THE EFFECTS OF TWELVE-WEEK FUNCTIONAL TRAINING ON THE POWER OF THE LOWER LIMBS OF YOUNG FOOTBALLERS

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Abstract

The aim of the study was to verify the functional state of young football players by the use of selected tests of the Functional Movement Screen (FMS) protocol, as well as the impact of the 12 weeks functional training on the power of the lower limbs. Twenty young male football players under 17 (U17) participated in the study. The research was carried out in two stages: in the first part of the study, the functional assessment was measured using the FMS test, then the measurement of the power of the lower limbs was done with the Optojump system. The conducted research showed a significant improvement in the functional state of young footballers. After the functional training program, there was also an improvement in the parameters of the power of the lower limbs. Attention should be paid to the importance of enabling the functional training in all physical preparation of football players and the correlation between functional and special efficiency.

Key words*: functional training, functional movement system, movement patterns, lower limbs power, football*

Introduction

Football is a sport which involves short sprints, rapid accelerations, decelerations, quick changes in directions, jumping and tackling (Kaplan, Nurtekin, & Taskin, 2009; Stølen, Chamari, Castagna, & Wisløff, 2005). Chmura et al. (2017) emphasizes that there were enormous changes in the game of football in the last few decades. The tempo of the game has increased, the style of the game, techniques and tactics changed as well as the regulations. Players ability to create action at a very fast pace has a significant impact on the course and outcome of the match. It is emphasized, however, that the maximum effort is only 11% of the total playing time. Thus, proper use of motor skills is crucial in the context of gaining or losing a goal (Reilly, Bangsbo, & Franks, 2000). Science can provide help for football (Stølen et al., 2005). The best teams are still improving their results and sports level, whilst worse ranked teams have the same results as years ago (Stølen et al., 2005).

Many authors point out that football is a multi-faceted sport and requires a player to be not only fast enough, but also capable of generating the appropriate power to play at the highest level (Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001; Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004). The power of the lower limbs is necessary to initiate a fast run, or the possibility of a quick change of direction and for high body challenge. It should be emphasized that the vertical jump is correlated with the short sprint (Wisløff et al., 2004). That is why strength & conditioning coaches in football should focus on lower limbs power training.

Football is also a discipline with a high risk of injury. The latest research among young footballers playing at various game levels showed that approximately 40% of athletes had non-mechanical injury (Lisman, Nadelen, Hildebrand, Leppert, & de la Motte, 2018). The Functional Movement Screen (FMS) protocol was invented to evaluate the risk of injuries among athletes through the analysis and scoring of movement patterns. Kiesel, Plisky, & Butler (2011) research confirms that this test is an appropriate injury prevention tool to use in football. FMS is getting more popular and attention of this tool has attracted scientists. The research number associated with FMS protocol involving recreational, college and Olympic athletes is still increasing (Bernardes Marques, Menezes Medeiros, de Souza Stigger, Yuzo Nakamura, & Manfredini Baroni, 2017). Functional training should be fundamental for developing special and tactic skills. The essence of functional training is an individual approach and the form should be as close as possible to those that the player encounters during training or in match conditions. The key role in functional training is to achieve and maintain optimal balance between mobility and stability while performing fundamental movement patterns with accuracy and efficiency (Bernardes Marques et al., 2017; Sprague, Mokha, & Gatens, 2014).

The aim of this study is to verify the functional state of young football players using selected components of the FMS protocol, as well as to assess the 12-week functional training impact on the power of the lower limbs of the young footballers.

Methods

Participants. Research participants were athletes (n = 20) – younger juniors (U17), practicing football at the Silesian Football Academy at the level of the Central Youth Junior League (Table 1). The research was carried out in the time of preparations for the autumn season and just after the autumn round of matches, directly before the preparations for the spring round. Before participating in the research, each competitor was informed about their purpose and confidentiality of results, as well as the possibility of giving up research without any consequences. The inclusion criterion was: consent for participation in the research, good health and active participation in functional training. The exclusion criteria were: lack of consent of the trainer, injury or illness and rehabilitation not allowing the participant to participate in regular training. All participants and their parents were informed of the purpose, nature, testing procedures, possible risks, and their right to terminate participation at will, before they gave their voluntary written consent to participate. Written informed consent was signed by the parents of minors before participation. The study was approved by the Ethics Committee of The Jerzy Kukuczka Academy of Physical Education in Katowice (Poland).

