DOI: 10.4025/jphyseduc.v32i1.3258

**Original Article**

# YOUNG SOCCER PLAYERS WITH HIGHER SOMATIC MATURATION ARE STRONGER, MORE POWERFUL AND FASTER THAN THOSE WITH LOWER MATURATION

## JOVENS FUTEBOLISTAS DE MAIOR MATURAÇÃO SOMÁTICA SÃO MAIS FORTES, POTENTES E VELOZES QUE OS DE MENOR MATURAÇÃO

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**RESUMO**

A identificação do nível maturacional de futebolistas em formação, ao longo da puberdade, é fundamental para verificar a influência de aspectos que interferem no desempenho esportivo, tais como o tamanho corporal e as capacidades físicas. O objetivo do presente estudo foi verificar as diferenças de desempenho físico de jovens futebolistas em estágios maturacionais pré e pós pico de velocidade de crescimento. Participaram do estudo 49 futebolistas (14,49 ± 1,00 anos) das categorias de base de um clube da cidade de Fortaleza. Foram aferidas a massa corporal, a estatura e a altura tronco-cefálica. A maturação somática foi estimada por meio da distância ao pico de velocidade de crescimento (DPVC). Foram realizados os testes Sprint 10 metros e 20 metros lançado, Illinois modificado, Altura do salto (CMJ), RAST e o Yo Yo IRT 1. As Diferenças de Média Estandardizada (DME) e Intervalo de Confiança (IC = 90%) foram utilizados para comparar as variáveis do estudo (PRÉ-PVC vs PÓS-PVC). Os nossos achados mostraram que o grupo PÓS-PVC apresentou valores mais elevados no CMJ (0/3/97, Very likely) e no RAST (potência máxima, média, mínima) e inferiores no Sprint 20m L (100/0/0, Most Likely), quando comparado ao grupo PRÉ-PVC. Concluimos que jovens futebolistas com maturação somática pós pico de velocidade de crescimento apresentam melhor capacidade de força de membros inferiores, potência anaeróbia e velocidade.

**Palavras-chave**: Adolescente. Crescimento corporal. Aptidão física.

**ABSTRACT**

The identification of young soccer players' maturation level throughout puberty is crucial to verify the influence of aspects that interfere on sport performance, such as body height and physical capacities. The aim of the present study was to verify the differences in physical performance of young soccer players in maturation stages before and after peak height velocity. This study comprised 49 soccer players (14.49 ± 1.00 yrs) belonging to the youth teams of a club in the city of Fortaleza. Body weight, height and trunk-cephalic height were measured. Somatic maturation was estimated using distance in years from peak height velocity (DPHV). 10 Meters Sprint and 20 Meter Flying Sprint, Modified Illinois, Jump Height (CMJ), RAST and Yo Yo IRT 1 tests were applied. Standardized Mean Difference (SMD) and Confidence Intervals (CI = 90%) were used to compare the study variables (PRE-PHV vs POST-PHV). Our findings showed that POST-PHV group showed higher values in CMJ (3/3/97, Very likely) and RAST (peak, average, minimum power) and lower in the 20 Meter Flying Sprint (100/0/0, Most Likely) when compared to the PRE-PHV group. We concluded that young soccer players with somatic maturation after peak height velocity presented better capacity of lower limb strength, anaerobic power and speed.

**Keywords**: Youth. Body growth. Physical fitness.

## Introduction

The design of formation categories with the year of birth as a division landmark causes that players exhibiting different maturational levels get the same training and are homogeneously evaluated, which presents advantages and disadvantages in the sport environment[1]. The identification of young soccer players' maturation level throughout puberty is crucial to verify the influence of aspects that interfere on sport performance, such as body height [2] and physical capacities[3]. Bidaurrazaga-Letona et al.[4] investigated the factors involved in the identification and selection of young soccer players and found that body height and maturation were key aspects that could not be underestimated. Throughout the formation process it came to light that coaches upgraded young players' identification and promotion based on age factors[5].

Peak height velocity (PHV) age is the most common indicator used to assess adolescents' somatic maturation focusing on the age of maximal peak height[6]. The distance in years from PHV can be predicted through a noninvasive and practical method using anthropometric variables[7]. A high and negative association is reported between the distance of peak height velocity and acceleration and between speed and agility [1], whereas higher values of aerobic resistance performance and lower limbs muscle strength are verified in players exhibiting a more developed maturation status[8]. Maturation has predicted the performance of the explosive power test, assessed through the vertical Sargent jump[9], besides being the strongest predictor of the result of vertical Squat jump[10] in young soccer players.

