

Comparative Study of Aerobic Performance Between Football and Judo Groups in Prepubertal Boys

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Abstract

Purpose: The aim of this study was to compare the impact of the practice of football and judo on lung function and aerobic performance of prepubertal boys.

Methods: A total of ninety six prepubertal boys were studied. They assessed a measure of body composition using the skin folds method. They performed lung plethysmography at rest, followed by an incremental exercise test.

Results: There was no significant difference in baseline spirometry between all groups ($P > 0.05$). The maximal oxygen uptake [VO_{2max}] and the VO_2 at the ventilatory threshold [VT] were similar between all groups ($P > 0.05$). The maximal minute ventilation [VE_{max}] of judokas was significantly higher than footballers ($P < 0.01$) and similar at the [VT]. The Heart rate [HR] at [VT] of footballers and judokas was similar and significantly higher than control group ($P < 0.01$). VO_{2max} was significantly related to LM and negatively associated with FM. At the [VT] there was a significant relationship between P[VT] and LM and mainly with VE to VO_2 [VT], P[VT] and HR[VT] in all groups.

Conclusion: Training in football and judo does not affect lung volumes and capacities, VO_{2max} and VO_2 at the [VT].

Key Words: Aerobic Performance; Ventilatory Threshold; Football; Judo; Spirometry; Prepubertal Boys

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INTRODUCTION

There is increasing evidence that physical activity during childhood and adolescence has an important impact on short and long-term health and behavior outcomes [1]. The literature dealing with the effects of increased physical activity on pulmonary morphology and function is equivocal. Cross-sectional or longitudinal studies comparing child athletes with non athletes (or with reference values) indicate slightly greater [2,3] or equal [4,5] lung volumes, capacities, and flow rates. Possible reasons for the lack of association between physical activity and lung function could be

inadequate stimulus, age, growth status, and type of activity [6].

Moreover, the aerobic system in children is usually often used in their activities. Aerobic metabolism participating in total energy intake is higher in children than adults [7]. The assessment and interpretation of peak aerobic fitness in children and adolescents is fraught with problems. Numerous investigations have been conducted in children concerning the effect of training on the cardiorespiratory system [8,9]. The effect of added activity or training on VO_{2max} during growth is well documented and conflicting results exist in prepubertal boys. Several studies have shown that

VO_{2max} does not increase with training before the peak of puberty [10-16]. In contrast, others [17-23] suggest that the VO_{2max} can be increased after a training program with aerobic dominance.

Football and judo are two very different sports. However, they are similar in that they include aerobic and anaerobic components. The amount of aerobic and anaerobic activity varies among these sports [24]. Indeed, judo is an individual sport which is played indoors on a tatami and its training increases equilibrium, coordination, speed, strength, suppleness, skill, endurance and resistance [25]. Thus, competitive judo can be described as a combative, high intensity sport in which the athlete attempts to throw the opponent onto his back or to control him during groundwork combat [26]. On the other hand, football is a team sport that is played in an outdoor field and training is mainly based on movement implementing the endurance qualities consisting of moderate activity alternating with periods of intermittent high intensity, leading to a significant production of metabolic heat [27] and is characterized by short-duration high-speed runs, jumps, headings and ball disputes, besides other activities, such as trots, low-speed running and walks [28].

Previous research on prepubertal children has indicated that lung function parameters of athletes are equal or slightly greater than non athletes. Moreover, it has been indicated that the improvement of the aerobic performance is possible by specific training programs with regard to the number of sessions per week, duration and intensity of work. To the best of our knowledge, there is very limited data available regarding the adaptive response of the lung function parameters and aerobic performance to training in judo and football especially in prepubertal children. However, our study expands past research by comparing the lung function and the aerobic performance between these two different styles of sports. Thus, based upon the results of previous studies, we hypothesized that neither lung size nor lung function appears to be affected by practicing judo or football. The aim of this study was therefore to analyze and compare lung function and aerobic performance of footballers and judokas in prepubescent boys, with reference to a control group.

