ORIGINAL RESEARCH PAPER

ESTIMATION OF BODY MASS INDEX IN TEAM SPORTS ATHLETES

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Abstract

The aim of our investigation is to prove that an increased body mass index (BMI) in football and handball players does not always give evidence about overweight or obesity, but may appear due to skeletal muscles hypertrophy, and that higher body mass index does not influence the vertical jump height in athletes. 29 male football players and 20 handball players participated voluntary in the investigation. The anthropometrical characteristics and the body mass composition are measured by the bioelectrical impedance analysis method using the Body Composition Analyzer „X – Scan Plus". Vertical jumps heights are measured on special platform "PD 3A". The significant correlation is determined between the BMI and the lean body mass ($r=0.36$, $p<0.05$), as well as, between the BMI and the body fat content in % ($r=0.54$, $p<0.003$) in the football players. This proves that high BMI can be caused by growth of the body fat content and by skeletal muscles hypertrophy. The BMI is close to the upper border of norm in football players (23.4±1.4 kg/m^2) and handball players (24.2±1.7 kg/m^2) from the team of students. The overweight can be determined due to high BMI (25.1±2.9 kg/m^2) in handball players from Murjani Sports Gymnasia, but this is due to high lean body mass. The body fat content in handball players (13.6±2.8 %) is in norm. The vertical jumps height is not possible to predict from the value of the BMI because the significant correlation between the BMI and the height of vertical jumps is not determined in team athletes ($p>0.05$).

Key words: *body mass index, lean body mass, fat content, football, handball, vertical jump*

Introduction

Human body contains different tissues. The main of them are muscles (35 - 50 % from the body weight), bone tissues and internal organs. These tissues together form body lean mass (LM). It provides all body movements, strength and power production. Other kind of tissues is fat (7 - 20 % from the body weight in males), which is passive body mass. Increase of the body fat content causes overweight or obesity in people.

Body mass index (BMI) is a useful screening tool for overweight and obesity diagnostics in children, adolescents and adults. BMI can be detected quickly and inexpensively. It is possible to calculate using the equation (McArdle W.D. et al., 2000): BMI = m (kg)/ h^2 (m^2); where: m – a body mass in kg, h – a height of athlete in m. BMI correlates with adult morbidity and mortality. High BMI is associated with increased risks for hypertension, atherosclerosis etc. (Witt K. and Bush E., 2005). BMI gives evidence about overweight if its value varies from 25 to 29.9 kg/ m^2, but obesity can be determined it BMI is greater than 30 kg/ m^2 (Mathews E.M. and Wagner D.R., 2008).

Human body parts proportions and body mass composition are not taken into account if anybody determines BMI from tables of norms. There are from 12 to 15 % of fat tissue in young male’s body in norm, and from 25 to 28 % of fat in young female’s body (McArdle W.D. et al., 2000). The body mass index depends not only on the fat content in the human body, but also on the muscles and bones mass, as well as, on the water content in the body of athletes. High value of the MBI can be estimated as overweight in athletes with great skeletal muscles mass. It means that training in many sports specializations causes increase of the body mass index (Ode J.J. et al., 2007). High value of the BMI is observed in weight lifters, body builders, rowers, professional football and handball players etc. For example, the mean body mass index in seven defensive linemen from a former National Football League Super Bowl team is 31.9 kg/ m^2, but the mean BMI in all players of the team is 28.7 kg/ m^2 (McArdle W.D. et al., 2000). However, their fat content – 18 % for linemen and 12.1 % - average for the team, misclassified them for fatness using only BMI as the overweight standard. The body mass composition in football players depends on their specific role during the game: linemen, goal keepers, backs, forwards, midfielders etc. (Melchiorri G. et al., 2007). From the data from Wittich A. et al. (2001) the fat content in the body of football players varies from 6.1 % to 19.5 %, and it depends on the position of the football player in the game: the midfielders have a significantly higher percentage of fat (13.5 ± 3.3 %) than backs or forwarders (11.0 ± 2.3 %). These authors determined significant positive correlation between age and fat content in the body of football players. BMI in basketball players differs from its value in football players. For example, the mean BMI in USA National Basketball league players is only 24.5 kg/ m^2 (upper limit of norm) (McArdle W.D. et al., 2000).

