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The Impact of the Soccer Training Season on the Body Composition and Physical Performances of Young Soccer Players

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Abstract

The purpose of this research was to prove the effectiveness of a soccer training program during a macrocycle (preparation and competition season) on the body composition and physical performances of young players. The research was conducted with a sample of 24 soccer players in two age groups: U15 (n=12) and U17 (n=12). The initial testing took place prior to the start of the preseason, whereas the final testing was performed after four months of training. The results prove that the soccer training program for the U15 age range causes important significant differences in the isokinetic force: peak torque flexion and peak torque extension. No significant changes were seen in body composition (body height/mass and muscle and fat mass) or vertical jump (Squat Jump - SJ, Counter-Movement Jump - CMJ, Maximal Counter-Movement Jump - CMJmax). The results also prove that the U17 soccer training program causes important statistical differences in muscle mass, fat mass, SJ, CMJ, CMJmax, and peak torque flexion, but there were no statistically significant changes in peak torque extension or body height/mass of the U17 soccer players. This research shows that the sensitive phase for relevant improvements in explosive force occurs after the age of 15 years, a period that is characterized by the dramatic development of muscle mass.

Keywords: *association football, training programs, anthropometry, jumping, strength*

Introduction

Training programs for young soccer players are designed to stimulate optimal body development in terms of its composition and physical performances relevant to soccer's gameplay (Sermaxhaj et al., 2022). Nowadays, modern soccer requires players with a perfect technical level, developed tactical thinking, and physical training to be able to cope with game-play difficulties. Fulfilling these prerequisites requires planning precise training processes with scientific support and continuous assessment knowledge during the growth and development period (Huijgen et al., 2014).

Soccer is a sport that is characterized by many different and complex dynamic kinesiology activities characterized by a large number of cyclic and acyclic movements (Gardasevic, Bjelica, & Vasiljevic, 2016; Matin & Sæther, 2017). If they wish to identify game play's success determinants, they need to understand that simply knowing its movements is not enough. Yet, they also need to study the impact of soccer training on the development of body composition and physical performance during growth and the biological development phases in young soccer players. A five-year study monitoring morphological characteristics and physical performance changes over puberty found that the highest body height and mass increases occur at 13.8±0.8 yrs, when height and mass change per year peak at 9.7±1.5 cm·yr-1 and 8.4±3 kg·yr-1, respectively (Philippaerts et al., 2006). Even explosive power, speed, agility, and anaerobic endurance development peaks occur at the highest heights of age (Philippaerts et al., 2006). Bodily

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structure changes should cope with the specific sport's ability to make body development healthy (Popovic et al., 2013; Gontarev et al., 2016). Currently available technology allows obtaining accurate sportsman's bodily structure data (total, lean, and fat body and segments' mass). Such data quick detection allows matching together sound bodily structure, development, and specific sport training. Body composition assessment needs to be longitudinal to support the search for adequate methods and procedures for effective soccer player selection (Sermaxhaj et al., 2022). Another study showed how a training program for soccer players can significantly improve body composition in terms of overall (-1.6 kg) and fat mass (-2.8 kg) (Melchiorri et al., 2000). Skeleton longitudinal dimensionality showed an increase over age (from U13 to U19). Body composition was found to differ in soccer players with two years of training experience (U11, U13, and U15) compared with boys not playing soccer (Vänttinen et al., 2011). Also, at the young soccer players U13, it is confirmed that regular training increases lean mass by 1.15 kg, or 1.81%, and body fat reduction by 0.77 kg, or 3.1 (Sermaxhaj, 2019).

