Body composition in 10 to 14-year-old handball players

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SUMMARY

This study analyses the body composition of male school children with an age range of 10–14: players from 11 league teams. The sample corresponds to 29.32% of the total population (854) and enabled us to find highly reliable conclusions.

Besides the 5 specific data, we measured eight skinfolds, six lengths, eight heights, thirteen girths or perimeters, and nine diameters.

The study of body composition was done following Matiegka's method. The percentage of fat mass was estimated using the equation of Slaughter et al; muscle mass by the Drinkwater and Ross formula; bone mass by Rocha's formula and residual mass by Würch's equation.

The results show that these athletes are taller, weigh more and have a larger span than the athletes of other papers. From ages 10 to 14, the percentage of fat mass decreases, and a change in the distribution of subcutaneous fat is observed.

Key Words: Handball players – Schoolchildren – Body composition – Kineanthropometry

INTRODUCTION

Handball is a team sport whose players, due both to the size of the court and to the nature of the game itself, develop certain morphological characteristics and physiological features.

The importance of this sport in Spain is evident from the fact that most papers published at international level are by Spanish researchers.

Rubio and Franco (1995) analyzed the influence of physical activity on body composition and somatotype in 550 boys and 165 girls (aged 7 to 14), all of which played handball and basketball at local training centers in Reus (Tarragona, Spain). The most striking findings were that the percentage of fat mass in these subjects was higher than the recommended values for that age group, and that in boys the percentage of fat mass increases progressively with age, whereas in girls it remains between the ages of 8 and 12. These data essentially agree with the results of studies published by McKeang (1991) and Roque et al. (1993).

Alvero et al. (1992) performed a kinanthropometric evaluation of 15 members of a first-division handball team during activity and training, and of 18 medical students who did not engage in any form of sport regularly. Body composition and somatotype were determined following De Rose and Guimarães (1980) and Heath and Carter (1967), respectively. A statistically significant inverse correlation is seen between total body weight and the percentage of fat mass in handball players; weight gain takes place at the expense of muscle and bone compartments (direct correlation); in the case of those not engaged in any sport, it is fat mass that influences total weight. Moreover, the skinfold correlation shows that fat distribution is not proportional and is related to the regular practice of this sport.

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Galiano (1989) studied 59 male handball players from a total of 1,035 Olympic sportsmen and women; average height was 185.3 cm, average weight 83.6 Kg and the subscapular skinfold was the largest. The percentage of fat mass decreased as a function of the sport concerned in the following order: track cycling, basketball, handball, water polo, swimming, athletics-soccer, tennis and gymnastics.

A study of the Spanish Junior Handball Team by Ruiz (1986) showed that handball players (especially wingers) tend to be tall and heavy, with a higher percentage of fat mass than that of athletes and soccer players, and similar to that found in players of indoor sports such as basketball and volleyball.

Jiménez et al. (1988) charted morphology in a top-level handball team over one season. The mean age of the players was 25, mean height 184 cm, mean span 198 cm and mean total weight 82.77±7.25 kg. The four-compartment division proposed by De Rose and Guimarães yielded the following values: fat mass 12%±2,02; muscle mass 40.02%±3.22; residual mass, 19.93%±1.75 and bone mass 12.66%±1.23.

Canda et al. (1991) examined the biotypological characteristics of 16 male handball players from the Spanish Junior Team; the player's average age was 19.8, mean weight was 85.96 Kg., and mean height was 189.96 cm. The mean somatotype was endomesomorphic and the values of the three components were 3.18 - 4.89 - 2.47.

The present transversal study analyzed several anthropometric variables with a view to establishing the current morphological characteristics of a population of schoolboys aged between 10 and 14, who play handball as part of the curriculum. Kinanthropometric models for that age group were adjusted to obtain both a suitable strategy for estimating four-compartment division and a highly-reliable regression equation that might facilitate application of this study.

