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Original article

Influence of different sports on fat mass and lean mass in growing girls

Esther Ubago-Guisado [a,*], Esmeralda Mata [b], Javier Sánchez-Sánchez [c], María Plaza-Carmona [a], María Martín-García [b], Leonor Gallardo [a]

[a] *IGOID Research Group, University of Castilla-La Mancha, Toledo 45071, Spain*
[b] *GENUD Toledo Research Group, University of Castilla-La Mancha, Toledo 45071, Spain*
[c] *School of Sport, UCAM, Universidad Católica San Antonio, Murcia 30107, Spain*

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Abstract

Purpose: The aim of this study was to analyze and compare the effects of different sports (swimming, football, basketball, and handball) on fat mass and lean mass in prepubertal and pubertal girls.

Methods: Two hundred girls (10.6 ± 1.5 years old, Tanner stages I–III) participated in the study and were divided into 5 groups: 40 swimmers, 40 football players, 40 basketball players, 40 handball players, and 40 controls. Fat and lean masses at whole body, arms, trunk, and legs were measured using dual-energy X-ray absorptiometry (DXA). Pubertal status was determined using Tanner test. Effects of different sports on fat and lean masses were assessed through analysis of covariance with height as covariates. Analyses were performed separately in 2 groups depending on the Tanner stage (prepubertal and pubertal).

Results: The girls of the control group had less lean mass and more fat mass compared to the girls who play sports ($p < 0.05$). There were differences in body fat between sports. The swimmers and football players had less body fat ($p < 0.05$). On the other hand, handball players showed the highest values in lean mass ($p < 0.05$).

Conclusion: Impact sports (football, basketball, and handball) and low-impact sports (swimming) provide an appropriate development of lean mass in growing girls. We can conclude that people practicing sports at early ages ensure a lower fat mass and higher lean mass compared to those who do not practice. These results may be useful as a preventive method of adult obesity.

Keywords: Body composition; DXA; Female players; Physical activity; Sports

1. Introduction

In the last few years, there has been an alarming increase in overweight and obesity among young people.[1] Among other reasons, this is because of low levels of habitual physical activity and associated negative health outcomes among young people, especially females.[2] Physical inactivity is a risk factor for many diseases such as type 2 diabetes, cardiovascular diseases, high blood lipid, arthritis, asthma, and cancer.[3] Obesity in childhood is closely related to adult obesity,[4] because these children have twice the risk of developing obesity in later life than those who are not obese.[5] Studies such as Boreham et al.[6] show that physical activity during childhood prevents obesity in later life. For these reasons, the prevention of obesity in childhood is an international priority given the impact it has on chronic diseases, general health, development, and well-being.[7]

The direct relationship between physical activity and body composition results in sport having a positive effect on body composition.[8] Physical activity has an influence on muscle mass as a result of increased energy expenditure and helps maintain lean mass, bone mineral density, and body weight.[9] It is known that sport is an important factor that regulates body mass of children, which is associated with lower obesity.[8] Exercise practiced continuously and regularly produces changes in body composition.[3] Physically active people have a lower percentage of fat than people who do not exercise.[10]

For these reasons, health institutions are increasing their interest in assessing body composition of schoolchildren.[4] During the study of body composition, health problems can be identified in relation to body fat, lean mass (excluding bone mass), or muscle mass and changes associated with different types of exercise can be compared.[11] This measurement of body

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* Corresponding author.
E-mail address: esther.ubago@gmail.com (E. Ubago-Guisado).

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composition can be performed through indirect techniques, such as the dual-energy X-ray absorptiometry (DXA). This has become an important tool for evaluating and monitoring obesity and related diseases.[12] It is recognized as an accurate and precise method to measure body composition[13] and it is useful to quantify fat mass and fat-free mass in separate segments or total body.[14] Several reviews claim its theoretical and empirical validity to estimate fat mass and fat-free mass.[15,16]

Moreover, the type of sport has some influence on the development of body composition. Each sport has a different player profile, as each sport has different physical requirements.[17] Most studies are focused on the analysis of high-performance[18] or a particular sport.[19–21] Therefore, studies focused on children's health and proper growth through sport and its various forms are needed. The present study was planned to fill the gap in the literature.

