METABOLIC SPECIALIZATION IN PRE-PUBERTAL YOUNG FOOTBALLERS

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RESUMO

Avaliou-se as respostas fisiológicas de vinte e duas crianças pré-pubescentes em testes de potência aeróbia (PA) e potência anaeróbia (PAN). Onze sujeitos futebolistas federados (T) e onze sujeitos sem prática desportiva formal (NT). O grupo T tinha 11,3 ± 0,5 anos de idade (Idd) tendo o NT apresentado uma Idd de 10,9 ± 0,3 anos.

Utilizando o protocolo de Balke modificado com análise directa de gases (Cosmed K^4b_2, Rome) avaliou-se o consumo de oxigénio absoluto e relativo (VO_{2Abs} e VO_{2Rel}), a ventilação (V_E) e a frequência cardíaca (FC_B). Enquanto que, num teste anaeróbio (protocolo Wingate - WAnT), avaliou-se o pico de potência absoluto e relativo (PP_{abs} e PP_{rel}), o pico de potência médio absoluto e relativo (AP_{abs} e AP_{rel}), o índice de fadiga (%DP) e a frequência cardíaca (FC_{Want}).

Analisaram-se os resultados (PASW 18.0). Verificou-se diferenças significativas entre os grupos nas variáveis de FC_B (T: 193,7 ± 7,11 b•min^{-1}; NT: FC_B: 104,5 ± 5,97 b•min^{-1}), de PP (T: 333,2 ± 39,0 watts; NT: 288,6 ± 59,4 watts) e AP (T: 210,5 ± 22,1 watts; NT: 183,5 ± 31,8 watts).

Concluiu-se assim que, para a amostra analisada, não se verifica a existência de especialização metabólica.

Palavras-chave: Potência Aeróbia (PA), Potência Anaeróbia (PAN), Especialização Metabólica, Pré-Pubescentes, Metabolismos Energéticos

ABSTRACT

This study compares the physiological response in aerobic and anaerobic potency tests in order to evaluate if there is metabolic specialization in pre pubertal children. Eleven subjects trained (age: 11.3 ± 0.5 years old) in football (T) whereas the other eleven (age: 10.9 ± 0.3 years old) without any formal sports training (NT). Both groups were matched for Tanner Maturity Test stage I.

Using the modified Balke protocol with direct gas analysis and treadmill, the absolute and relative uptakes of oxygen (VO_{2Abs} e VO_{2Rel}), the Ventilation (V_E) and heart rate (HR_B) were evaluated. Using the Wingate protocol for anaerobic parameters (WAnT) and a cycle ergometer, the relative and absolute peak power (PP_{Abs} e PP_{Rel}) were calculated, as well as the average absolute and relative power (APP_{Abs} e APP_{Rel}), the drop power (%DP) and the heart rate (HR_W).

There were significant differences (PASW 18.0) between the groups in the HR_B (T: 193.7 ± 7.11 b • min^{-1}; NT: HR_B: 104.5 ± 5.97 b • min^{-1}), PP_{Abs} (T: 333.2 ± 39.0 W; NT: 288.6 ± 59.4 W), and AP_{Abs} (T: 210.5 ± 22.1 W; NT: 183.5 ± 31.8 W) variables.

Therefore, it was concluded that there wasn't metabolic specialization in the sample analyzed.

Keywords: Aerobic Power (AP), Anaerobic Power (ANP), Metabolic Specialization, Pre-pubertal, Energetic Metabolism

INTRODUCTION

In highly competitive and different types of sport, it is possible to attest that the participants have an elevated level of specialization, be it morphologically (by the size of the muscles of body structure), in a neuromuscular manner (in motor coordination and speed of execution), cognitively (with high recognition and reaction to visual, sensitive or audible stimuli) and energetically (by means of a more effective use of the aerobic and anaerobic system, which interchanges in specific sports) (Bar-Or & Rowland, 2004; Fernandes, 2006; Heyward, 2006; Mendez-Villanueva et. al, 2010).

The ANP and AP of athletes are the two metabolic parameters which, at an energetic, morphological and functional level, are not developed to their maximum values simultaneously. This is, thus, the case of marathoners and elite sprinters, which are specialized in their categories, and have one of those metabolisms better and far more developed than the other, and who present specialized functional and morphological adaptations (Mendez-Villanova et al., 2010).