MATERIAL AND METHODS

The study covered a total of 251 randomly selected handball players, ranging in age from 10 to 14, from the city and province of Cordoba (Spain). The age breakdown was as follows: 45 x 10-year-olds, 47 x 11-y-o, 51 x 12-y-o, 60 x 13-y-o and 48 x 14-y-o. These 251 boys represented 29.39% of the 854 schoolboy members of the Cordoba Handball Federation. Six clubs were selected randomly for sampling, from a total of eleven; the numbers drawn from each club were as follows: 37, 39, 50, 44, 38, and 43. Mean age was 12±1,38; mean weight was 53,74±13,74 and mean height was 159,96±13,31.

The I.S.A.K. protocol was used. Apart from weight, height, seated height, total height and span, eight skinfolds were measured (biceps, triceps, subscapular, suprailiac, supraspinal, abdominal, upper- thigh and mid-calf, using the SlimGuide© caliper by Creative Health Products), seven lengths, eight heights (sesmometer 3m Stanley Powerlock© 33-193 <+50mm>), 13 perimeters or girths (Harpenden Anthropometric Tape© by Holtain Ltd.) and 9 diameters (Berfer© anthropometer). The intra-observer technical error of 2.14% was well below the accepted maximum (5%). Table 1 shows the data for the variables used in the study of body composition.

The four-compartment division of body composition was felt to be the most suitable in athletes, and also avoids many of the errors commonly affecting the two-compartment division.

Fat mass was calculated using equations and formulae proposed by Siri (1961), Brozeck et al. (1963), Faulkner (1968), Bencke and Wilmore (1974), Lohman (1981) and Slaughter et al. (1988). Body density was obtained using the equations of Parizkova (1961), Durning and Womersley (1974), Sloan and Weir (1970), Guedes (1994), depending on the fat mass equation used.

Table 1. - Different variables used in the body composition estimation.

Age (y-o)	10	11	12	13	14
Height	143,84	151,30	158,32	167,94	175,29
Span	144,88	153,66	160,69	172,65	179,55
Sk. Triceps	10,92	10,30	9,90	9,37	9,03
Sk. Calf	9,74	9,18	9,05	8,80	8,29
G. Arm relax.	23,14	23,43	25,98	26,09	26,88
G. Chest	72,22	76,64	81,46	85,45	88,16
G Thigh 1	48,03	50,24	53,70	54,85	56,16
G. Calf	31,06	32,35	34,60	35,63	36,49
D. Humeri	5,94	6,17	6,47	6,75	6,90
D. Femori	9,31	9,66	10,08	10,26	10,55

Table 2. - Highly significant correlation between real weight and estimated weight

Aged (y-o)	Real Weight (Kg)	Estimated Weight (Kg)	Person's correlation
10	40,27	40,93 (+ 0,66)	0,985
11	45,96	46,89 (+ 093)	0,982
12	53,43	55,66 (+ 2,23)	0,987
13	59,77	62,03 (+ 2,26)	0,979
14	66,77	67,94 (+ 1,17)	0,985

The muscle component was estimated using the equations of Kerr (1988), Martin et al. (1980) and the "tactical" method of De Rose and Guimarães (1980). Bone mass was calculated using the Von Döbeln equation (1964), as modified by Rocha (1975), and residual mass was calculated using Würch's (1974) formula.

Statistical analysis of data and results was performed using the SPSS PC+ program, version 7,52. Inter-group age differences for each variable were examined by one-way ANOVA. Where significant differences ($p< 0.05$) were detected, the Scheffé contrast test was used to compare different age-groups.

RESULTS

Although all the equations and formulas indicated in the material and methods section were applied, the ones that are the most suitable for the four-compartment model, in that they afforded the best statistical correlation, were the Slaughter et al. (1988) equation for fat mass, the Drinkwater and Ross (1984) formula for muscle mass, the Rocha (1975) equation for bone mass and, obviously, the Würch (1974) equation for residual mass.

