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The Trainability of Explosive Power Features and Their Negative Correlation with Body Fatness in Collegiate American Football Players

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Abstract

Both sports education and training interventions create a dose-response relationship in the body which change the body composition. The aim of this study is to investigate the relationship between pre-season body composition and physical performance parameters of collegiate American football players. 23 American football players (age: 22.3±3.1 years, height: 180.6±5.6 cm, weight: 94.2±16.9 kg) voluntarily participated in the study. The body compositions of players were determined via Dual-Energy X-ray Absorptiometry (DEXA) device and countermovement jump (CMJ), 10 and 40-yard sprinting and pro-agility tests were applied to evaluate physical performance. Pearson Correlation analysis was used to determine whether there was a relationship between body composition parameters and field tests. As a result, a statistically significant negative correlation ($p < 0.05$) was found between body fat percentage ($r = -.736$; $p < .001$) and body fat mass ($r = -.717$; $p < .001$) with CMJ. A statistically significant relationship ($p<0.05$) was found between body fat percentage ($r = .622$; $p < .002$; $r = -.759$; $p < .001$) and body fat mass ($r = .595$; $p < .003$; $r = -.736$; $p < .001$) with 10 and 40-yard sprints respectively. Body fat percentage ($r = .659$; $p < .001$) and body fat mass ($r = .638$; $p < .001$) also correlated with pro-agility. Our results support earlier research by showing a direct correlation between body composition and power attributes and performance in American football. Coaches were advised to pay attention to body adiposity in terms of a decline in physical performance for this reason.

Keywords: Body fat percentage, Body fat mass, Countermovement jump, Sprint, Pro-agility

1. Introduction

The importance of body composition in athletic performance has been broadly examined in relation to overall and regional fat and muscle ratios. Body composition is widely accepted to significantly impact a player's physiological parameters and game performance (Milanese et al., 2011). In detail, having excess fat tissue harms activities that require players to move their bodies against gravitational and drag forces several times during certain activities such as accelerating, decelerating, jumping and sprinting; resulting in a decrease in performance and higher energy demands depending on the activity (Reilly, 2003). Furthermore, by boosting strength and power performance levels, lean muscle mass becomes another essential contributor to power generation during activities requiring high performance (Mala et al., 2015). As any kind of sports and physical education interventions and public health applications create a dose-response relationship in the body which changes the body composition (Segovia & Gutiérrez, 2020). Also, the trainability of motoric features such as jumps, sprints and agility are important to overall performance and they are directly related to body fat percentage and body composition in American football players (Lukaski & Raymond-Pope, 2021).

American football has become more and more popular in many countries, including Turkey, especially over the last two decades (Severo-Silveira et al., 2017; Özkan et al., 2009; Tatlıcıoğlu et al., 2020). As an aggressive contact sport, American football involves many collisions between players during the game, and players often impact the ground as well (Turnagöl, 2016). Therefore, players need to have many motoric features such as speed, jumps, effective acceleration and deceleration, change of direction, strength, coordination, reaction, perception and technical skills in the game (Robbins & Young, 2012; Nimphius et al., 2013). Anthropometric and physical performance characteristics are more closely linked to the successful execution of such movement structures (Fields et al., 2018).

