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The Influence of Sport Practices on Body Composition, Maturation and Maximum Oxygen uptake in children and youth
La influencia de las prácticas deportivas en la composición corporal, la maduración y la absorción máxima de oxígeno en niños y jóvenes

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Abstract: Systematic sport practice at younger ages positively influences body composition and maximum oxygen uptake (VO_{2max}). On the other hand, its influence on maturation is still not consensual, and some studies claim a negative effect. Few studies have approached the differences in this influence according to different sport practices. The present study aims to analyse and compare the influence of karate and swimming practices, and the non-practice of sports, on body composition, VO_{2max} and maturation in children and youth. Data were collected in 126 youth, 54 karate athletes, 36 swimming athletes and 36 participants with no sport practice (M=11.56±2.06 years). The type of sport practice had a different influence on body composition and VO_{2max}, no negative influence was verified on maturation. In general, the sport practices revealed a positive influence in children and youth's body composition. The karate practice provided significant lower body fat mass and higher lean mass in males. Swimming athletes revealed a significant higher VO_{2max} compared to all other groups, while karate didn´t differed from no-practice group. The different influence of sport practices verified highlighted the importance of a multilateral development of children and youth by practising several sports.
Keywords: Lean mass, maturation, VO_{2max}, Karate, Swimming, Non-practitioners.

Resumen: La práctica deportiva sistemática a edades más tempranas influye positivamente en la composición corporal y la absorción máxima de oxígeno (VO_{2max}). Por otro lado, su influencia en la maduración aún no es consensuada, y algunos estudios afirman un efecto negativo. Pocos estudios se han acercado a las diferencias en esta influencia según las distintas prácticas deportivas. El presente estudio tiene como objetivo analizar y comparar la influencia de las prácticas de kárate y natación, y la no práctica de deportes, sobre la composición corporal, el VO2máx y la maduración en niños y jóvenes. Los datos fueron recolectados en 126 jóvenes, 54 atletas de kárate, 36 atletas de natación y 36 participantes sin práctica deportiva (M = 11.56 ± 2.06 años). El tipo de práctica deportiva influyó de manera diferente en la composición corporal y el VO_{2max}, no se verificó influencia negativa en la maduración. En general, las prácticas deportivas revelaron una influencia positiva en la composición corporal de niños y jóvenes. La práctica del karate proporcionó una masa grasa corporal significativamente más baja y una masa magra más alta en los hombres. Los atletas de natación revelaron un VO_{2max} significativamente más alto en comparación con todos los demás grupos, mientras que el karate no difirió del grupo sin práctica. La diferente influencia de las prácticas deportivas verificada resaltó la importancia de un desarrollo multilateral de la niñez y la juventud a través de la práctica de varios deportes.
Palabras clave: Masa magra, maduración, VO2max, Karate, Natación, No practicantes.

Introduction

Systematic sport practice at an early age may be an additional factor that influences body composition and proportions (Malina & Geithner, 2011). Generally, young athletes have lower levels of fat, including smallest skinfolds, lower body index mass and lower percentage of body fat mass (Rodrigues-Ferreira, VencesBrito, Mendes, Fernandes, & Fernando, 2015; Strong et al., 2005). Some studies claim that this influence depends on the type of sport practice (Bala & Drid, 2010; Malina & Geithner, 2011). For example, in the past, elite female gymnastics have consistently revealed a smaller height and leaner body composition, compared to no practice population and other sports' athletes (Baxter-Jones & Helms, 1996; Benardot & Czerwinski, 1991).

In sport context, especially in competition, the evaluation of biological maturation and growth is essential for selection, talent identification and even to adjust the training and planning. The effects of biological maturation are broadly studied in sports teams, being

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that, within identical chronological ages, the young athletes that are more matured reveal better strength, power and speed (Detanico, Kons, Fukuda, & Teixeira, 2020; Figueiredo, Gonçalves, Coelho E Silva, & Malina, 2009). Some previous studies reported a bigger maturation in young athletes compared to individuals with the same age but without sport practice (Baxter-Jones & Helms, 1996). However, until know the role of the sport practice's influence in maturation is still not clear, being suggested that these differences could result from sports selection (Damsgaard, Bencke, Matthiesen, Petersen, & Müller, 2001).

The physiological response to effort in young athletes, namely the increase in the maximum oxygen uptake (VO_{2max}), is influenced by several factors as genetic endowment, developmental rate, body composition, age or gender (Armstrong & Welsman, 2019; Faludi, Farkas, Zsidegh, Petrekanits, & Pavlik, 1999). The sport practice also influences this response and adaptation, different intensities and stimulus, during different developmental phases, conducts to different outcomes and adaptations (Eliakim et al., 2019; Malik, Williams, Weston, & Barker, 2019; Martínez-Pérez & Vaquero-Cristóbal, 2020).

