

Comparative Study of Anthropometric Measurement and Body Composition between Elite Soccer and Volleyball Players

Estudio Comparativo de Medidas Antropométricas y Composición Corporal entre Jugadores Élite de Fútbol y Voleibol

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SUMMARY: The purpose of this study was to describe anthropometric characteristics and body composition of elite soccer and volleyball players as well as to make comparisons between them. Seventy-one males were enrolled in the study, divided into three groups: twenty-six soccer players, fourteen volleyball players and thirty-one healthy sedentary subjects. All subjects were assessed for the anthropometric measures required for the calculation of body composition variables, using the standardized procedures recommended by established literature. Data was analyzed using SPSS and the descriptive statistics were expressed as a mean (SD) for each variable, while the ANOVA and LSD Post Hoc tests were carried out to detect the effects of each type of sport. The results showed that a significant difference was found for body height, body weight and body mass index as well as for all three of the body contents measured (muscle, bone and fat) among the groups. Volleyball players were significantly taller than soccer players and the subjects of the control group, while soccer players were significantly heavier than volleyball players and the subjects of the control group. Hence, the subjects of the control group had significantly higher body mass index when compared with other counterpart. The muscle contents in soccer players were significantly higher than that of all other subjects. On the other hand, the bone contents in soccer players were only significantly higher than the bone contents in the subjects of the control group. Lastly, the fat content in the body of all groups in this study was significantly different and soccer players had the lowest percent of the fat content, while the subjects of the control group had the highest. Therefore, these findings may give coaches from the region better working knowledge and suggest to them to follow recent selection process methods and to be more careful during the recruitment.

KEY WORDS: Sport; Top-Level; Football; Volleyball; Male.

INTRODUCTION

For all athletes involved in high professional competitive sports the body is required to perform at optimum capacity in terms of biomechanics and physiology (Zaccagni, 2011). Hence, it is more than logical to expect from top-level athletes to have a physique, optimal strength and endurance suited to the functional requirements of the sport in question. However, selection of gifted athletes into representative teams is often based on the subjective opinion of so-called expert selection coaches (Matthys *et al.*, 2011). Nevertheless, it is widely known that there is a growing interest in improving the human performance of athletes as relates to the characteristics associated with consciousness, awareness and cognitive effort (Micoogullari *et al.*, 2012) as well as identifying talents, strengths and weaknesses, assigning player positions and

helping in the design of optimal training programmes (cited in Hadzic *et al.*, 2012) all over the world, including Western Balkan countries. However, in many places much more time is spent on increasing the physical fitness of athletes without taking into consideration the assessment of their body composition and their nutritional status (Triki *et al.*, 2012). Contemporary sport science is designed to improve the performance of elite players and to discover talents as precisely as possible. Although many studies have shown that specific anthropometric characteristics are significantly associated with success in sports (Malina *et al.*, 2004), this process is very demanding, as various athletic events require differing body types to achieve maximum performance. Therefore, understanding the body composition of top-level athletes, and then assigning corresponding

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competitive weights for the athletes, has been done for decades and is considered an essential part of the total management process (Wilmore, 1982). On the other hand, although children and adolescent sportsmen grow in a manner similar to non-sportsmen (Rexhepi & Brestovci, 2010a), it is widely addressed in the scientific literature that adequate profiles are primarily important in various sports, mostly due to the reason that absolute size contributes a significant percentage of total variance associated with athletic success (Carvajal *et al.*, 2012). Therefore, scientists all over the world are looking for a standard formula that can improve the performance of elite players and discover talents as efficiently as possible (Popovic *et al.*, 2013a).