Robbins and Young (2012) tested some of those movement structures (*i.e.*, speed, jumps) of American football players grouped in terms of playing positions and reported strong relationships between sprint and jump tests. Numerous studies reported strong correlations between sprint and jump skills for different genders and sports, taking into account the need for explosive strength in both the sprint and the jump abilities (Young et al., 2005; Cronin & Hansen, 2005; Misjuk, 2007; Vescovi & McGuigan, 2008; Nimphius et al., 2013; Tatlıcıoğlu et al., 2020; Cerrah & Bayram, 2022). However, the number of studies comparing agility, sprint and jump performance with detailed body composition parameters of American football players is limited in the literature. Previous studies also investigated the anthropometric and some physiological profiles of American football players based on their Body Mass Index (BMI) and most of them neglected the sprint, strength and agility needs of the game (Laurson & Eisenmann, 2007). In addition, most research failed to indicate whether the measuring period was pre-season or throughout the season (Robbins & Young, 2012; Tatlıcıoğlu et al., 2020). Turnagöl (2016) compared whole and segmental body composition and Bone Mineral Density (BMD) of collegiate American football players in terms of playing positions and reported a higher fat percentage of linemen in parallel with the results of Bosch et al. (2019). Even though American football players have been categorized as overweight or obese (Harp & Hecht, 2005; Laurson & Eisenmann, 2007; Malina et al., 2007; Miller et al., 2008; Selden et al., 2009; Tucker et al., 2009; Steffes et al., 2013) based on their BMI, Lambert et al. (2012) reported that this BMI categorization could be misleading due to increased body size and higher fat-free mass of those athletes.

Among others, skinfolds, Dual-Energy X-ray Absorptiometry (DEXA), and Bioelectrical Impedance Analysis (BIA) are some of the most common procedures for measuring the body composition of athletes (Suarez-Arrones et al., 2018). DEXA enables to determine of body composition with high accuracy due to its 3-compartment [fat mass, lean mass and bone mass (and density)] model and is considered as the gold standard (Oates et al., 2006; Bilsborough et al., 2014) by the authorities for many years.

Many studies have been conducted to see how body composition impacts the performance of American football players. Few research, however, has studied the links between jumping ability, sprinting in different distances, agility performance and body composition, in young male collegiate American football players. This study aims to investigate how body composition affects agility, sprint and vertical jump performance in young male collegiate American football players. The results of this prominent study might help coaches to assign their players to the correct positions based on their body compositions. Besides, coaches can either decrease the fatness of players or increase the explosive power of players with appropriate training to develop effective performance in the team. These results could be generalized to interpret both physical and sport education interventions.

2. Method

2.1 Participant (Subject) Characteristics

Twenty-three collegiate American football players (age: 22.3±3.1 years, body height: 180.6±5.6 cm, weight: 94.2±16.9 kg) participated in the study voluntarily. All the participants were playing for the college-level teams in Turkish American football 1 league. They regularly train for 60 to 90 minutes five days a week during competition season as their normal training cycle. Players were at the in-season stage during the data collection process and injured players were excluded from the study. All the participants were informed verbally first about the test procedures and then signed a consent form for participation. This study was conducted in accordance with the principles of the Helsinki Declaration. As for the ethical issues, the local Research Ethics Committee approved the research (Board approval numbers: 15525).

2.2 Procedures

All measurements and tests were carried out at the beginning of the in-season period (August). The test sessions were completed in two days between 9:00 and 12:00 a.m. On the first day, anthropometry, body composition measurement and jumping performance were carried out at the Laboratory of Kinanthropometry at the Faculty of Sport Sciences, Eskişehir Technical University. On the second day, the Sprint (10, 40 yards) and pro-agility tests were carried out on a natural grass football field. Subjects were warned not to take any drugs, drink coffee, and get involved in vigorous physical activities at least 24 hours before the test day.

2.3 Anthropometric and Body Composition Analysis

A scale (Seca, Vogel & Halke, Hamburg) with a precision of 0.1 kg was used to measure the body mass of participants (kg). The height of the players was measured barefoot, heads placed in the Frankfurt plane using a stadiometer (Holtain Ltd., UK) with an accuracy of 0.1 cm.

As for the evaluation of regional and total body composition (fat percentage, muscle mass, and fat mass) through DEXA, the researchers preferred a total body scanner called the Dual-energy X-ray absorptiometry (Lunar Prodigy Pro; GE, Healthcare, Madison, WI, USA). In addition, they used phantoms in order to calibrate the scanner in the morning before the actual measurements by following the manufacturer's standard guidelines. Consistency was provided by performing all the scans and analyses with the same operator. Before the measurements, the participants were asked not to wear any jewelry or have any metal objects in their bodies while being screened. A standard supine position was achieved during the scans by tying the subjects' knees and ankles with a Velcro strap and their arms were extended by their sides. Typically, the examinations lasted between 6 and 8 minutes depending on the height of the participant.