During a soccer match, a player carries out 1400–1600 activities (runs, dribbles, jumps, kicks, headers, tackles, etc.). 700–800 of these activity changes consists of changes of direction and/or speed, and only 11% of the total traveled distance is run at high speed, which is therefore relevant for the match result (Williams & Reilly, 2005). Strength and vertical jump ability are acknowledged determinants of many soccer fundamentals (Ferrete et al., 2014; Lehnert et al., 2014). Namely, explosive force development over knee flexion and/or extension is the determinant of effective runs and jumps (Newman et al., 2004). Isokinetic contraction is a kind of exercise in which one contracts some muscles maximally against a resistance provided by the isokinetic dynamometer that allows movement at a fixed speed (i.e., "iso-kinetic") around a fixed range of motion (Padulo et al., 2013a). That is a common exercise testing and training modality. Isokinetic contraction can be both concentric and eccentric and around many different specific joints (Padulo et al., 2013a). Peak torque, an absolute value, is the greatest amount of force that a muscle can develop. That can be assessed for both a single repetition (1-repeat maximum isotonic strength test) and a multiple-repetition set (Kowalski, 2003).

Hammami et al. (2013) found that a soccer-training season provided balanced improvements in both anthropometric (body height, mass, and fat) and performance variables (Yo-Yo Intermittent Recovery Test Level 1, counter-movement-jump, squat-jump, five-jump-test, and 10-m and 30-m sprints) in young players. Together with body height, mass, (lower) fat, and (relatively higher), viz., being born in the first six months of the year (Rađa et al., 2018), age, speed, maximum oxygen consumption, agility, and shooting precision make teenagers more likely to be selected as soccer players (Gil et al., 2007; Sermaxhaj et al., 2015). A speed, agility, and quickness training program were shown to improve sprints, jumps, and agility performances in young soccer players (Jovanovic et al., 2011; Sermaxhaj, 2017). Training them is meant to improve their body composition and physical performance and to prevent injuries.

An optimal training program for body composition and physical performance improvement needs specific periodization. That is made up of three phases: preparation, competition, and transitions. Each coach's main task is to ensure that his or her players achieve a satisfactory sporting condition over the preparation and maintain that condition over the competition season. A satisfactory sports condition is a state where players' physical, technical, and tactic skills allow the team optimal match performance. From a longer perspective, an optimal training program is a systematic, multi-year activity. Although football training may impact body composition and physical performance, based on previous research, it is unclear what the effects of football training are on young players aged 15 to 17. The aim of the present study was to assess the impact of soccer training on young (U15 and U17) players' body composition and physical performance over the preparation and competition seasons. The hypothesis was that they hypothesized that 1) age-specific training programs designed following expert advice cause different effects on body composition and physical performance of different-age young soccer players' groups (U15 and U17), and 2) the best effects, in terms of bodily and performance improvement, are achieved in the older age group (U17).

Materials and Methods

Participants

Two different age groups of young soccer players from the Football Club Ramiz Sadiku of Prishtina participated in this research: a group of U15 players (U15, n=12), and a group of U17 players (U17, n=12). The average age of the players in the initial measurements were; U15 (14.0±0.4 years) and U17 (15.6±0.4 years). Players were involved for 16 weeks in the regular soccer training sessions in preparation and during the competition period. Before participating in the study, participants underwent a medical checkup at the sports medicine center in Prishtina. Check-up cleared all participants for participating in the study. Furthermore, all participants were informed about the purpose and procedures of testing and provided written consent to participate in this study. In accordance with the Declaration of Helsinki, the local university ethics committee approved the study (Universe College Ethics Committee; Prof. Jeton Havolli; protocol number: FCP 11/10/2016-2), and participants were informed of its goals and procedures and signed a written consent.

Measurements were taken in the sports performance laboratory of the Sports College of the University of Prishtina. Pre-tests took place before the 1st of August, the season's beginning, and post-tests took place four months later, within November's end, the macrocycle's end.

Procedures and measures

The first were body height and composition (total, lean, and fat mass) measured sequentially with a Martin anthropometer and a specific analyzer (InBody 720, InBody, Seoul, Korea).