Although specialized literature shows several investigations reporting the relationship of somatic maturation with young soccer players' physical characteristics, only few of them combined physical capacities of aerobic resistance, anaerobic resistance and power, strength, speed and agility targeting a complete evaluation. In this sense, this study aims to fill in this gap, and targets the differences on young soccer players' physical performance during pre and post PHV maturational stages on aerobic resistance physical tests, anaerobic resistance and power, strength, speed and agility, thus allowing the identification of which motor abilities have played different roles on pre and post PHV.

## Methods

*Participants*

This study encompassed 49 young soccer players (14,49 ± 1,00 yrs.; 169,95 ± 8,04 cm; 60,95 ± 10,29 kg; 20,98 ± 2,39 kg/m$^2$) from U-13 e U-15 belonging to a team of Fortaleza city, Ceará, Brazil. Young soccer players in the club at least for 1 year or competing for at least 6 months; with no injury that might have kept them away from training for one week or more, in the last 2 months, besides those whose guardians presented the Written Informed Consent, were eligible to participate. The study has been approved by the Committee of Ethics of Federal University of Ceará (n. 3.066.291).

*Experimental Design*

After selecting participants, the study was conducted throughout 4 days, interspersed with at least 48 horas in-between. On the first day we conducted the anthropometric evaluations, on the second lower limbs strength, speed and agility tests. Aerobic resistance tests and anaerobic resistance and power tests were separately performed on the third and fourth days, respectively.

Figure 1 shows study experimental design, with detailed assessments and the performance of physical tests .

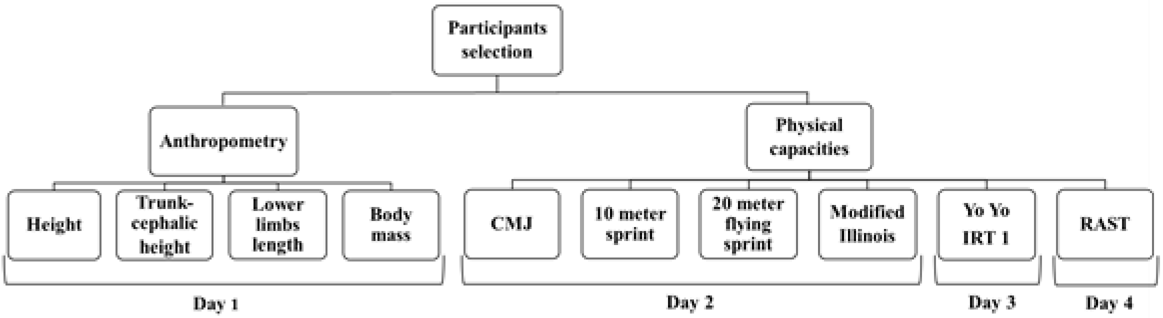


**Figure 1.** Study experimental design
**Source**: Authors

*Anthropometry*

Height and trunk-cephalic height have been assessed with a stadiometer (Sanny, Caprice model, with a 0,1 cm scale), in accordance to Guedes & Guedes[11]. Lower limb length was obtained by subtracting height trunk-cephalic height[11]. The estimation of athletes' body mass was conducted with a digital scale (Oxer, Home model, with a 0,1 kg scale).

*Maturation*

Somatic maturation was assessed by evaluating the distance in years a subject is placed in relation to peak height velocity (DPHV) through Mirwald et al. equation[7],

$$DPHV = -9.236 + 0.0002708 \times (LLL \times TCH) - 0.001663 \times (CA \times LLL) + 0.007216 \times (CA \times TCH) + 0.02292 \times (BM/H)$$

Where:
H = height (cm)
BM = body mass (kg)
CA = chronological age (years)
LLL = lower limb length (cm)
TCH = trunk-cephalic height (cm)

Athletes' chronological age described as centesimal will be determined based on the difference between players' birth date and data collection date, as referred by Guedes & Guedes[11].

DPHV positive values indicate that a subject has been assessed after his peak height and negative values refer that the subject will attain its peak height[7].