The anthropometrical characteristics and body compositions of athletes has been the subject of many investigations as many researchers have hypothesized that practicing athletes might be expected to exhibit structural and functional characteristics that are specifically favorable for their specific sport (Singh *et al.*, 2010). Since each sport has its own specific demands, every athlete should have specific anthropometrical characteristics and body composition figures for his or her own sports discipline. Some sports, such as wrestling, require much more knowledge regarding this topic than others, because of its weight limits as well as favoring the selection of athletes with a limited vertical skeletal development (Norton *et al.*, 2004). On the other hand, some sports, such as armwrestling, require the selection of athletes with the longer bones of the forearm (Akpınar *et al.*, 2012). However, this fact does not decrease the need to investigate the anthropometrical characteristics and body composition numbers of soccer and volleyball players, as adequate body composition and body mass figures, among other factors, contribute to optimal exercise routines and performance (Massuça & Fragoso, 2011). According to these two authors, body mass can influence an athlete's speed, endurance, and power, whereas body composition can affect strength and agility. In other words, successful participation in both soccer and volleyball games, next to the high level of technical and tactical skills, also requires from each athlete suitable anthropometrical characteristics and body composition. Most of the descriptive data concerning characteristics of soccer and volleyball players come from America and Western Europe, although there is a lack of data from Eastern Europe, especially Western Balkan. Hence, this study aims to check if this is true for Western Balkan countries to follow many previous studies that have evaluated ideal anthropometric profiles of successful soccer player (Milanovic *et al.*, 2012; Reilly *et al.*, 2000; Veale, 2010) as well as volleyball player (Bayios *et al.*, 2006; Gualdi-Russo & Zaccagni, 2001; Hooper,

1997; Lidor & Ziv, 2010) that provide insight into the requirements for competing at the zenith of their particular sports.

Indeed, soccer is a team sport that is played in an outdoor field and requires a high standard of preparation through the development of physical performance skills, as well as tactical and technical expertise, in order to complete 90 minutes of competitive play. According to Triki *et al.*, soccer training is mainly based on movement implementing the endurance qualities consisting of moderate activity alternating with periods of intermittent high intensity, leading to a significant production of metabolic heat, mostly due to the fact that the average work intensity during a soccer match is usually about 75–90% of maximum heart rate, respectively 70–85% of $VO_2\max$ (Rexhepi & Brestovci, 2010a). On the other hand, volleyball is generally played in an indoor field that is much smaller than that of a soccer field, in which two teams of six players are separated by a net. It requires a high standard of preparation in order to complete for three sets of competitive play and to achieve success. In this game, movement patterns significantly differ from soccer, as it requires their attack and defense to be much more effective as well as the dominance over the net becomes the most decisive factor for victory. The top-level volleyball players do not possess $VO_2\max$ values on the high level as typical endurance trained elite players in other sports, but they possess an optimum level of aerobic capacity that is required for playing this game since it may sometimes continue for longer time (Lidor & Ziv; Sheppard *et al.*, 2009). This game also includes large number of spiking, jumping, power hitting, blocking, and setting that is mainly based on a high level of strength and power (Lidor & Ziv; Popadic Gacesa *et al.*, 2009).

Hence, the purpose of this study was to describe anthropometric characteristics and body composition profiles of elite soccer and volleyball players and to detect possible differences in relation to competition level.

MATERIAL AND METHOD

Seventy-one males were enrolled in the study. They were divided into three groups: twenty-six soccer players (23.23 ± 3.35 yrs) from the soccer premier league in Serbia, fourteen volleyball players (20.21 ± 2.51 yrs) from the volleyball premier league in Serbia and thirty-one healthy sedentary subjects from the same country (24.94 ± 3.10 yrs). The measurements were carried out in the first three months of 2007.

All subjects were clinically healthy and had no recent history of infectious disease, asthma or cardio-respiratory disorders. All of them gave their written consent and the local ethics committee approved the protocol of the study. All subjects were assessed for the anthropometric measures required for the calculation of body composition variables, using the standardized procedure recommended by the International Biological Program (IBP) standards respecting the basic rules and principles related to the parameter choice, standard conditions and measurement techniques, as well as the standard measuring instruments adjusted before measurement was carried out. Height and weight were measured in the laboratory with the subject dressed in light clothing. Height was measured to the nearest 0.1 cm using a fixed stadiometer, and weight was measured to the nearest 0.1 kg with a standard scale utilizing a portable balance. Body mass index (BMI) was calculated as body mass in kilograms divided by height in meters squared (kg/m^2). Skinfolds (mm) were measured at six sites: triceps skinfold thickness, forearm skinfold thickness, thigh skinfold thickness, calf skinfold thickness, chest skinfold thickness and abdominal skinfold thickness (using a skinfold caliper). Each individual measurement and the sum of the six measurements was used for analysis. The circumferences of the upper and lower arm and the upper and lower leg were measured in centimeters and the following diameters were measured to the nearest 0.1 cm: elbow diameter, wrist diameter, knee diameter, ankle diameter, upper arm diameter, forearm diameter, thigh diameter, and calf diameter. To reduce measurement variation, the same investigator examined all of the subjects.