Despite of the abundant information regarding body composition, maturation and oxygen uptake in young athletes, the influence of different sport practices on these variables is still not clear. There are very few studies that compare it between two or more sports practices (Malina & Geithner, 2011) and, according to our knowledge, no study so far had performed this comparison including a combat sports' group. Considering that a deeper understanding of this influence according to the type of sport, could be a valuable information to aid coaches to adjust and plan better their intervention. The present study aimed to analyse and compare the influence of different sport practices, karate and swimming, and the non-practice sport on body composition, maturation and VO_{2max} in children and youth.

Material and Method

Study Design and Sample

The present study consisted of a cross-sectional study with one moment of observation in three distinct groups, karate practitioners, swimming practitioners and a third group of participants who did not practice any sports activities. This last group was defined as the control group, as it did not benefit from any sports practice intervention.

The sample was composed by 126 youth, 60 girls and 66 boys, divided by 54 karate practitioners (20 girls, 34 boys), 36 swimming practitioners (20 girls, 16 boys) and 36 participants with no sport practice (20 girls, 16 boys), with a mean of 11.56±2.06 years, the descriptive statistic are presented in table 1 according to gender and group. The sample was recruited in karate and swimming clubs and associations affiliated to their corresponding National Federations, and the control group was recruited in schools, all from the central region of Portugal.

Table 1
Sample characterization by group and gender

	Karate			Swimming			No-practice		
	M±SD	Min	Max	M±SD	Min	Max	M±SD	Min	Max
Girls	11.8±2.55	7	16	11.95±1.96	9	16	12±1.92	9	15
Boys	11.74±2.5	8	15	10.75±1	9	13	10.7±.95	9	12

Before data collection, the study was explained to parents and children. The informed consent was elaborated according to the ethics principles for research with children (Winter & Cobb, 2008) and applied to the parents. The assent of children was always considered. The study was conducted according to the Helsinki Declaration, and it was approved by the Ethics Committee of the Research Unit of the Polytechnic Institute of Santarém.

Procedures and Protocol

The data collection was performed at the Research Laboratory in Sport Sciences School of Rio Maior. The anthropometric data was collected according to the International Society for the Advancement of Kinanthropometry (ISAK) protocol (Slater, Woolford, & Marfell-Jones, 2013; Stewart, Marfell-Jones, Olds, & Ridder, 2011), by level II certified anthropometrists. The anthropometric measurements collected were: height, weight, bicipital skinfold (BIC), tricipital skinfold (TRI), subscapular skinfold (SBS) and iliac crest skinfold (SIL). It was used a Tanita BC558 (Japan), a Seca stadiometer (Germany) and a Slim guide adipometer (Canada). The collections were performed in a calm and reserved space in the presence of children's parents or coaches.

The biological maturation was assessed through self-rating by asking children to indicate their own stage of development according to the secondary characteristic of pubic hairiness (Baxter-Jones, Eisenmann, & Sherar, 2005). To facilitate the children's understanding of the request and to ensure the feasibility of responses, the self-rating has performed with the help of their parents or coaches, and with the support of schematic illustrations with brief descriptive criteria (Branco et al., 2019; VencesBrito et al., 2019). The years of competition practice were asked to children with their parents and coaches help.

To evaluate the maximum oxygen uptake, VO_{2max}, it was applied the modified Balke test, an incremental treadmill protocol, until the participant's exhaustion assessed by volitional fatigue or until the maximum criterion was achieved (Eliakim et al., 2019; VencesBrito et al., 2019). It was used a Technogym Runrace Treadmill HC1200 (Italy), and a COSMED $K4b^2$ portable metabolic measurement system (Italy).

Data and Statistical Treatment

The anthropometric data were treated to obtain the body mass index (BMI). The percentage of body fat mass (%BFM) was calculated according to the Lohman's equations (Lohman, Roche, & Martorell, 1988). The percentage of lean mass (%LM) was then calculated by subtracting the %MG from the individual's total weight. It was performed the transformation of the BFM and LM percentages into kilograms. For the analysis of the maximum oxygen consumption (VO_{2max}) it was used the relative values, which was calculated by dividing the value of VO_{2max} by the body weight.

The sample's normality was tested for all the variables according to the groups under study, due to the groups' sample size it was applied the Shapiro-wilk test. Normal distribution was only found in heigh for all groups in analysis, for this reason it was applied nonparametric tests. To verify possible differences between genders it was applied the *U* Mann-Whitney test. To verify differences between the several groups of sport practices it was applied the Kruskal-Wallis test, followed by *U* Mann-Whitney test to access the differences in sport practices pairs. For all tests it was calculated the effect size (Tomczak & Tomczak, 2014). To verify possible associations between the variable under study it was applied the Spearman correlation test. The data treatment was performed with the Statistical Package for Social Sciences, version 26 (SPSS Inc, USA), and the significance level was $p<0.05$.