However, some studies indicate that there is a strong tendency for children who present good performance levels in aerobic tasks, to also obtain better results in highly anaerobic tasks (Bar-Or & Rowland, 2004; Matos & Winsley, 2007; Rowland, 2005), contrarily to what is seen in elite athletes, raising, henceforth, the hypothesis that pre-pubescent children might not be metabolically specialized (Rowland, 2002).

This study aims at analyzing the subject of metabolic specialization in pre-pubescent children who practice football (which in itself is an acyclic modality) (McMillan, Helgerund, Macdonald & Hoff, 2005).

Football is defined as being an acyclic sport, in which one uses the aerobic metabolism (especially in the recovery stages, in the slow movements, and whenever the players are far away from the ball) and the anaerobic metabolism simultaneously (in the decision stages, in the moments of individual dispute, unbalance and essentially whenever the player is close to the ball) (Bangsbo, 1993; Matos & Winsley, 2007; Mendez-Villanueva et al., 2010). Due to the length of gameplay it becomes impossible to perform all tasks while sprinting, and additionally the field measurements make it almost obligatory for players to work at an intensity level which is very nearly equal the highest level of their highest anaerobic capacity (Chamari et. al., 2005).

From a physiological perspective, the high intensity moments can be defined as those which cause more individual fatigue due to being executed through the solicitation of the anaerobic metabolism, which in turn has the biological and chemical capacity to resynthesize ATP through non-oxidative procedures, which may allow (or not) for the accumulation of lactate. (Harichaux & Medelli, 2006; Matos & Winsley, 2007).

The aerobic metabolism that predominates during a football game is seen as an “infinite” form of energy production, being more requested in the longer lasting efforts of low intensity.

Aerobic aptitude can be defined, physiologically, as the ability to intake oxygen, or in other words, by the highest level at which muscle cells can use oxygen to produce energy (Vinet, Nottin, Lecog & Obert, 2002).

This research project with pre pubertal children, tried to examine whether there were differences in the anaerobic and aerobic capacity of soccer players, when compared to other children who were not playing any type of sport, and exercised only in physical education classes. The variables for the anaerobic and aerobic tests were also correlated in order to answer the question:

-Are pre-pubertal children who practice football metabolically specialized?

METHODOLOGY

A total of eleven children who practice football competitively (between 10 and 12 years old), and eleven children who are did not practice any formal sports training (of the same ages) were evaluated anthropometrically.

Their heights were measured (H) using a scale with a stediometer (SECA), and their weight (W), body fat percentage (%BF) and body mass index (BMI) were measured, through bioimpedance, and resorting to the Tetrapolar Scale (Tanita – BC558). Both groups were matched for Tanner Maturity Test stage I (Bar-Or, 1996).

Table1. Table with the description of the groups, for the dependent variables in the anthropometric tests: Trained Individuals (T); Non- trained individuals (NT), Age (Age), Height (H), Weight (W), Body Fat (BF), Body Mass Index (BMI).

	Mean ± StdDev		Min - Max	
	T (*n* = 11)	NT (*n* = 11)	T (*n* = 11)	NT (*n* = 11)
Age (years)	11.3 ± 0.5	10.9 ± 0.3	11 – 12	10 – 11
Height (cm)	146.3 ± 6.4	144.1 ± 5.5	138 – 156	135 – 156.5
Weight (kg)	44.1 ± 6.9	40.1 ± 7.3	37.4 – 62.0	31.7 – 55.8
BF (%)	26.1 ± 5.3	22.8 ± 6.1	16.6 – 34.2	17.7 – 34.4
BMI (kg • m^{-2})	20.6 ± 2.7	19.2 ± 2.4	16.2 – 25.8	16.1 – 23.0

The same subjects were subsequently evaluated in terms of their anaerobic and aerobic metabolism. Most evaluation methods, for both metabolisms, were found in the literature revision, and were developed and created for adults, and subsequently adapted for children (Matos & Winsley, 2007).

For the evaluation of the aerobic metabolism the adapted Balke protocol was used, which consists in a maximum effort test. This protocol is valid for the evaluation of children (ACSM, 2000; Fernandes, 2006; Heyward, 2006; Rowland, 1996). It is a progressive test with three levels (3 minutes) of effort without interruptions, and with a progressive increase in speed (2 km • h^{-1} at the end of each level) and in inclination (2% at the end of each level).

