml \cdot kg^{-1} \cdot min^{-1}$ [19].

The Academy players' results of VO_{2max} equal those of the best two senior teams of Macedonia: FC Sloga – 51.9 $ml \cdot kg^{-1} \cdot min^{-1}$ and FC Vardar – 48.8 $ml \cdot kg^{-1} \cdot min^{-1}$ [25], semi-professional rugby players in Australia – 50.5 $ml \cdot kg^{-1} \cdot min^{-1}$ [26]. The results were better than those of Serbian third league amateur players – 42.9 $ml \cdot kg^{-1} \cdot min^{-1}$ [27].

Judging by the facts mentioned above, it can be stated that the VO_{2max} level of Football Academy players is lower than those of professionals. Among factors influencing the results there can be listed: genetic factors and the amount of the training load. Furthermore, the length of training experience plays a significant role (it was 2 years in most Academy players at the beginning of the tested year-long training cycle).

However, mean values of maximal power and the total work volume in Wingate test of Academy players resemble values of Polish representatives for Olympic Games in Barcelona – 11.26 $W \cdot kg^{-1}$ [28] and judo experts – 11.36 $W \cdot kg^{-1}$, 259.53 $J \cdot kg^{-1}$ [29]. Wingate test results (mean value of maximal power and total work volume) indicate high anaerobic potency in Academy players. This profile is probably a result of the administered training load. Also entrance tests for the Academy selected candidates with high speed abilities.

Young players should be submitted to a pyramid system of fitness training. The base of the structure comprises aerobic endurance preparation properly dosed according to the players' age and training experience, while specialist preparation should focus on building subsequently: aerobic endurance then strength and speed.

Bearing in mind these principles, the structure of training load at Football Academy which administers more aerobic and mixed energy system performance proves to be justified.

Apart from physical and psychological qualities or tactical skills, a certain level of technical skills constitutes an indispensable factor of sports progress and success [30]. According to Stuła et al. [12] just technical skills are an essential indicator of match effectiveness in leading football teams. Therefore, the main principles of Academy are similar to those of German program supporting young talents DFB: teaching, developing and mastering of technical elements of football.

As results show, a relevant improvement in technical skills of Academy footballers occurred within one-year training cycle. In longer prospect this fact can constitutes a base for achieving success in adulthood.

Conclusions

1. Variation of physical capacity indexes and sport-specific skills occurs in footballers aged 15–16 within one-year long training cycle.
2. The highest level of anaerobic capacity in young football players was confirmed in the second half of the training cycle, at the end of the preparatory season.
3. The highest level of aerobic capacity and technical skills of Football Academy in Malbork players occurred at the end of a year-long training cycle.

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