Results

Descriptive and comparative data

It was found significant differences between gender for height (U=1563, z=2.04, p=0.042, r=0.18), body weight (U=1416, z=2.76, p=0.006, r=0.245), body mass index (U=1438.5, z=2.65 , p=0.008, r=0.24), bicipital skinfold (U=1493.5, z=2.38, p=0.017, r=0.21), tricipital skinfold (U=1364.5, z=3.01, p=0.003, r=0.27), subscapular skinfold (U=1470.5, z=2.5, p=0.013, r=0.22), iliac crest skinfold (U=1501.5, z=2.34, p=0.019, r=0.21), percentage of body fat mass (U=1387, z=2.9, p=0.004, r=0.26), percentage of lean mass (U=1387, z=2.9, p=0.004, r=0.26), body fat in kilograms mass (U=1279, z=3.43, p=0.001, r=0.301), and lean mass in kilograms (U=1469, z=2.47, p=0.013, r=0.222). Due to this reason, for these variables, the subsequent statistical treatment was carried out with gender division.

In table 2, are shown the statistical data for comparisons between groups. For girls, it was found significant differences between group in weight ($H(2)$= 7.18, p=0.028), body mass index ($H(2)$=13.16, p=0.001), bicipital skinfold ($H(2)$=27.91, p<0.001), tricipital skinfold ($H(2)$=16.66, p<0.001), subscapular ($H(2)$=24.49, p<0.001), iliac crest skinfold ($H(2)$=26.57, p<0.001), percentage of body fat mass ($H(2)$=24.65, p<0.001), percentage of lean mass ($H(2)$=24.65, p<0.001), and body fat in kilograms mass ($H(2)$=16.92, p<0.001); and for boys, in bicipital skinfold ($H(2)$=21.71, p<0.001), tricipital skinfold ($H(2)$=10.59, p=0.005), subscapular skinfold ($H(2)$=6.52, p=0.038), percentage of body fat mass ($H(2)$=19.4, p<0.001), percentage of lean mass ($H(2)$=19.4, p<0.001), and body fat in kilograms mass ($H(2)$=6.78, p=0.034).

Table 2
Anthropometric characterization and comparation between groups by gender

Gender/Group		Height (cm)	Weight (kg)	IMC (kg/m^2)	BIC (mm)	TRI (mm)	SBS (mm)
Girls	N	154.45±11.24	57.09±16.43	23.68±5.11	12.15±5.54	18.25±5.84	17.75±7.67
	K	151.1±13.09	43.98±13.68	18.83±3.38	4.81±1.57	11.94±4.23	8.04±4.08
	S	154.59±14.88	46.86±13.55	19.15±2.56	6.1±2.59	11.2±3.64	7.9±3.54
	Sig	p=0.762	p=0.028*¥	p=0.001*¥	p<0.0001*¥	p<0.0001*¥	p<0.0001*¥
	E_R^2	NA	0.122	0.223	0.473	0.282	0.415
Boys	N	146.93±7.44	39.64±8.05	18.24±2.84	7.5±4.32	13.75±6.4	10.13±6.05
	K	150.07±16.56	42.57±14.63	18.28±2.98	4.4±2.59	9.26±4.3	6.93±3.62
	S	148.09±7.76	41.33±8.92	18.64±2.53	7.5±2.66	12.31±4.42	9.25±4.92
	Sig	p=0.863	p=0.916	p=0.809	p<0.0001*#	p=0.005*#	p=0.038*#
	E_R^2	NA	NA	NA	0.334	0.163	0.100

Gender/Group		SIL (mm)	%BFM	%LM	BFM (kg)	LM (kg)
Girls	NP	20.5±7.89	23.66±3.95	76.34±3.95	13.68±5.03	43.41±12.05
	K	7.79±4.13	16.82±4.11	83.18±4.11	7.89±4.07	36.27±10.14
	S	9.15±5.29	16.8±3.81	83.2±3.81	8.05±3.36	38.81±10.84
	Sig	p<0.0001*¥	p<0.0001*¥	p<0.0001*¥	p<0.0001*¥	p=0.160
	E_R^2	0.450	0.418	0.418	0.287	NA
Boys	NP	10.19±6.24	19.67±5.96	80.33±5.96	8.10±3.79	21.54±5.22
	K	7.85±4.98	13.74±4.37	86.26±4.37	6.04±3.03	36.61±12.48
	S	10.44±5.77	19.01±4.15	80.99±4.15	8.10±3.21	33.22±6.09
	Sig	p=0.142	p<0.0001*#	p<0.0001*#	p=0.034#	p=0.587
	E_R^2	NA	0.298	0.298	0.104	NA

Notes: NP - no practice; K - karate; S - swimming; E_R^2- effect size; NA - not applicable; *- significant differences between no-practice and karate groups; ¥- significant differences between no-practice and swimming groups; #- significant differences between karate and swimming groups.