The protocol used in this study for the evaluation of the Aerobic Potency (PA), is an adaptation of the Balke protocol, with reductions in time and effort, of 2 minutes per level (Fernandes, 2006; Pitetti, Fernhall & Figoni, 2002; Rowland, 2005).

For the procedure, a Technogym Treadmill (Runrace Treadmill HC1200) was used, as well as a direct technique of respiratory gas analysis (Cosmed $K4b^2$, Rome, Italy).

The test was preceded by a warm up period of three minutes, which happened at a 3 km • h^{-1} speed, with 0% inclination. The test started with a 6km/h speed, and 4% inclination, which would increase every 2 minutes, by 2 units.

The variables of absolute and relative oxygen uptake (VO_{2Abs} e VO_{2Rel}, respectively) were measured, as well as the Ventilation (V_E) and Hart Rate (HR_B).

During the application of the protocols, certain criteria for the interruption of the tests were defined, such as HR theoretical being exceeded and Respiration Quotient (Q) being higher than 1. The test could also be interrupted by request of the subjects, or whenever they showed evident signs of exhaustion, such as nausea, excessive blushing or a falling sensation.

The values considered for the determination of the VO_{2Max} were the maximum results verified during the Balke test. The same happened for the V_E e HR_B values.

In order to evaluate the anaerobic metabolism, the Wingate protocol was used (WAnT), given that it's the most recommended protocol for the evaluation of this metabolism (Armstrong, Weslman & Chia 2001; Bar-Or, 1996; Harichaux & Medelli, 2006; Inbar, Bar-Or & Skinner, 1996; Matos & Winsley, 2007; Rowland, 2005).

The WAnT is a test that lasts no longer than 30 seconds, and is performed in a cycle ergometer which stresses the anaerobic energy system, by means of a resistance related with the individual's body mass (Andreacci, Hail & Dixon*,* 2007; Marjerrison, Lee & Mahon 2007; Mastrangelo et al*.,* 2004).

The WAnT protocol (Bar-Or, 1996) was used in this research to evaluate the AP, and ANP, with an adapted resistance related to the weight of the subjects ($70\ g \bullet kg^{-1}$), in a cycle ergometer (Monark 894E) controlled through computer software (Monark Anaerobic Test Software).

The test was preceded by a warm up period of 3 minutes, and a resting period of 1 minute after the warm up. After the test, the individuals were asked to remain seated in the cycle ergometer for 3 minutes, during which they were monitored and their data was registered.

In the application of the WAnT, the data relative to the Peak Power (PP) and Peak Power Relative to the weight of the subject (PP_{Rel}), the Average Power (AP), and Relative Average Power (AP_{Rel}), the Drop Power (DP), and Drop Power Percentage (%DP), and the Lowest Power (LP).

The values considered for determining the PP, were the maximum values verified during the WAnT. The same was true for the HR values. The AP variable represents the mean of the work values verified throughout the 30 seconds for all individuals.

Statistically, the normality of the samples was checked and confirmed using Kolmogorov Smirnov test. A parametric Student t-test was conducted for both groups, in the variables analyzed. This was then confirmed by a non-parametric Mann-Whitney test. The correlation between variables in the AP test, and the ANP test was also measured, in order to verify, or not, the existence of metabolic specialization. All differences were significant for $P \leq 0.05$ and the values are expressed as mean ± standard deviation. All statistic treatment of the data was made through PASW (18.0) software.

RESULTS

With the application of the adapted Balke protocol, the data for the aerobic variables were obtained and registered.

For all the subjects the VO_{2Abs} and VO_{2Rel} values taken were the highest values achieved during the maximum effort test, given that children tend not to reach a “plateau” stage (Heyward, 2006; Rowland, 2005).

Table 2 presents the data relative to the aerobic characteristics of both groups.

Table 2. Trained Individuals (T), Non Trained Individuals (NT), VO_{2Max} absolute (VO_{2Abs}), VO_{2Max} relative (VO_{2Rel}), Ventilation (V_E), Heart Rate during Balke test (HR_B). * Variable which presents statistically significant differences between groups (*P* <0.05).

