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Original Article. Influence of fat mass for the VO2max and ventilatory thresholds in young athletes of endurance sport specialties

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Influence of fat mass for the VO2max and ventilatory thresholds in young athletes of endurance sport specialties

Influencia de la masa grasa para el VO2max y Umbrales Ventilatorios en jóvenes deportistas de especialidades deportivas de resistencia

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Abstract

The aim of the study is to analyse the influence of total fat mass and its % regarding total body weight, as well as the regionalized fat mass (Σ trunk folds, Σ abdominal folds, ratio TS/TI, phantom (Ph) of the folds) and its % regarding total fat mass in relation to VO2max and ventilatory thresholds (VT1, VT2) in young according to their sport specialty and age group. The sample is composed of 400 athletes of both sexes from Centro de Tecnificación de Cheste (Valencia) classified into 3 age groups: <12-13, 14-16 and 17-20 years of age, and endurance sports disciplines: athletics, swimming and triathlon (n = 134, n = 135 and n = 131 respectively). The physiological data was obtained from and ergospirometric incremental ramp test on a treadmill following the Wasserman protocol; and the anthropometric data from an anthropometric measurement following the ISAK protocol. The results obtained from the Variance Analysis (ANOVA) indicate significant differences ($p<0,05$) for the case of sport specialties, those being athletics, swimming and triathlon. But there were no significant differences ($p<0,05$) between athletics and swimming. For the case of age groups, the findings indicate significant differences ($p<0,05$) between the age groups 14-16 and 17-20, as well as <12-13 and 14-16 years of age. But this was not the case for the age groups <12-13 and 17-20 years of age.

Keywords

Age; fat mass; maximum oxygen consumption; specialty.

Resumen

El objetivo del estudio es analizar la influencia de la masa grasa total y su % respecto al peso corporal total, así como la masa grasa regionalizada (Σ pliegues tronco, Σ pliegues abdomen, cociente TS/TI, phantom (Ph) de los pliegues) y su % respecto a la masa grasa total, en relación al VO2max y los Umbrales Ventilatorios (VT1 y VT2) en jóvenes deportistas en función de su especialidad deportiva y grupo de edad. La muestra está compuesta por 400 deportistas de ambos sexos del Centro de Tecnificación de Cheste (Valencia) clasificados en 3 grupos de edad: <12-13, 14-16 y 17-20 años, y de especialidades deportivas de resistencia: atletismo, natación y triatlón (n=134, n=135 y n=131 respectivamente). Los datos fisiológicos se han obtenido de un test ergoespirométrico incremental en rampa en cinta rodante siguiendo el protocolo de Wasserman; y los datos antropométricos de la realización de una antropometría siguiendo el protocolo ISAK. Los resultados derivados del Análisis de Varianza (ANOVA) indican que para el caso de las especialidades deportivas se han encontrado diferencias significativas ($p<0,05$) entre atletismo y triatlón, y natación y triatlón. No se han encontrado diferencias significativas ($p>0,05$) entre atletismo y natación. Para el caso de los grupos de edad se han encontrado diferencias significativas ($p<0,05$) entre los grupos de 14-16 y 17-20 años, y <12-13 y 14-16 años. No se han encontrado diferencias significativas ($p>0,05$) entre los grupos de <12-13 y 17-20 años.

Palabras clave

Consumo máximo de oxígeno; edad; especialidad; masa grasa.

Introduction

The body composition represents the mass of the different tissues that form our organism (Drinkwater, D.T., Martin A.R, Ross W.D., Clarys J.P, 1984), being the fat mass very important for sports performances (Ramos N.J. & Zubeldía G.D, 2003), as it is proven that the excess adipose tissue acts as deadweight when practicing activities where the body mass needs to be repeatedly moved against gravity to produce force (Ramos N.J. & Zubeldía G.D, 2003). That is why, it is stated that fat mass has a negative impact in sports performance (Bangsbo J., 1999; Gutin B. et al., 2002). To that end, there are several anthropometric equations, more than 100 (Alba, 2005), which calculate the subcutaneous adipose tissue (adipose panicle). Through this process, it is possible to obtain the estimation of the total amount of fat (Madain P.S. et al, 2013), and it can be affected by the implemented method, and the measurement and calculation technique. It can also present some differences due to the distribution pattern of the adipose tissue (Sáez, 2005), and the anatomical divisions

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(Janssen, I. et al., 2004) can affect the assessment of the $VO_{2máx}$. and the ventilatory thresholds.