The average fat content in female long distance runners' body 15.2 % is significantly lower than its value in the same age sedentary females – 26 % (Pollock M.L. et al., 1977). Male endurance runners have extremely low body fat content – only approximately 3 %. These endurance runners represent the lower end of the fat – to – lean continuum for top flight athletes. It gives them some advantages in long distances running: improves heat dissipation during sport load and allows to maintain thermal balance because the isolation layer of fat tissues is thin; the greater amount of fat tissues forms passive body mass, which causes increase of energy cost to bear the additional weight.

Thickness of skinfolds in champion wrestlers is smaller than in elite wrestlers. It means that elite wrestlers have greater lean mass in the body. The mean fat content in their body is 11.0 ± 4.0 % (from Minnesota and Nebraska high schools) (Clarke K.S., 1974, Housh T.J. et al., 1989).

Mean fat content in the body of bodybuilders is 9.3 %, in weight lifters – 9.1 %, but in the Olympic level weight lifters – 10.8 % (McArdle W.D. et al., 2000). These athletes can be estimated as "overweight" using only BMI as criterion of obesity. The skeletal muscles mass in body builders is higher by 16 kg in comparison with the height and weight norm. The muscles mass in weight lifters is by 15 kg higher than in norm. All these athletes have increased body mass index due to great lean body mass.

One of the methods to determine fat content in the body is skinfolds thickness measurement by kalipometer. This gives possibility to estimate the fat tissue amount, but does not allow directly measurement of the skeletal muscles mass in the body.

A small, alternating current flowing between two electrodes passes more rapidly through hydrated fat – free body tissues (lean body mass) with greater electrolyte content (lower electrical resistance) in comparison with fat tissues. Therefore bioelectrical impedance analysis is useful method to determine the human body mass composition (McArdle W.D. et al., 2000, Bovell D. et al., 1996). Increase of the body weight can be due to additional amount of skeletal muscles in trained athletes or due to growth of the fat content in the body (Witt, K. A., and Bush E. A., 2005, Temfemo A. et al., 2009).

The aim of the present investigation is to prove that an increased body mass index in football and handball players does not always give evidence about overweight or obesity, but may appear due to skeletal muscles hypertrophy, and that higher body mass index does not influence the vertical jump height in athletes.

Material and Methods

Twenty nine male football players from the team “Skonto” (Riga), 11 male handball players from the team of Latvian Academy of Sports Education (LASE) (Pontaga I. and Zidens J., 2006) and nine young male handball players from Murjani Sports Gymnasia (Rusko D. and Pontaga I., 2009) participated voluntary in the investigation. The study was performed in conformity with the standards of the Ethics Committee of the Latvian Council of Sciences. The measurements of football players and LASE handball players were performed in the laboratory of the Latvian Olympic team, and the measurements of handball players from Murjani Sports Gymnasia - in the Latvian Sports Medicine Agency.

The standard conditions during the tests were: the air temperature in the room was 22˚ ± 2˚ C, the measurements should be performed approximately two hours after eating and within 30 minutes of voiding.
The body mass composition was measured by the bioelectrical impedance analysis method using the Body Composition Analyzer „X – Scan Plus” (Jawon Medical, Korea).

Every athlete had to stay straight on the platform of the apparatus during the measurements. All athletes were weighted by the scales included in the Body Composition Analyzer. The height was measured by special ultrasound device (UHM – 101) build in the Body Composition Analyzer.
Body mass composition is estimated by measurement of the electrical resistance to a small, alternating current flowing between four electrodes: two electrodes are positioned below the feet of every athlete and two electrodes are hold in the hands. The duration of measurement was one minute. The obtained data were automatically processed by Dr. Lukasaki body mass composition formula taking into account the height, body mass, gender, age and body tissues electrical resistance of every examined athlete. The characteristics measured and calculated by the Body Composition Analyzer are: the body mass, height, body mass index, lean body mass and fat content in the body in percentages. The error of measurement of the equipment was ± 4 %.

Vertical jumps heights are measured on special platform (PD. 3A, Moscow, Russia). Two kinds of jumps are performed: from standing position on the apparatus platform: 1) with the knees at the angle 90˚ and the hands on hips (SJ) and 2) from the standing position and before to

jumping counter - moved until the knee was flexed approximately to 90˚ and free movements of the arms (CMJ). Every kind of jumps repeated five times, and the best results (highest SJ and CMJ) are taken into account.
The mean values and standard deviations were calculated for all determined characteristics in football players and young handball players. The relationships between the body mass index (BMI), the body lean mass, body fat content and the height of jumps (SJ and CMJ) are determined.