2.4 Physical Performance Assessment

2.4.1 Vertical Jump Measurements

The testing was preceded by a standard warm-up procedure (5-minute self-paced running and 10 minutes of callisthenic and dynamic stretching). The participants were asked to perform jump tests Counter Movement Jump (CMJ) in order to measure the explosive power of their lower limbs by using a Smartspeed (Fusion Sport Pty Queensland, Australia). The participants came to the CMJ from the standing position and were asked to do a maximal vertical thrust (stretch-shortening cycle) by bending their knees to a 90° angle. Finally, the participants were asked to keep their bodies straight and descend with their knees fully extended during the jump. Any incorrectly performed jump was repeated. As in previous studies, a one-minute rest was allowed between consecutive trials, to minimize the effects of fatigue (Copic et al., 2014). The measurements from the best performance of two trials were recorded and expressed in “cm”.

2.4.2 Sprint (10, 40-Yards)

Players performed a 40-yard sprint test measured by timing gates (Smart Speed; Fusion Sport Pty, Ltd., Brisbane, Queensland, Australia) with a 10-yard split. They performed a self-determined 10-min easy jogging/running warm-up before the actual sprint tests. Two submaximal sprints were performed by each player before the actual tests as a part of the warm-up. There was a 3-min rest between the warm-up and actual tests. Each player ran two maximal 40-yard distances with a 3 min rest interval where the best sprint time was determined for further assessment (Nimphius et al., 2013; Tatlıcıoğlu et al., 2020).

2.4.3 Pro-Agility

Specify all subjects were allowed to perform two trials for the pro-agility test as familiarization. They ran 5 yards right, 10 yards left and 5 yards right again subsequently constituting a total of 20 yards during two actual tests. This order was reversed for the second trial with a 3-mins rest between each trial. The best out of two shuttle-run was recorded for further evaluation. The test was repeated after a 3-mins resting period when the player failed to cut off the light of the gate (Jones & Lorenzo, 2013).

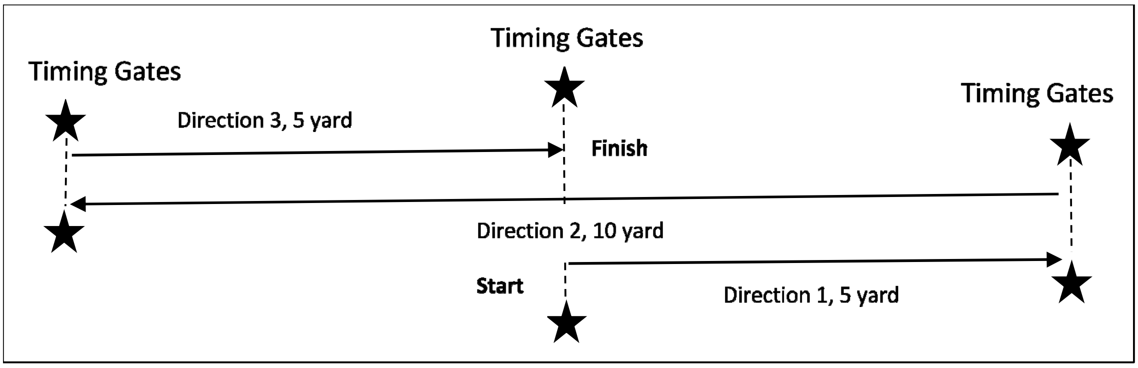

Figure 1. Pro-agility test

2.4.4 Statistical Analysis

The data were statistically analyzed by using SPSS 18 software (SPSS Inc., Chicago, IL, USA) and presented in means and standard deviations. The level of significance was taken as 0.05 in the analyses. In order to test the normality of the data, the Shapiro-Wilk test was applied. Finally, the Pearson correlation coefficient was used to analyze the correlation between body composition, vertical jump, sprint and pro-agility test. The probability level was taken as ≤ 0.05.