*Physical capacities*

The assessment of displacement speed was performed with the 10 m Sprint and 20 m Flying Sprint tests. During the 10 m test, the player moved from a static position and ran 10m distance on the shortest time possible[12]. On the 20 m Flying Sprint test, the player after running 10 m distance with maximal speed performed a 20m run in the shortest time he could, with the latter time being considered only[13]. Each running time was recorded in seconds and hundredths of seconds, using the photocells (Cefise, Speed Test 6.0 Telemetric model) positioned at the start and at the finish lines.

Athletes' agility was assessed through the *Modified Illinois Change of Direction Speed Test* (Illinois), described by Hachana et al.[14]. This test was set up with four cones delimiting the agility area distancing 5 m among them. Other three cones were positioned 2,5 meters apart, each aligned in the center of this area and delimiting the zigzag zone. From a standing position, the athlete sprinted 5 m maximal speed, rounded the cones and ran towards the zigzag zone, where he swerved the cones, turned and returned, and finally heading to the finish line with a final sprint. No guidance was given as to the most effective movement technique. Athletes were instructed to complete the test as quickly as possible, swerving the cones. When the athlete did not follow the guidelines or failed the route, the test was interrupted and a new attempt was made after a recovery period. Each run time was recorded in seconds and hundredths of seconds with the photocell use (Cefise, Speed Test 6.0 Telemetric model) positioned at the start and finish test lines.

Lower limb strength was assessed through the *Counter Movement Jump* (CMJ). We used a jump platform (Cefise, Jump System Duo model). Bosco et al.[15] described that to perform the CMJ the athlete should be guided to stay in an upright position on the jump platform, arms along the body and the weight uniformly distributed on both feet. Then, the athlete squatted down by flexing the knees at 90°, immediately before jumping vertically the highest possible. The athlete was commanded to maintain the knee on extension during all the flight and simultaneously land on both feet. Upper limbs stayed free to move during all test. Each athlete executed CMJ six times and the mean value of all was considered as the outcome.

Anaerobic resistance and power have been assessed through the ability test to perform repeated cyclic runs with maximal speed, the *Running Based Anaerobic Sprint Test* (RAST), as by Zacharogiannis, Paradisis and Tziortzis[16]. RAST comprises six cyclic runs of 35 meters each, maximal speed with 10s of passive recovery between each run. Each run time was recorded in seconds and hundredths of seconds with the use of photocells (Cefise, Speed Test 6.0 Telemetric model) positioned at the start and finish test lines. We calculated peak ($RAST_{peak.power}$), average ($RAST_{average\ power}$) and minimum ($RAST_{min.\ power}$) power of each athlete , and fatigue index ($RAST_{FI}$)[17] from the recorded times and with athlete's body mass data (kg) and the distance covered (35 meters).

The *Yo Yo Intermittent Recovery Test Level 1*[18] (Yo Yo) was used to assess aerobic resistance. The Yo Yo consists of out and back running bouts on a 20 m course, with a progressively increased velocity, with programmed audio cues. Between each bout, participants have a 10 s active recovery period to jog to a point 5 m distant from the start/finish line and return to it. When the participants cannot reach for the second time the finish line, before the recorded beep, or when they cease the test, the distance covered was recorded as the test result.

*Statistical analysis*

Results are presented by descriptive statistics (mean and standard deviation). DPHV values were divided into two groups: PRE-PHV (DPHV < 0) and POST-PHV (DPHV > 0) to verify the differences of players' physical performance holding distinct maturational stages. We estimated the magnitude of the effect based on inference, through the Standardized Mean Difference (SMD) and Confidence Intervals (CI = 90%)[19] .The quantitative odd of finding differences among the tested variables was qualitatively evaluated with the scale: < 1%, almost certainly not; 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; >99%, almost certain. If the lower and greater results are both > 5%, the likelihood of a difference is classified as unclear. Additionally, the effect size was used according to the scale: 0-0.2 (trivial), >0.2 (small), >0.6 (moderate), >1.2 (large), >2.0 (very large).

## Results

Height, body mass, body mass index and DPHV of the players are shown in Table 1.