A very important aspect to take into account is the distribution of the adipose tissue, that is to say, its regionalisation. Within the anthropometric variables, which assess the distribution pattern of the adipose tissue, it is possible to find: the waist-hip ratio, the circumference of the waist, the trunk folds, and within these, there are subsets like the abdominal folds (Casajús et al., 2006 & Nassis et al., 2004), as well as the phantom (Ph) of the skinfolds (Lentini, 2004; Maestre et al., 2005), particularly the phantom of the waist. All of them affect the maximal oxygen consumption (VO2max) and the ventilatory thresholds. However, a partial observation is possible when the amount of skinfolds regarded for the assessment does not represent most of the body regions (Valenzuela, 1996). It thus happens with Durnin and Womersley's equation (1974), which is used to assess the body composition and only records the skinfolds of the upper body, or Goldman and Buskirk's equation (1961), which suggests to use three skinfolds separately.

Therefore, in the research study by Madain P.S. et al (2013) the anthropometric variables (abdominal fold, iliocrestal fold, subscapular fold and waist circumference) inversely correlated with the $VO_{2máx}$, and the anthropometric variables (abdominal and iliocrestal fold) did it with the ventilatory threshold, being it not possible to find any significance between these skinfolds and the $VO_{2máx}$. percentage in which the ventilatory threshold is evidenced.

Consequently, the fat mass is a limiting factor in resistance (Martin & Coe, 2007) because it increases the load that has to be moved by the athlete in each movement, which means that more energy is required to move the body, since the mass increases (Brunet, M. et al., 2007). This is even more important in the VO2max, as it is the functional capacity of a person, because it is the maximum amount of O2 the organism can absorb, transport and consume per unit of time (López Chicharro & Fernández, 2006).

With regard to the internal and external layers of subcutaneous adipose tissue, there are some confrontations among researchers, since Brozek (1971) proposed that the 50 % of the total adipose tissue was subcutaneous; Martin, Ross, Drinkwater and Clarys (1986) suggested it was almost the 80 %; and Jones et al (1969) discovered that the variability among individuals, in connection with the subcutaneous and internal adipose tissue, is very high.

That being said, the aim of this study is to analyse the impact of the total fat mass and its % regarding the total body weight, as well as the regional fat mass and its % regarding the total fat mass, with regard to the VO2max and the ventilatory thresholds, in the different sports specialties, for each age and sex groups.

Materials and Method

Design of the Study

The study has a descriptive and cross-sectional nature and it was conducted in 2015. The assessments were carried out in March, April and May (concurring with the season's competition period), from 2007 to 2015, when a new database was created, which was organised by age and sex.

Ethical Aspects

Inasmuch as the data the study is based on correspond to the databases of the Centro de Tecnificación, the respect to the ethical principles for this kind of studies is met, as these studies were once conducted by the centre in terms of access to the field, the consent of the participants, the protection of the anonymity and/or the confidentiality of the data.

Sample

The sample is composed of a total of 400 young athletes of the Centro de Tecnificación of Cheste, which reports to the Valencian Department of Culture, Education and Sports. Out of these individuals, 134 practised athletics, 135 practised swimming and 131 practised triathlon; they were men and women from the Valencian Community. The sample is classified by age groups: <12-13, 14-16, and 17-20 years old.

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The distribution of the sample according to the tests is the following:

Table 1: Sample size

	SAMPLE SIZE (N=)				AGE
	<12-13	14-16	17-20		ATHLETICS
M	22	23	23		SWIMMING
F	20	23	23		TRIATHLON
M	21	24	23		M=MALE
F	24	23	20		F=FEMALE
M	23	23	21		
F	23	21	20		

Variables and Protocols

Physiological Variables

In order to create the physiological profiles, the following parameters were analysed:

- VO_2 max/kg/min (direct)
- VO2umb/kg/min (direct)
- VT1 (direct)

Firstly, to obtain the physiological profile, the data were collected by means of an ergospirometry incremental ramp test on a pulsar h/p/cosmos treadmill. The test correlates with the Wasserman 7 protocol for women and the Wasserman 8 protocol for men, which, after a warming up period, consists on an initial load of 8km/h and a constant 1% gradient (simulates the conditions of the track and the friction of the air) throughout the test, increasing it in 1km/h each minute until exhaustion. The previous day, the athlete carried out a lighter training, so as not to interfere with the stress test results.

As gas analysing systems, the CPX Ultima System model by Medgraphics and the Breeze Gas Suite 6.4.1. software were used. The following variables were measured: oxygen consumption (VO_2), carbon dioxide production (VCO_2), ventilation (VE), ventilatory equivalent for oxygen (VE/VO_2) and carbon dioxide (VE/VCO_2), and the end-tidal oxygen pressure ($PETO_2$) and end-tidal carbon dioxide pressure ($PETCO_2$). The gas is measured breath by breath through a method called V-Slope.

Secondly, a biological and hormonal control was conducted due to the fact that these variables can modify the interpretation of the results at these ages (Tanner, 1962), especially in women (Godoy LA. et al., 2010). The groups aged <12-13, 14-16, and 17-20, were representative of the developmental period to the prepuberty, puberty and postpuberty, concluding that their chronological age was similar to their biological age.