3. Results

Table 1 displays the descriptive statistics related to physical and total/regional body composition while Table 2 presents the results of vertical jump, sprint and pro-agility test results. Additionally, the relationship between total/regional and vertical jump, sprint, and pro-agility tests are shown in Table 3. There was a significant negative correlation between CMJ and percentage of body fat (BF%), leg fat percentage (LF%), arm fat percentage (ARMF%), trunk fat percentage (TF%), android fat percentage (AF%), gynoid fat percentage (GF%) and fat mass (FM) kg. However, no significant correlation was observed among CMJ with another total/regional lean body mass weight. As another finding of this study, there was a significant correlation between sprints and BF%, LF%, ARMF%, TF%, AF%, GF% and FM kg. However, there was no statistically significant correlation ($p < 0.05$) between lean body mass (LBM), leg mass, trunk mass, android and gynoid mass with sprint and pro-agility tests.

Table 1. The descriptive statistics of physical and total/regional body composition

Variable	Mean±sd (n = 23)	Minimum	Maximum
Age (years)	22.30±3.1	18.4	30.5
Height (cm)	180.6±5.6	171.0	193.0
Weight (kg)	94.21±16.9	69.0	131.0
Body Mass Index (kg/m^2)	8.88±2.2	20.8	36.3
Body Fat Percentage (%)	23.23±6.99	13.50	35.9
Body Fat Mass (kg)	21.86±10.2	9.3	42.3
Lean Body Mass (kg)	68.93±8.5	52.9	86.4
Arm Fat Percentages (%)	20.10±7.40	10.5	35.3
Arm Fat Mass (kg)	2.67±1.98	1.0	8.1
Lean Arm Mass (kg)	9.65±3.26	6.8	22.4
Leg Fat Percentages (%)	23.19±6.28	14.1	34.3
Leg Fat Mass (kg)	7.66±3.43	3.3	14.8
Lean Leg Mass (kg)	24.18±3.87	18.1	31.9
Trunk Fat Percentages (%)	24.14±8.65	10.1	40.0
Trunk Fat Mass (kg)	11.48±7.66	3.1	37.9
Trunk Lean Mass (kg)	33.27±10.59	25.5	79.5
Android Fat Percentages (%)	27.41±13.20	8.4	46.0
Android Fat Mass (kg)	1.97±1.97	0.3	9.9
Lean Android Mass (kg)	4.70±.70	3.4	6.2
Gynoid Fat Percentages (%)	20.64±9.35	0.3	38.3
Gynoid Fat Mass (kg)	3.87±2.71	1.2	14.3
Lean Gynoid Mass (kg)	10.72±1.25	8.8	13.3
Total BMC (kg)	3.37±.39	2.3	4.2
Whole BMD (g·cm^2)	1.37±.11	1.1	1.6
Z-Score	1.30±.97	-0.4	3.5

Note. BMC: Bone Mineral Content, BMD: Bone Mineral Density.

Table 2. The results of the vertical jump, sprints and pro-agility test

Variable	**Mean±sd (n = 23)**	**Minimum**	**Maximum**
Counter Movement Jump (cm)	47.18±7.50	31.0	61.9
Sprint (10 yard) (s)	1.90±.08	1.79	2.14
Sprint (40 yard) (s)	5.39±.32	4.96	6.20
Pro-agility (s)	5.01±.21	4.59	5.43

Table 3. Relationship between total/regional tests and vertical jump, sprint, and pro-agility tests for collegiate American football players