The research was carried out in two stages: in the first part of the study, the functional assessment was measured using the FMS test, then the measurement of the power of the lower limbs was done with the Optojump testing device. All tests were performed from 8.00 to 12.00, keeping the order of approaching competitors to the test trials. All tests were carried out in the sports hall. Each time before testing (except for the FMS test) warm-up including stretching, strength and speed exercises has been carried out.

Table 1. Characteristics of basic somatic parameters of the tested group of players (n = 20)

Parameters	m ± SD	Me	Range (min-max)	V	As	Ku
Age	16,8 ± 0,6	17	15–17	3,4	-3,14	8,61
Height (cm)	175,7 ± 6,4	176	167–187	3,7	0,21	-0,87
Body weight (kg)	66,5 ± 7,4	64	54,8–81	11,1	0,48	-0,85
BMI (kg×m^{-2})	21,5 ± 1,8	21,62	18,8–24,6	8,5	0,20	-1,16
FAT (%)	12,59±2,2	12	9,46–15,5	12,9	0,31	-0,09

LEGEND:
m ± SD - mean and standard deviation; Me - median; Range - the smallest and largest value; V - coefficient of variation; As - skewness coefficient (asymmetry); Ku - coefficient of focus (kurtosis)

Functional screen

Three functional FMS concept tests assessing global movement patterns were used for functional assessment. FMS test is a comprehensive screening tool that assesses the quality of basic movement patterns and identifies movement limitations and asymmetries (Cook, Burton, & Hoogenboom, 2014). The FMS test is popular in the coaching environment, mainly due to its simplicity and easy equipment to use. Fundamental movement patterns were tested which are the basis for more efficient sports movements (Kiesel, Plisky, & Voight, 2007). In the conducted studies, global movement patterns were assessed, those which require appropriate mobility, stability and range of motion in the joints as well as balance. Three tests were used to assess global movement patterns: 1) deep squat, 2) hurdle step and 3) in line lounge. Each test is evaluated on a four-point scale from 0 to 3 points, where 0 means pain during the test, 1 – inability to perform the test, 2 – perform motion with compensation, 3 – correct movement. Individual tests are carried out three times and evaluated for the best test. In case of doubt, the grade was downgraded.
The Researcher evaluated the movement in the frontal and sagittal plane. The FMS evaluation is done without warm-up and athletes wear sporty outfits and footwear. Specialized equipment "FMS Test KiTM" was used to perform the test. The kit includes a base - a board with dimensions of 5 × 15 × 150 cm, tubes with a centimeter scale and rubber cord (Cook et al., 2014). In these studies, the assessment of global movement patterns was carried out by a physiotherapist with FMS certification and by a strength & conditioning coach.

Lower limbs power tests

The lower limbs power was assessed by a vertical jump in three different forms: vertical jump from a static position (squat jump), vertical jump preceded by a lower limb attack with the hands on the hips (akimbo countermovement jump, ACMJ) and the vertical jump preceded by the countermovement jump (CMJ).

Test performance

Performing a vertical jump SJ consisted of a jump up from a fixed position, in which the thighs were at a 90-degree angle to the lower legs and the palms were resting on the hips, which excluded the possibility of making upper limb movements. Performing the ACMJ vertical jump was preceded by a rapid deflection of the lower limbs with the hands resting on the hips, while the CMJ jump differed from the previous one in that the player could also move his upper limb up during bending of the lower limbs. The jumps were repeated if knee or hips were bent during the dynamic phase.
Before the power tests, players performed a warm-up conducted by the coach. The warm-up prepared the player by stimulating and warming up the muscular and nervous systems before the test. A properly conducted warm-up determines the achievement of a maximum vertical jump (Viitasalo, Salo, & Lahtinen, 1998).
The lower limbs power jump test took place in the gym with the Optojump Optical Data Acquisition System from Microgate (Bolzano, Italy), which allows measuring all air and ground-related times with precision up to 1/1000 of a second. The Optojump system consists of two bars, one of which is a transmitter and the other a receiver. The LEDs in the transmitter are in constant contact with the LEDs in the receiving bar. The system detects movement of the object between the strips, precisely calculating the contact time with the ground during the jump, and then sends the recorded data to the computer, which calculates such parameters as: flight altitude and flight time. In order to calculate power generated during the vertical jump, the Seyers formula was used [Power (W) = 60.7 × Height of stroke (cm) + 45.3 × Body weight (kg) – 2055] (Sayers, Harackiewicz, Harman, Frykman, & Rosenstein, 1999).