Anthropometry

Subsequently, the anthropometric variables that internationally correspond to the ISAK (International Society for the Advancement of Kinanthropometry) protocol (ISAK, 2001) were analysed, specifically with the GREC (Kinanthropometry Spanish Group) protocol that uses William Ross' terminology (Esparza, 1993), supervised by the SEMED (Spanish Federation of Sports Medicine). During the sports season, the athlete follows a proper diet, thus the previous days to the anthropometry, the same diet was followed so that it would not interfere with the results.

Out of the anthropometries we collected the following data: Age, Weight, Height, Skinfolds (biceps, triceps, subscapular, ileocrestal, abdominal, thigh and leg), Bone Diameter (biestiloid, humeral biepicondylar, femoral bicondylar) and Perimeters (arm, thigh, leg).

In order to assess the fat mass, the equation by Yuhasz (Yuhasz, M.S, 1974) modified by Faulkner (sum of 4 skinfolds x 0,153 + 5,783 for men, and sum of 4 skinfolds x 0,213 + 7,9 for women) (Faulkner JA, 1968) was used. The folds are triceps, subscapular, suprailiac and abdominal. To regionalise the adipose mass, the following equations were used: Σ trunk folds (subscapular fold + ileocrestal fold + abdominal fold), Σ abdominal folds (trunk except for the subscapular fold), TS/TI quotient (quotient between the upper body and the lower body skinfolds) and the Phantom model (Ph) (Z index) of the proportionality skinfolds by Ross and Wilson ($Z= [v\ x(170,18/E)^{d}\ ] - p\ /\ s\ )$ (Ross & Wilson, 1974). The "d"

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dimensionality factor equals "1" if the variable is a length, it equals "2" if it is a surface, and "3" if it is a volume or a mass.

The muscle mass (Martin) (Martin et al., 1991) and its percentage were also calculated. It was obtained by means of the following equation: (Height * 0,0553 x M^2 + 0,0987 x A^2 + 0,0331 x P^2 – 2445) / 1000. Where "M" is: (thigh perimeter – pi x thigh fold) / 10.

The materials used for the anthropometry were the following: the weight was established with a mechanical scale, with a precision of 100g, and the height was measured with a Holtain stadiometer, with a precision of 1mm. The skinfolds were measured with a Holtain calliper, with a precision going from 0,1mm up to 0,2mm and a constant pressure of 10 g/mm^2. With a dermographic pencil, we marked all the anatomic spots where the skinfolds were located. The perimeters were measured with a Holtain anthropometric tape, with a precision of 1mm. The data were gathered in an anthropometric (or pro-forma) sheet.

Data Analysis and Statistical Treatment

The statistical calculations were performed with Microsoft Excel 2010 and the SPSS software 21.0 version (IBM). We calculated central tendency statistics and dispersion (median and standard deviations), as well as comparison statistics (Pearson correlation coefficient, T-test and ANOVA).

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Results

Table 2: Values of the anthropometric and physiological variables samples in athletics, swimming and triathlon.

VALUES OF THE SAMPLE							
AGE	<12-13	14-16	17-20	AGE	<12-13	14-16	17-20
	$\bar{x}$ +- ds				$\bar{x}$ +- ds		
ATHLETICS							
MALES				FEMALES			
VO2max/Kg/min	62,7+-7,12	58,38+-8,34	58,25+-6,76	VO2max/Kg/min	47,77+-8,12	46,48+-6,89	48,98+-7,34
VO2 umb/kg/min	52,96+-4,91	50,52+-4,18	52+-3,39	VO2 umb/kg/min	44,02+-6,82	43,53+-4,90	44,78+-2,64
VO2 VT1	43,76+-3,09	39,71+-4,29	39,59+-5,28	VO2 VT1	34,15+-6,09	33,43+-7,26	34,95+-7,26
Fat Mass	4,17+-6,78	5,77+-4,68	6,67+-7,59	Fat Mass	7,16+-6,62	9,17+-5,81	8,83+-4,82
Fat Mass %	10,25+-7,72	10,05+-4,72	10,85+-3,62	Fat Mass %	15,8+-3,72	17,37+-2,37	17,35+-4,72
SWIMMING							
MALES				FEMALES			
VO2max/Kg/min	56,44+-6,89	55,22+-7,46	52,73+-6,12	VO2max/Kg/min	46,71+-6,81	49,61+-8,19	37,57+-6,57
VO2 umb/kg/min	48,75+-5,18	48,63+-7,91	47,23+-3,82	VO2 umb/kg/min	41,36+-2,29	43,63+-3,12	34+-2,06
VO2 VT1	37,64+-3,71	37,67+-4,82	37,85+-4,27	VO2 VT1	31,73+-4,28	34,49+-5,29	29,45+-5,07
Fat Mass	5,05+-8,56	6,96+-7,89	8,41+-7,71	Fat Mass	9,2+-3,71	11,44+-3,52	11,31+-4,89
Fat Mass %	10,02+-6,61	10,76+-5,71	10,94+-8,72	Fat Mass %	17,73+-5,82	19,42+-4,71	17,93+-6,81
TRIATHLON							
MALES				FEMALES			
VO2max/Kg/min	60,34+-7,89	58,03+-6,24	57,82+-7,12	VO2max/Kg/min	50,33+-7,91	46,37+-6,13	47,76+-7,29
VO2 umb/kg/min	53,27+-6,15	51,06+-7,35	51,2+-5,89	VO2 umb/kg/min	44,84+-5,89	40,28+-8,21	41,54+-9,12
VO2 VT1	43,29+-4,91	38,88+-4,09	39,44+-4,91	VO2 VT1	34,26+-7,91	32,69+-5,91	33,58+-5,16
Fat Mass	5,62+-5,89	6,91+-4,81	7,72+-3,17	Fat Mass	8,42+-5,89	11,38+-7,89	10,18+-3,45
Fat Mass %	11,56+-5,61	11,42+-7,89	11,26+-4,51	Fat Mass %	17,1+-4,62	19,57+-5,61	18,85+-4,71