After that, players started with a 12-min freely chosen speed-running warm-up. Then, they performed squat jump (SJ), countermovement jump (CMJ), maximal countermovement jump (CMJmax; Bosco et al., 1983; Philippaerts et al., 2006), and knee isokinetic flexion and extension peak torques (Lehnert et al., 2014).

Jumping performance

SJ is a vertical jump from a static crouched position without previous downward countermovement. Knees bend down to 90°, the body is upright, and hands remain in contact with hips. Players were asked to jump as high as possible, starting from such a position (Padulo et al., 2013b; Gheller et al., 2015). CMJ is a vertical jump with a previous downward countermovement. Jump begins in an upright posture with hands remaining in contact with hips and body center of mass lowering until knees become about 90° bent before the final vertical push. Players were asked to jump as high as possible in the above way. CMJmax is a vertical jump. The only difference with respect to CMJ is that hands are free to enhance momentum. All vertical jump tests were performed on a tenziometric system (Powertimer 300, Newtest Oy, Tyrnävä, Finland). The system used in this study consisted of a controlling computer and a high-sensor-density 84x95 cm mat (Balciunas et al., 2006; Enoksen et al., 2009). Jump height was calculated using the equation h=t2×1.22625, where h is the jump height in meters and t is the time in the air of the jump in seconds (Bosco et al., 1983).

Knee flexion and extension

The dominant leg's knee flexors and extensors' isokinetic strength was measured with an isokinetic dynamometer (Biodex System 4, Biodex Medical Systems, New York, USA). Knee isokinetic flexion and extension peak torques were measured at 120°/s in the seated position and 100° hip angle. Players were asked to randomly flex and extend their dominant knee with maximal force three times (Stastny et al., 2018). The strongest repetition was chosen for further analysis. Considering the short exercise duration (<1 sec) and to minimize any fatigue effect, a 1-min passive recovery between two same-type repetitions and a 2-min passive recovery between the two repetition types were allowed for the players. During testing, players were provided with concurrent visual feedback as an isokinetic strength curve on a dynamometer monitor (Vico et al., 2013).

Training program

During the season's first macrocycle, participants trained three times per week (48 sessions in total) and played three friendly and 11 tournament matches. Training was designed following literature and relevant bodies' recommendations (Bisanz & Gerisch, 2008). Both age groups' training programs were based on four components: conditional (CO), technical (TE), tactic (TA), and mental component (ME). All components were managed by Union of European Football Associations-certified trainers.

Both age groups' weekly cycles were designed as functions of the programs' components. In the first training session (on the week's beginning), TE prevailed; in the second training session (on the week's middle), CO prevailed; in the third training session (on the week's end), TA prevailed; and friendly and tournament matches took place on weekends. Training sessions were made up of a general and specific warm-up (20–25 min), a main part (40–50 min), and a cool-down (10-min running recovery). The main content of the program is shown in Table 1.

Table 1. Training schedule season's first macrocycle

Soccer players U15	Soccer players U17
4 week pre-season period and 12 week season period	4 week pre-season period and 12 week season period
Target: training to build the game	Target: focused on achieving results
TE - Technical (training to improve the technical approach to the game)	TE -Technical (situational techniques - application of technical elements during the game),
CO - Conditioning (development of coordination, basic endurance, speed and strength),	CO - Conditioning (development of fast force, coordination, speed and specific endurance),
TA - Tactical (learning individual and group tactical elements to improve the soccer game).	TA - Tactical (collective tactics in the game system—training for the soccer game).
ME - Mental (socializing, motivation, communication and confidence).	ME - Mental (motivation, courage, striving to win and team spirit).

Statistical analysis

Statistical analysis was performed with SPSS 21.0 (IBM, Armonk, USA). The Shapiro-Francia test was first used to assess normal data distribution. For both U15 and U17, it was calculated pre- and post-training means and standard deviations (SD) of body composition (body height, total lean, and fat mass) and physical performance variables (SJ, CMJ, and CMJmax heights, and knee isokinetic flexion and extension peak torques). Differences between initial and final measurements were assessed for both groups using a analysis of ANOVA. The level of significance was 0.05.