**Table 1.** Descriptive data of the players enrolled in the study

| Anthropometry | PRE-PHV | | | POST-PHV | | | TOTAL | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | N | Mean | SD | N | Mean | DP |
| Height (cm) | 20 | 164,41 | 7,63 | 29 | 173,77 | 5,85 | 49 | 169,95 | 8,04 |
| Body Mass (kg) | 20 | 52,44 | 7,27 | 29 | 66,82 | 7,42 | 49 | 60,95 | 10,20 |
| Body Mass Index ($kg/m^2$) | 20 | 19,32 | 1,62 | 29 | 22,12 | 2,16 | 49 | 20,98 | 2,39 |
| DPHV (years) | 20 | -0,875 | 0,658 | 29 | 0,637 | 0,438 | 49 | 0,020 | 0,921 |

**Note:** DPHV = distance in years a subject is placed in relation to peak height velocity
**Source**: authors

Table 2 presents results (mean and standard deviation) of PRE and POST-PHV of physical tests and the values referring all the assessed sample.

**Table 2** Results of PRE and POST- PHV physical tests

| Variable | N | PRE-PHV | N | POST-PHV | N | TOTAL |
|---|---|---|---|---|---|---|
| 10m Sprint (seg) | 19 | 1,59 ± 0,20 | 27 | 1,55 ± 0,14 | 46 | 1,56 ± 0,17 |
| 20m Flying Sprint (seg) | 19 | 2,69 ± 0,23 | 27 | 2,49 ± 0,14 | 46 | 2,57 ± 0,20 |
| Illinois (seg) | 19 | 10,86 ± 0,45 | 27 | 10,87 ± 0,37 | 46 | 10,86 ± 0,40 |
| CMJ (cm) | 15 | 28,31 ± 3,90 | 20 | 32,83 ± 5,73 | 35 | 30,89 ± 5,46 |
| $RAST_{(peak\ power)}$ (w) | 17 | 385,60 ± 62,25 | 23 | 486,01 ± 89,15 | 40 | 443,33 ± 92,74 |
| $RAST_{(average\ power)}$ (w) | 17 | 302,38 ± 49,00 | 23 | 372,29 ± 60,18 | 40 | 342,57 ± 65,22 |
| $RAST_{(min.\ power)}$ (w) | 17 | 232,69 ± 43,45 | 23 | 289,24 ± 56,70 | 40 | 265,21 ± 58,22 |
| $RAST_{(IF)}$ (w/seg) | 17 | 4,59 ± 1,62 | 23 | 6,33 ± 2,20 | 40 | 5,59 ± 2,14 |
| Yo Yo (m) | 11 | 941,82 ± 299,53 | 22 | 942,73 ± 387,88 | 33 | 942,42 ± 356,05 |

**Note:** Values expressed in mean and standard deviation. N = Number of participants; 10m Sprint = 10 m Test; 20m Flying Sprint = 20m Test ; Illinois = Modified Illinois Change of Direction Speed Test; CMJ = Counter Movement Jump; $RAST_{(peak\ .power)}$ = Peak power obtained from the Running Based Anaerobic Sprint Test; $RAST_{(averaage\ power)}$ = Average power obtained from the Running Based Anaerobic Sprint Test; $RAST_{(min.\ power)}$ = minimum power obtained from the Running Based Anaerobic Sprint Test; $RAST_{(FI)}$ = Fatigue index obtained from the Running Based Anaerobic Sprint Test; Yo Yo = Yo Yo Intermittent Recovery Test Level 1
**Source**: Authors

Figure 2 shows SMD, 90% CI, ES, odds of physical tests performed of PRE-PHV and POST-PHV. POST-PHV group showed greater CMJ (0/3/97, Very likely) than PRE-PHV group, $RAST_{(peak\ power)}$, $RAST_{(average\ power)}$, $RAST_{(min.\ power)}$ (0/0/100, Most Likely) and $RAST_{(FI)}$ (0/2/98, Very likely). PRE-PHV group presented lower values than POST-PHV on *20m Flying Sprint (*100/0/0, Most likely).

Results of the 10 *m Sprint* test (53/35/11, Unclear), Illinois (24/45/31, Unclear) and Yo Yo (33/44/23, Unclear) tests, evidenced no effects between PRE-PHV and POST-PHV groups.