In table 1, it is possible to observe the studied physiological variables, and the general anthropometric variable of the fat mass and its % regarding the total mass, finding significant differences ($p<0,01$), with an "r" that is very close to 1, according to Pearson correlation coefficient, as well as in the sex category ($p<0,05$), when the T-Test was conducted.

Table 3: Pearson Correlation Coefficient of the anthropometric and physiological variables

Pearson Correlation Coefficient	VO2max/Kg/min	VO2 umb/kg/min	VO2 VT1	Fat Mass	Fat Mass %
VO2max/Kg/min		0,832**	0,759**	0,841**	0,874**
VO2 umb/kg/min	0,832**		0,743**	0,812**	0,746**
VO2 VT1	0,759**	0,743**		0,835**	0,873**
Fat Mass	0,841**	0,812**	0,835**		0,917**
Fat Mass %	0,874**	0,746**	0,873**	0,919**	

A very important issue is seeing which anthropometric variables form the fat mass, as these can have an impact on the physiological variables. That is why, we calculated the median and standard deviations for each skinfold and their % regarding the total fat mass. The results were the following:

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Table 4: Values of the anthropometric variables samples in athletics, swimming and triathlon.

VALUES OF THE SAMPLE							
AGE	<12-13	14-16	17-20	AGE	<12-13	14-16	17-20
	$\bar{x}$ +- ds				$\bar{x}$ +- ds		
ATHLETICS							
MALES				FEMALES			
Biceps	4,84+-3,15	3,94+-3,72	4,66+-3,71	Biceps	5,75+-4,31	6,3+-5,02	5,93+-3,29
Triceps	9,25+-3,74	7,43+-2,89	8,68+-4,62	Triceps	10,77+-4,07	12,03+-3,08	12,15+-2,10
Subscapular	5,82+-5,61	6,72+-2,01	8,01+-2,81	Subscapular	7,45+-6,18	9,33+-3,89	8,97+-3,19
Ileocrestal	5,44+-3,89	5,92+-3,19	6,3+-3,82	Ileocrestal	7,51+-4,98	9,2+-2,78	10,11+-3,01
Abdominal	7,71+-4,71	8,24+-4,04	10+-1,72	Abdominal	11,35+-5,01	13,88+-5,72	13,12+-3,01
Thigh	12,63+-2,18	10,22+-3,67	12,24+-4,82	Thigh	16,62+-3,71	18,42+-5,23	19,21+-3,19
Leg	14,48+-3,10	7,29+-3,40	8+-5,72	Leg	10,62+-5,08	11,72+-4,72	12+-3,92
SWIMMING							
MALES				FEMALES			
Biceps	4,95+-3,71	4,81+-4,01	4,98+-4,82	Biceps	7,12+-4,98	8,48+-3,01	13,48+-3,81
Triceps	8,29+-4,61	8,32+-4,82	7,4+-5,82	Triceps	12,44+-4,89	13,54+-4,81	16,43+-2,01
Subscapular	5,89+-3,83	7,84+-3,27	8,1+-4,89	Subscapular	9,06+-3,09	11,12+-4,39	9,34+-6,08
Ileocrestal	5,85+-4,70	6,84+-4,72	8,02+-6,87	Ileocrestal	9,77+-3,92	11,9+-3,33	8,5+-3,07
Abdominal	7,68+-3,80	9,57+-4,09	10,1+-2,13	Abdominal	14,25+-3,01	17,5+-3,82	12,75+-3,07
Thigh	12,48+-3,63	12,05+-2,89	10,54+-3,08	Thigh	19,99+-2,01	21,5+2,12	20,7+-3,01
Leg	8,63+-3,82	9,55+-1,98	8,52+-1,92	Leg	12,64+-4,78	14,81+-3,72	14,88+-3,78
TRIATHLON							
MALES				FEMALES			
Biceps	6,41+-2,99	4,94+-3,71	4,53+-4,56	Biceps	7+-2,91	7,44+-3,10	8,57+-3,38
Triceps	11,08+-2,07	9,05+-2,09	8,64+-1,72	Triceps	12,26+-4,29	14,3+-4,24	13,1+-5,12
Subscapular	7,43+-3,92	8,03+-3,27	8,74+-4,91	Subscapular	8,25+-3,19	11,4+-3,15	12,92+-5,28
Ileocrestal	7,74+-3,06	8,13+-3,28	7,47+-3,28	Ileocrestal	9,26+-3,13	11,44+-2,10	14,57+-4,29
Abdominal	11,5+-3,24	11,63+-4,01	10,98+-3,78	Abdominal	13,44+-4,83	17,65+-3,08	19,9+-4,19
Thigh	14,2+-4,43	12,59+-3,83	10,39+-4,73	Thigh	17,56+-3,87	22,4+-3,16	16,75+-4,92
Leg	11,+-3,33	9,45+-2,20	7,47+-2,63	Leg	11,37+-2,20	15,95+-4,27	12,37+-3,39

