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# The Influence of Team Invasion Sports' Participation in the Phase Angle of Youth Athletes

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**ABSTRACT:** Team invasion sports are characterized as ball games, played by two opponents, aiming to score points or goals. The aim intended to verify which team invasion sport presents a greater probability to obtain a higher phase angle (PhA) value, considering the age, time of practice, vertical jump tests and handgrip strength of young athletes. A total of 248 young athletes were evaluated. After performing the correlations between the PhA and categorical variables (sport and sex) and covariables (age, time of practice- t, squat jump- SJ, countermovement jump- CMJ, and handgrip strength left or right- HGSl or HGSr), we developed an equation from a logistic regression model, aiming to better interpret the probability to obtain a higher PhA. Our findings showed a significant correlation ($p<0.05$) ranging from weak to moderate between the PhA and age ($r=0.268$), t ($r=0.206$), SJ ($r=0.330$), CMJ ($r=0.277$), HGSr ($r=0.537$), and HGSl ($r=0.523$). Considering the median value of the PhA (7.7º) as a cut-off point, youth soccer players were the most likely to have 2.2 more chances to reach a higher PhA, followed by Futsal (2.13), and Rugby (2.01) players. Considering our equation, we suggested that higher PhA values predisposed the Soccer, Futsal and Rugby players to express greater jumping capacity or handgrip tests. Considering the advantage of using PhA as a marker of a healthy body composition profile, the magnitude of these probabilities to reach higher values of strength performance in young athletes may depend on the sport practiced and their exposure to specific training.

**KEYWORDS:** Sport Participation; Body Composition; Strength; Performance

## I. INTRODUCTION

Team invasion sports are characterized by ball games played with two opponents, where their aim is scoring points or goals, while trying to prevent the opponent from invading their own space and scoring [1]. There are several team invasion sports, including those where the ball is thrown into a net (e.g. basketball or netball) or the ball is hit with the foot or a bat into a goal (e.g. Soccer, Australian Football, Field Hockey), or the ball is carried across a line (e.g. American Football, Rugby) [1].

These sports present frequent changes in the playing situation, imposing a high degree of unpredictability, where behaviors and actions are subject to randomness and variability, demanding a great adaptative ability from the practitioner [2]. Improvements in the performance of athletes in these sports depends, to a large extent, on the ability of technical committees to select and organize training methods and contents that are related to the competitive practice of a given modality [3].

Therefore, the practice of exercises has also been associated with the development of bone and muscle tissue, where fat-free mass is considered a predictor of muscle capacity to promote tension and physical abilities [4], in which body composition assessments and strength tests can help to verify the effects of physical activity and sports practice over time [4]. Moreover, the measurement of muscle strength has been used to optimize the results of athletes in competitions and to assess muscle balance in athletes, where the measurement of muscle strength can be performed by using methods requesting different types of contraction, such as: isometric (HGS), isokinetic and isotonic (CMJ and SJ) [5].

The capacity to express muscle dynamic power and maximal isometric force is widely recognized as an important component in the physical performance of young athletes, and it positively impacts sports' performance, daily activities, quality of life, growth, motor development, bone mineral density, and muscle mass development [4, 6, 7]. The evaluation of muscle strength expressions is therefore essential, whether for upper limbs (e.g., handgrip tests, 1 repetition maximum- RM), or lower limbs (e.g., vertical jump tests, 1 RM), and the information obtained from them is very useful to periodize the training programs for this population [4, 8, 9].

The phase angle (PhA) is obtained through the relationship between Resistance (R) and Reactance (Xc) measurements, using the bioelectrical impedance test (BIA). The PhA is equivalent to a direct measure of cell stability, which reflects the disposition of water in the intra and extracellular media [10]. Its values are proposed as an indirect indicator of functional muscle mass and muscle strength [11], as well as a muscle fitness index, expressing both the quantity and quality of soft tissue [12], and is being a strong predictor of total skeletal muscle participation and limb muscle mass [13]. For example, Hetherington-Rauth et al. [11] observed that regional measures of lower limb PhA explained a similar variation in muscle power compared to whole body (WB) PhA in athletes from different sports. Factors such as age, body mass index, and sex are primary determinants of PhA [14, 15], with values in healthy individuals varying from 5º to 7.5º [9, 14, 16, 17], while in trained athletes values can reach 8.5º [9, 18].