All the sports of this research have their own special features. Football is considered as a resistance sport that generates different levels of intermittent activity at variable intensities,[22] which involves mainly the lower body. On the other hand, the movements that basketball players perform during the games are multiple and differ in terms of intensity, distance, and duration.[23] Movements such as consecutive jumps, changes of direction, several sorts of accelerations and quick counterattacks (short runs) are usually very powerful.[24] However, swimming allows an improvement of the aerobic capacity, flexibility, strength, coordination, and muscle tone of the whole body.[25] Finally, handball is a dynamic sport, with a high aerobic demand, characterized by runs, jumps, throws, passes, and blocks.[26] According to Hatzimanouil and Oxizoglou,[27] handball is a sport that requires certain skills such as speed, agility, reaction speed, speed strength, resistance, strength, and coordination. During game tasks such as pushes and blocks, a great power and strength are required for the limbs and the trunk.[28,29]

To study the body composition of child athletes is important not only to detect young talent but also to track their optimal development.[30] This can be helpful to reconsider teaching and training programs in different contexts (school, training, and performance). Thus, the objective of the study is to analyze and compare the effects of different sports (swimming, football, basketball, and handball) on fat and lean masses in prepubertal and pubertal girls. The hypothesis, in which this research is based on, was that sport practice reduces girls' fat mass and improves their lean mass. The results of the study will show the influence that a particular sport has on the body composition development of growing girls.

2. Materials and methods

2.1. Participants

Healthy prepubertal (Tanner stage I) and pubertal (Tanner stages II–III) female children from different schools and football clubs of Toledo, Ciudad Real, and Madrid (Spain) were recruited for the study. In total, 200 girls aged 9–13 years (10.6 ± 1.5 years) were divided into 5 groups (swimming, football, basketball, handball, and control groups) according to their sport activity patterns. The characteristics of each group and descriptive statistics are presented in Table 1. Once the sample was recruited, the participants underwent a series of tests to assess the degree of sexual development and body composition (fat mass and lean mass).

All the girls practicing sport were recruited from sport clubs, whereas all the control group participants were recruited from schools. According to the answers given during a personal

Table 1
Descriptive characteristics of 5 groups of prepubertal and pubertal girls.

	Swimming	Football	Basketball	Handball	Control
Prepubertal					
n	20	20	20	20	20
Age (year)	9.16 ± 0.69	9.63 ± 0.98	10.36 ± 0.51[a,b]	9.86 ± 0.64	10.01 ± 0.52[a]
Height (cm)	135.03 ± 6.19	141.20 ± 9.84	151.18 ± 10.74[a,b,d,e]	142.04 ± 8.24	141.15 ± 6.32
Body mass (kg)	29.01 ± 4.38	35.73 ± 8.74	43.04 ± 9.34[a]	37.50 ± 8.69[a]	38.44 ± 8.79[a]
BMI (kg/m^2)	15.85 ± 1.66	17.67 ± 2.60	18.74 ± 2.98[a]	18.52 ± 3.86	19.12 ± 3.38[a]
Years of training	4.68 ± 2.00	3.85 ± 1.81	3.37 ± 1.52	3.35 ± 1.35	0
Weekly training hours	3.83 ± 1.89	3.00 ± 0.00	2.88 ± 0.39	3.05 ± 0.22	0
Total BMC (g)	973.68 ± 115.32	1171.74 ± 186.41[a]	1302.71 ± 286.73[a,e]	1133.46 ± 183.35	1122.66 ± 151.60
Total BMD (g/cm^2)	0.78 ± 0.06	0.86 ± 0.07[a]	0.87 ± 0.09[a]	0.84 ± 0.06	0.82 ± 0.06
Pubertal					
n	20	20	20	20	20
Age (year)	12.20 ± 0.62	12.31 ± 0.60	13.05 ± 0.34[a,b,e]	12.69 ± 0.86	12.10 ± 0.72
Height (cm)	154.55 ± 8.41	153.85 ± 6.25	163.12 ± 8.27[a,b,e]	159.96 ± 8.14	155.76 ± 8.32
Body mass (kg)	49.06 ± 11.24	45.61 ± 9.95	56.85 ± 13.20[b,e]	52.66 ± 11.21	46.39 ± 11.27
BMI (kg/m^2)	20.34 ± 3.13	19.13 ± 3.40	21.11 ± 3.51	20.35 ± 2.73	18.91 ± 3.24
Years of training	4.08 ± 2.36	4.45 ± 1.70	4.35 ± 1.42	3.90 ± 1.77	0
Weekly training hours	4.44 ± 2.71	3.55 ± 0.76	3.09 ± 0.19	4.20 ± 2.78	0
Total BMC (g)	1458.32 ± 271.96	1488.10 ± 233.64[e]	1761.62 ± 409.35[a,e]	1784.40 ± 410.98[a,b,e]	1207.70 ± 131.84
Total BMD (g/cm^2)	0.93 ± 0.08[e]	0.95 ± 0.08[e]	1.00 ± 0.13[e]	1.01 ± 0.12[e]	0.83 ± 0.04