Results

The mean anthropometrical characteristics of the football and handball players are shown in the Table 1. The mean height of all team sports players is above 180 cm. The mean body weight is close to 80 kg in football players and LASE handball players, but in young athletes from Murjani Sports Gymnasia the mean weight is greater - 86.3 ± 8.2 kg. The mean value of the body mass index is close to the upper border of norm in football players and LASE handball players, but in the players from Murjani Sports Gymnasia the BMI gives evidence about overweight. The differences between the mean values of every characteristic in three groups of athletes are not significant ($p > 0.05$).

Table 1.

The mean anthropometrical characteristics of team sports athletes

Sports specialization	**Age, years (±SD)**	**Height, cm (±SD)**	**Body mass, kg (±SD)**	**Body mass index, kg/m^2 (±SD)**
Football (Skonto)	23.6 ± 5.1	183.7 ± 7.3	79.3 ± 8.0	23.4 ± 1.4
Handball (LASE)	20.0 ± 1.0	186.7 ± 8.1	84.7 ± 11.1	24.2 ± 1.7
Handball (Murjani)	17.6 ± 1.0	182.4 ± 7.1	86.3 ± 8.2	25.1 ± 2.9

Body mass composition analysis by bioelectrical impedance measurement allows us to estimate the main reasons of the BMI growth in team athletes. The BMI shows overweight in young handball players (25.1 ± 2.9 kg/m^2), but this is due to high lean body mass, Table 2. The lean body mass is significantly greater in the handball players than in the football players, $p<0.05$. The body fat content in handball players (13.6 ± 2.8 %) is significantly lower in comparison with football players (18.4 ± 3.7 %), but the BMI in football players is not significantly higher ($p > 0.05$).

Table 2.

The body mass composition in male football and handball players

Sports specialization	**Body mass index, kg/m^2 (±SD)**	**Lean body mass, kg (±SD)**	**Fat content, % (±SD)**
Football (Skonto)	23.4 ± 1.4	64.6 ± 6.1	18.4 ± 3.7
Handball (Murjani)	25.1 ± 2.9	73.9±5.2	13.6±2.8
Signif. of diference	*$p > 0.05$*	*$p < 0.05$*	*$p < 0.05$*

The correlation between the body mass index in the football players (Fig.1.), the handball players from the LASE team (Fig.2.) and squat jump height is not statistically significant ($p> 0.05$), as well as, the correlation between the BMI and counter – movement jump height ($p> 0.05$).

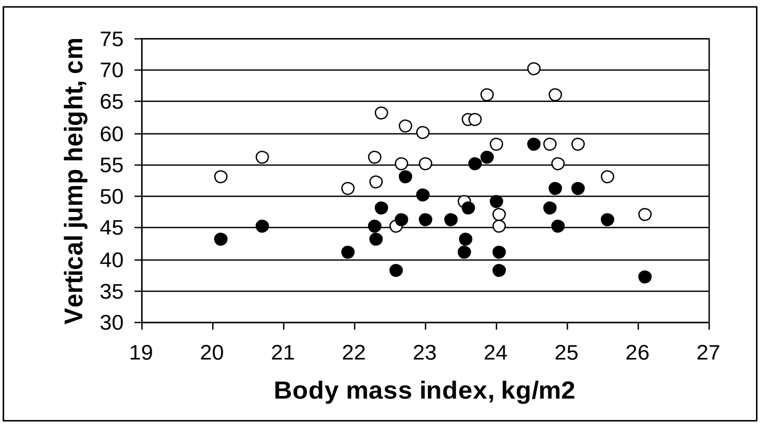

Figure1. Relationship between the body mass index in the football players and the vertical jump height

Relationship between the body mass index in the football players and the vertical jump height from static squat position is not significant (●), coefficient of correlation $r = 0.14$; $p> 0.05$;

Relationship between the body mass index in the football players and the vertical jump height with previous squat and movements of arms is not statistically significant (○), $r = 0.08$; $p > 0.05$