Table 2 shows the comparison between real weight and estimated weight (i.e. weight obtained using the four-compartment model to add together the four masses, each determined by the equation considered most suitable for this population).

All correlations were strongly positive, and values estimated figured among the statistical values providing the best results.

Mean body weight for the sample as a whole was 53.74 kg, with individual means of 40.27 kg, 45.96 kg, 53.43 kg, 59.77 kg and 66.77 kg for children of 10, 11, 12, 13 and 14, respectively.

The contrast test revealed no significant differences between handball players aged 10 and 11. However, highly significant differences were recorded between this age group and all the others studied (i.e. 12, 13 and 14). The findings for **estimated weight** (by application of the four-compartment model) followed exactly the same pattern.

Body composition

The values for the four-compartment breakdown are shown in Table 3 and are analysed below.

The skinfold profile (Graph 1) shows the lowest values recorded in each age group. Although no statistically significant differences in skinfold values were found between 10- and 11-year-old subjects, or between 13- and 14-year-olds, comparison of these two age groups revealed significant differences.

Fat mass

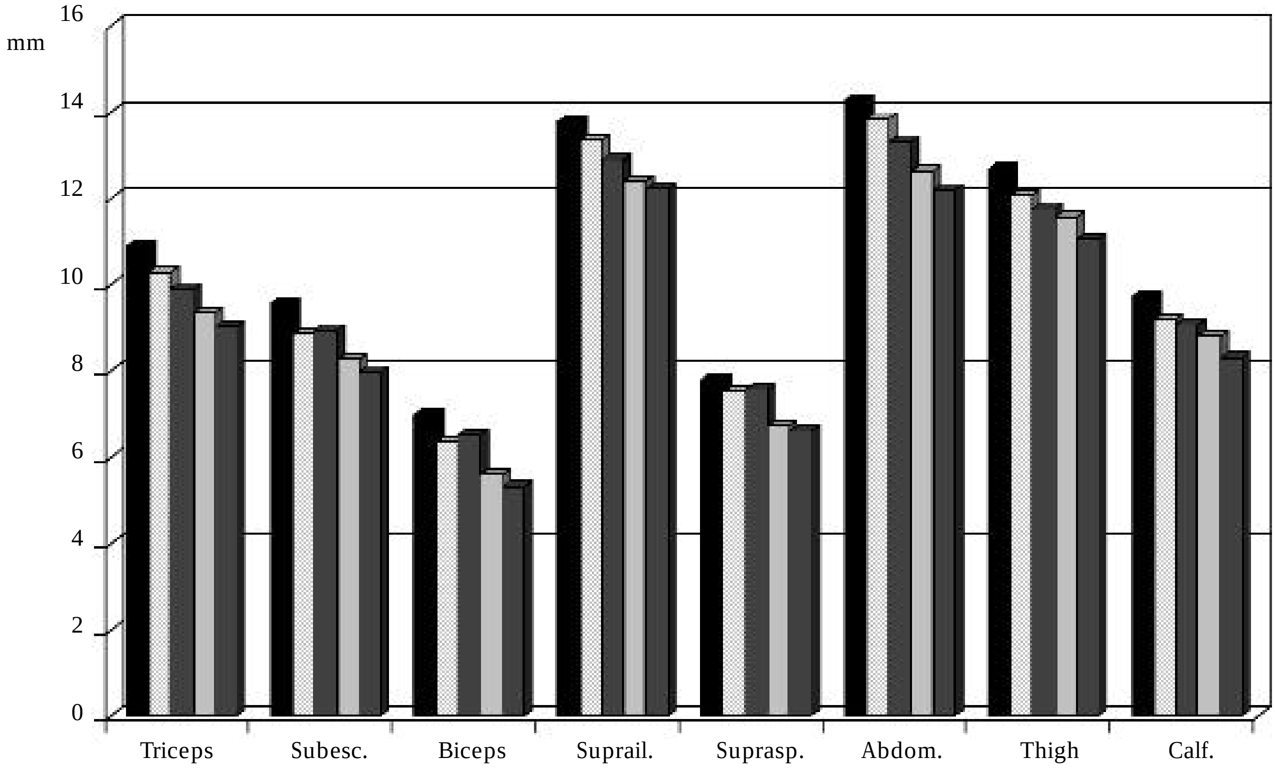
The percentage of fat mass (calculated using the equation proposed by Slaughter et al., 1988) was greater in 10- than in 14-year-olds (16.19% v. 13,73%, respectively; Table 3), suggesting a progressive decrease with age.