Girls without sport practice differed from karate and swimming girls, having more weight (respectively U=126, z=2, p=0.045, r=0.258; U=108, z=2.49, p=0.013, r=0.321), higher body mass index (U=90,

$z=2.97$, $p<0.001$, $r=0.384$; $U=81$, $z=3.22$, $p=0.001$, $r=0.416$), bigger bicipital skinfold ($U=59$, $z=3.83$, $p<0.001$, $r=.494$; $U=17.5$, $z=4.96$, $p<0.001$, $r=0.640$), tricipital skinfold ($U=63.5$, $z=3.7$, $p<0.001$, $r=.478$; $U=77.5$, $z=3.32$, $p<0.001$, $r=0.428$), subscapular skinfold ($U=42$, $z=4.28$, $p<0.001$, $r=0.553$; $U=43$, $z=4.25$, $p<0.001$, $r=0.549$) and iliac crest skinfold ($U=47$, $z=4.15$, $p<0.001$, $r=0.536$; $U=28$, $z=4.66$, $p<0.001$, $r=0.601$), higher percentage of body fat mass ($U=36.5$, $z=4.43$, $p<0.001$, $r=.571$; $U=47$, $z=4.14$, $p<0.001$, $r=0.534$), lower percentage of lean mass ($U=36.5$, $z=4.43$, $p<0.001$, $r=.571$; $U=47$, $z=4.14$, $p<0.001$, $r=0.534$), and higher body fat mass in kilograms ($U=68$, $z=3.57$, $p<0.001$, $r=0.461$; $U=70$, $z=3.52$, $p<0.001$, $r=0.454$) as shown in figures 1 and 2.

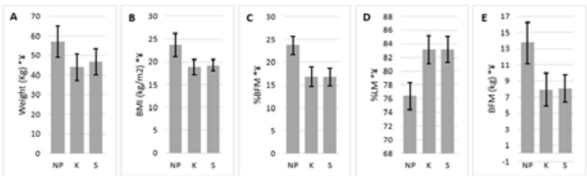

Figure 1. Girls' weight (A), body index mass (B), percentage of body mass fat (C), percentage of lean mass (D), body fat mass in kilograms (D) and lean mass in kilograms according groups (E) (NP- no-practice, K- karate, S- swimming, *- significant differences between NP and K, ¥- significant differences between NP and S).

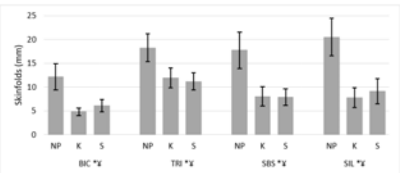

Figure 2. Graphic of girls' skinfolds according to group (NP- no-practice, K- karate, S- swimming, BIC- bicipital, TRI- tricipital, SBS- subscapular, SIL- iliac crest skinfold, *- significant differences between NP and K, ¥- significant differences between NP and S).

Boys without sport practice didn´t differed from swimming boys, but as shown in figures 3 and 4, they revealed higher bicipital skinfold ($U=103$, $z=3.55$, $p<0.001$, $r=0.437$), tricipital skinfold ($U=140$, $z=2.75$, $p=0.006$, $r=0.339$) and subscapular skinfold ($U=169.5$, $z=2.14$, $p=0.032$, $r=0.264$), higher percentage of body fat mass ($U=110$, $z=3.37$, $p=0.001$, $r=0.415$) and lower percentage of lean mass ($U=110$, $z=3.37$, $p=0.001$, $r=0.415$) than karate boys.

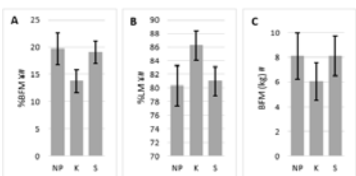

Figure 3.Graphic of boys' percentage of body mass fat (A) and percentage of lean mass (B) according groups (NP- no-practice, K- karate, S- swimming, ¥- significant differences between NP and S; #- significant differences between K and S).

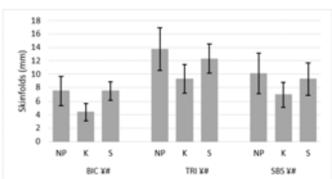

Figure 4. Graphic of boys' skinfolds according to group (NP- no-practice, K- karate, S- swimming, BIC- bicipital, TRI- tricipital, SBS- subscapular, ¥- significant differences between NP and S; #- significant differences between K and S).

There are no differences between karate and swimming female athletes, while in boys, the karate athletes revealed lower bicipital skinfold ($U=82$, $z=3.97$, $p<0.001$, $r=0.489$), tricipital skinfold ($U=152$, $z=2.50$, $p=0.012$, $r=0.308$) and subscapular skinfold ($U=177$, $z=1.98$, $p=0.047$, $r=0.244$), lower percentage of body fat mass ($U=91$, $z=1.71$, $p<0.001$, $r=0.463$), higher percentage of lean mass ($U=91$, $z=1.71$, $p<0.001$, $r=0.463$), and higher body fat mass in kilograms ($U=162$, $z=2.29$, $p=0.022$, $r=0.282$).