Relationship between the body mass index in the handball players (Fig.2.) and the vertical jump height from static squat position is not significant (●), coefficient of correlation $r= -0.08$; $p> 0.05$;

Relationship between the body mass index in the handball players and the vertical jump height with previous squat and movements of arms is not statistically significant (○), r = -0.11; $p > 0.05$

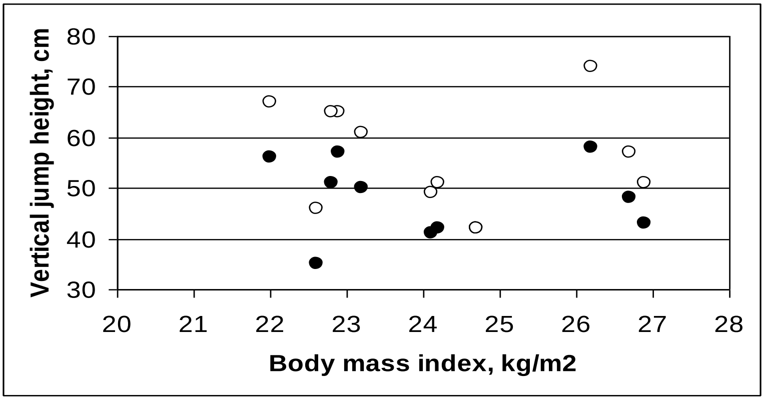

Figure 2. Relationship between the body mass index in the handball players and the vertical jump height

The significant relationship is determined between the body mass index in the football players and the lean body mass (correlation coefficient $r = 0.36$, $p < 0.05$), Fig.3. This means that increase of the BMI in the athletes can be explained by growth of the skeletal muscles mass. The similar significant relationship is detected between the body mass index and the fat content in the body in % ($r = 0.54$, $p < 0.003$), Fig.4. Therefore the increased value of BMI depends also on the greater content of fat tissue in the body.

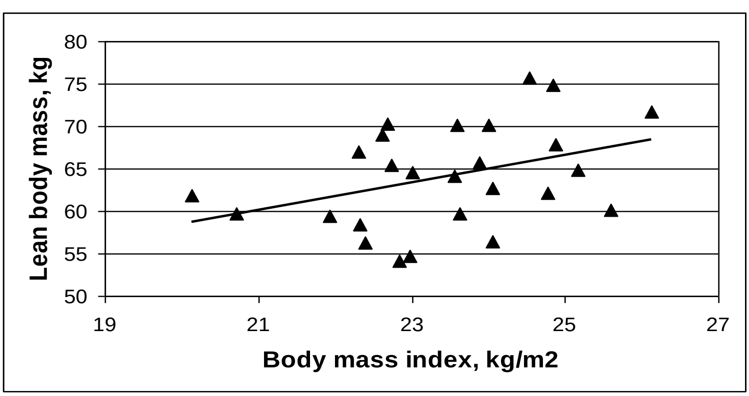

Figure 3. Relationship between the body mass index (BMI) and lean body mass (LM) in football players

Relationship between the body mass index (BMI) and lean body mass (LM) in football players: LM (kg) = 26.57 + 1.62 · BMI (kg/m^2); where: r = 0.36; standard error of the regression equation Sxy = 5.70 kg; $p < 0.05$

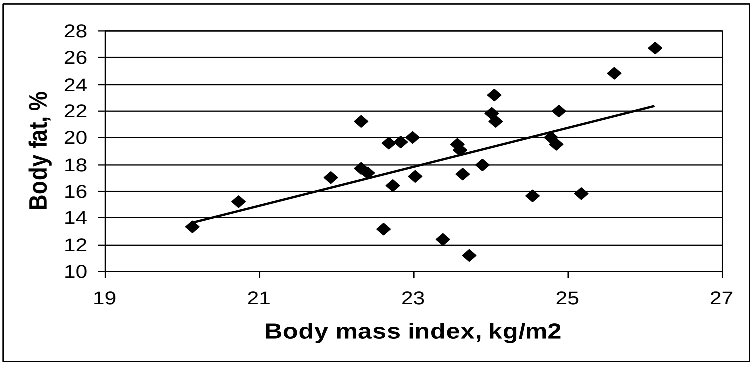

Figure 4. Relationship between the body mass index (BMI) and body fat content (BF) in football players