As with skinfolds, no statistically significant differences in the percentage of fat mass were observed between 10- and 11-year-olds, or between 13- and 14-year-olds. However, highly significant differences ($P < 0.000$) were found between these two age groups. The differences between 12-year-olds and other age groups were not significant. Differences in fat mass between age groups were therefore significant, and the age of 12 appears to mark a watershed in fat mass development.

Expressed in weight terms (Graph 2), this mass increased by 2.67 kg between the ages of 10 and 14, the yearly increase being almost constant: (10-11 = 0.57 kg; 12-13 =0.56 kg, 13-14 =0.55 kg), with the exception of the 11-12 age group, where the increase was almost double that of the others (0.99 kg).

Table 3. - Percentage of different masses by the four-compartment breakdown model.

	10 y-o	11 y-o	12 y-o	13 y-o	14 y-o
% Fat Mass	16,19	15,32	14,93	14,35	13,73
% Muscle Mass	42,23	43,21	45,11	46,23	45,90
% Bone Mass	19,33	19,26	18,90	19,06	18,66
% Residual Mass	24,10	24,10	24,10	24,10	24,10



Graph 1.- Skinfold Profile. The bars of each skinfold correspond the ages correlatively.

Muscle mass

This compartment was the most strongly related to physical activity. Expressed as a percentage (Table 3), an increase was recorded from the age of 10 (42.23%) to the age of 13 (46.23%). In 14-year-olds, the percentage dropped slightly to 45.90%. It is assumed that this decrease is in reality due to an overestimation of the muscle compartment in 12- and 13-year-olds (maximum estimated weight of 102.54 and 103.14%, respectively). A hypothetical adjustment to 100% would yield a continuous increase from 10 to 14. As seen in Graph 2, in weight terms there was a progressive increase in muscle mass from 17.05 kg (10-year-olds) to 30.64 kg (14-year-olds).

No statistically significant differences in muscle mass were found between 10- and 11-year-olds, or between 12-, 13- and 14-year-olds. However, the differences between these two groups (10-11-year-olds group and 12-13-14-year-olds group) were highly significant.

Bone mass

Bone mass (Rocha's formula, 1975) displayed a virtually constant increase of around 1 kg/year with age (Graph 2). As a percentage of total mass, it remained constant at around 19% (Table 3).

No statistically significant differences were found for percentage bone mass between the various age groups studied.