In addition, scientific evidence has shown a relationship between PhA and upper limb (handgrip strength- HGS) and lower limb strength tests (Squat jump- SJ, and countermovement jump test- CMJ) [19, 20, 21, 22]. There seems to be a consensus that PhA can be used to monitor physical condition and sports performance in adolescent athletes, and could be crucial to assess body composition in athletes, providing useful data on percentage of body cell mass and fat free mass [23].

Moreover, Koury et al. [24] verified the association of body composition, skeletal maturity and zinc biochemical indexes with PhA and BIA parameters, in 40 male adolescent soccer athletes (13.4±0.6 years), since PhA values was significantly higher in adolescents classified by bone age as "Early" (6.8±0.9°) compared to "Late" (5.7º±0.5).

However, it still seems uncertain to what level the PhA differs between several sports, and while the results are promising, large cross-sectional studies and, possibly, longitudinal studies are needed to confirm that the current use of BIA is valuable in assessing muscle quality, and in evaluating differences due to gender, training volume, and playing position, among others [18].

As far as we know, no studies have verified the viability to discriminate young team invasion sports participation accordingly to their PhA.

In view of the existence of similar particularities between the practice of team invasion sports and the information above, the aim of the present study intended to verify which team invasion sport (i.e., Basketball, Football, Futsal, Handball and Rugby) presents a greater probability to obtain a higher PhA value, considering the age, time of practice (t), vertical jump tests (SJ and CMJ) and handgrip strength (HGS) of young athletes. We hypothesized that sports with more contact could be more likely to obtain higher PhA value than those with less physical contact.

## II. METHODS

### A. Study design

A cross-sectional observational study design was adopted to perform full body BIA and vertical jump tests (i.e., SJ and CMJ) and handgrip strength tests (HGS) in athletes practicing team invasion sports (i.e., Basketball, Soccer, Futsal, Handball, and Rugby). Assessments were carried out during the season phase of the Paraná Youth Games, particularly during September of 2019. Athletes underwent full-body BIA analysis (in a fasted state for 4 hours) for PhA verification, in addition to motor testing of SJ, CMJ, and HGS (on both hands: Left and Right).

### B. Participants

Two hundred and forty-eight Brazilian adolescent athletes (male = 152, 16.8±1.0 years; female = 96, 16.2±1.2 years) were recruited to participate in this study. Of these athletes, 28 practice Basketball (male = 15; female = 13), 14 Soccer (male = 14), 64 Futsal (male = 54; female = 10), 127 Handball (male = 60; female = 67), and 15 Rugby (male = 9; female = 6).

We performed the sample calculation using G*Power, version 3.1.9.7 (Dusseldorf, Germany), considering Z tests, suitable for calculating the effect size within a logistic regression model, was used to calculate sample size and a minimum of 221 players were required (α = 0.05 and β = 0.95), which resulted in the appropriate sample size for carrying out this study [25]. The sample characteristics, organized by sport and sex, are presented in Table 1.

**Table 1. Mean (± SD) values obtained from the athletes (n) by sport, sex (male- M; female- F), age (y), weight (W; Kg), height (H; cm), body mass Index (BMI; Kg/m2), and time of practice per years (t; years).**

| | Basketball | | Soccer | | Futsal | | Handball | | Rugby | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sex** | **M** | **F** | **M** | **F** | **M** | **F** | **M** | **F** | **M** | **F** |
| **n** | 15 | 13 | 14 | - | 54 | 10 | 60 | 67 | 9 | 6 |
| **Age** | 16.7±1.1 | 16.4±1.4 | 16.6±1.2 | - | 17.3±0.9 | 16.7±0.8 | 16.5±0.9 | 16.2±1.2 | 16.9±0.8 | 15.2±1.5 |
| **W** | 77.9±10.2 | 69.7±16 | 66.2±8.5 | - | 70.3±9.1 | 57.7±8.2 | 72.9±10.1 | 63.1±9.6 | 79.5±15.1 | 55.5±5.9 |
| **H** | 180±1 | 170±1 | 170±1 | - | 170±1 | 160±0 | 180±1 | 170±1 | 180±1 | 160±1 |
| **BMI** | 23.5±2. | 24.1±3 | 22.3±2 | - | 23.5±2 | 23.7±3 | 23.4±2. | 23.0±3. | 25.6±3. | 23.1±2. |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | .5 | .2 | | .7 | .4 | 9 | 3 | 6 | 2 |
| **t** | 4.4±2.7 | 5.6±2.2 | 8.3±2.6 | - | 9.6±2.2 | 7.1±1.9 | 5.1±2.3 | 5.3±1.9 | 3.0±2.4 | 2.2±2.4 |