METHODS AND SUBJECTS

Subjects:

Ninety six pre-pubertal boys (32 footballers, 32 Judokas and 32 healthy sedentary subjects) were enrolled in the study. The tests were in the in-season phase of competition and all subjects were clinically healthy and had no history of recent infection, asthma or cardiorespiratory disorders. The athletic subjects were selected according to the exclusion criteria defined as follows: Subjects not having a good health at the moment of tests, subjects who are non confirmed, and who did not have a regular presence in their training sessions or having been engaged for less than 3 years. On the basis of these criteria 24 subjects from 120 were excluded. Finally, 96 athletes were included in subsequent analysis. Control subjects were randomly recruited from primary schools of the same location of the experimental group and they were engaged in ≤ 2 hours of physical activity per week at school. The football and judo players were enrolled in a training program which consisted of four sessions a week (each session lasting for about 90 minutes) in addition to the weekly games in the official national championship usually held on Sundays. The training of the footballers was outdoors on a synthetic turf for athletic fields and was based specially on the technique aspect, agility, balance, coordination and speed exercises and, in judo, the training was indoors in a well equipped hall and focused on the technique aspect, physical coordination, flexibility, body control, balance and fast reflexive action. All subjects gave their written consent and the study protocol was approved by the local ethics committee. Physical and physiological measurements were done, body composition was estimated with the skinfold method of Durnin and Wormersley [29] and the pubertal status was assessed using Tanner stage [30]. All the children were tanner stage 1 according to genitalia and pubic hair development by a nurse resident in the laboratory and experienced in the use of the technique.

Anthropometric measures:

Height and mass were measured in the laboratory with the child dressed in light clothing. Height was measured to the nearest 1 mm using a fixed stadiometer

(Seca, Hultafors, Sweden) and body mass was measured to the nearest 0.1 kilogram with a standard scale (Avery Berkel model HL 120; Avery Weigh-Tronix Inc., Fairmont, MN, USA). Body mass index (BMI) was calculated as body mass in kilograms divided by height in meters squared (kg/m^2). Skinfolts (mm) were measured at 6 sites: triceps, subscapular, abdominal, suprailiac, thigh and lower leg, using a Harpenden skinfolts caliper (Holtain Ltd, Crosswell, UK). Each individual measurement and the sum of the 6 measurements were used for analysis. The circumferences of the upper arm, thigh, and lower leg were measured (cm), as well as the following 4 diameters (cm): biepicondylar humerus (elbow), biestylod at the wrist, biepicondylar femur (knee), and bimaleolar in the ankle. All the measurements were made following the previous validated tests^[29] (Durnin et Wormersley, 1974). Each skinfold thickness was measured in duplicate on the left side of the body, and the mean value was used for calculation. The errors of measurement were <1 mm, and the reliability was $>95\%$. All the anthropometric measurements of all subjects were taken by the same technician resident in the laboratory.

Spirometric and exercise challenge tests:

Spirometric tests were performed at rest before exercise using a body plethysmograph (SensorMedics V6200 Autobox; SensorMedics Co., California, USA). Forced vital capacity [FVC], total lung capacity [TLC], forced expiratory volume in one second [FEV₁] and

peak expiratory flow [PEF] are the parameters measured. Then, an exercise test was performed in a laboratory in early spring when ambient temperature was approximately 20°C (68°F) and humidity was low (38%), on a cyclo-ergometer (SensorMedics: V_{max} encore 29c; SensorMedics Co., California, USA). Cardiorespiratory variables were determined using a calibrated breath by breath system allowing continuous measurement of heart rate, oxygen uptake and lung ventilation. The ventilatory threshold [VT] was measured automatically.

Each subject performed a continuous and progressive exercise test to exhaustion. During the test, the pedaling rate was kept constant at 60 rpm. After a 3 min warm-up period at a work rate of 30 watts, 10 watt increments were applied every minute until the pedaling rate could no longer be sustained.