Variables	**CMJ (cm)**		**Sprint (10yd) (s)**		**Sprint (40yd) (s)**		**Pro-agility (s)**	
	r	**p**	**r**	**p**	**r**	**P**	**r**	**p**
Body Fat Percentage (%)	-.736**	.001	.622**	.002	-.759**	.001	.659**	.001
Body Fat Mass (kg)	-.717**	.001	.595**	.003	-.736**	.001	.638**	.001
Lean Body Mass (kg)	.209	.340	.260	.231	.308	.241	.162	.460
Arm Fat Percentage (%)	-.682**	.001	.611**	.002	-.814**	.001	.604**	.002
Arm Fat Mass (kg)	-.678**	.001	.665**	.001	-.814**	.001	.705**	.001
Lean Arm Mass (kg)	.453**	.001	.440	.036	.485*	.019	.580**	.005
Leg Fat Percentage (%)	-.695**	.001	.620**	.002	-.748**	.001	.615**	.002
Leg Fat (kg)	-.606**	.002	.489*	.018	-.698**	.001	.520*	.011
Lean Leg Mass (kg)	.051	.818	.056	.789	-.227	.673	.031	.887
Trunk Fat Percentage (%)	-.713**	.001	.577**	.004	-.694**	.001	.656**	.001
Trunk Fat Mass (kg)	-.607**	.002	.412	.051	-.489*	.018	.403	.056
Trunk Lean Mass (kg)	.161	.464	.036	.872	.180	.009	-.106	.631
Android Fat Percentage (%)	-.526*	.010	.419*	.047	.493*	.017	.490*	.018
Android Fat Mass (kg)	-.687**	.001	.424*	.044	.556**	.006	.605**	.002
Lean Android Mass (kg)	-.281	.193	.303	.160	.341	.111	.099	.654
Gynoid Fat Percentage (%)	-.681**	.001	.657**	.001	.704**	.001	.619**	.002
Gynoid Fat Mass (kg)	.-604**	.002	.561**	.005	.589**	.003	.528*	.010
Lean Gynoid Mass (kg)	.305	.158	-.183	.402	-.301	.163	.259	.233

Note. CMJ = Countermovement Jump. * $p < 0.05$, ** $p < 0.01$.

4. Discussion

The purpose of this study was to investigate the effect of body composition on physical performance parameters in collegiate American football players. There was a negative significant correlation ($p < 0.05$) between the percentage of whole body fat and body fat kg and CMJ. There was also a statistically significant correlation between the percentage of total body fat and body fat kg ($p < 0.05$) sprint and pro-agility test. There was no statistically significant correlation ($p < 0.05$) between lean body mass, leg mass, trunk mass kg, sprint and pro-agility tests. The results of the study showed that a higher %BF had a substantial negative influence on some performance metrics of American football players. These metrics included pro-agility, sprinting ability, and vertical jump.

Body mass and height values of football players were consistent with those reported in previous studies (Oliver et al., 2012; Bilsborough et al., 2014; Boykin et al., 2021). Moreover, the BF% found in this study (23.23%) was similar to those reported in some other studies (Jacobson et al., 2016; Trexler et al., 2017; Oliver et al., 2012) however, it was found to be lower compared to some other studies (Turnagöl, 2016). This discrepancy was regarded to stem from different methods used to obtain data on body fat percentage, different data collection times (pre or during the season), and differences in training programs.

It was found in the study that there was a significant negative correlation between CMJ and BF%, LF%, ARMF%, TF%, AF%, GF% and FM kg. These findings were similar to those of several studies. For example, Silvestre et al., (2006) found a negative correlation between BF% and vertical jump ($r = -0.55$). Their study also found that vertical jump correlated moderately with total mass and lean tissue ($r = -0.48$; $r = -0.54$) in soccer players. In terms of BF%, our research group has recently reported a negative large correlation between BF% and fatigue index ($r = -.785$ $p = .037$) in female badminton players (Akdogan et al., 2022) as well. Even though we did not report any correlation between LBM and any of the performance tests, Ishida et al., (2021) reported significant moderate correlations between LBM and CMJ jump height ($p = 0.01$, $r = 0.50$) in soccer players. Contrary to our study, Jacobsen et al. (2016) did not find a significant relationship between body fat and vertical jump performance in their study conducted with American football linemen players.