Table 5: Values of the anthropometric variables samples in athletics, swimming and triathlon.

VALUES OF THE SAMPLE							
AGE	<12-13	14-16	17-20	AGE	<12-13	14-16	17-20
	$\bar{x}$ +- ds				$\bar{x}$ +- ds		
ATHLETICS							
MALES				FEMALES			
Biceps %	8,04+-4,29	7,92+-4,29	8,05+-2,10	Biceps %	8,21+-4,29	7,79+-4,27	7,28+-3,56
Triceps %	15,37+-3,18	14,93+-2,14	14,99+-4,18	Triceps %	15,37+-3,49	14,87+-5,25	14,91+-3,56
Subscapular %	9,67+-4,91	13,5+-3,10	13,84+-3,90	Subscapular %	10,63+-4,18	11,54+-3,29	11,01+-3,65
Ileocrestal %	9,04+-4,10	11,9+-3,20	10,88+-3,28	Ileocrestal %	10,72+-5,82	11,37+-5,73	12,41+-4,85
Abdominal %	12,81+-3,18	16,56+-4,81	17,27+-3,49	Abdominal %	16,2+-3,39	17,16+-3,84	16,1+-3,94
Thigh %	20,99+-3,19	20,54+-2,08	21,14+-3,48	Thigh %	23,72+-4,27	22,77+-5,73	23,57+-4,04
Leg %	24,07+-5,13	14,65+-4,19	13,82+-4,28	Leg %	15,16+-5,37	14,49+-4,15	14,73+-5,98
SWIMMING							
MALES				FEMALES			
Biceps %	9,21+-4,27	8,16+-3,98	8,64+-2,08	Biceps %	8,35+-3,84	8,58+-2,38	14,02+-3,89
Triceps %	15,42+-4,28	14,11+-2,31	12,83+-5,19	Triceps %	14,59+-5,33	13,69+-3,61	17,08+-3,73
Subscapular %	10,95+-3,01	13,29+-2,19	14,05+-3,19	Subscapular %	10,63+-3,19	11,25+-5,58	9,71+-4,29
Ileocrestal %	10,88+-3,09	11,6+-4,01	13,91+-3,89	Ileocrestal %	11,46+-4,20	12,07+-6,55	8,91+-2,78
Abdominal %	14,28+-2,29	16,23+-4,82	17,52+-3,18	Abdominal %	16,71+-4,27	17,7+-3,71	13,26+-4,19
Thigh %	23,21+-3,18	20,43+-3,09	18,28+-2,38	Thigh %	23,44+-3,18	21,74+-4,19	21,53+-4,18
Leg %	16,05+-3,03	16,19+-3,10	14,78+-2,39	Leg %	14,82+-4,49	14,98+-4,09	15,47+-4,10
TRIATHLON							
MALES				FEMALES			
Biceps %	9,2+-3,08	7,74+-4,39	7,78+-3,49	Biceps %	8,85+-3,20	7,39+-2,46	8,73+-3,98
Triceps %	15,91+-3,49	14,18+-3,20	14,84+-5,38	Triceps %	15,49+-2,93	14,25+-3,45	13,34+-3,85
Subscapular %	10,67+-2,84	12,58+-2,49	15,01+-4,34	Subscapular %	10,42+-3,28	11,33+-4,93	13,16+-4,29
Ileocrestal %	11,11+-4,29	12,74+-3,59	12,83+-3,22	Ileocrestal %	11,7+-4,28	11,37+-6,38	14,84+-3,20
Abdominal %	16,51+-3,59	18,22+-4,93	18,86+-3,54	Abdominal %	16,98+-2,84	17,54+-4,28	20,27+-2,34
Thigh %	20,38+-4,23	19,73+-3,09	17,85+-3,20	Thigh %	22,19+-3,49	22,26+-4,92	17,06+-3,29
Leg %	[illegible]	[illegible]	[illegible]	Leg %	[illegible]	[illegible]	[illegible]