Residual mass

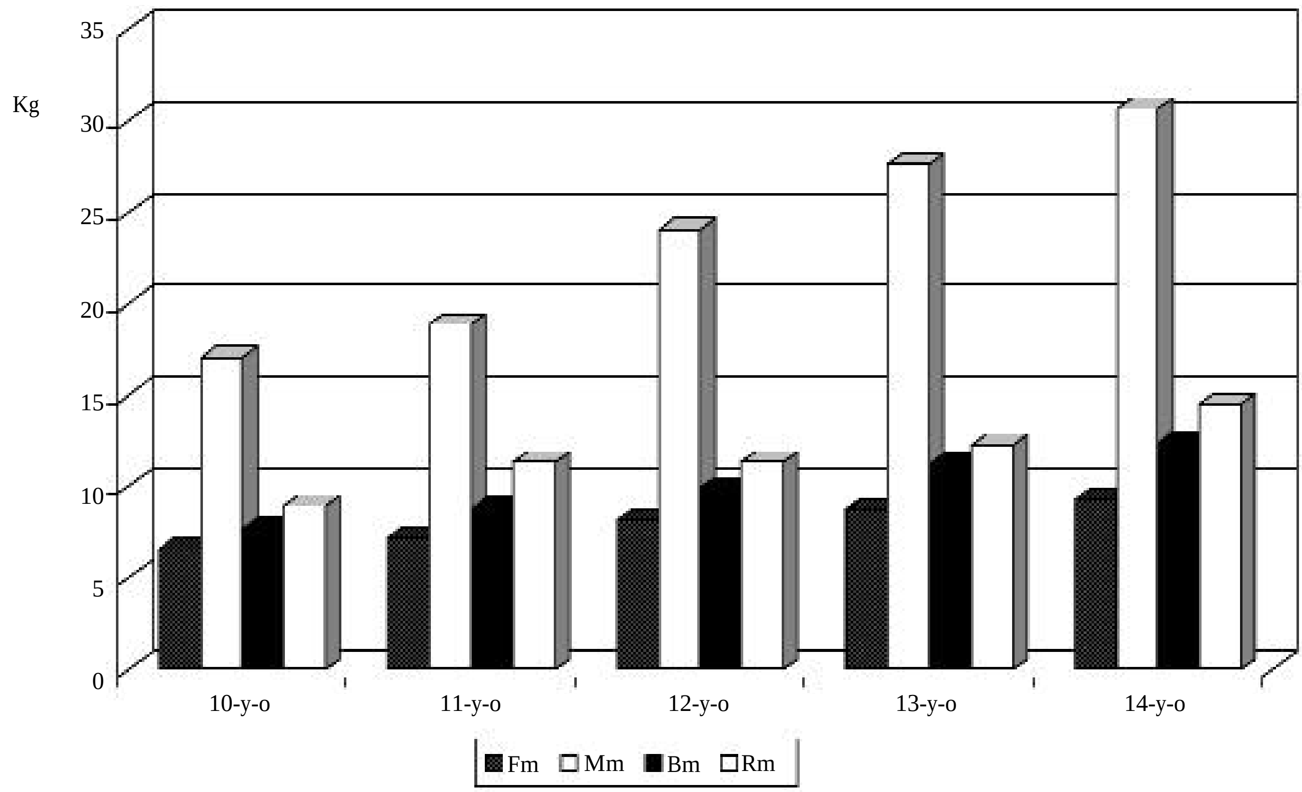
No statistically significant differences in residual mass (Würch's formula, 1974; Table 3) were found between 10- and 11-year-olds, or between 12-, 13- and 14-year-olds. However, the differences between these two groups (10-11-year-olds group and 12-13-14-year-olds group) were highly significant.

Regression

With a view to enhancing the applicability of kinanthropometric research, stepwise linear regression was used to study the possibility of obtaining an equation that might permit reliable calculations of masses, especially by non-experts.

This possibility was examined for the different masses and other variables studied, and interesting results were obtained for muscle mass measured using the Drinkwater and Ross formula, and for several of the muscle girths studied.

An evident and statistically interesting equation was obtained upon estimating muscle mass on the basis of just two girths: chest and calf. The estimate affords 89.2% ± 2.20 reliability, i.e. the value calculated using this regression equation has an 89.2% likelihood of being correct; this clearly makes it a valuable tool for the assessment and control of muscle mass by trainers and physical education teachers, as long as it is applied to populations with similar characteristics.



Graph 2.- Weight (Kg) of different masses by age. Fm: fat mass; Mm: muscle mass; Bm: bone mass; Rm: residual mass.