The data obtained in the research was processed using the application statistics program SPSS 20.0, adjusted for use on personal computers. The descriptive statistics were expressed as a mean (SD) for each variable. Analysis of the variance (ANOVA) and the LSD Post Hoc test were carried out to detect the effects for each type of sport (soccer or volleyball) on each variable: body height, body weight, body mass index (BMI), and muscle, bone and fat content

of the body, as well as to control it by sedentary subjects. The significance was set at an alpha level of 0.05.

RESULTS

The anthropometric characteristics of subjects are shown in Table I. There were significant differences in all variables among the groups. Hence, a significant difference was found for body height ($F= 30.55$), body weight ($F= 5.96$) and body mass index ($F= 4.01$) as well as all contents of body among the groups: muscle ($F= 4.31$), bone ($F= 3.87$) and fat ($F= 32.18$).

The significant differences of anthropometric characteristics among particular sports are shown in Figure 1. The LSD Post Hoc test indicates that volleyball players were significantly taller than soccer players and the subjects of the control group, while soccer players were significantly heavier than volleyball players and the subjects of the control group. Hence, the subjects of the control group had significantly higher body mass index when compared with other counterparts. The muscle contents in soccer players were significantly higher than that of all other subjects. On the other hand, the bone contents in soccer players were only significantly higher than the bone contents in the subjects of the control group. Lastly, the fat content in the body of all groups in this study was significantly different and soccer players had the lowest percent of the fat content, while the subjects of the control group had the highest.

DISCUSSION

The results of this study support previous investigations indicating a strong difference regarding the body height among the volleyball players from one side and soccer players and the subjects from the control group that represents general population on the other side (Gaurav *et*

Table I. Descriptive data and ANOVA of 71 males enrolled in the study.

Variables	Soccer (n=26)	Volleyball (n=14)	Control (n=31)	ANOVA
	Mean \pm Standard Deviation			
Height (cm)	182.11 \pm 6.73	198.53 \pm 3.89	183.72 \pm 7.60	0.000*
Weight (kg)	80.10 \pm 7.13	92.64 \pm 7.85	86.50 \pm 14.70	0.004*
BMI (kg/m^2)	24.11 \pm 1.14	23.52 \pm 2.14	25.61 \pm 3.49	0.023*
Muscle content of body (%)	49.90 \pm 2.78	47.22 \pm 2.13	48.32 \pm 3.27	0.017*
Bone content of body (%)	15.77 \pm 0.92	15.46 \pm 0.82	14.78 \pm 1.78	0.026*
Fat content of body (%)	9.64 \pm 1.60	13.57 \pm 2.52	18.51 \pm 5.89	0.000*

n= number of subjects; BMI= body mass index; *= significant difference between groups.