By conducting a comparison analysis, it was possible to find significant differences (p<0,01) between the skinfolds and the VO2max/Kg/min and the VO2umb/Kg/min, and the VT1, expressed both with absolute values and with its % regarding the total, in terms of the

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Pearson coefficient, having the abdominal, iliocrestal, subscapular, biceps, thigh, leg and triceps a higher to lower correlation. Likewise, it was possible to find a negative correlation between the total fat mass and its % regarding the physiological variables. When conducting a T-Test in the sex category between the skinfolds and the VO2max and the VT2 and the VT1, expressed both with absolute values and also with its % regarding the total, it was possible to find significant differences ($p<0,05$). We could also verify that there is a statistically inverse relation in the formulas for the regionalisation of the adipose mass, with the maximal oxygen consumption (VO2max) and the ventilatory thresholds (Σ trunk folds, Σ abdominal folds, TS/TI quotient, phantom (Ph) of the folds), being it impossible to find statistically inverse relations among the IMC. There is a higher significant inverse relation in Σ abdominal folds (specially due to the fold in the abdomen) than in the Σ trunk folds. The phantom (Ph) of the skinfolds matches with the skinfolds without the Phantom (Ph), having the abdominal, iliocrestal, subscapular, biceps, thigh, leg and triceps a lower to higher correlation.

Finally, by conducting an Anova with Tukey's HSD multiple correlations, both by age groups and sports specialty, the results were the following:

In the anthropometric and physiological variables, in each sports specialty, for all the values expressed in VO2max/Kg/min, VO2umb/Kg/min, VO2 VT1, and Fat Mass and Fat Mass %, significant differences ($p<0,05$) were found between athletics and triathlon, and triathlon and swimming, but it was not possible to find significant differences ($p>0,05$) between athletics and swimming.

Table 6: Tukey's HSD multiple comparisons by sports specialty of the anthropometric and physiological variables

Multiple correlations											
Tukey´s HSD											
	Sports Speciality		Sig.		Sports Speciality		Sig.		Sports Speciality		Sig.
VO2max/Kg/min	Athletics	Swimming	0,751	VO2 umb/kg/min	Athletics	Swimming	0,5	VO2 VT1	Athletics	Swimming	0,61
		Triathlon	0,003*			Triathlon	0,0035*			Triathlon	0,001*
	Swimming	Athletics	0,751		Swimming	Athletics	0,5		Swimming	Athletics	0,61
		Triathlon	0,001*			Triathlon	0,001*			Triathlon	0,000*
	Triathlon	Athletics	0,003*		Triathlon	Athletics	0,0035*		Triathlon	Athletics	0,001*
		Swimming	0,001*			Swimming	0,001*			Swimming	0,000*
Fat Mass	Athletics	Swimming	0,812	Fat Mass %	Athletics	Swimming	0,7				
		Triathlon	0,0045*			Triathlon	0,005*				
	Swimming	Athletics	0,812		Swimming	Athletics	0,7				
		Triathlon	0,001*			Triathlon	0,001*				
	Triathlon	Athletics	0,0045*		Triathlon	Athletics	0,005*				
		Swimming	0,001*			Swimming	0,001*				

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In the same way, both in the anthropometric and physiological variables, in the age groups, for all the values expressed in VO2max/Kg/min, VO2umb/Kg/min, VO2 VT1 and Fat Mass and Fat Mass %, significant differences ($p<0,05$) were found between athletics and triathlon, and triathlon and swimming, however it was not possible to find significant differences ($p>0,05$) between athletics and swimming.