Statistical analysis:

Statistica Kernel version 5.5 was used to analyze the data. Descriptive statistics were expressed as mean (+SD) for each variable. Analysis of variance (ANOVA) was carried out to detect the effects of type of sport (football or judo). When significant interactions were detected, post-hoc tests LSD were used to compare the different groups. Pearson correlation coefficient tests were used to assess the strength of relationships between the different variables. Significance was set at an alpha level of 0.05.

Table 1: Physical, anthropometric and lung functions measurements of the three groups

Parameter	Football (n=32) Mean (SD)	Judo (n=32) Mean (SD)	Controls (n=32) Mean (SD)	P. Value
Age (months)	129.88 (9.94)	130.56 (9.62)	130.91 (9.10)	0.9
Weight (Kg)	35.91 (5.46)	38.41 (5.98)	36.97 (5.65)	0.2
Height (m)	1.43 (0.08)	1.44 (0.06)	1.46 (0.07)	0.2
Body Mass Index (Kg/m^2)	17.43 (1.62)	18.40 (2.17)	17.25 (2.05)	0.04
Lean mass (Kg)	11.21 (1.09)	11.45 (1.03)	10.42 (1.25)	0.001
Fat mass (Kg)	10.97 (4.71)	13.21 (5.57)	15.04 (6.39)	0.02
Forced Vital Capacity (l)	2.35 (0.37)	2.44 (0.38)	2.49 (0.33)	0.3
Total Lung Capacity (l)	3.50 (0.57)	3.72 (0.73)	3.66 (0.56)	0.7
FEV1 (l)	2.11 (0.28)	2.17 (0.31)	2.20 (0.29)	0.4
Peak Expiratory Flow (l/s)	4.27 (0.61)	4.37 (0.73)	4.54 (0.78)	0.3

SD: Standard Deviation; FEV1: Forced Expiratory Volume in 1 second

Table 2: Ventilatory threshold and maximal physiological responses of the three groups

Parameter	Football (n=32)	Judo (n=32)	Controls (n=32)	P. Value
	Mean (SD)	Mean (SD)	Mean (SD)	
Power [VT] (W)	44.84 (14.08)	42.84 (12.89)	44.25 (12.95)	0.8
VO ₂ [VT] (l/min/Kg)	28.15 (6.18)	26.21 (8.06)	29.98 (8.25)	0.1
RER [VT]	0.90 (0.08)	0.89 (0.10)	0.83 (0.05)	0.0003
VE [VT] (l/mn)	26.88 (6.54)	26.53 (7.27)	26.72 (7.27)	1
HR [VT] (bpm)	127.53 (11.01)	129.88 (15.66)	138.31 (15.35)	0.007
Power _{max} (W)	114.06 (22.34)	115.22 (24.23)	98.59 (17.67)	0.003
VO _{2max} (l/min/Kg)	53.86 (7.28)	52.45 (7.86)	53.25 (7.48)	0.8
RER _{max}	1.07 (0.12)	1.12 (0.16)	0.99 (0.09)	0.0002
VE _{max} (l/mn)	62.86 (14.38)	74.61 (19.99)	62.92 (11.33)	0.003
HR _{max} bpm	186.55 (8.57)	188.19 (11.70)	187.56 (10.42)	0.2

SD: Standard Deviation; VT: Ventilatory Threshold; VO₂: Oxygen Consumption; RER: Respiratory Exchange Ratio; VE: Minute Ventilation; HR: Heart Rate

RESULTS

Table 1 shows the physical and lung function measurements in the three groups. The lean mass of footballers and judokas was similar and significantly higher than the control group ($P<0.01$). Furthermore, there was a significant difference ($P<0.05$) between the three groups in fat mass, the FM of controls was significantly higher than footballers ($P<0.01$) and similar to judokas whereas the FM of footballers and judokas were similar. The body mass index (BMI) of the judokas was significantly higher ($P<0.05$) than both footballers and the control group who had similar values. There was no difference in lung function parameters between any of the groups.