There were no differences between genders in age, biological maturation (Tanner's stage), VO_{2max}, and years of competition practice. Subsequently, to compare these variables between groups no gender division was performed. As shown in table 3, it was verified differences between groups for Tanner ($H(2)=6.72$, $p=0.035$), VO_{2max} ($H(2)= 12.31$, $p=0.002$), VO_{2max} ($H(2)= 35.89$, $p<0.001$) and years of competition practice ($H(2)= 76.72$, $p=0.035$), no difference was found in age, see table 3.

Table 3

Comparation of age, Tanner, VO_{2max} and years of competition practice between groups

Group	Age	Tanner	VO_{2max} (L/min)	VO_{2max} (mL/kg/min)	Years Competition
Karate	11.76±2.49	3.02±1.49	1960.94±735.73	46.46±8.8	2.09±2.26
Swimming	11.42±1.70	2.39±1.32	2561.45±738.96	58.28±6.24	2.81±1.06
No-practice	11.42±1.68	2.39±1.32	2311.47±853.67	46.97±8.15	0
Sig	$p=0.559$	$p=0.035$*#	$p=0.002$#	$p<0.001$¥#	$p=0.001$*¥#
E_R^2	NA	0.054	0.109	0.312	0.054

*- significant differences between no-practice and karate groups; ¥- significant differences between no-practice and swimming groups; #- significant differences between karate and swimming groups

Participants without sport practice revealed lower biological maturation than karate athletes ($U=718$, $z=2.15$, $p=0.032$, $r=0.191$), lower VO_{2max} than swimming athletes ($U=140$, $z=5.15$, $p<0.001$, $r=0.482$), and lower years of competition than karate and swimming athletes (respectively $U=324$, $z=6.03$, $p<0.001$, $r=0.537$; $U=0$, $z=7.89$, $p<0.001$, $r=0.703$). Swimming athletes when compared to karate athletes revealed a lower biological maturational ($U=718$, $z=2.15$, $p<0.0032$, $r=0.191$) and higher VO_{2max} and VO_{2max} ($U=378$, $z=3.15$, $p<0.001$, $r=0.329$; $U=200$, $z=5.34$, $p<0.001$, $r=0.500$) and years of competition practice ($U=648$, $z=2.72$, $p=0.007$, $r=0.242$).

Correlation Data

To a greater understanding of the possible influence of sport practice in body composition, it was performed the Spearman correlation to verify the presence of associations between the body composition variables of body fat mass and lean mass in percentage and in kilograms, with the years of competition, by practice group. In karate group, no association was found. In swimming, it was found significant and moderates associations with body fat and lean mass in kilograms with years of competition in (respectively ρ=0.441, p=0.007; ρ=0.687, p<0.001).

Regarding maturation, in the no-practice group, Tanner stage was strongly associated with age (ρ =0.767, p<0.001), moderate associated with height (ρ=0.661, p<0.001) and lean mass in kilograms (ρ=545, p=0.001), and weakly associated with weight (ρ=0.389, p=0.02) and VO_{2max} (ρ=0.398 p=0.016). In karate group the Tanner stage was strongly associated with age (ρ=0.823, p<0.001), height (ρ=0.854, p<0.001) and weight (ρ=0.838, p<0.001); and moderate associated with body mass index (ρ=0.648, p<0.001), subscapular and iliac crest skinfolds (ρ=0.459, p<0.001; r=0.482, p<0.001), body fat and lean mass in kilograms (ρ=0.536, p<0.001; ρ=0.857, p<0.001). At least, in swimming group Tanner stage was strongly associated with age (ρ=0.802, p<0.001), height (ρ=0.844, p<0.001), weight (ρ=0.776, p<0.001) and lean mass in kilograms (ρ=0.789, p<0.001); moderate associated with body mass index (ρ=0.524, p<0.001), iliac crest skinfold (ρ=0.418, p<0.001) and body fat in kilograms (ρ=0.567, p<0.001) and years of competition (ρ=0.696, p<0.001). The statistical data regarding correlations with Tanner stage are presented in table 4.

Table 4
Correlations with tanner stage by groups

Tanner	No-practice		Karate		Swimming	
	ρ	Sig	ρ	Sig	ρ	Sig
Age	0.767	p<0.001	0.823	p<0.001	0.802	p<0.001
Height	0.661	p<0.001	0.854	p<0.001	0.844	p<0.001
Weight	0.386	p=0.02	0.839	p<0.001	0.776	p<0.001
BMI	0.103	ns	0.648	p<0.001	0.524	p=0.001
SBS	-0.069	ns	0.459	p<0.001	0.317	ns
SIL	0.022	ns	0.482	p<0.001	0.418	p<0.001
BFM kg	0.095	ns	0.536	p<0.001	0.567	p<0.001
LM kg	0.545	p=0.001	0.857	p<0.001	0.789	p<0.001
VO_{2max}	0.398	p=0.016	0.008	ns	0.114	ns
Years Competition	na	na	0.078	ns	0.696	p<0.001