Notes: Data adjusted by height. Differences concerning the mentioned group at [a]swimming, [b]football, [c]basketball, [d]handball, [e]control, $p < 0.05$.
Abbreviations: BMC = bone mineral content; BMD = bone mineral density; BMI = body mass index.

interview, the girls in the control group did not participate in any kind of sport outside school (2 weekly sessions of 45 min each). The general questions about health and sport activity habits, which included information regarding type and years of sport practice, number of hours of sport activity, bone diseases, any other known disease, injuries, other sport practice and medication, were asked at the beginning of the study. Thus, these questions were used as selection criteria for the sample in order to homogenize its characteristics. Other inclusion requirements were that they had to practice their sports at least 3 h per week[31] and had been practicing their sports for a minimum of 8 months.[32]

Both parents and children were informed about the aims and procedures of the study, as well as the possible risks and benefits prior to the start of the study. Children gave their verbal assent, and a written informed consent was signed by their parents. The study was approved by the Ethical Committee of Clinical Research (Hospital of Toledo), according to the Declaration of Helsinki regarding the ethical principles for medical research involving human subjects.

2.2. Anthropometry and body composition

Weight (kg) and height (cm) were measured using a Seca scale (model 711; seca GmbH & Co. KG, Hamburg, Germany). Body mass index (BMI) was calculated as weight (kg)/height $(m)^2$. Fat mass (g) and lean mass (g) (body mass − (fat mass + bone mass)) were measured using a DXA (Hologic Serie Discovery QDR., Bedford, MA, USA). Lean mass of the limbs was assumed to be equivalent to the muscle mass. The DXA was calibrated using a lumbar spine phantom as recommended by the manufacturer. Participants were placed in supine position with the body and limbs fully extended and within the limits set by the scan lines. Whole body scanning time was about 7 min. The total X-ray irradiation absorbed by a subject was about 10% of standard chest X-ray film. All scanning and analyses were performed by the same operator to ensure consistency.

2.3. Pubertal stage

Maturity assessment is necessary for studies on growing children because the maturation range between individuals of the same chronological age is wide, especially during the pubertal years.[33] Pubertal status was determined by self-assessment using photographs of the Tanner stages,[34] a tool designed by Marshall and Tanner.[35] Pubertal status was classified as prepubertal (Tanner stage I) and pubertal (Tanner stages II–III).

2.4. Data analysis

All data were analyzed statistically by means of the SPSS for Windows (Version 19.0; IBM Corp., Armonk, NY, USA) with a significance level of $p < 0.05$. The Kolmogórov–Smirnov test resulted in a normal distribution of the variables. The characteristics of the study groups (mean and SEM) were determined through basic descriptive tests. The differences between groups were determined using a covariance analyses (ANCOVA), including height as covariate. This covariate was used because of the scientific evidence about its influence on body composition.[36,37] A preliminary analysis indicated that the fat and lean masses differed for prepubertal and pubertal. Therefore, because of the interactions between Tanner groups and the bone mass variables, every analysis was performed independently for the prepubertal and pubertal group.