The regression equation proposed is as follows:

$$Mm = 0.423\ (TG) + 0.674\ (CG) - 33.213.$$

Mm = muscle mass (kg); TG = chest girth (in cm); CG = calf girth (in cm).

Comments and Discussion

Monitoring of several anthropometric parameters in young handball players of various ages indicated that physical activity was beneficial to health, prompting a decrease in fat mass and an increase in muscle mass. The study population lies between the 90th and 97th percentiles for both height and weight by age group in the growth tables of the Spanish Research and Development Institute.

In the following discussion, the values and data of the study population are shown in bold to avoid unnecessary repetition.

On comparing the results obtained by different authors it is essential that the same technique be applied; for this reason, as well as using the most statistically suitable equations for this type of athlete, it was considered appropriate to obtain estimates for the different masses obtained using the equations or formulae of other authors to be compared.

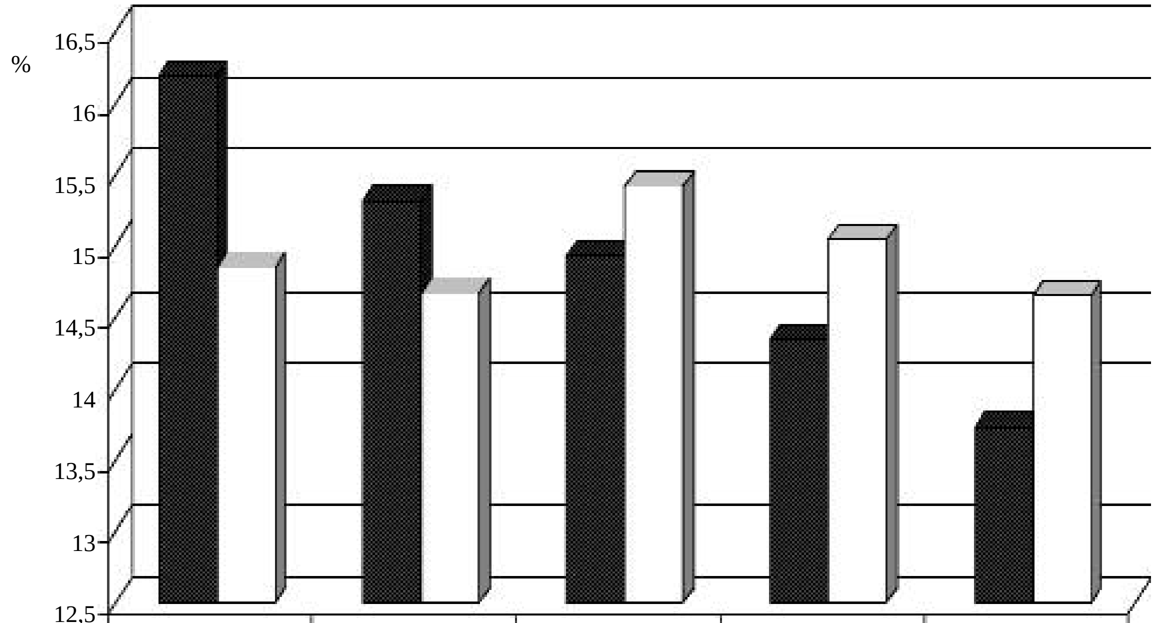
The mean heights and weights in school-age handball and basketball players studied by Rubio and Franco (1995) were very similar to those recorded for 10-year-olds in the present study (40.36 kg and 144.39 cm *versus* 40.27 kg and 143.84 cm). However, development differed considerably: the 14-year-old group in the present study had a mean weight of 66.77 Kg and a mean height of 175.29 cm, as compared to 58.65 Kg and 165.72 cm reported by those authors.

In the present study, the mean values for all skinfolds decreased progressively from the age of 10 to the age of 14; in contrast, Rubio and Franco report an increase in all skinfolds up to 12 years old, with a subsequent decrease. The skinfold values and their sum reported by those authors were greater than those recorded in the present study; the values for upper thigh and mid-calf skinfolds were 10 and 5 mm lower, respectively, in the present group.