Results

Table 2 shows the values of body composition variables before and after training U15. ANOVA results showed that the training program made positive changes but was statistically insignificant on the body composition variables of U15 players.

Table 2. U15 pre- and post-training body composition variables values

Variable	U15-pre (Mean±SD)	U15-post (Mean±SD)	F	p
Body height (cm)	169±9.6	171.3±9.6	0.279	0.603
Body mass (kg)	52.3±8.9	54.3±9.1	0.109	0.745
Lean mass (%)	50.52±2.23	50.86±1.88	0.162	0.691
Fat mass (%)	8.46±3.96	8.24±3.07	0.022	0.885

Note: Mean=arithmetic mean, SD=Standard Deviation, F=F score, p=p value

Table 3 shows the values of the physical performance U15 variables before and after the training. ANOVA results showed that the training session affected positively physical performances, but positive significant changes were achieved only in the isokinetic force of knee flexor peak torques (p=0.007) and extensor peak torques (p=0.014). Hypothetically, it can be concluded that the non-improvement of jumping force (SJ, CJM, and CJMmax) was preceded by insufficient muscle development in relation to height during this period.

Table 3. U15 pre- and post-training physical performance variables values

Variable	U15-pre (Mean±SD)	U15-post (Mean±SD)	F	p
Squat jump (cm)	28.3±5.9	29.9±4.8	0.555	0.464
Countermovement jump (cm)	32.5±5.1	33.2±5.2	0.119	0.733
Max. countermovement jump (cm)	38.4±4.9	38.7±5.2	0.024	0.878
Flexion peak torque (Nm)	68.54±16.5	93.90±24.80	8.716	0.007**
Extension peak torque (Nm)	72.67±21.2	94.40±18.60	7.123	0.014*

Note: Mean=arithmetic mean, SD=Standard Deviation, F=F score, p=p value, bold=significant values

Table 4 shows the values of body composition U17 variables before and after training. ANOVA results showed that the training session affected all body composition variables, but significant changes were achieved in muscle mass with an increment p=0.024 and a decrease of fat mass, p=0.048.

Table 5 shows the values of physical performance U17 variables before and after training. ANOVA results showed that the training program had a positive effect on physical performances, but statistically significant changes were achieved on the jumping force variables SJ (p=0.026), CJM (p=0.46), CJMmax (p=0.011) and isokinetic force of knee flexor peak torques (p=0.004).

Table 4. U17 pre- and post-training body composition variables values

Variable	U17-pre (Mean±SD)	U17-post (Mean±SD)	F	p
Body height (cm)	175.7±6.4	177.1±6.5	1.292	0.268
Body mass (kg)	61.1±10.2	62.2±8.8	0.293	0.594
Lean mass (%)	49.50±3.92	52.58±1.96	5.919	0.024*
Fat mass (%)	9.13±3.03	6.94±2.79	3.370	0.048*

Note: Mean=arithmetic mean, SD=Standard Deviation, F=F score, p=p value, bold=significant values

Table 5. U17 pre- and post-training physical performance variables values

Variable	U17-pre (M±SD)	U17-post (M±SD)	F	p
Squat jump (cm)	31.4±4.8	35.5±3.5	5.670	0.026*
Countermovement jump (cm)	34.9±3.6	37.7±3.5	3.739	0.046*
Max. countermovement jump (cm)	38.3±3.7	43.3±5.1	7.621	0.011*
Flexion peak torque (Nm)	76.60±28.80	115.40±29.90	10.437	0.004**
Extension peak torque (Nm)	109.30±30.10	120.20±30.30	0.788	0.384

Note: Mean=arithmetic mean, SD=Standard Deviation, F=F score, p=p value, bold=significant values

Discussion

This research was performed on soccer players of two age groups (U15 and U17) in a relevant phase of biological growth, which is characterized by important shaping of body composition and an increase in physical performance (Philippaerts et al., 2006). Through training sessions, it is intended to optimize muscular mass and fat mass, especially during the growth and development phase (Melchiorri et al., 2000; Helgerud et al., 2001).