To identify meaningful changes, 95% confidence interval (95%CI) and effect size (ES; Cohen's *d*) were calculated. ES was assessed using the following criteria: 0 ≤ trivial < 0.2, 0.2 ≤ small < 0.5, 0.5 ≤ medium < 0.8, large ≥ 0.80.[38]

3. Results

Table 2 presents the data related to fat and lean masses from both the prepubertal and pubertal groups of girls.

3.1. Fat mass

Firstly, results for fat mass for the 5 groups of prepubertal girls are described. The control group has significantly higher values of percentage for body fat (5.51%; 95%CI: −0.06% to 11.09%; ES = 0.89), total fat mass (4868.83 g; 95%CI: 1174.93 to 8562.73 g; ES = 1.31), and arms fat mass (319.65 g; 95%CI: 92.98 to 546.33 g; ES = 1.27) than swimmers ($p < 0.05$). The control group also has higher values for legs fat mass than swimmers and handball players ($p < 0.01$). The football players show significantly lower values for arms fat mass (−247.92 g; 95%CI: −474.59 to −21.24 g; ES = 1.11) and trunk fat mass (−1679.56 g; 95%CI: −3738.50 to 379.39 g; ES = 0.82) compared to the basketball group ($p < 0.05$).

In a different way, the pubertal girls did not obtain significant differences either in trunk or in arms fat mass for any of the sports. The swimmers show significantly lower values for legs fat mass (−189.20 g; 95%CI: −1137.81 to 759.41 g; ES = 0.45) than the control group ($p < 0.05$) and lower body fat percentage when compared to footballers ($p < 0.05$) and control group girls ($p < 0.01$). Finally, the basketball players have higher total body fat (5173.58 g; 95%CI: 292.51 to 10,054.64 g; ES = 0.91) than the control group ($p < 0.05$).

3.2. Lean mass

Secondly, the lean mass differences between prepubertal girls are shown. The handball players have significantly higher values for total lean mass (5559.32 g; 95%CI: 1466.05 to 9652.58 g; ES = 1.53) than swimmers. Likewise, the handball players also show significantly higher trunk lean mass ($p < 0.01$) when compared to swimmers, footballers, and control group girls. Finally, the handball players obtained significantly higher legs muscle mass results (494.16 g; 95%CI: −223.84 to 1212.15 g; ES = 0.60) than the control group. Trunk lean mass (−2779.68 g; 95%CI: −4946.46 to −612.91 g; ES = 1.06) and arms muscle mass (−218.59 g; 95%CI: −414.03 to −23.15 g; ES = 0.95) were lower in the control group in comparison with the basketball players ($p < 0.05$). The football players obtained significantly higher leg muscle mass results than the control group ($p < 0.01$).

Similarly, the pubertal girls of the control group show significantly lower total lean mass and trunk lean mass ($p < 0.01$)

Table 2
Fat mass and lean mass in the 5 groups of prepubertal and pubertal girls.