**C. Inclusion and Exclusion Criteria**

Inclusion criteria were: (i) athletes who participated in all tests and (ii) being an active participant in the included competition. The exclusion criteria were: (i) refusal to participate in data collection; (ii) non-authorization of parents or guardians; and (iii) any physical problem that temporarily or permanently prevented the athlete from carrying out any of the measures.

After being fully informed about the experimental procedures, aims, and potential risks of the study, all participants and their parents/guardians provided written consent prior to starting the study. As there were a large number of athletes under the age of 18y, this term was signed by the coach responsible for the team. According to the Declaration of Helsinki, the study was approved by the Ethics Committee of the lead institution (protocol number S2121). We also received authorization through a consent form from the institution that is responsible for organizing the event, allowing the collection of data.

The tests were carried out in the following order, so that the effort of a test did not influence the result of the next assessment: 1) Brief questionnaire; 2) Weight and height; 3) BIA; 4) Manual grip on the dynamometer; 5) Vertical Jump.

**D. Testing Procedures**

**1) Body composition and Bioelectrical Impedance analysis:**

Before performing the BIA and body composition test, height and body mass were recorded to the nearest 0.1 cm and 0.1 kg, respectively, using a stadiometer (Cardiomed Model Avanutri, Ref. 5130332, Rio de Janeiro, Brazil) and a high-precision digital scale (Cristal Seven Plenna, Ref. SIM00530, São Paulo, Brazil), respectively.

For body composition, WB BIA parameters of R, Xc, PhA, fat mass, lean mass, intra- and extracellular mass, total body water, intra- and extracellular water, and basal energy metabolism were obtained using a BIA (Biodynamics model 450, version 5.1, BiodynamicsR, Corp. Seattle, WA, USA) and Resting Tab ECG electrodes (Conmed R Corporation, Utica, NY, USA). This device provided the all the body parameters through the flow of an alternating current of low frequency and high voltage (800 mA and 50 kHz) and the accuracy was 0.1% in R, 0.2% in Xc and 0.2% in PhA.

The athletes were positioned in a comfortable supine position, without the use of metal objects (e.g., watches, bracelets, and earrings), without shoes, with the legs open at 45º in relation to the midline of the body and with the upper limbs positioned at 30º from the trunk. After cleaning the skin with pads soaked in alcohol, four adhesive electrodes were positioned in the recommended locations, namely: one electrode on the dorsal surface of the right wrist, one on the third metacarpal, one on the anterior surface of the right ankle between the prominent portions of the bones, and the last electrode on the dorsal surface of the third metatarsal. In order to minimize possible interference in the results, some recommendations were followed, such as: not drinking alcoholic beverages and diuretics and fasting for at least four hours.

The device allows the inclusion of information on age, sex, height, weight of the individual, and weekly training hours, and provides results in less than 1 min.

**2) Handgrip Strength:**

In the handgrip strength test (HGS), the athlete sat on a chair, holding a North Coast Medical dynamometer (Precision Instruments, Morgan Hill, California, USA), with their elbows at 90º. The power grip involved holding the object between partially flexed fingers, as opposed to the counterpressure generated by the palm, the thenar eminence, and distal segment of the thumb [26]. Each athlete performed three attempts with the right hand (HGSr) and 3 attempts with the left hand (HGSl), alternately, with the greatest possible force, and the highest value in kg/f was recorded.