	Mean ± StdDev		Min – Max	
	T (*n* = 11)	NT (*n* = 11)	T (*n* = 11)	NT (*n* = 11)
VO_{2Abs} (L • min^{-1})	2.5 ± 0.4	2.3 ± 0.3	3.3 – 2,0	3.0 – 1.9
VO_{2Rel} (ml • kg^{-1} • min^{-1})	58.02 ± 9.75	57.50 ± 9.93	75.6 – 43,5	70.7 – 41.2
V_E (L • min^{-1})	84.72 ± 18.24	75.41 ± 10.88	109.3 – 52,9	91.5 – 57.4
HR_B (b • min^{-1})	193.7 ± 7.11 *	204.5 ± 5.97 *	205.0 – 182,0	213.0 – 195.0

The biggest differences found were in the means of each group for the HR_B variable, which were statistically significant. In this parameter the NT Group presents higher values (204.5 b • min^{-1} ± 5.97), than the T Group (193.7 b • min^{-1} ± 7.11).

Considering the aerobic test, given the values obtained and displayed in Table 2, it is verifiable that between the two groups the average absolute oxygen uptake (Group T: 2.5 L • min^{-1} ± 0.4; Group NT: 2.3 L • min^{-1} ± 0.3) and the average relative oxygen uptake (Group T: 58.02 ml • kg^{-1} • min^{-1} ± 9.75; Group NT: 57.50 ml • kg^{-1} • min^{-1} ± 9.93), had very similar values, both in their means and standard deviations.

In the V_E variable, for the aerobic test there were higher mean scores for Group T individuals (84.72 L • min^{-1} ± 18.24), than for Group NT individuals (75.41 L • min^{-1} ± 10.88). In observing their standard deviations, it is also clear that there is a bigger dispersion in the samples of each group, which makes it not as homogenous as the previously mentioned variables (VO_{2Abs} and VO_{2Rel}).

With the application of the WAnT, the ANP values were obtained and registered, and can be consulted in Table 3.

Table 3. Trained Individuals (T), Non Trained Individuals (NT), Absolute Peak Power (PP), Average Absolute Power (AP), Relative Peak Power (PP_{Rel}), Average Relative Power (AP_{Rel}), Drop Power (DP), % Drop Power (%DP), Heart Rate in the WAnT (HR_W). * Variable which presents statistically significant differences between groups (sig. <0.05).

	Mean ± StdDev		Min – Max	
	T (*n* = 11)	NT (*n* = 11)	T (*n* = 11)	NT (*n* = 11)
PP (W)	332.2* ± 39.0	288.6* ± 59.4	399 – 289	403 – 209
AP (W)	210.5* ± 22.2	183.5* ± 31.8	60 – 185	49 – 152
PP_{Rel} ($W \bullet kg^{-1}$)	7.6 ± 0.8	7.2 ± 1.0	8.7 – 6.3	8.7 – 5.4
AP_{Rel} ($W \bullet kg^{-1}$)	4.8 ± 0.7	4.6 ± 0.7	6.2 – 3.7	5.5 – 3.3
DP (W)	172.3 ± 40.5	157.1 ± 41.7	260 – 127	221 – 79
%DP (%)	47.2 ± 5.5	45.5 ± 7.9	66.1 – 37.6	56.5 – 33.8
HR_W ($b \bullet min^{-1}$)	186.8 ± 6.4	185.7 ± 14.5	196 – 172	203 – 156

Through the analysis of all the variables for the anaerobic test, it is observed that Group T individuals present higher average values than the individuals in the NT Group. This trend is accentuated even more so, for the PP and AP variables. For the PP variable there are statistically significant differences in the means of both groups (333.2 W ± 39.0 in Group T and 288.6 W ± 59.4 in the NT Group).

Table 3 shows that the remaining variables analyzed in the anaerobic test (PP_{Rel}; AP_{Rel}; DP; %DP and HR_W) do not present statistically significant differences between both groups studied, although mean values are very similar.

These results allow us to say that, in absolute terms, the T individuals are capable of producing more strength (PP), and maintain it longer over time (AP), when compared to NT individuals.

Mean values between the groups for the PP_{Rel} variable, are very similar (Group T 7.6 W ± 0.8 and Group NT 7.2 W ± 1.0). This is also the case for the mean values of the AP_{Rel} variable (4.8 W ± 0.7 in Group T and 4.6 W ± 0.7 for Group NT), and for its maximum and minimum values.