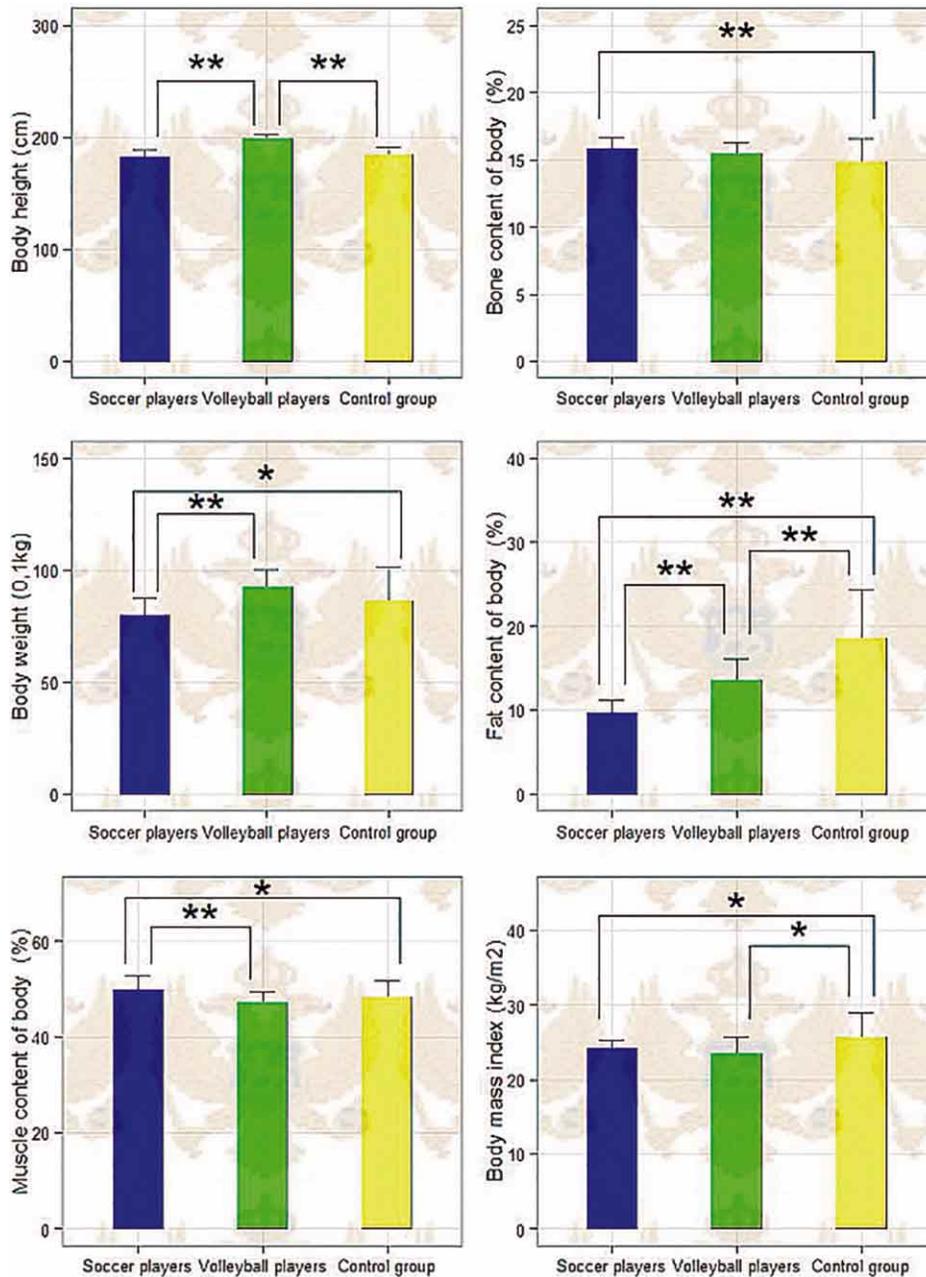


Fig. 1. LSD Post Hoc test for the different parameters evaluated.
 **= significance ≤ 0.01 ; *= significance ≤ 0.05

al., 2010). Thus, this confirms the well-known axiom that selection is the main reason that can explain the observed difference, while selection criteria, different type of play and game rules between the soccer and volleyball game can also explain the observed difference (cited in Popovic *et al.*, 2013a). However, much more important finding regarding the body height is the fact there was no significant difference among elite soccer player and the subjects from the control group which represents general population, mostly due to

the reason there has been a tendency to recruit taller and heavier soccer players (cited in Gil *et al.*, 2010). The absence of the differences between soccer players and subjects of the control group in this study, raises doubt the selection process has been carried out correctly, especially because soccer players are shorter than the subjects from the control group that represent the general population. Nevertheless, it has to be considered that the average height of all the participants in the 2002 World Soccer Championship was