	Swimming	Football	Basketball	Handball	Control
Prepubertal					
Percent body fat (%)	26.86 ± 6.79	26.99 ± 5.55	28.94 ± 5.62	27.81 ± 6.90	32.38 ± 5.65[a]
Total fat mass (g)	7779.80 ± 2807.73	9388.80 ± 3114.85	12,430.72 ± 4608.84	10,588.96 ± 4754.89	12,648.63 ± 4599.68[a]
Fat mass arms (g)	451.88 ± 198.67	471.56 ± 189.50	719.47 ± 255.71[b]	606.35 ± 276.95	771.53 ± 305.87[a]
Fat mass trunk (g)	2887.40 ± 1139.96	3507.98 ± 1416.40	5187.54 ± 2692.31[b]	5052.47 ± 2264.05	5099.30 ± 3159.16
Fat mass legs (g)	1632.54 ± 681.82	2099.25 ± 677.85	2534.79 ± 837.76	1780.46 ± 570.79	2657.81 ± 906.24[a,d]
Total lean mass (g)	19,632.44 ± 2460.38	23,698.05 ± 4363.06	28,182.20 ± 5280.04	25,191.76 ± 4827.06[a]	23,257.44 ± 5014.84
Muscle mass arms (g)	882.18 ± 129.85	1064.92 ± 191.93	1252.38 ± 253.07[e]	1109.14 ± 266.77	1033.79 ± 205.68
Lean mass trunk (g)	9405.51 ± 1316.65	11,347.95 ± 2213.93	14,127.28 ± 3123.16[e]	13,204.71 ± 2731.77[a,b,e]	11,347.60 ± 2136.99
Muscle mass legs (g)	3014.55 ± 460.98	3864.05 ± 865.34[e]	4374.80 ± 887.07	4012.07 ± 901.74[e]	3517.92 ± 747.72
Pubertal					
Percent body fat (%)	25.83 ± 6.23	27.43 ± 4.71[a]	29.32 ± 6.50	26.99 ± 4.90	27.74 ± 7.06[a]
Total fat mass (g)	12,782.56 ± 5666.25	12,247.14 ± 4580.89	16,548.59 ± 6439.27[e]	14,349.03 ± 5035.06	11,375.02 ± 4930.07
Fat mass arms (g)	711.22 ± 333.15	615.00 ± 300.47	931.10 ± 376.64	803.07 ± 303.27	616.24 ± 336.12
Fat mass trunk (g)	5888.63 ± 2935.90	4796.38 ± 2252.87	7055.00 ± 3342.12	6311.68 ± 2567.08	4301.61 ± 2387.68
Fat mass legs (g)	2361.57 ± 1135.92	2680.50 ± 855.57	3429.01 ± 1232.18	2550.77 ± 983.54	2831.14 ± 969.02[a]
Total lean mass (g)	33,711.83 ± 6493.51[b,e]	29,708.51 ± 4898.89[e]	36,161.50 ± 5945.94[e]	35,565.89 ± 5887.83[b,e]	26,919.27 ± 3960.52
Muscle mass arms (g)	1610.21 ± 347.71[b,e]	1490.67 ± 241.65	1631.51 ± 239.70[e]	1606.98 ± 287.07[b,e]	1234.88 ± 187.11
Lean mass trunk (g)	18,160.29 ± 3789.42[b,e]	14,555.66 ± 2663.12[e]	18,176.47 ± 3721.08[e]	19,127.48 ± 3435.61[b,e]	12,579.14 ± 1963.78
Muscle mass legs (g)	4720.14 ± 1047.43	4985.56 ± 849.41[e]	5870.78 ± 980.56[e]	5125.49 ± 871.92	4341.65 ± 1271.40

Notes: Data adjusted by height. Differences concerning the mentioned group at [a]swimming, [b]football, [c]basketball, [d]handball, [e]control, $p < 0.05$.

results in comparison with the rest of the sports groups (swimming, football, basketball, and handball). The controls present significantly lower arms muscle mass values than swimmers (−375.36 g; 95%CI: −617.23 to −133.45 g; ES = 1.40), basketball players (−396.63 g; 95%CI: −638.52 to −154.74 g; ES = 1.86), and handball players (−372.11 g; 95%CI: −614.00 to −130.22 g; ES = 1.57). The legs muscle mass of the control group was lower ($p < 0.01$) in relation to football and basketball players. Finally, the football players have significantly lower values ($p < 0.01$) for total lean mass, trunk lean mass, and arms muscle mass than handball players and swimmers.

4. Discussion

The main purpose of this study was to compare the fat and lean masses in prepubertal and pubertal girls practicing 5 different sports and as a consequence, determining the influence that a particular sport has on the development of growing girls' body composition. Most of the previous researches that investigated the influence of physical activity on children and adolescents' body composition focused only on talent identification,[39] adiposity,[40] or bone accumulation[41] in active and sedentary people. On the contrary, few researches have studied the influence of the physical activity on the muscle and fat masses of children and adolescents' practicing different sports from a health-related perspective.