Relationship between the body mass index (BMI) and body fat content (BF) in football players: BF (%) = 1.45 · BMI (kg/m^2) – 15.55; where: r = 0.54; Sxy = 3.13 kg; $p < 0.003$

Discussion

Our results are in positive agreement with the data of many other authors (Melchiorri G. et al., 2007, Ode J.J. et al., 2007, Wittich A. et al., 2001) opinion concerning estimation of the body mass index value with caution in athletes. The body mass index depends not only on the body fat content, but also on skeletal muscles mass. From our data: the significant correlation is determined between the body mass index and the lean body mass (r = 0.36, $p < 0.05$), as well as, between the BMI and the body fat content in % (r = 0.54, $p < 0.003$) in the football players. High value of the MBI can be estimated as overweight in athletes with skeletal muscles hypertrophy.

Some authors determined high BMI in high qualified football players (the mean value- 28.7 kg/ m^2), which can be misclassified than overweight or fatness of these athletes (McArdle W.D. et al., 2000). However the fat content in their body 12 – 18 % was in norm. Sutton L. et al. (2009) determined that the body composition is important for elite English football players, but homogeneity between players at top professional clubs results in little variation between individuals. The body fat content depends on inheritance: the non-Caucasian players demonstrated significantly lower percent body fat (9.2 ± 2.0%) than the Caucasian players (10.7 ± 1.8%).The body mass composition in football players depends on their specific role during the game (linemen, goal keepers, backs, forwards, midfielders etc.) (Melchiorri G. et al., 2007). The midfielders have a significantly higher percentage of fat than backs or forwarders (Wittich A. et al. 2001). The body mass index (23.4 ± 1.4 kg/m^2) and body fat content (18.4 ± 3.7 %) in Latvian highly qualified football players is close to the upper border of norm. This can be explained by the young age of our players (23.6 ± 5.1 years) in comparison with elite international level football players, because the significant positive correlation between age and fat content in the body of football players is determined (Wittich A. et al. 2001).

The height and weight of our handball players correspond with these characteristics in European National level players (Gorostiaga E.M. et al., 2005, Rannou F. et al., 2001.). Our athletes are 2 – 4 cm shorter and have approximately 10 kg less weight (the team handball players of Latvian Academy of Sports Education) and 8 kg less weight (the team from Murjani Sports Gymnasia) in comparison with the Spanish International level handball players (Gorostiaga E.M. et al., 2005). This can be explained by lower qualification and young age (17 – 21 year old) in Latvian handball players in comparison with International level professional players. The skeletal muscles mass must be larger in elite professional handball players than in our amateur level handball players. The BMI (25.1 ± 2.9 kg/m^2) is high in young handball players from Murjani Sports Gymnasia, but this is due to high lean body mass. The body fat content in handball players (13.6 ± 2.8 %) is in norm.

The muscle power characteristic of our athletes (counter – moved jump height) coincides with the data of Spain players (Gorostiaga E.M. et al., 2005). The significant correlation between the BMI and the height of vertical jumps (squat jump and counter – moved jump) is not determined in Latvian football and handball players ($p > 0.05$). This means that the vertical jumps height is not possible to predict from the value of the BMI. The main reason of the BMI increase is skeletal muscles mass growth or hypertrophy due to long term training in handball or football. This allows maintain the same vertical jump height in team players with smaller and larger body weight.

Conclusions

1. The significant correlation is determined between the body mass index and the lean body mass ($r = 0.36$, $p < 0.05$), as well as, between the BMI and the body fat content in % ($r = 0.54$, $p < 0.003$) in the football players. This means that high body mass index can be caused by growth of the body fat content and by increased skeletal muscles mass (muscles hypertrophy).
2. The body mass index mean value is close to the upper border of norm in football players (23.4 ± 1.4 kg/m^2) and handball players (24.2 ± 1.7 kg/m^2) from the team of Latvian Academy of Sports Education.
3. The overweight can be determined due to high BMI (25.1 ± 2.9 kg/m^2) in young handball players from Murjani Sports Gymnasia, but this is due to high lean body mass. The body fat content in handball players (13.6 ± 2.8 %) is in norm.
4. The significant correlation between the BMI and the height of vertical jumps (squat jump and counter – moved jump) is not determined in football and handball players ($p > 0.05$). This proves that the vertical jumps height is not possible to predict from the value of the BMI.

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