180.90 centimeters, while the average height of all players from Czech league (183.29 cm), Germany (183.2 cm), Denmark (183 cm) was higher. This official statistical data proved that soccer players are tall enough and that the doubt may be quenched through investigating the high score of the general population. The tendency to recruit taller soccer players is not unsworn in the scientific literature yet (Popovic *et al.*, 2012); however, five of the ten best soccer players in the World for the 2013-2014 season (Top 50 Footballers in the World for the 2013-2014, 2013) are shorter than 180 centimeters, e.g. Lionel Messi (169 cm), Andres Iniesta (170 cm), Franck Ribery (170 cm), Philipp Lahm (170 cm) and Neymar (175 cm). On the other hand, the volleyball players tend to be tall athletes because they are players handling a ball above their heads (Gaurav *et al.*) and their height helps them to reach toward the top of the net as well as defend the ball against the opponents. Taller players in volleyball have an advantage because they can easier control both, defensive and offensive actions over the top of the net (Hadzic *et al.*). Thus, selection criteria can explain the observed results, as there has been a tendency to recruit the tallest children in volleyball too. However, extra talented short players, especially those with a high vertical jump, shall also be selected and play a significant role. This conclusion can confirm the fact that male college and professional volleyball players, even the shortest players, are usually above average in height compared to the general population. For example, the average body heights of the volleyball teams were next (Hadzic *et al.*): USA (196.2 cm), Brazil (194.3 cm), Russia (200.3 cm) and Italy (198.5 cm). This proves that the players from our volleyball premier league are tall enough and they do not lag behind the top World players. However, this is not surprise, as it is well-known that the density of very tall subjects appears to be characteristic of the people from this area, since a high percentage of people from general population were measured at 190 cm or more in body height (Bjelica *et al.*, 2012; Pineu *et al.*, 2005; Popovic *et al.*, 2013b). Therefore, this fact may give coaches from the Dinaric Alps better working knowledge of this particular group of athletes and suggest they follow recent selection process methods and more carefully during the recruitment as they have a very tall population in general (Pineu *et al.*) which confirms the high score of the subjects from the control group (183.72 cm). Furthermore, it was expected that volleyball players were heavier than soccer players and the subjects of the control group, mostly due to the fact they are significantly taller than both groups mentioned. However, the reason we have such heavier players in volleyball also has to do with the fact that the average size of the volleyball players has increased dramatically in the past 20-30 yrs. This could be a function of better nutrition, especially in professional volleyball leagues, partly due to the use of nutritional supplements as

well as anabolic steroids etc. On the other hand, the body mass index (BMI; weight/height²) is parameter that is widely used in adult populations such as an internationally recognized definition of overweight and obesity (Kovac *et al.*, 2012). Fortunately, the body mass index of both groups of athletes is in the area of normal weight, according to the established literature and it has just shown significantly higher scores than subjects from the control group.

Indeed, we found that muscle content of soccer players was significantly higher than volleyball players and control subjects, while bone content of soccer players was significantly higher only than control subjects. We didn't find any differences among volleyball players and control subjects in these two categories. According to the discussion regarding the differences of body weight among all three groups, it was expected that soccer players have higher percent of muscle content, while it is interesting that volleyball players and control subjects did not show any differences, although volleyball requires much more physical activity than control subjects do. These results may be explained by more demands to grow the muscle contents of the body in sportsmen, while a slightly higher percentage of muscle content of volleyball players was found as this game requires intermittent activities when high-intensity activities are followed by low-intensity intensity type movements (Popovic *et al.*, 2013a). On the other hand, the range of the percent of bone content among all three groups is not too wide. Nevertheless, there is a significant difference between soccer players and control subjects. Moreover, it is well-known that low body fat is desirable for high physical performance in all sports. Therefore, the low percentage of fat content in the body of our soccer and volleyball players and significantly lower than the percentage of fat content in the body of control subjects, showed that our players have high physical performance. However, the soccer players had significantly lower percentage of fat and these results were expected, because much of the previous research recognized soccer as a predominantly aerobic sport (Kemi *et al.*, 2003; Stolen *et al.*, 2005), while anaerobic energy is essential only to performance in sprints, high-intensity runs, and duel plays, all of which may contribute to the final outcome of the game (Sporis *et al.*, 2008). Whereas, volleyball training contains more anaerobic activity than soccer, mostly due to the reason this game is intermittent and changes continuously in response to different offensive and defensive situations and demands more anaerobic exercises that are high-intensity exercises done at a short and explosive burst. Furthermore, it is very important to remember that athletes in elite team sports such as soccer and volleyball need a determined body fat percentage to perform well enough and achieve their full playing potential. The NSCA indicates that body fat percentages vary from less than 7 percent to 17 percent