Notes: ns- no significant; na- not applicable

Regarding relative maximum oxygen consumption (VO_{2max}), several moderate and weak associations were found between no-practice and karate groups, with bicipital (respectively ρ=-0.509, p=0.00; ρ=-0.468, p=0.001), tricipital (ρ=-0.383, p=0.021; ρ=-0.459, p=0.001), subscapular (ρ=-0.425, p=0.01; ρ=-0,323 p=0.025), and iliac crest skinfolds (ρ=-0.407, p=0.014; ρ=-0.341, p=0.018), and with the percentages of body fat mass (ρ=-0.590, p<0.001; ρ=-0.447, p=0.001), and lean mass (ρ=0.590, p<0.001; ρ=0.447, p=0.001). In no-practice group it was also found weak associations with Tanner (ρ=0.398, p=0.016) and height (ρ=0.331, p=0.049), and a strong association with age (ρ=0.890, p=0.019). In karate it was also verified weak associations with body fat mass in kilograms (ρ=-0.339, p=0.018) and years of competition (ρ=0.291, p=0.0.045). In swimming group, no associations have been found. The statistical data regarding correlations with VO_{2max} are presented in table 5.

Table 5
Correlations with VO_{2rel} by groups

VO_{2max}	No-practice		Karate		Swimming	
	ρ	Sig	ρ	sig	ρ	sig
Tanner	0.398	p=0.016	0.008	ns	0,114	ns
Age	0.890	p=0.019	0.103	ns	0,194	ns
Height	0.331	p=0.049	0.039	ns	0,149	ns
BIC	-0.509	p=0.002	-0.468	p=0.001	-0,115	ns
TRI	-0.383	p=0.021	-0.459	p=0.001	-0,050	ns
SBS	-0.425	p=0.010	-0.323	p=0.025	-0,153	ns
SIL	-0.407	p=0.014	-0.341	p=0.018	-0,040	ns
BFM%	-0.590	p<0.001	-0.447	p=0.001	-0,070	ns
LM%	0.590	p<0.001	0.447	p=0.001	0,070	ns
BFM kg	-0.317	ns	-0.339	p=0.018	0,050	ns
Years Competition	na	na	0.291	p=0.045	0.112	ns

Notes: ns- no significant; na- not applicable

Discussion

Body Composition

The influence of the gender in body composition during growth has been extensively studied. Due to physiological and genetic differences between genders, especially after puberty, girls tended to gain body fat mass while boys increase their lean mass (Malina & Geithner, 2011). In the present study, this gender's differentiation approach by Malina and Geithner (2011) was also verified for the total sample, with girls revealing significantly higher weight, body mass index, bigger bicipital, tricipital, subscapular and iliac crest skinfolds, higher body fat mass in percentage and in kilograms, and lower lean mass in kilograms, compared to boys.

Regarding the differences in body composition between practice, in girls, the no-practice group reported a significant poorer body composition compared to karate and swimming girls, revealing significant higher body mass index, higher values in all skinfolds, higher boy fat mass in percentage and kilograms, and lower percentage of lean mass (figures 1 and 2). Still in the girl's body composition, no significant differences were found between karate and swimming groups. In boys, the same tendency has found between no-practice and karate groups, with karate male athletes revealing better values of body composition with significant smaller bicipital, tricipital and subscapular skinfolds, and lower values of body fat mass in percentage and kilograms, compared to the boys in no-practice and swimming groups (figures 3 and 4). Karate male practitioners also revealed a higher lean mass in kilogram than swimming athletes. Curiously, in boys no difference in body composition variables was found between no-practice and swimming groups. In general, these results corroborates previous studies, reinforcing the positive influence of sports practices in children and youth's body composition (Baxter-Jones & Helms, 1996; Granacher & Borde, 2017; Rodrigues-Ferreira et al., 2015; Strong et al., 2005). In this study, it was also verified that karate and swimming practice had a different impact on boys' body composition, with karate providing better outcomes. Maybe, for being a high intensity intermittent combat sport with a great demand on the anaerobic energy systems (Fandos Soñén, Falcón Miguel, Moreno Azze, & Pradas De La Fuente, 2020) which, consequently, leads to a greater EPOC (excess post-exercise oxygen consumption), karate may promote greater energy expenditure and, in this way, better improvement in body composition compared to swimming. These results reinforce the theory that different sports has different influences in children and youth's body composition (Damsgaard et al., 2001).

Still in relation to the influence of sport practices on body composition it was performed a Spearman correlation of the body composition variables, lean and body fat mass, with the years of competition by sport practice (table 4). Contrary to expectations, in the karate group, the lean and body fat mass weren´t associated with the years of competition. A positive correlation would be expected, reflecting a direct and positive influence in the improvement of body composition with the increase of competition years in karate, as it was verified in swimming. In this last group it was reported moderate correlations between years of competition with body fat mass and lean mass, with a higher value of correlation in lean mass, which suggest that the competition years has a bigger influence in lean mass than in body fat mass. Nonetheless, swimming revealed significantly more years of competition compared to karate (table 3). So, possibly, the absence of correlations in karate group was due to the characteristics of this sub-sample, which includes fewer competition years than swimming. Unfortunately, according to our literature search, the previous studies which investigates the influence of swimming on the practitioners' body composition and/or proportion, did not assess and investigate the roll of years of competition (Baxter-Jones & Helms, 1996; Baxter-Jones, Helms, Baines-Preece, & Preece, 1994; Malina & Geithner, 2011; Rodrigues-Ferreira et al., 2015). Also in karate, no study was found that investigated the influence of its practice on body composition and related it to years of competition. For the reasons, it was not possible to compare the present results with previous literature. In the future, it should be evaluated not only the short- and medium-term effect of the practice of different sports practices on the body composition, but also its long-term effect, namely investigating the role of years of competition