Estimating the percentage of fat mass using Carter's equation (1982), Rubio and Franco reported a very similar figure at 10 and 11 years old (14.85% v. 14.67%), which increased at 12 (15.42%) and fell slightly at 13 (15.05%) and again at 14 (14.65%).

Graph 3 compares these values with those recorded in the present study using the same fat mass equation.

Fat mass was **16.19%** at age 10 (higher), **15.31%** at age 11 (higher), **14.93%** at age 12 (lower), **14.35%** at age 13 (lower) and **13.73%** at age 14 (lower). The percentage of fat mass



	10 y-o	11 y-o	12 y-o	13 y-o	14 y-o
■ Hbp-C	16,19	15,32	14,93	14,35	13,73
□ Rubio y Franco (1995)	14,85	14,67	15,42	15,05	14,65

Graph 3. Comparison of the results of the% of fat mass of this study (Hbp-C) and the data of Rubio and Franco (1995). In both cases the Carter Equation is used (1982).

thus fell from **16.19%** at age 10 to **13.73%** at age 14, pointing to a constant and progressive decrease that clearly demonstrates the beneficial effect of physical activity.

No other data are available to enable comparison with other handball players of the same ages. However, taking into account relative proportions, the results can be compared with those reported for adult top-level handball players, since the purpose is to chart a trend towards peak performance. Galiano (1989) found that adult top-level handball players had a mean weight of 83.6 kg and mean height 185.3 cm. The 14-year-old group in the present study was the closest to these figures; although adults were roughly 10 cm taller and 17 kg heavier, the fat mass percentage, using Faulkner's equation in both, was 12.13%, as compared to 12.40**%** for the adult top-level handball players (recall that the% fat mass by Slaugther et al. is 13.73%).

The fact that these schoolboys have a fat mass similar to that of top-level professionals is again indicative of the value of physical activity and the benefit of this sport in reducing the percentage of fat mass.

The results obtained in top-level professional handball players by Jimenez et al. (1988) and Alvero et al. (1990, 1992), are based on the analysis of the four masses, determined by using the anthropometric equations of Faulkner (fat mass), Würch (residual mass), Rocha (bone mass) and the "tactical method" of De Rose and Guimaraes (muscle mass).

Jiménez et al. (1988) and Alvero et al. (1990 and 1992) reported very similar results for each mass. As expected, these differed from the results of the present study for fat mass, muscle mass and bone mass. Fat mass in 10-year-olds was slightly higher, whilst fat mass in 14-year-olds was similar to that reported by both Jiménez et al. (1988) and Alvero et al. (1990), and slightly higher than that recorded by Alvero et al. (1992); the muscle mass in 10-year-old handball players was **43.36%** , i.e. 4 to 5% lower. However, muscle mass in 14-year-olds **(45.11%)** was at most 3% lower than in adult players. Bone mass was higher in schoolchildren than in the adult subjects.

It is not easy to compare the data obtained in schoolchildren with the results reported in the above studies. Muscle mass was greater in adult players due to progressive development over many years' training; in the case of schoolchildren, adaptation of muscle mass to this physical activity will still take some years.

Anthropometric evaluation of male basketball players of mean age 15.43 (García, 1986) yielded the following results: mean height 173.20 cm; mean weight 63.48 kg; fat mass (Faulkner's equation) 12.88%; muscle mass (De Rose and Guimarães "tactical" method) 44.77%; bone mass (Rocha's equation) 18.24%; and residual mass (constant value) 24.10%.

Although the handball players also belonged to the Junior category, they were one year younger. However, their profile was more similar to that of older athletes, with greater mean height (**175.29** cm), greater mean weight (**66.77** kg), a lower percentage of fat mass (**13.73%** by Slaugther's formula and **12.12%** by Faulkner's equation), higher percentage muscle mass **(45.12%)** and a similar percentage of bone mass **(18.66%)** .