Table 7: Tukey's HSD multiple comparisons by age groups of the anthropometric and physiological variables

Multiple correlations											
HSD de Tukey											
	Age Group		Sig.		Age Group		Sig.		Age Group		Sig.
VO2max/Kg/min	<12-13	14-16	0,005*	VO2 umb/kg/min	<12-13	14-16	0,025*	VO2 VT1	<12-13	14-16	0,020*
		17-20	0,7			17-20	0,5			17-20	0,65
	14-16	<12-13	0,005*		14-16	<12-13	0,025*		14-16	<12-13	0,020*
		17-20	0,001*			17-20	0,004*			17-20	0,001*
	17-20	<12-13	0,7		17-20	<12-13	0,5		17-20	<12-13	0,65
		14-16	0,001*			14-16	0,004*			14-16	0,001*
Fat Mass	<12-13	14-16	0,0035*	Fat Mass %	<12-13	14-16	0,003*				
		17-20	0,9			17-20	0,4				
	14-16	<12-13	0,0035*		14-16	<12-13	0,003*				
		17-20	0,002*			17-20	0,004*				
	17-20	<12-13	0,9		17-20	<12-13	0,4				
		14-16	0,002*			14-16	0,004*				

Given the importance of the muscle mass in the assessment of the VO2max and the fact that it can have an impact on the results due to the relationship between muscle mass and fat mass (Ramos N.J. & Zubeldía G.D., 2003), the muscle mass of the athletes and the percentages were calculated, since the muscle mass is related to the volume of oxygen that is being metabolized and consumed at a muscular level (Torres et al., 2016; Garrido Chamorro et al., 2006). It is thus, the most suitable and the least misleading one (Torres et al., 2016). It is possible to see in the results, how the muscle mass of the athletes progressively increases in each age group, abruptly increasing in the puberty (Kraemer WJ. et al., 2005), due to the biological and hormonal changes (Granell, 2003). The athletes who had a greater total muscle mass and a higher total muscle mass %, and also a lower level of body fat and a lower body fat %, are the ones who had the highest VO2max/Kg/min values.

Table 8: Values of the total muscle mass sample and its percentage in athletics, swimming and triathlon

VALUES OF THE SAMPLE							
MALES				FEMALES			
AGE	<12-13	14-16	17-20	AGE	<12-13	14-16	17-20
	$\bar{x}$ +- ds				$\bar{x}$ +- ds		
	ATHLETICS				*ATHLETICS*		
TOTAL MASS MUSCLE	28,84+-2,68	36,83+-2,72	38,54+-2,16	TOTAL MASS MUSCLE	29,42+-1,97	32,45+-1,61	31,83+-1,39
TOTAL MUSCLE MASS %	71,47+-8,72	64,78+-9,72	62,75+-10,52	TOTAL MUSCLE MASS %	66,21+-11,62	62,49+-10,62	63,24+-9,52
	SWIMMING				*SWIMMING*		
TOTAL MASS MUSCLE	33,91+-2,11	39,33+-2,15	43,94+-1,93	TOTAL MASS MUSCLE	31,75+-1,76	34,15+-2,11	35,8+-2,67
TOTAL MUSCLE MASS %	67,76+-9,61	61,78+-8,51	57,49+-9,81	TOTAL MUSCLE MASS %	62,42+-8,71	58,77+-9,71	59,19+-10,62
	TRIATHLON				*TRIATHLON*		
TOTAL MASS MUSCLE	32,25+-1,23	37,13+-2,32	40,87+-1,45	TOTAL MASS MUSCLE	30,55+-2,34	33,98+-2,37	31,47+-1,56
TOTAL MUSCLE MASS %	67,24+-6,88	62,43+-9,51	60,23+-10,55	TOTAL MUSCLE MASS %	63,66+-8,52	58,91+-7,98	58,68+-8,27

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Discussion

The results show that the total fat mass is inversely related to the oxygen consumption (VO2max) and the ventilatory thresholds, meeting the assertions by Shephard and Astrand (2000). That can be seen in figure 1.

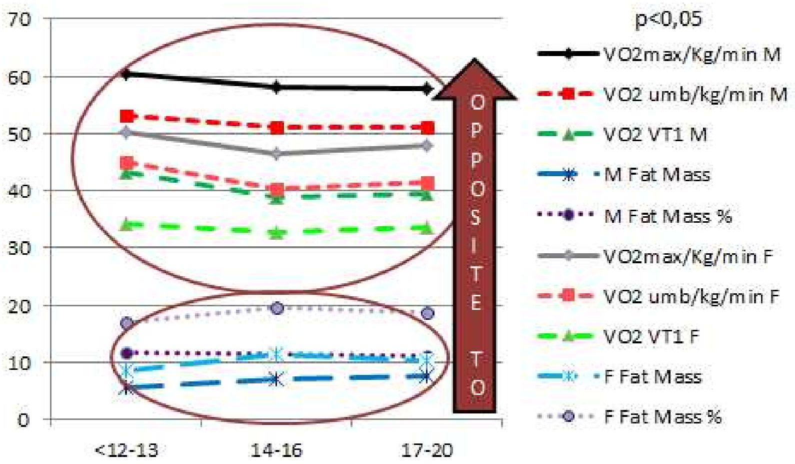

Figure 1: Analysis of triathlon athletes of both sexes according to the anthropometric and physiological variables