Notwithstanding, the performances of the groups, and their differences alone, do not allow for a straightforward answer to the question posed in this study. Therefore it becomes important to correlate the variables in each test, in order to understand whether or not there is a relationship between the individual performances in the aerobic and the anaerobic tests.

The values registered for the VO_{2Abs} are strongly correlated with the absolute values for PP and AP, in other words, the individuals who present the higher values of oxygen uptake in the aerobic test, tend to also have better performance values in the Anaerobic test.

There is also a significant correlation between the VO_{2Rel} and the PP_{Rel} and AP_{Rel}. This indicates that the higher the oxygen uptake for kilogram, the higher the value for the PP, per kilogram, and AP in the WAnT test, per kilogram. These correlations are indicated in the figures below.

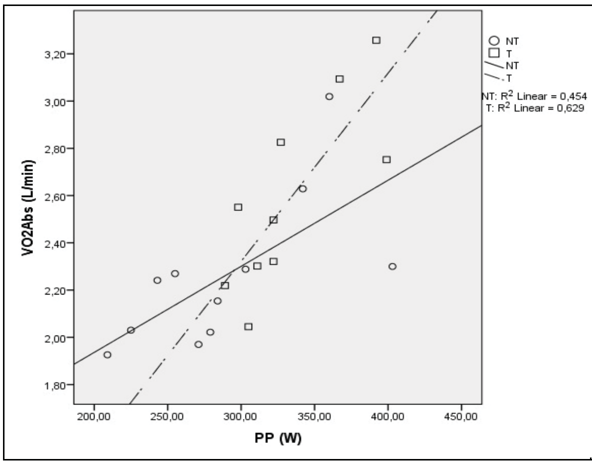

Figure 3: Correlation between the VO_{2Abs} and the PP.

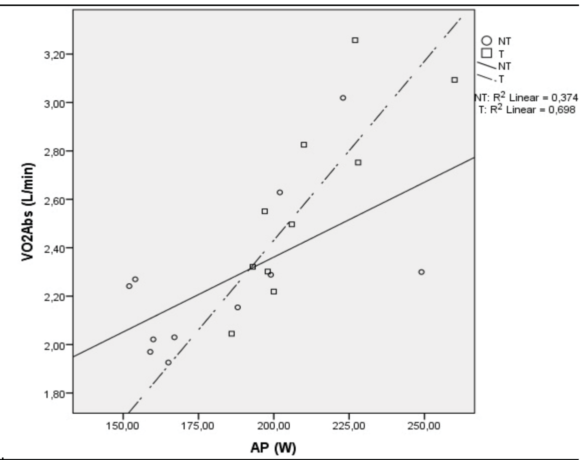

Figure 4: Correlation between the VO_{2Abs} and the AP.

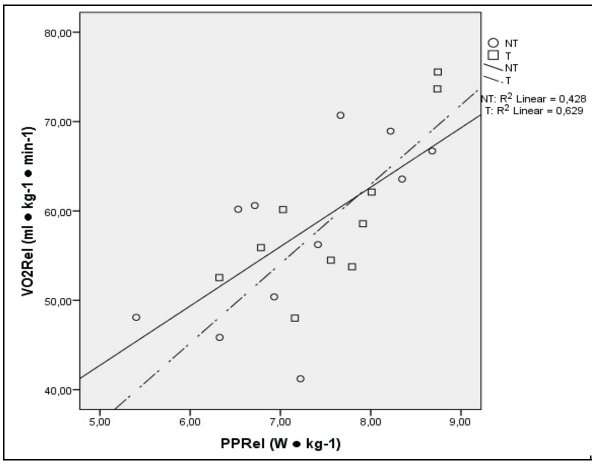

Figure 5: Correlation between VO_{2Rel} and PP_{Rel}.

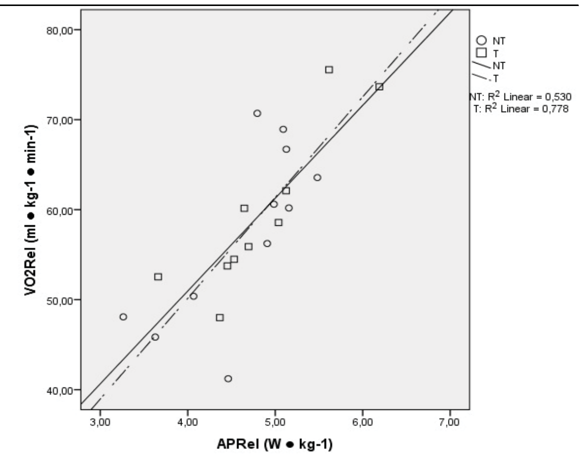

Figure 6: Correlation between VO_{2Rel} and AP_{Rel}.