among the male athletes, depending on the sports discipline. However, we would like to stress that these are just guidelines and the athlete would work together with their coaches and their personal physician to determine the individual body fat percentage to enhance their physical abilities and their health.

The importance of body composition in sport performance is a primary concern in creating athletes profiles as well as conditioning programs throughout a season at all levels of competition (Silvestre *et al.*, 2006), in that describing anthropometric characteristics and body compositions of athletes and detecting possible differences in relation to competition levels may give coaches a better working knowledge of the studied groups of athletes. Moreover, the results of this study suggests that soccer and volleyball decreased percent of fat content if we compare it to control group. On the other hand, this study also suggests that the muscle content of soccer players seems to be explained by a

greater percent compared to the volleyball players and subjects of control subjects, while the differences in the bone content are logical consequences. Lastly, the part attributed to body weight could be the main causes of nutritional habits. Considering that the measurements were conducted in the middle of the season, this study is limited by the fact that changes in body composition and physical performance may occur from the start to the end of an athlete's training and competitive season (Silvestre *et al.*). Kraemer *et al.* (2004) reported that soccer players who enter a season with a high catabolic metabolic status could experience reductions in performance during a competitive season accompanied by detrimental changes in body composition. Accordingly, further studies should be very careful in projecting timelines for measuring anthropometric characteristics and body composition, mostly due to the fact that it has to be conducted either at the beginning or at the end of a season. It also has to be explicitly reported when the measurement was conducted.

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RESUMEN: El propósito de este estudio fue describir las características antropométricas y composición corporal de jugadores de élite de fútbol y de voléibol con el objetivo de realizar las comparaciones entre ellos. Fueron incluidos en el estudio 71 hombres. Los participantes fueron divididos en tres grupos: 26 jugadores de fútbol, 14 de voléibol y 31 sujetos sedentarios sanos. Todos los sujetos fueron evaluados para las medidas antropométricas requeridas para el cálculo de las variables de composición del cuerpo. Se utilizaron los procedimientos recomendados por la literatura establecida. Los datos fueron analizados utilizando el programa SPSS y la estadística descriptiva se expresó como Media (DE) y para cada variable se realizaron pruebas ANOVA y LSD post hoc para detectar los efectos de cada tipo de deporte. En los resultados se registró una diferencia significativa de altura corporal, peso corporal e índice de masa corporal, como también para las tres medidas de contenido corporal (músculo, hueso y grasa) entre los grupos. Los jugadores de voléibol eran significativamente más altos que los jugadores de fútbol y los sujetos del grupo de control. Los jugadores de fútbol eran significativamente más pesados que los jugadores de voléibol y los sujetos del grupo de control. Por lo tanto, los sujetos del grupo control tuvieron significativamente mayor índice de masa corporal en comparación con los otros grupos. El contenido muscular de los jugadores de fútbol fue significativamente mayor que el de los otros sujetos. Por otra parte, el contenido óseo en jugadores de fútbol solamente fue significativamente más alto que los sujetos del grupo control. El contenido de grasa en todos los grupos de este estudio fue significativamente diferente y los jugadores de fútbol registraron el porcentaje de proporción de grasas más bajo, mientras que los sujetos del grupo control registraron el más alto. Estos hallazgos pueden ser útiles para los entrenadores de la región, como también para mejorar el conocimiento práctico y seguir los métodos de un proceso de selección con mayor cautela durante el reclutamiento.

PALABRAS CLAVE: Deporte; Nivel superior; Fútbol; Voleibol; Hombres.

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