Maturation

During the nineties, several studies reported a negative sports influence on height and maturation in young athletes (Baxter-Jones & Helms, 1996; Baxter-Jones et al., 1994; Benardot & Czerwinski, 1991). In elite female gymnastic, Baxter-Jones et al. (1996) reported a below-average height according to British growth standard charts; while Benadot & Czerwinski (1991) verified that as the gymnastics' age increased, their height percentile decreased. The sports negative effect was also found on delayed entry into puberty, Baxter-Jones et al. (1994) analysed female elite practitioners of swimming, tennis and gymnastic, and verified that all groups presented a delayed menarche (respectively 13.3, 13.2 and 14.3 years), with gymnastics having a greater impact in entering puberty. The lower stature and the delayed puberty could be explained by nutritional deficits (Benardot & Czerwinski, 1991), being that the reduced fat mass delay and condition menarche (Frisch, Wyshak, & Vincent, 1980). It could also result from a lower energy uptake in relation to the intensity and training volume, if the child spends most of its energy training, the rest may not be enough to grow (Benardot & Czerwinski, 1991). For gymnastic practice, another possibility could be based on a preferential retention of shorter gymnasts with lower fat mass. This negative influence even led authors to recommend that athletes should be monitored by a nutritionist to ensure adequate energy and nutrient intake (Benardot & Czerwinski, 1991). A later review about the sports influence in menstrual disorders highlighted that many women acquire their menstrual disorders in athletics, including the latter menarche, by didn´t fulfilled a dietary energy intake in compensation for exercise energy expenditure (Redman & Loucks, 2005).

Nowadays the paradigm has changed, there is a greater general and even governmental concern for the wellbeing, sporting opportunities and simultaneously a healthy growth for all children and youth (e.g., America.; EuropeActive). This new vision is reflected in the present study, contrary to what happened in the past (Baxter-Jones & Helms, 1996; Baxter-Jones et al., 1994; Benardot & Czerwinski, 1991), in this data it wasn´t verified a delay in sports athletes maturation. On the contrary, it was identified a significant greater maturation in karate athletes compared to other groups. It seems that, for these athletes in study, the training process took into consideration the maturation and growth process. Which is corroborated by positive and strong associations between maturation and age, with a slightly higher value in karate and swimming compared to no-practice group. The same occurred for grown, the maturation have a moderate association with height for no-practice group, and strong associations for karate and swimming athletes, proving the absence of a negative sports influence in height. In sports athletes, maturation was also associated with body fat mass in kilograms and several skinfolds. Possibly and, although swimmers are not significantly more mature than no-practice participants, the greater maturity leads to higher fat mass.

Although this study did not verify a maturation delay in sports practice, it's important to denote that any sports practice at an elite level with young athletes imposes a severe physical, mental and emotional stress, and promotes the activation of hypothalamo-pituitary-adrenal axis, which could lead to several disorders, including delayed menarche. Not all sports have the same risk, aesthetic sports such as rhythmic gymnastics are those with greatest risk (Czajkowska et al., 2019).

Regarding to lean mass, it was associate with maturation for all groups in study. The maturation is associated and linked with development, which in turn is linked to the increase in lean mass, so this positive association was expected. This association is moderate in no-practice group, and strong for karate and swimming groups. Probably this strongest association in athletes results from their greater lean mass, being that karate athletes, which revealed a significant bigger lean mass than no-practice and swimming groups, presented the biggest association.

Curiously the VO_{2max} was just associated with maturation for no-practice group, through a weak positive association, the more maturation the higher the $VO_{2max.}$ Possibly, the karate and swimming athletes revealed more higher and constant values of VO_{2max} in all maturation stages, due to their sports practice, which make the association unavailable.

Maturation was positive and moderate associated with years of competition in swimming group, which implies that the greater the swimmers' maturation, the greater their experience in competition. Previous studies suggested that constitutional factors, namely maturation level, are important for the children and youth sports choice (Damsgaard et al., 2001). It's also known that more mature athletes reveal better strength, power and speed (Detanico et al., 2020; Figueiredo et al., 2009). So, we can hypothesize that for being more mature, these athletes could have more success in competition, and, for this reason, they tend to accumulate more years and experience, leading to this association. So, maturation could influence the athletes' affiliation to competition, however more studies will be needed to confirm this hypothesises. On the other hand, the karate athletes didn´t revealed this association, however they had significant lower years of competition than swimmers, so this could be the reason for the inexistence of association.