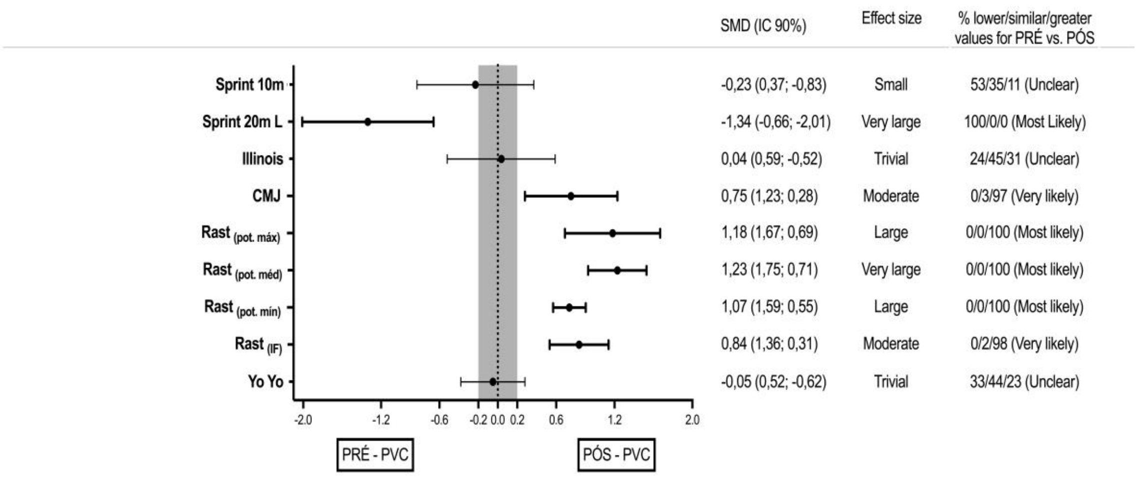


**Figure 2.** Differences on physical fitness tests (CI 90%) between PRE and POST-PHV

**Note:** SMD =Standardized Mean Difference; 10m Sprint = 10m Test ; 20m Flying Sprint = Sprint running 20m = ; Illinois = Modified Illinois Change of Direction Speed Test; CMJ = Counter Movement Jump; $RAST_{(peak\ power)}$ = peak power obtained from the Running Based Anaerobic Sprint Test; $RAST_{(average\ power)}$ = average power obtained from the Running Based Anaerobic Sprint Test; $RAST_{(min.\ power)}$ = minimum power obtained from the Running Based Anaerobic Sprint Test; $RAST_{(FI)}$ = fatigue index obtained from the Running Based Anaerobic Sprint Test; Yo Yo = Yo Yo Intermittent Recovery Test Level 1

**Source:** authors

## Discussion

This research aimed to verify the differences of physical performance in young soccer players in a pre and post peak height velocity maturation stage. The main findings have shown that the group exhibiting a greater maturation (POST-PHV) presented greater results on lower limbs strength, anaerobic power and speed in relation to the group with lower maturation (PRE-PHV). Therefore, the importance of monitoring the maturation throughout the process of formation of young soccer players is paramount as it influences physical capacities and consequently, sport performance.

Soccer players with greater somatic maturation are stronger than the others who have not reached the peak height velocity[8], suggesting that the more advanced the maturational stage, the better the performance on the lower limbs strength assessment tests[20]. In this sense, Murtagh et al.[21] verified that the best performance on vertical jump tests with CMJ has been the one performed by the POST-PHV youngsters, followed by the middle group (mid-PHV), with the PRE-PHV group exhibiting the worst performance .

It is expected that within the same age adolescents in more advanced maturation stages have higher strength than those in late maturation. Soccer players are significantly stronger than non- soccer players[21,22] in all ages . When the maturation effect is removed differences cease, suggesting a greater maturation importance of lower limb strength[22]. This increasing of young soccer players' lower limb strength who present greater maturation can be related to the connections of the volume and the transverse area of quadriceps femoris muscle group and the height of the jump[23]. Therefore, the increasing of muscle mass associated to the development of maturational process[5] could influence the performance of lower limbs strength tests.

POST-PHV group presented in this study greater values on the minimum, mean and peak anaerobic power, due to the low sprint times. Selmi et al.[20] have found a significant difference among the four maturational groups (Pre-PHV, Circum-PHV 1, Circum PHV 2 and Post-PHV) when assessing anaerobic power in relation to the best sprint times. Accordingly, the groups with greater maturation presented the lowest test times. Duarte et al.[24] have determined the small effect magnitude when they analyzed the best sprint times and the mean time of each sprint of maturation groups studied (early, middle and late). The differences among results are due to the amplitude of sample sizes. Duarte et al.[24] investigated players aged 13-14 yrs. , while our study and Selmi et al.[20] investigated wider ages, thus providing an assessment of players with a broader maturation level.