Our findings also showed no significant correlation among CMJ with another total/regional lean body mass weight of collegiate American football players ($p > 0.05$). Supporting these findings, Robbins and Young (2012) found no significant correlation between vertical jump and body mass in lineman players. They also indicated that correlations between body mass and jump ability were low in the running back football players group. The current results show that an increase in total/regional BF% and weight negatively affects the vertical jump performances of American football players. Therefore, the decrease in fat mass may substantially improve elastic (reactive) power. Moss et al. (2015) recommended that greater gluteal and calf girths were also beneficial for CMJ, suggesting that increased muscle mass in these areas contributes to movements involving a strength and power component.

As another finding of this study, there was a significant correlation between sprints and BF%, LF%, ARMF%, TF%, AF%, GF% and FM. However, there was no statistically significant correlation ($p < 0.05$) between LBM, leg mass, trunk mass, android and gynoid mass with sprint and pro-agility tests. The findings of our study are consistent with those of previous studies. For example, in the study of Ishida et al. (2021), they also reported statistically significant moderate to large correlations between LBM and sprint times at 10 m ($p = 0.03$, $r = 0.44$) and 20 m ($p = 0.02$, $r = 0.50$) in soccer players. Again, Robbins and Young (2012) found moderate and large correlations between body mass and the various sprint times (36.6-m) in the running back players group. Therefore, considering the relevant literature (Potteiger et al., 2010; Robbins & Young, 2012; Ishida et al., 2021) and findings of the previous studies, it can be concluded that improving lean body mass might positively impact explosive performance, while the excess BF% and fat mass might cause vice versa.

The pro-agility test is widely used in football to assess quickness in the change of direction manoeuvres (Mann et al., 2016). The amount of research designed to correlate anthropometric variables and change of direction speed performance is quite limited. Theoretically, body fat and body segment lengths are accepted among the factors that contribute to agility performance. When two athletes of equal total body mass are compared, the fatter one is not only likely to have less lean mass to contribute to the speed requirements of agility performance but also will have a greater mass of excess fatty tissue (not lean body mass) and inertia. Thus, a greater force production per unit of lean mass to produce a given change in velocity or direction will be required (Sheppard & Young 2006).

The present study also showed a significant correlation between total/regional body fat and agility performance. However, there are a few studies to correlate body composition variables DEXA and agility in American football players as well. Due to limited research in the literature similar studies were used to support the discussion. Chaouachi et al. (2009) found that agility (T-test) performance was significantly related to body mass ($r = 0.58$; $p = 0.03$) and percent body fat ($r = 0.80$; $p < 0.001$) in elite male professional basketball players. Similar to the present study, Bartolomei et al. (2021) reported a high level of positive correlations between body fat and both pro-agility and sprint ($r = 0.58$; $p = 0.012$ and $r = 0.61$; $p = 0.009$, respectively), in hockey players. Contrary to our study, Sattler et al. (2015) reported no significant differences in body mass and FM% in males (American football, basketball and handball) between achievement groups on the stop-and-go reactive agility and stop-and-go change of direction speed (CODS) drills. Moreover, Atakan et al. (2017) found no significant correlation between agility and body fat in football players. The results of this research indicated a relationship between total/regional fat percentage and agility, demonstrating that the higher the fat percentage, the lower the agility performance in football players.

This significant difference might be due to the variety in the duration of the training and the content of the practice. In addition, different protocols and the number of participants might have caused such a difference. Further studies should be carried out with larger samples. It is advised to conduct additional research on the data collected during the season to identify trends in body composition and performance factors among American football players as these variables were only measured before the season in this study.

5. Conclusion

The findings of the study showed that there was a significant correlation between some total/regional body composition, vertical jump, sprint and agility performance in collegiate American football players. Body composition is considered as a significant factor that has an impact on the physical performance level of football players since excess body fat may cause a decrease in performance. Deriving from the findings of this study, it could be concluded that football players with less body fat and increased lean mass percentage prior to the season are advantageous for certain physical performance indicators. This comprehensive study is expected to provide new insights to coaches in terms of leading their players into correct playing positions regarding their body composition.

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