**3) Vertical Jump Tests:**

For the vertical jump tests, the SJ and CMJ were used [27] and the system for measuring and analyzing vertical jumps through opto-electronic sensors from the Sys Jump brand (Sys Jump, Systware, Miami, USA). Starting from half-flexion of the knees, the SJ involved the athlete remaining on the jumping area, in the position of half squat, with hands resting on the waist and knees at a 90º, for at least 5 seconds. The evaluator then gave a verbal signal for the athlete to perform the jump as high as possible without removing their hands from the waist, and without retracting the feet or throwing them forward. In the CMJ, the athlete was positioned on the jumping area in a standing position, hands resting on the waist and legs extended. After the evaluator's verbal command, the athlete performed a quick squat and then a jumped as high as possible, without removing their hands from their waist, and without retracting the feet or throwing them forward. Three attempts were performed at both vertical jump tests, with a five-second interval between them, and the best result was recorded in cm.

**4) Statistical Procedures:**

The distribution of data sets was analyzed using Kolmogorov-Smirnov tests. A Spearman correlation (r) analysis was performed, subsequently those variables who will show a significant correlation with PhA a binary logistic regression analysis [28] was used to verify the probabilities of an athlete practicing a team invasion sport reaching a PhA value greater than the median of all the sample. Instead of using the mean PhA value, we used the median value as cut-off point to avoid the influence of possible outliers. Furthermore, and in accordance with the proposed aims, an adjusted logistic model was defined by the equation below:

$$P(Af = 1 | m_a, s_b, age, t, sj, cmj, hgsr, hgsl) = \frac{e^{\beta_0 + \beta_1 m_a + \beta_2 s_b + \beta_3 age + \beta_4 t + \beta_5 sj + \beta_6 cmj + \beta_7 hgsr + \beta_8 hgsl}}{1 + e^{\beta_0 + \beta_1 m_a + \beta_2 s_b + \beta_3 age + \beta_4 t + \beta_5 sj + \beta_6 cmj + \beta_7 hgsr + \beta_8 hgsl}} + \varepsilon$$

This model allowed us the interpretation of the probability of an individual presenting a PhA equal to or greater than the median value, based on the specifications for each covariate, represented respectively by ma (a=1,....,5), as a categorical variable, which sequentially indexes the sports: Basketball (a=1), Soccer (a=2), Futsal (a=3), Handball (a=4), and Rugby (a=5). The sex variable was defined by s=1 (male) and s=2 (female).

The other covariables follow continuous and discrete values, mentioning age, t, SJ, CMJ, HGSr, and HGSl. Finally, the term ε represents the random error on a continuous scale. For each term of the model, the parameter $\beta 0$ corresponding to the intercept was associated to give numerical restrictions. The first level of each factor of the categorical variables m and s are confounded and $\beta$u (u=1, ...,8) represents the parameters associated with the other covariates.

Validation of the goodness of fit of this model was determined using the simulated envelope technique, whose graph represents the quantiles obtained as a function of the deviation components and associated with a normal distribution. Thus, with the imposition of confidence bands, this adjustment was considered adequate, as the quantiles were in a position within the margins obtained through the simulation [29]. The collected information was organized and analyzed in a database in "R" statistics software. The alpha level for significance was set at $p < 0.05$.

## III. RESULTS

The data obtained for the PhA and all other variables used in our research are presented in Table 2.

It was observed a similar PhA values of Basketball (M = 8.1º±0.8; F = 7.2º±0.6); Soccer (M = 8.1º±0.8); Futsal (M = 8.3º±1.2; F = 6.8º±0.4); Handball (M = 8.1º±0.6; F = 7.2º±0.6) and Rugby players (M = 7.7º±0.4; F = 7.4º±0.6).

**Table 2. Mean (±SD) values obtained from all athletes, organized by sport, sex (male- M; female-F), phase angle (PhA; º), squat jump (SJ; cm), countermovement jump (CMJ; cm), handgrip strength right (HGSr; Kg/f), and handgrip strength left (HGSl; Kg/f).**