Statistical analysis

Descriptive statistics (mean and standard deviation) were calculated. Before using parametric tests, the assumption of normality and homoscedasticity were verified using the Shapiro–Wilks W-Test. In order to compare the data from the power tests of the lower limbs obtained before and after the implementation of the training program, a paired sample t-test was used. In contrast, a non-parametric Wilcoxon pair order test was used to compare functional evaluation results. For all analyzes, a level of $p \leq 0.05$ was selected to indicate statistical significance. All calculations were done with the STATISTICA – statistical package ver. 13.3 PL of TIBCO Software Incorporation (Tibco, 2017).

Functional training program

The implemented program was planned in accordance with the FMS concept and based on functional training implemented of selected sports disciplines (Kiesel et al., 2011; Peate, Bates, Lunda, Francis, & Bellamy, 2007) as well as on the experience of coaches and physiotherapists (Table 2).

Table 2. A detailed description of the training program implemented in the research group

Part of the training unit	exercises / goal / execution (Volume)
Warm-up (10 min)	1. Running (4’) 2. Run with the delivery and delivery step (2x20m) 3. Cross step (interlace) (2x20m) 4. Forward shoulder circulation (30’’) 5. Back arm circulation (30’’) 6. Dynamic stretching (5’) 7. Hip rotation (2x10 rep) 8. A twist with a trunk torsion (2x5 rep) 9. Buttocks Activation with a mini band (2x10 rep) 10. Skip A (10m) 11. Skip C (10m) 12. Running rhythm (15m)

Main Part (45-60 min)	1. Back Stretching exercises (2-3 ex.) 2. Mobilization of shoulder complex (2 ex.) 3. Mobility of the thoracic spine.: Extension of the thoracic spine (1-2 ex.) 4. Four - point kneeling position. Thoracic spine rotation (2 ex.) 5. Hip mobilization in the direction of flexion, extension, external and internal rotation (5 ex.) 6. Ankle Mobilization towards the dorsiflexion (2 ex) 7. Central stabilization, stabilization of the ilio-lumbar-pelvic complex (3 ex.) 8. Exercises with bands, global patterns (2 ex.) 9. Balance and coordination exercises (2 ex.)
Cool Down (15 min)	1. Foam rolling (15’)

Results and discussion

Functional status of global patterns in the FMS test

The assessment of the functional status of young players conducted before the training program indicates (Table 3) that in the FMS 1 test the average score on a scale from 1 to 3 was 1.6 ± 0.51. The calculated skewness coefficient of -0.21 indicates that the majority of respondents achieved a score higher than the average. In the case of the FMS2 test, the average value for the whole group was 1.9 ± 0.49 and, similarly to the FMS1 test, the majority of people achieved a score higher than the average for the whole group (AS = -0.442). The average result for the whole group for the FMS3 test was 1.7 ± 0.59. It should be emphasized that in test 3, results of the examined persons were the most diversified, which was confirmed by the calculated coefficient of variation (V = 35.6%). Moreover, contrary to the FMS1 and FMS2 test, the majority of respondents obtained a score lower than the average calculated for the whole group.