The estimates of body composition by Muñoz et al. (1986) in 214 top-level Spanish sportsmen aged between 15 and 24 (swimming, volleyball, cycling, rowing, canoeing, basketball and athletics) is of interest in that it enables comparison of geographically similar populations.

Naturally, only the 14-year-old handball players can be compared with age-matched subjects engaged in other sports. The mean height and weight of handball-players were lower than those of subjects engaged in volleyball, rowing, canoeing and basketball, and higher than those of subjects engaged in swimming, cycling, gymnastics and athletics.

Fat mass was similar to that of subjects engaged in volleyball, basketball, cycling, rowing and canoeing, and greater than that of swimmers, gymnasts and athletes.

Muscle mass was similar to that of rowers, volleyball players and basketball players, and lower than that of swimmers, cyclists, canoeists, gymnasts and athletes.

The percentage of bone mass was lower than that of gymnasts, similar to that of swimmers and rowers, and greater than that of volleyball-players, cyclists, canoeists, basketball-players and athletes.

Another important anthropometric study was performed by Pacheco and Canda (1999) in athletes (235 men of mean age 21.3 and 159 women of mean age 20.4) specializing in ten different events, and a control population of 61 male and 58 female university students not engaging in sporting activity (mean age 22.8 for men and 22.5 for women). The Drinkwater and Ross method, employed here to evaluate muscle mass, was used in that study to evaluate body composition. For this reason, only the muscle mass results were compared, since this is the major component in top-level athletes.

The percentage of muscle mass in 14-year-old handball players studied here was **45.90%** , and therefore similar to that reported for middle-distance runners (45.89%), long-distance specialists (45.66%), pole-vaulters (45.65%), high-jumpers (46.59%) and mixed-event specialists (46.05%); lower than that for sprinters (46.23%), long-jumpers (46.91%) and javelin specialists (46.39%), and higher than that of walkers (44.95%) and non-athletes (44.10%).

It is natural to seek an explanation of the fact that the percentage of muscle mass in teenage athletes is similar to, and sometimes greater than, that of adult athletes, when one would expect it to be lower, as is indeed the case compared to the sprinters, long distance-runners and javelin specialists studied by Pacheco and Canda. The training of the handball players may have been particularly thorough and intense, or –conversely– the other athletes may not have been on top physical form. The method used to estimate muscle mass was the same: Pacheco and Canda (1999) used the Drinkwater and Ross four-compartment method to estimate all four masses, whilst in the present study it was used only to estimate muscle mass. However, this should not affect the final results, since the measurements were independent. The Drinkwater and Ross method is based on estimation by the phantom method; consequently, each compartment is estimated separately. Accordingly, comparison of the percentage of muscle mass between school-age handball players and the other athletes is perfectly feasible.

Conclusions

Analysis of this pioneering kinanthropometric study in handball players aged 10 to 14 keeping a rigorous schedule of training and competitions enables the following conclusions to be drawn:

1. Rigorous handball playing leads to a decrease in percentage fat mass from age 10 to age 14, and to a corresponding increase in percentage muscle mass. It also prompts changes in the distribution of subcutaneous fat.
   Although impossible to demonstrate, there seems to be a clear causal relationship between physical training in these children and a tendency towards a healthier constitution (lower fat mass and higher muscle mass).
2. The four-compartment method proposed as providing the best statistical correlation for this type of population and sport uses the following equations: fat mass (Slaughter et al.), muscle mass (Drinkwater and Ross), bone mass (Rocha) and residual mass (Würch).
3. The regression equation obtained to calculate muscle mass from only two girths (chest and calf) affords a high degree of reliability and accuracy (89.2%), and should facilitate more widespread application of kinanthropometric studies.

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