Table 2 shows the Ventilatory threshold and maximal Physiological responses of the exercise challenge test in the three groups. At the Ventilatory threshold, the RER [VT] of controls was significantly lower than footballers ($P<0.001$) and judokas ($P<0.01$), while the RER [VT] of footballers and judokas were similar. The HR [VT] of the footballers and judokas

was similar and slower than the control group ($P<0.01$ and $P<0.05$) respectively. At the maximal exercise, the P_{max} of footballers and judokas were similar, while the P_{max} of controls was lower than footballers ($P<0.01$) and judokas ($P<0.01$). The RER_{max} of footballers and judokas were similar, while the RER_{max} of controls was significantly lower than footballers ($P<0.01$) and judokas ($P<0.001$). The VE_{max} of the judokas was significantly higher than footballers ($P<0.01$) and controls ($P<0.01$), while the VE_{max} of footballers and controls were similar.

Table 3 shows the correlations between anthropometric variables and lung function parameters. There was a significant relationship between lung function parameters and age, height and weight. All mean values of FEV1, PEF, FVC and TLC are significantly related mainly with height in all 3 groups with the exception of PEF in judo.

Table 4 shows the correlations between anthropometric variables and aerobic performance parameters. VO_{2max} was significantly related to LM and negatively associated with FM. At the [VT] there was a

Table 3: Pearson correlation values (r) between anthropometric variables and lung function parameters

Lung function parameter	Football			Judo			Controls		
	Age	Height	Weight	Age	Height	Weight	Age	Height	Weight
FEV1	0.49*	0.73*	0.71*	0.36*	0.63*	0.49*	0.54*	0.68*	0.26
PEF	0.50*	0.63*	0.39*	0.41*	0.19	0.09	0.30	0.54*	0.30
FVC	0.41*	0.70*	0.75*	0.23	0.64*	0.64*	0.54*	0.75*	0.21
TLC	0.19	0.46*	0.57*	0.31	0.45*	0.17	0.34	0.44*	-0.16

* $P<0.05$; FEV1: Forced Expiratory Volume in 1 second; PEF: Peak Expiratory Flow; FVC: Forced Vital Capacity; TLC: Total Lung Capacity

Table 4: Pearson correlation values (r) between anthropometric variables and aerobic performance parameters

Variable	Football	Judo	Controls
VO ₂ max vs. LM	0.51*	0.38*	0.39*
VO ₂ max vs. FM	-0.36*	-0.36*	-0.53*
Pmax vs. LM	0.11	0.36*	0.62*
VO ₂ [VT] vs. LM	-0.07	-0.30	0.07
P[VT] vs. LM	0.36*	0.13	0.42*
VE[VT] vs. VO ₂ [VT]	0.65*	0.86*	0.75*
VE[VT] vs. P[VT]	0.75*	0.66*	0.60*
VE[VT] vs. HR[VT]	0.42*	0.54*	0.50*

* $P < 0.05$; VO₂: Oxygen Consumption; VE: Minute Ventilation; VT: Ventilatory Threshold; HR: Heart Rate

significant relationship between P[VT] and LM and mainly with VE to VO₂ [VT], P[VT] and HR[VT] in all groups.

DISCUSSION

This study shows that the practice of football and judo had no effect on lung function volumes and capacities at rest in prepubertal boys. There was no effect also on VO_{2max} and VO₂ at ventilatory threshold. The literature shows the existence of very controversial results. The heterogeneity of the type of sport and the training regimens are factors that may explain such discrepancies [19].

In the initial analysis of our results, the control group was found to have significantly greater fat mass and lower lean mass levels than both footballers and judokas. Furthermore, the LM and FM of footballers and judokas were similar. Physical activity is one of fat mass reduction [31]. Thus, the decrease of FM was confirmed by our study in footballers and judokas compared to controls. Scientists observed that aerobic training induced decrease in body weight as a result of reduction in body fat [32-34] and reported that dynamic, aerobic physical loads of moderate intensity had the most effective impact on fat body mass reduction due to an increase in the activity of enzymes of aerobic oxidation. In addition, it was indicated in a comparative study of McIntyre [35] between Gaelic footballers, hurlers and soccer players that the percentage body fat of soccer players was lower than Gaelic footballers because of full time prolonged and