Table 3. Characteristics of the results of the functional status of movement patterns carried out prior to the start of the training

Variables	m ± s	min–max	± 95% PU	V	As	Ku
FMS 1	1,6 ± 0,51	1–2	1,3–1,8	32,9	-0,218	-2,183
FMS 2	1,9 ± 0,49	1–3	1,6–2,1	26,5	-0,442	1,304
FMS 3	1,7 ± 0,59	1–3	1,4–1,9	35,6	0,212	-0,552

Influence of the 12-week functional training program on the functional state of global patterns in the FMS

The 12-week functional program was aimed to improve selected motor skills among young footballers. It is interesting to what extent the change occurred in global patterns in the FMS test. Based on the results presented in Table 4, it can be concluded that in the FMS1 test there was a statistically significant (p = 0.004) improvement in results by 45.2% (1.55 vs. 2.25). To a slightly lesser extent, but also statistically significant (p = 0.012) there was an improvement of 24.3% in the FMS2 test (1.85 vs. 2.3). The highest progression was recorded in the FMS3 test, where the difference between the measurement at the end of the training program and before its introduction was 48.5% (1.65 vs. 2.45, p = 0.001).

Table 4. Results of the assessment of the functional status of the tested group of players (n = 20). The significance of differences was assessed using the Wilcoxon test.

Variables	Pretest	Posttest	difference (%)	*p*-Value
FMS 1	1,55 ± 0,51	2,25 ± 0,55	-0,7 (-45,2%)	0,004
FMS 2	1,85 ± 0,49	2,3 ± 0,57	-0,45 (-24,3%)	0,012
FMS 3	1,65 ± 0,59	2,45 ± 0,69	-0,8 (-48,5%)	0,001

Impact of the 12-week functional training program on the power of the lower limbs

The functional training applied program was aimed to improve movement limitations, eliminate asymmetries and compensations that occurred during the first test. This, in turn, was to be put into more efficient and, above all, safer use of the movement tasks. Thanks to this, after the conducted training program, the athletes were more functional, and thus they could perform better with improved motor skills and characteristics patterns to a given discipline. Based on the data presented in Table 5, it is noticeable that a results improvement was achieved in all tests performed after the end of the training program compared to the initial tests. The power of the lower limbs is presented in power units (Wat) and as the height of the vertical stroke in centimeters.

The CMJ test showed a difference in generated power of 3.1% (3331.9 vs. 3436 W; p = 0.076) and in the amount of a jump, where the difference was 4.3% (39.9 vs. 41.6 cm; p = 0.069). Slightly smaller differences occurred in the CMJ test without swing, where the power improvement was demonstrated at 2.1% (2,980.8 vs. 3042.7 W; p = 0.082) and a jump differential of 2.9% (34.1 vs. 34.1). 35.1 cm, p = 0.089).

The highest progression was noted in the SQUATJUMP test, in which a difference of 5.3% (3082.7 vs. 3253.6 W) was observed before and after the introduction of the training program. This result is statistically significant (p = 0.008). The difference in the amount of jump measured was 7.3% (35.8 vs. 38.6 cm) and the result is also statistically significant (p = 0.008).

Table 5. Lower limbs power tests results in the group of football players (n = 20)

Variables	Pretest	Post test	Difference (%)	Test t (*p*-Value)
CMJ(cm)	39,9 ± 5,2	41,6 ± 4,8	-1,7 (-4,3%)	-1,931 (0,069)
CMJ(W)	3331,9 ± 511,6	3436 ± 467,2	-104,1 (-3,1%)	-1,879 (0,076)
CMJ without swing(cm)	34,1 ± 4,6	35,1 ± 5	-1 (-2,9%)	-1,792 (0,089)
CMJ without swing(W)	2980,8 ± 414,3	3042,7 ± 471,2	-61,9 (-2,1%)	-1,834 (0,082)
SQUATJUMP(cm)	35,8 ± 5,5	38,6 ± 4,8	-2,8 (-7,3%)	-2,977 (0,008)
SQUATJUMP(W)	3082,7 ± 463,7	3253,6± 429,4	-170,9 (5,3%)	-2,977 (0,008)

The FMS test is a tool created to assess the risk of injury by analyzing the fundamental movement patterns in seven individual tests that check, among others, coordination, mobility and stability. However, it should be emphasized that the deficiencies in the basic motor skills (coordination, mobility, stability) develop into deficiencies in targeted motor skills (strength, power, speed, endurance) and then futher into the limitation of the special performance to a given discipline. On the foundations of basic movement patterns known from neurophysiological development, athletes are able to achieve progress in the next stages of motor development. Neglect of the first stages of functional development of youth athletes may result in the lack of adequate anxiety of the body segments, leading to compensation, excessive overloads, improper transmission of force, for example in the case of sudden change of direction, acceleration, braking. Such excessive physical activity of athletes speeds up the risk of injury and reduces its motor potential. As Cook (2003) emphasizes, a player with functional movements may show better skills and techniques of movement.