The cloud dispersion in the dots is very condensed in relation to the regression line, hence affirming that there is a strong correlation between the performances of the individuals in both tests, being that the highest performance values in the aerobic test are related to the highest values achieved in the anaerobic test. Therefore, a strong correlation between the VO_{2Abs} and the PP_{Abs} and AP_{Abs} variables was found, as well as a strong correlation between the VO_{2Rel} variable and the PP_{Rel} and AP_{Rel}.

These data allow us to verify that the individuals with a higher aerobic capacity are those which score better in the Power and Anaerobic Capacity tests.

DISCUSSION

The question "are pre-pubescent children metabolically specialized" has been debated throughout the years (Bar-Or & Rowland, 2004; Rowland, 2002; Rowland, 2005).

It is expected that, contrarily to adults, children that are fast are also able to run for a longer amount of time at an elevated speed.

The present study, ±as though out and developed in order to answer that question. As such, the data collected resulted from the application of an aerobic test (the adapted Balke protocol), and of an anaerobic test (WAnT – 30sec), performed on 11 T subjects and 11 NT subjects between the ages of 10 and 12 years old.

Anthropometrically, the samples were similar, there being no significant differences between the groups. The same was observed in 3 (VO_{2Abs}, VO_{2Rel} e V_E) of the 4 variables studied during the AP test. Only the values for HR_B showed statistically significant results, (NT – 204.5 b • min^{-}1 ± 5.97; T – 193.7 b • min^{-1} ± 7.11), which allow us to conclude that the T individuals do not differ from the NT individuals in their oxygen consumption, although T individuals show better cardiac efficiency during periods of physical effort. This may be attributed to the regular practice of football, where the energetic metabolism is more solicited than the aerobic metabolism (Bangsbo, 1993; Matos & Winsley, 2007; Mendez-Villanueva et al., 2010). Hence, despite not being metabolically adapted, the T individuals have adapted their cardiac muscle to sustain effort.

Relatively to the anaerobic test, 5 (PP_{Rel}; AP_{Rel}; DP; %DP e HR_W) of the 7 variables analyzed, show similar results, differing only in the PP (T – 333.2 W ± 39.0; NT – 288.6 W ± 59.4) and AP (T – 210.5 W ± 22.2; NT – 183.5 W ± 31.8), with results being significantly more elevated in the T group. One can, thus conclude that T individuals can produce more strength and keep that strength up, for longer periods of time, than NT individuals.

Theoretical data indicate that the regular practice of sports leads to an increase in the level of motor coordination, both inter and intramuscularly, in the nervous system and in the moment of applying strength, which may allow for the production of more strength, especially in these ages (Rowland, 2005). In other words, the differences observed probably aren't the results of an effective metabolic adaptation. The proximity of the observed values between the groups in the PP_{Rel} and AP_{Rel}, as well as the absence of significant differences in another 3 variables, supports this idea.

Looking at the results obtained in both tests AP, and ANP, simultaneously, and through the Pearson correlation, one can effectively observe that the individuals who obtain higher and better performances in one test, are the ones who achieved better results in the other test, either absolutely or relatively.

The graphics shown support this observation, beyond the fact that they show , in relative terms, that the higher results belong both to T and NT individuals, thus supporting the idea that for the population evaluated, there is no metabolic specialization.

The facts presented allow one to conclude that the differences shown are hardly due to the existence of a metabolic evolution or a metabolic specialization. In a total of eleven variables obtained across both tests, there were only significant differences when arguments that there is an effective metabolic specialization are toned down.

It can be concluded that the practice of sports or physical exercise leads to a better cardiac efficiency in long term efforts, as was sustained by the bibliography (Bar-Or & Rowland, 2004; Heyward, 2006; Matos & Winsley, 2007; Rowland, 2005) and that, in absolute terms based on the production of strength, individuals that reach higher values, are more likely to show better motor and muscular coordination.

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