This research in U15 showed that a three-times per week over a four-month macrocycle training program increased significantly both flexion (+25.36 Nm, +37%) and extension (+21.73 Nm, +30%) peak torques without any changes to either body composition variables or vertical jump performances. The results of this study show that the training program made positive changes but was statistically insignificant for the body composition variables of U15 players. The results of this study are consistent with the research of other authors (Philippaerts et al., 2006; Sperlich et al., 2011). Another study indicates that football practice in young U10 and U12 football players produces benefits in body composition and physical fitness (Wong et al., 2010; Thaheri et al., 2014; Sermaxhaj, 2019; Martin et al., 2023).

Based on the results of this research and several other studies, it is proposed that individual training sessions with the purpose of achieving positive changes between muscle mass and fat mass are the best approach. This shows that the sensitive phase for improvement of jumping force is not at this age. Similar results were proven in another research (Sperlich et al., 2011).

This research was performed on U17 soccer players as well, but with a different training program and results. Regarding the effect of training programs on U17 soccer players, the results of this research have shown a sensitive increase in muscle mass (+3.08%, -6%) and a reduction in fat mass (-2,19%, -24%). Results of this research confirm that the increment in body weight is a result of the increase in muscle mass percentage and the decrease in subcutaneous fat mass percentage in total value, which is normal when considered that the balance between body height and weight begins in the U17 category. The obtained results show that the muscle mass increase and fat mass decrease are a product of the regular 4-month training program and the intensive growth and development of soccer players U17 muscles. Similar results were achieved by other researchers (Melchiorri et al., 2000; Vänttinen et al., 2011). There was no statistical impact proven by the soccer training program on the physical composition of senior-aged teams (Campos et al., 2013). This shows that soccer training is more effective in the development of body composition. This shows us that soccer training is more effective in the development of body composition at the age of puberty.

Regarding physical performance variables, significant increases in squat (+4.1 cm, +13%), countermovement (+2.8 cm, +8%), and maximal countermovement (+5.0 cm, +13%) jump heights and knee flexion peak torque (+38.8 Nm, +51%) were assessed without any change to knee extension peak torque. Therefore, it can be conclude that the reasons behind the positive changes in physical performances (jumping and isokinetic force) are the content of the training program and muscle mass increment. Although a number of studies have focused on the changes in isokinetic strength of knee flexors and extensors after a training program applied during the season (Gioftsidou et al., 2008; Brito et al., 2010; Sermaxhaj et al., 2018), results also indicate that peak torque values of knee flexors and extensors varied differently in trained youth soccer players depending on muscle group (Lehnert et al., 2014).

In U17, body composition variables improved along with physical performance variables.In addition, this study did not consider biological maturity status (Tanner, 1962).

Seeing the limits of this study, we suggest research with a larger sample and with a control group, as well as researching not the general impact of the sports program but the separate impact of conditional preparation (CO), technical (TE), tactical (TA), and mental preparation (ME). This would enable more specific conclusions regarding the preparation of football players of young ages.

Conclusion

This research showed that growth phase sensitivity for relevant explosive force improvements occurs after the age of 15 years, a time marked by a concurrent muscle mass increase. It is suggested that with age groups U15 and U17, in addition to regular training, it might be effective to perform very carefully specific explosive force training to maximize such body composition and physical performance changes in young soccer players. This research further contributes to describing the different body compositions of young players as they age. The bodily and performance spurts described are due to both soccer training and puberty. These research results may prompt further studies on the relationships between training, body composition, and physical performance in youth.

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Conflict of Interest

The author declares that there is no conflict of interest.

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