Research by Zhixiong, Chen, Wang, & Yabin (2016) showed that the overall outcome of FMS test in young football players is correlated with SJ and CMJ tests.

The results in many sports, including football, are strongly dependent on power, especially at the level of match-fighting (Baker & Nance, 1999; Stanula & Roczniok, 2014; Wisløff et al., 2004). The power of the lower limbs directly affects the special efficiency components: acceleration, maximum speed, and the ability to perform sudden turns (Stanula et al., 2013; Wisløff et al., 2004). It should be emphasized that the power measured by the vertical jump is correlated with the short sprint effort (Wisløff et al., 2004). Similar observations were made by Chamari et al. (2008) showing that the vertical jump is related to the match success of semi-professional teams of players. Therefore development of power is very important in football, where accelerations and quick turns are evident throughout the whole match.

The aim of the conducted research was to verify whether functional training would improve the functional status tested by FMS and will be submitted to the result of measuring the lower limbs power tested in three vertical jump tests. Study of López-Segovia, Marques, Van Den Tillaar, & González-Badillo (2011) showed the positive effect of a workout consisting of full squats and vertical jumps on the generated power of the lower limbs and a positive correlation with a short sprint for players under 21. According to Boyle (2017), squatting in an incomplete range of motion prevents full muscle involvement in the exercises so it is also difficult to develop strength, power and speed through this exercise. Limiting of ankle mobility towards the dorsiflexion may reduce the rebound power abilities during plyometric exercises (Driller & Overmayer, 2017).

First FMS test - squat; evaluates 7 functional components (Kritz, Cronin, & Hume, 2009). First assessment of the test showed lots of deficiencies in the proper performance of testing movement patterns. The most deficiencies were noted in ankle , hip mobility and shoulder girdle. The functional training program was aimed to improve dysfunctions and was supposed to improve the quality of movement patterns. Based on the results presented in Table 3, it can be stated that the results have improved in all tests. The highest progression was recorded in the FMS 3 test, where the difference between the measurement after the training program and before was 48.5%. The improvement of the functional state resulted in the progression of the power of lower limbs, because the achieved results were improved in all tests carried out after the training program in comparison with the initial tests. The biggest progress appeared in the SJ test. Performing these tests is based on the squat pattern. Correct performance without compensation allows to increase the load in strength training, which translates than into generating more power (Adams, O'Shea, O'Shea, & Climstein, 1992). In other controlled studies, a functional squat technique was found to improve vertical jump performance (Berning et al., 2010; Ferreira, Weiss, Hammond, & Schilling, 2010; Loturco et al., 2017). In subsequent studies, significant changes were also noted in the tests of uplift, kicks and vertical jump tests as a result of a 6-week training plan based on functional movements (Goss, Christopher, Faulk, & Moore, 2009). In baseball, after the FMS correction training program, stabilization improved and the results of functional fitness, strength and flexibility were also better (Song et al., 2014).

There is a lack of research of functional training impact on the power generated by football players. Some researches indicate positive influence (Kiesel et al., 2011; Song et al., 2014), as well as some of them showed no influence after such interventions on individual motor skills (Lockie et al., 2015). Undoubtedly functional training aimed to shaping fundamental motor skills or eliminating functional limitations (pre-hab) can be a good tool to supplement training at various stages of the macrocycle. The presented results should lead to considerations to apply a longer training program and conducting studies showing the correlation of the speed test with the lower limbs power test.

Conclusion

The aim of this study was to check the functional state of global movement patterns and the level of lower limbs power of young footballers after the introduction of 12-week training intervention. Training program was aimed at improving the condition of selected movement patterns. It should be emphasized that the functional condition of the examined players has significantly improved. The power of the lower limbs after training intervention also improved. Attention should be paid to the essence of implementation of training intervention and monitoring of players in terms of correlation of functional state with the level of power of lower limbs and other motor skills. The purpose of subsequent studies should be to introduce an intervention program and compare it with the control group.

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