Regarding anaerobic resistance and in line with the outcomes of this study, Selmi et at.[20] verified that among the four maturational groups , the lowest maturational stage group exhibited fatigue index values significantly lower than the other three groups. Male gender has presented either a reduction on fatigue resistance and on the capacity to recover from high intensity exercises from childhood to adolescence[25,26], which corroborates the increasing values of fatigue index of PRE-PHV group to POST-PHV presented by our study.

Moreover, Duarte et al.[24] found that the middle maturational state group presented lower fatigue values when compared to the groups of lower and greater maturation. This divergence in relation to literature and to that corroborated by our study might be due to the low age of participants assessed by these authors, which hampered the observation of decreasing of fatigue resistance.

Our study has shown that PRE-PHV group presented substantial lower values than POST-PHV on 20m *Flying Sprint*. This result shows that low maturation players (DPHV<0) performed lower than the more mature players on this test due to their maturation stage (ES: very large). Other authors had also observed that groups with lower maturation performed worse on sprint tests[1,21]. This might be due to the lower limb strength that results from the lower muscle volume exhibited by lower maturation groups [5,23].

PRE-PHV and POST-PHV groups have not exhibited effect between them on 10m Sprint, Illinois and Yo Yo tests in our work. Matos et al.[27] have not found maturation effects over linear speed and agility and therefore they corroborate our study. While Borges et al.[8] observed that the further the somatic maturation the more resistant the players were when they assessed aerobic resistance through the Yo Yo Intermittent Recovery Test Level 1, which is in agreement with our investigation .

This difference can be explained by the wider age range under research and by participants' competitive level in both studies. Borges et al.[8] have shown that participants (12,0 to 17,9 yrs.) belonged to a faculty project , while our participants (14,49 ± 1,00 yrs.) came from formation teams of a regional club. Competitive level differences and consequently physical fitness are evident when we compare means of PRE- PHV (316,00 ± 96,97 m), PHV age (490,52 ± 163,21 m) and POST- PHV (831,57±288,00 m) shown by Borges et al.[8] (2017) with our results : PRE-PHV (941,82 ± 299,53 m) and POST-PHV (942,73 ± 387,88 m).

As a result, it is clear that Borges et al.[8] participants' wider age range might have contributed to put in evidence the differences of performance on aerobic resistance assessment among the maturational groups under investigation . On the other hand, players' physical fitness level assessed in our study, associated to the lower age range, might have influenced the outcomes, thus hampering the observation of a substantial maturation effect on physical fitness of aerobic resistance.

This study has evidenced the differences of physical performance of young soccer players in pre and post peak height velocity maturational stage , namely the lower limb strength, anaerobic resistance and power and speed. Hence, the development of the maturational process has led to better performance on strength tests and anaerobic power and worse on anaerobic resistance. A lower maturation has contributed for a worse performance on linear speed, specifically on the 20m Flying Sprint test.

Therefore, the importance of coaches and sport investigators throughout the formation process is quite important to monitor and consider when selecting, training, evaluating and researching the maturational stage of each athlete, since this condition influences the performance of specific abilities that are cardinal to a greater performance in the modality.

Concerning agility and aerobic resistance, although the outcomes have not been able to establish the influence of maturation over these physical capacities, our findings in relation to these two variables might be a raw model to the selection and formation of young soccer players, as they suggest that agility and aerobic resistance are not performance indicators sensitive to maturation.

Further investigations are recommended to encompass a wider age range, with practitioners and non-practitioners and, mainly, monitor the maturation process and its outcomes upon the performance of physical capacities over time in cross-sectional studies. This aims to broaden the maturation knowledge to different scopes and its influence over the capacities that limit soccer performance .

As limitations of the study, training load of the different age groups was not monitored.Neither has this investigation assessed anthropometric variables  associated to the young players' growth and development nor those related to body composition. Besides that, training load monitoring.

## Conclusions

We concluded that young soccer players who exhibited Post-Peak Height Velocity somatic maturation presented a better capacity of lower limbs power, anaerobic power and speed.

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**Acknowledgements**: The students of the Research Group in Biodynamics of Human Movement for their support, to the athletes and technical commissions of Juazeiro Empreendimentos Esportivos for their participation and collaboration and to the Board and Technicians of FutCenter for their cooperation

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Received on Apr, 22, 2020.
Reviewed on Aug, 08, 2020.
Accepted on Aug, 26, 2020.

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