| | Basketball | | Soccer | | Futsal | | Handball | | Rugby | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sex** | **M** | **F** | **M** | **F** | **M** | **F** | **M** | **F** | **M** | **F** |
| **n** | 15 | 13 | 14 | - | 54 | 10 | 60 | 67 | 9 | 6 |
| **PhA** | 8.1±0.8 | 7.2±0.6 | 8.1±0.8 | - | 8.3±1.2 | 6.8±0.4 | 8.1±0.6 | 7.2±0.6 | 7.7±0.4 | 7.4±0.6 |
| **SJ** | 39.3±5.4 | 31.7±8.2 | 38.1±6.3 | - | 37.2±6.5 | 29.4±6.2 | 38.9±6.0 | 33.9±7.9 | 35.9±4.3 | 30.0±3.6 |
| **CMJ** | 45.0±6.2 | 33.5±7.3 | 46.2±9.2 | - | 42.8±7.0 | 36.6±9.2 | 45.3±7.2 | 37.1±10.2 | 42.1±7.3 | 33.3±2.7 |
| **HGSr** | 43.6±7.8 | 26.6±5.4 | 36.3±8.9 | - | 34.4±7.1 | 24.5±4.1 | 40.5±9.4 | 28.4±5.4 | 43.1±11.5 | 26.7±4.5 |
| **HGSl** | 39.1±6.5 | 25.1±4.7 | 31.0±7.5 | - | 30.9±6.7 | 23.3±3.9 | 35.8±9.1 | 24.9±5.5 | 41.1±11.8 | 25.7±5.3 |

The age, t, SJ, CMJ, HGSr, and HGSl, showed a significant correlation with PhA, ranging from weak to moderate (r=0.268; r =0.206; r=0.330; r=0.277; r=0.537; r=0.523), respectively (Table 3).

**Table 3. Correlation values obtained between the phase angle (PhA) and age, time of practice (t), SJ, CMJ, HGSr, and HGSl.**
**** The correlation is significant at 0.01.**

| | | Age | t | SJ | CMJ | HGSr | HGSl |
|---|---|---|---|---|---|---|---|
| **PhA** | R | 268** | 206** | 330** | 277** | 537** | 523** |
| | p | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |

The median PhA value stablished as the cut-off point was 7.7º (Table 4). Additionally, it was established the value of 1 (which represents success) to athletes who obtained PhA values equal to or greater than 7.7º, and value of 0 (which represents failure) to those who obtained PhA values lower than the median.

**Table 4. Values of central tendency values obtained of the phase angle (PhA).**

| Statistical Variables | Value |
|---|---|
| Mean | 7.8 |
| Standard deviation | 0.9 |
| Minimum | 6.0 |
| Maximum | 16.0 |
| Median | 7.7 |
| Mode | 7.5 |

The PhA mean value obtained were 7.8º±0.9, the smallest value measured of PhA was 6.0º and the largest was 16º, the median was 7.7º and the mode 7.5. Moreover, we detected an outlier (PhA value = 16º), which is not very common.

The parameters estimated by the proposed logistic model are presented in Table 5.

All the parameters with a p-value greater than 5% had the same importance in relation to the predictive power of the model. These results did not make the model unfeasible, by the opposite, these results make perfect sense. Given the parameter estimates, it can be seen from the simulated envelope graph (Figure 1) that the quantiles of the normal distribution, considering the deviation component, were within the confidence bands generated by Monte Carlo simulation [29]. Thus, the model proposed provides a predictive power of probabilities considered adequate.

**Table 5. Parameters values estimated by the logistic model and its significance.**

| Parameters | Estimates | p |
|---|---|---|
| **(Intercept) $\beta 0$** | -5.60257 | 0.0371 |
| **$m_2$ ($\beta_{1a=2}$)** | 0.24538 | 0.7899 |
| **$m_3$ ($\beta_{1a=3}$)** | -0.21310 | 0.7564 |
| **$m_4$ ($\beta_{1a=4}$)** | -0.30063 | 0.5774 |
| **$m_5$ ($\beta_{1a=5}$)** | -0.33232 | 0.6988 |
| **$se_1$ ($\beta_{2b=1}$)** | 1.80642 | 0.0004 |
| **age ($\beta_3$)** | 0.10726 | 0.5037 |
| **t ($\beta_4$)** | 0.04147 | 0.5782 |
| **sj ($\beta_5$)** | 0.04780 | 0.1802 |
| **cmj ($\beta_6$)** | -0.03288 | 0.2542 |
| **hgsd ($\beta_7$)** | 0.01380 | 0.7013 |
| **hgsl ($\beta_8$)** | 0.06769 | 0.0823 |