long term levels of exercise in training and duration of matches of soccer players (90 min vs. 70min), which also reduce stored body fat [36,37]. This finding partly confirms our results when the FM of judokas was higher than footballers despite the fact that this difference was not significant. Otherwise, the highest FM of our controls was explained by less physical activity in controls as reported by Triki et al [38] especially as they have registered no significant difference in dietary intake and socioeconomic status among their groups. There was a significant relationship between LM and VO_{2max} in all groups and mainly in footballers ($r=0.51$) where the significance is higher than in judokas ($r=0.38$) and controls ($r=0.39$), whereas, our results shows FM to be negatively associated with VO_{2max} mainly in controls ($r=-0.53$) that are higher than in footballers ($r=-0.36$) and judokas ($r=-0.36$). Similarly, Moreno et al [39] suggest that the practice of football increases LM and decreases FM. In judo, little is known about the prepubertal boys and to the best of our knowledge there is only the study of Bouhleb et al [40] which focused on the relationship between maximal anaerobic power measured by force-velocity test and performances in vertical jump and in 5-jump test in young boys aged 12±04 years. They show a significant correlation between peak power and the body mass ($r=0.80$; $P < 0.001$) and lean mass ($r=0.89$; $P < 0.001$). Therefore, the assessment of LM and FM is related to the level of physical preparation and more precisely by the intensity and the time spent in physical activity. Thus, the greater frequency of training and competition may be responsible for these differences.

The first major finding of the present study is that lung volumes and capacities are not affected by the

practice of football or judo in prepubertal boys; they are similar to the control group. There was a significant relationship between lung function parameters, mainly with height and secondarily with weight and age. This finding was in accordance with the study of Trabelsi et al [41] showing a significant increase of lung function with height in Tunisian children. Moreover, there was no correlation between these parameters and VO_{2max} . In this context, Bassett and Howley [42] have noted that pulmonary function had no association with VO_{2max} . Earlier studies show that young swimmers, *inter alia* the prepubertal children, have been shown to have larger lung volumes and a greater cardiorespiratory functional capacity than other children [43-45]. It has been suggested that ventilatory muscles, like other skeletal muscles, can increase their strength and endurance capacity in response to specific training [46]. Recent studies in children have shown an increase in lung volumes and capacities following exercise training [47,48]. FVC was about 3% greater in 7- 12 year olds following increased daily physical education, in which an average HR of 160 b/min was maintained for 23- 24 min, compared to controls [48]. It appears that habitual physical activity diaries are not related to lung volumes, capacities, and (or) flow rates in a sample of free living Quebec youth [6]. An earlier study by Jones et al [49] indicated that very active Chinese children, 5- 10 years of age, had greater ventilator capacity (FVC and FEV_1) than inactive peers. However, physical activity levels were subjectively rated by the school teacher. Lower FEV_1 % has been observed by Cordain et al [3] in a group of collegiate female swimmers compared to runners and controls. The authors noted that, if alveolar volumes are increased with no concomitant change in the conducting airway geometry, then a reduced flow may occur. A study of girl swimmers (n=5), Courteix et al [37] also found a significant difference in VC and total lung capacity (TLC) following one year of intensive training, compared to controls. The mean of body site of the swimmers was greater than the controls, but the increase in body size was similar between the two groups. Thus, the greater increase in VC and TLC was attributed to exercise training. The present study indicates no influence of training in football and judo on lung function. These results indicate that the

intensity and the volume of training in football and judo are not able to increase the lung volumes and capacities like in swimming, despite the fact that the spirometry tests were done in the full competition season. It appears that pulmonary differences in humans have been observed only in highly trained athletes or swimmers. Thus, the observed greater pulmonary volumes and capacities of swimmers may be due to the unique stresses imposed by the aquatic environment or to select, inherited traits [50].