After analyzing the results, the control group girls are observed to have greater fat mass than the girls who practice sports. In this manner, the results coincide with the studies of Andersen et al.[42] and Ferreira et al.,[43] who demonstrated that physical activity improves the body composition (decrease of fat mass and increase of muscle and bone mass) of children and adolescents. Moreover, Abbott and Davies[10] and Ball et al.[44] studied the relationship between physical activity and childhood obesity and obtained correlations between physical activity levels, BMI, and body fat mass. In the study by Ara et al.,[31] the children who had no physical activity had a higher percentage of fat mass, total body fat mass, and regional fat mass (trunk, arms, and legs) than those who had at least 3 h per week, which coincides with the results obtained in the present investigation. Regarding lean mass, the control group has less lean mass than physically active girls. Thus, physical activity increases the levels of muscle mass in male and female children[45] as well as during adolescence.[46]

According to the analysis between sports, the football players had lower arm and trunk fat masses at a prepubertal stage, which coincides with the studies of Gil-Gómez and Juan Verdoy[47] and Pérez-Guisado[48] that show the footballers' group to have less fat mass than the basketball group. The prepubertal basketball players had greater trunk and leg muscle mass than the control group. This could be because basketball being a more explosive sport produces greater muscle mass development, especially in the legs.[49] The study of Koley and Singh[50] with basketball players between the age 18 and 25 years, also shows how the basketball group had a higher percentage of lean mass than the control group. Likewise, the athletes who practice sports that require jumps and throws with the upper body are bigger, stronger, and heavier.[18,51,52] Withers et al.[53] investigated the anthropometric characteristics of basketball, football, and hockey players and concluded that basketball players were taller and heavier, having as a result greater muscle mass than other sports persons.

On the other hand, prepubertal and pubertal handball players have the highest total lean mass, as well as arm and trunk lean masses, which coincides with the study of Milanese et al.[54] where a clear tendency of female handball players to accumulate more lean mass, especially in the upper body, is shown. Handball as a sport requires strength in the trunk and explosive

strength in the arms to throw.[55] In handball, the trunk is usually used to perform actions such as throwing[28,29] whereas in football, the lower body is predominantly used.[56] Bayios et al.[18] compared the body composition of handball and basketball players' and showed that basketball players are taller. Recent researches[57] suggest that handball players have greater muscle mass when compared to footballers, as in our study also. When talking about pubertal female swimmers, they have greater muscle mass and lower percentage of fat mass than football players. These results coincide with the ones obtained in the study of Grijota et al.,[58] in which swimmers had a higher fat mass percentage than other sportspersons (handball and karate) in infant categories.

More sports could have been included in this study to see the influence of different sports on body composition. Likewise, male participants could have been included to see if there are changes in body composition depending on the gender, as other studies did.[59] In future researches, it can be interesting to develop this study longitudinally to see if there is a cause–effect relationship. Finally, we agree with Ara et al.[31] who state that regular involvement in sport activities or competitions (at least 3 h per week) is associated with lower fat mass values in prepubertal children. Therefore, participation in sports during the development stage decreases obesity risks and risks related to the increased obesity.[31,60] Regarding the type of sport, team sports (football, basketball, and handball) provide growing girls with a good body composition development.

5. Conclusion

In short, it can be concluded that sport activity at early ages (independently of type of sport), unlike sport inactivity, ensures lower fat mass and greater lean mass. Therefore, our initial hypothesis is accepted. This becomes a good argument for coaches, teachers, and doctors to promote sports and recommend physical activity.

Authors' contributions

EUG had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis; EUG and LG carried out the study concept and design; EUG, EM, JSS, MPC and MMG participated in the acquisition and analysis of data; EUG did the drafting of the manuscript; EUG, EM, JSS, MPC, MMG and LG carried out the critical revision of the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript, and agreed with the order of presentation of the authors.

Competing interests

That authors declare that they have no competing interests.

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