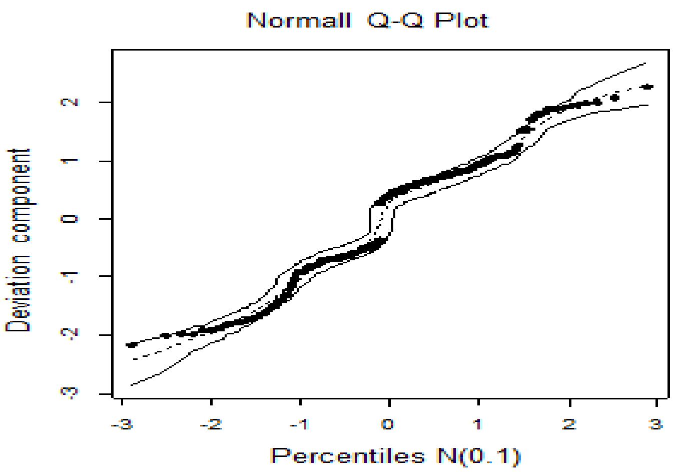


**Figure 1. Simulated envelope to verify the adequacy of the logistic model.**

Moreover, with the probabilities obtained by adjusting the model, the discrimination of the PhA in relation to sports and age of the practitioners are illustrated in Figures 2-6.

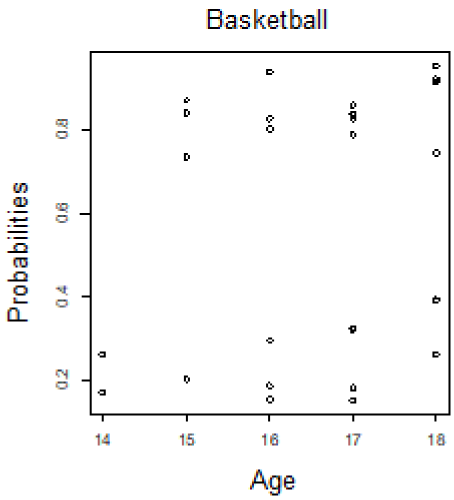


**Figure 2. Representation of the probabilities presented by the PhA values equal to or greater than 7.7º of Basketball players.**

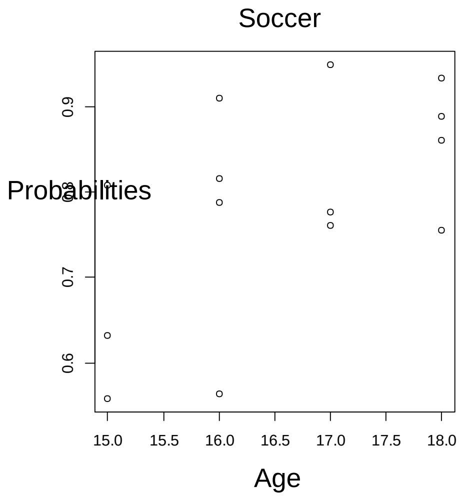


**Figure 3. Representation of the probabilities presented by the PhA values equal to or greater than 7.7º of Soccer players.**

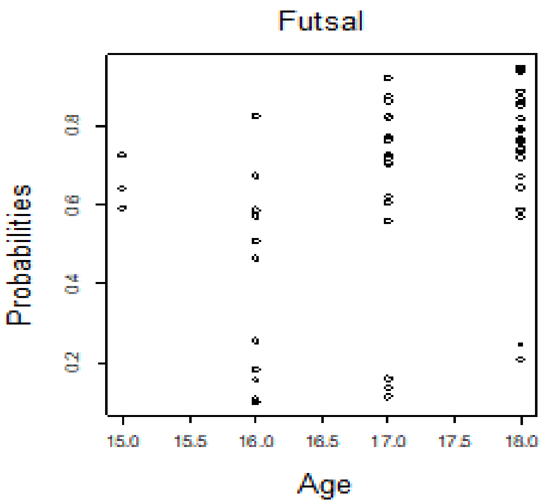


**Figure 4. Representation of the probabilities presented by the PhA values equal to or greater than 7.7º of Futsal players.**