Furthermore, the same happens with the fat mass % regarding the total. The physiological variables are by a higher fat mass % regarding the total. This can be noted in the following table:

Table 9: Analysis of athletes regarding the anthropometric and physiological variables

Specialty	Age Group	Sex	Fat Mass	Fat Mass %	VO2max/Kg/min	VO2umb/Kg/min	VO2 VT1
Athletics	<12-13	Males	4,43	9,5	59,55	52,67	43,65
		Females	7,15	15,58	47,57	43,8	34,9
Specialty	Age Group	Sex					
Swimming	14-16	Males	4,1	9,1	60,2	52,9	44,1
		Females	8,1	16,6	46,9	43,5	34,1
Specialty	Age Group	Sex					
Triathlon	17-20	Males	5,1	10,3	58,49	51,56	42,3
		Females	8,65	17,1	46,7	42,9	33,8

Although the results show that there is a negative significant correlation between the adipose tissue and the oxygen consumption (VO2max) and the ventilatory thresholds, it is necessary to state that conducting a study that only takes into account the total value of adipose tissue, detracts its regionalisation from consideration, as it is possible to better express the physiological variables in the individual's morphostructure (Cejuela R., 2009).

When the analysis focuses on the skinfolds as a way to consider the adipose mass, there are skinfolds that have a higher correlation with regard to the adipose mass and the oxygen consumption (VO2max) and ventilatory thresholds. Examples of that are the study by Venkata *et al*., (2004) involving athletes, or the one carried out by López Calbet (1993) involving cyclists. Both of them coincide with our study, in which the abdominal and iliocrestal folds are the ones that affect the physiological variables the most, and that also considers the subscapular fold, as it is seen in figure 2.

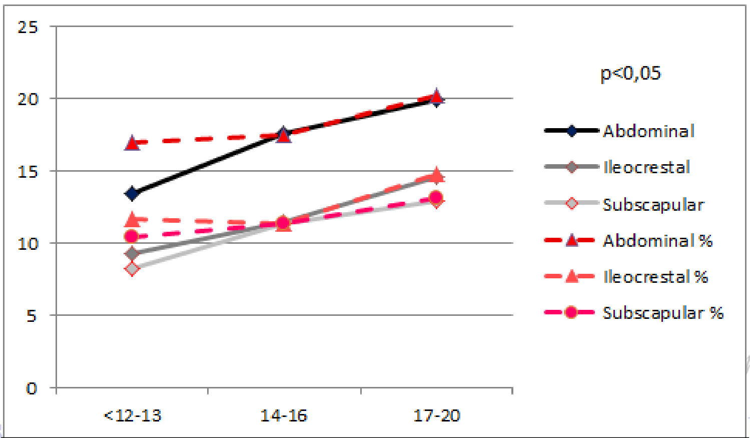

Figure 2: Analysis of female triathlon athletes regarding the anthropometric and physiological variables

What is more, it can also be noted that when the subjects are older, the adiposity increases, thus, there is a higher growth in the 14-16 years old age group, due to the puberty period, especially in women (Granell, 2003; McCarthy, HD. et al, 2003). This increasing adiposity affects the physiological variables (López Chicharro J. & Vaquero, A.F, 2006) like we can see in figure 1, where these variables decrease.

All in all, it is necessary to point out that the proportionality Phantom (Ph) model by Ross and Wilson (1974) presents some difficulties in elite athletes and growing individuals, due to the fact that the normal patterns step away from the average population standards. For this reason, variation proposals regarding the Phantom model have appeared in recent years, like the Combined Method by Lentini (2004) and the Scalable Method (Maestre et al., 2005).

Conclusions

1) The total fat mass and its % regarding the total body weight have a negative impact on the oxygen consumption (VO2max) and on the ventilatory thresholds (VT1 and VT2). The maximal oxygen consumption (VO2max), the ventilatory threshold 1 (VT1) and the ventilatory threshold 2 (VT”), respectively, have a higher negative correlation with the abovementioned.

2) The skinfolds of the regions that form the total body fat, expressed with absolute values and also with their % regarding the total body fat, have a negative impact on the maximal oxygen consumption (VO2max) and on the ventilatory thresholds (VT1 y VT2), having the following skinfolds a higher to lower correlation: abdominal, iliocrestal, subscapular, biceps, thigh, leg and triceps.

3) The regionalisation of the adipose mass has a negative impact on the maximal oxygen consumption (VO2max), and on the ventilatory thresholds (VT1 y VT2), having thus, the Σ abdominal folds a higher negative correlation with the Σ trunk folds. Regarding the phantom (Ph) of the skinfolds, there is a higher to lower correlation among the following skinfolds: abdominal, iliocrestal, subscapular, biceps, thigh, leg and triceps, coinciding with the skinfolds without the phantom (Ph).

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