The second major finding of the present study is that there is no effect of training in football and judo on VO_{2max} and VO_2 at the ventilatory threshold in prepubertal boys. Furthermore, the judokas ventilate significantly more than the footballers and controls at the end of the exercise. And the P_{max} of both sports groups is similar and significantly higher than the controls. We registered that VO_{2max} of our three groups was significantly related to LM and negatively associated with FM. Similarly, it has been demonstrated that parameters such as cholesterol or fat mass are related to VO_{2max} [51,52]. Concerning the improvement of VO_{2max} , our results are in accordance with those of Falgairette et al [14] who investigated the effects of physical activity on maximal oxygen uptake in active and non-active prepubertal boys. They concluded that active boys did not differ in aerobic performance when compared with non-active boys, despite a significant difference in physical activity. Williams et al [12], also, noted that neither eight week sprint interval running nor continuous cycle ergometer training programmes significantly improve maximal or submaximal indicators of the aerobic performance of prepubertal boys. However, the improvement of VO_{2max} was generally shown in longitudinal studies. However, Lussier and Buskirk [53] implemented a 12-week program with a group of 26 children, performed four times a week with 45 minutes per session. During the training, the experimental group (n=12) maintained their heart rate at “about 92% of heart rate maximum” during each session. This target heart rate was in the range of 75–85% VO_{2max} . After the 12 week program VO_{2max} relative to body mass had significantly increased (average 6.8%) in the trained group but not in the control group. Weltman et al [22] implemented a 14 week, four times a week, resistance training

program and showed an increase in mass related to peak VO_2 of 13.7% for the experimental group of prepubertal boys ($n = 16$). Mandigout et al ^[19], indicate that 13 weeks of endurance training increases the $\text{VO}_{2\text{max}}$ of prepubertal children. More recently, Mandigout et al ^[17] suggest that large muscle groups, organized on the basis of two sessions per week with 15 min at an intensity higher than 80% of HR_{max} at each session, was not sufficient enough to enhance $\text{VO}_{2\text{max}}$ in prepubertal boys and girls. Only three sessions per week with 25-35 min of exercise at intensity higher than 80% of HR_{max} improved $\text{VO}_{2\text{max}}$ in this specific pediatric population. However, longitudinal studies in which the effects of training on aerobic performance were observed produced conflicting results. Kobayashi et al ^[54] and Mirwald et al ^[55] both suggest that maximal aerobic power cannot be increased with training during the prepubertal years.

The largest longitudinal study comparing sports was that of Baxter-Jones et al ^[56], the training of young athletes (TOYA) study. The TOYA study investigated training effects on a total of 453 athletes from four sports, namely tennis, swimming, soccer and gymnastics. They indicated that training increases the aerobic power of prepubertal children above the normal increase attributable to age, physical growth, and maturation ^[56]. Moreover, our study shows that at the end of the exercise challenge test, many children have not reached the predicted HR_{max} and slightly less a $\text{RER} \geq 1.0$, although they subjectively indicated that they had made a maximum effort and this was particularly in controls. But, as it is not ethically acceptable to force a child to continue the test when they feel exhausted, some children's $\text{VO}_{2\text{max}}$ may have been underestimated. Maximum heart rate is obviously influenced by a child's motivation to exercise until exhaustion. A considerable inter-individual variation in HR_{max} exists and HR_{max} is also dependent upon type of exercise protocol and whether ergometer or treadmill running is used ^[57]. Maximum treadmill or cycle ergometer testing is known to give different results, where treadmill testing consistently gives higher $\text{VO}_{2\text{max}}$ compared to cycle ergometer protocol ^[58]. Moreover, the determination of the ventilatory threshold has a great importance especially for the individual training. Thus, at the ventilatory threshold,