Maximum oxygen consumption

As in previous studies (Rankoviæ et al., 2010), it was verified differences in the aerobic maximum capacity between different sports practices. In this study the swimming group revealed a significant greater VO_{2max} compared to no-practice and karate groups. Considering that swimming is a predominantly cardiovascular sport which promotes the increase of VO_{2max} even in small and conditioned practitioners (e.g., Beggs et al., 2013 for athletes with asthma; Sánchez-Lastra, Martínez-Lemos, Díaz, Villanueva, & Ayán, 2019 for preschoolers children), this higher VO_{2max} compared to the other groups is a consequence of its specific training. On the other hand, the karate athletes didn´t revealed a higher VO_{2max} than no-practice group. Karate is a predominantly anaerobic sport which emphasizes explosive movements such as punching and kicking during short duration (Hellín Martínez, García Jiménez, & García Pellicer, 2020). So, the aerobic conditioning is not the principal focus of karate, which may explain the inexistence of significant difference. In future studies that included predominantly anaerobic modality an anaerobic test is advised.

Unexpectedly, in swimming group the VO_{2max} didn´t revealed any association with the variables under analysis. By analysing the VO_{2max} associations in the other groups it's possible to denote that they are mostly negative associations with variables related to fat mass, including skinfolds and body fat mass in kilograms and percentage. However, inside water fat mass positively influences buoyancy (Byard, 2017), and the participant's weight is partially supported by the water. Whereas out of water, fat mass negatively influences the participants' fatigue, which must support all his bodyweight while running in the treadmill. In this sense, the fat mass weight has a different impact inside and out of water. So, possibly the inexistence of VO_{2max} associations in swimming group may lie in their specific context of sports practice and in the VO_{2max} collection method. In fact, swimming athletes are familiarised to a different context from the one in which the test was carried out, as it was performed on a treadmill and not in the pool. Ideally the evaluation of swimmers' VO_{2max} should be performed in an ecological and real swimming conditions to allow a more reliable and valid outcomes (Sousa et al., 2014). Perhaps, if the VO_{2max} test of the swimmers had been carried with this ecological way, it would have been possible to verify associations.

The variable of maturation, age and height were associated with VO_{2max} just in no-practice group. Perhaps, the sports athletes had a higher and more constant values of VO_{2max} in all ages, heights and maturation stages, due to their sports practice, which may invalidate the associations.

The lean mass in kilograms was just associated with VO_{2max} for karate athletes, which could result from the fact that the karate athletes, both girls and boys, revealed the biggest values of lean mass, in percentage and kilograms, from all groups. These higher values result from the training, which in turn, in positively related to VO_{2max}. In this sequence, it was also verified that a positive association in years of competition with the VO_{2max} for karate athletes.

Multilateral Development

The different influence of sport practices verified in this and in previous studies highlighted the importance of children and youth to practise different sports during their development. This multilateral development is extremely important during the early development of the athletes (Bompa & Buzzichelli, 2018). If properly implement, the practice of various sports will enable athletes to take advantage of the general benefits of practising sport, such as increasing their motor repertoire, improving their motor skills or developing their emotional and relational skills. But also the specific benefits of each sport, in this case, the significant improvement of aerobic capacity through swimming (Moura, Neiva, Faíl, Morais, & Marinho, 2020; Sánchez-Lastra et al., 2019) and, possibly, the improvement of anaerobic performance through karate (Guillen Pereira, Rojas Valladares, Formoso Mieres, Contreras Velázquez, & Estevez Pichs, 2018; Hellín Martínez et al., 2020).

Limitations and Recommendations

The present study presented two main limitations. The first related to the sample, by using a convenience sample without normal distribution, it was not possible to proceed to the regression models and study the causality of the variables under analysis.

The second limitation was related to the methodology. In future studies the VO_2 test might be applied in the training environment for all groups in order to obtain a more reliable and valid outcomes (Sousa et al., 2014). It also is recommended to collect a bigger and representative sample. As this is a cross-sectional study, there are some limitations to the understanding of adaptations to training.

Conclusions

The present data reinforced a positive influence of sport practices in children and youth's body composition, highlighting a different influence according practices. The karate practice provided significant better outcomes on body composition for males, probably, for being a high intensity intermittent combat sport, the karate practice could lead to a greater EPOC and promote a better improvement in body composition. The swimming practice provide better outcomes on VO_{2max} compared to all other groups, while karate didn´t differed from no-practice group. The cause should lie on training and sport specific typologies, swimming is a sport that focuses on power and aerobic endurance, so its higher VO_{2max} reflects its training.

Contrary to the past, the present results didn´t revealed a negative influence of sport practice on maturation. The training process seems to have into consideration the maturation and the growth process, corroborated by positive and strong associations of maturation with age and height for karate and swimming athletes.

This different influence according to different sports practices highlights the importance of the multilateral development during the early development of children and athletes (Bompa & Buzzichelli, 2018).

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