our results show that the VO_2 [VT] was similar in all three groups and that the aerobic performance parameters at the [VT] have not any relationships with the anthropometric parameters with the exception of P [VT] that was significantly correlated with LM in footballers ($r=0.36$) and in controls ($r=0.41$). Also, we registered that HR [VT] of controls was significantly higher than sports subjects. In this context, Denker et al ^[59] registered that factors contributing to $\text{VO}_{2\text{max}}$ per LM were mainly HR_{mx} and gender. Furthermore, VE [VT] was significantly correlated in all groups with HR [VT], VO_2 [VT] and mainly with P[VT] especially in footballers ($r=0.75$), then with judokas ($r=0.65$) and finally with controls ($r=0.58$). In a performance context, several studies, however, indicate that aerobic training aims to increase maximal oxygen uptake ($\text{VO}_{2\text{max}}$) or other indices of aerobic fitness (e.g. lactate/ventilatory threshold, exercise efficiency) ^[60]. The multi-longitudinal study of Prioux et al ^[11] showed no significant changes with age in ventilatory threshold expressed in percentage of maximal oxygen uptake: oxygen uptake at the ventilatory threshold and maximal oxygen uptake similarly increased during growth. The study of the linear correlations between oxygen uptake at the ventilatory threshold and anthropometric characteristics showed that LM was a major determinant of oxygen uptake at the ventilatory threshold during growth ^[11].

However, data are sparse and difficult to interpret, as there is considerable variation in the intensity of training in many programs, and different protocols have been employed. These conflicting results are dependent on the characteristics of the subjects and /or the differences in training modes and intensities used. And most of the studies on prepubescents have indicated that their trainability was found to be deficient. The results of the present study are in accordance with this hypothesis. However, the training mode and intensities can also be taken into account. It appears that trainability in football and judo may not be aerobic enough to involve $\text{VO}_{2\text{max}}$ and that the quantification of its intensity was unattainable. This finding is consolidated by the similar VO_2 in all groups at ventilatory threshold despite a significantly lower HR of the sports group compared to controls and the significantly lower P_{max} at the end of the exercise of

the control group compared to the footballers and judokas. The lower Pmax of controls seems to be explained mainly by a significantly lower LM and also by significantly greater FM compared to football and judo groups. Our study suggests that there is no “golden” period during which training has an especially pronounced effect or a maturational threshold below which significant physiological adaptations to training cannot occur [61].

Limitations of the Study:

This study suffers from some limitations that need to be acknowledged and addressed such as the relatively small sample size. An additional limitation of our study is that the mean of HR_{max} of all groups does not reach the predicted HR_{max}. This finding indicates that our subjects did not achieve a true maximum effort because they feel leg fatigue before reaching exhaustion and therefore limiting maximum cardiorespiratory responses. Nevertheless, Berthoin et al [62] indicated that VO_{2max} was significantly correlated to continuous critical velocity ($R^2 = 0.60$, $P < 0.01$), suggesting that this parameter is a valid index of aerobic fitness compared to an intermittent critical velocity ($R^2 = 0.47$, $P < 0.05$). Moreover, it could be assumed that an intensity at least higher than continuous critical velocity is needed to lead children to reach VO_{2max} during continuous exercises, and even an intensity higher than intermittent critical velocity to reach VO_{2max} during 15 s/15 s exercises. Thus, if the aim of the training is to reach high percentages of VO_{2max}, or even to reach VO_{2max}, velocities would have to be at least higher than continuous critical velocity or intermittent critical velocity [62]. However, in our study, the aerobic test protocol on ergocycle needs to extend the time to exhaustion to reach the predicted HR_{max} and the VO_{2max}; it means that the time spent of the work load must be reviewed.

Practical Applications:

The present study supported studies that had observed greater pulmonary volumes and capacities between groups based generally on highly trained athletes and swimmers. The improvement of VO_{2max} must follow a specific training program including a determined number of sessions per week, the number of weeks and a defined HR to be maintained at each session.

Improving lung function parameters or VO_{2max} of prepubertal boys practicing football and judo must not be a priority. Thus, it is better to focus training sessions mainly on the technical aspect and the physical fitness adequacy of each sport.

CONCLUSION

The present study indicates that in pre-pubertal boys trained in football and judo, the results are associated neither with pulmonary function nor with VO_{2max} and VO₂ at the ventilator threshold. The main difference between footballers and judokas is that the judokas ventilate more than footballers at the maximal exercise. We registered that VO_{2max} was related to LM and negatively associated with FM. We support that only a specific program of intensive aerobic training can increase the aerobic performance.

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