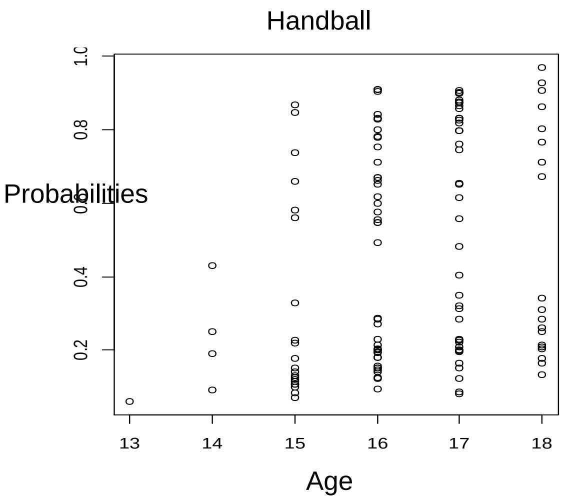


**Figure 5. Representation of the probabilities presented by the PhA values equal to or greater than 7.7º of Handball players.**

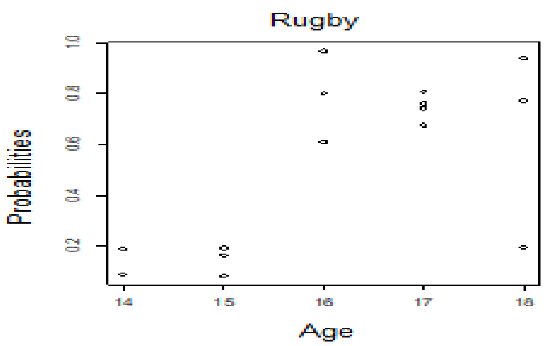


**Figure 6. Representation of the probabilities presented by the PhA values equal to or greater than 7.7º of Rugby players.**

Considering all the variables formulated in our equation of the logistic model, we calculated the exponential referring to each team invasion sport from the values of p (Table 5), where the Intercept parameters $\beta 0$ are confused with Basketball, m2 ($\beta 1a=2$)

represents Soccer, m3 ($\beta$1a=3) Futsal, m4 ($\beta$1a=4) Handball and m5 ($\beta$1a=5) Rugby, aiming verify the odds ratio (i.e., probability) of an athlete obtaining a PhA value higher or lower than the median of the presented study.

**Table 6. Odds Ratio (probability) of an athlete developing a PhA higher than the cut-off point stablished (median = 7.7º).**

| Sport | Exponential (Probability or Odds Ratio) |
|---|---|
| **Basketball (Confused with intercept parameter)** | Could not be calculate |
| **Soccer - $m_2$ ($\beta_{1a=2}$)** | 2.20 |
| **Futsal - $m_3$ ($\beta_{1a=3}$)** | 2.13 |
| **Handball - $m_4$ ($\beta_{1a=4}$)** | 1.78 |
| **Rugby - $m_5$ ($\beta_{1a=5}$)** | 2.01 |

**Sport Exponential (Probability or Odds Ratio)**

The results obtained for the odds ratio of an athlete developing a PhA higher than the cut-off point stablished (7.7º), our findings showed that Soccer, Futsal, Rugby and Handball players had 2.2, 2.13, 2.01, and 1.78 more chances to reach a higher PhA, respectively.

## IV. DISCUSSION

The aim of the present study was to verify which invasion team sport (i.e., Basketball, Soccer, Futsal, Handball and Rugby) presents a greater probability to obtain a higher PhA value, considering the age, time of practice (t), vertical jump tests (SJ and CMJ) and handgrip strength (HGS) of young players. As predicted the athletes who practice sports with more contact obtained higher PhA value than others who practice sports with less physical contact.

Some researchers have invested some efforts to study the PhA of players from several sports, for example Bongiovanni et al. [8] in Soccer, Koury et al. [24] in Basketball, and Cattem et al. [4], Cirillo et al. [9] and Campa et al. [30] in multisports. Moreover, our testing variables were stablished by the results obtained from the relationship confirmed between PhA and CMJ (r = 0.930)[31] and HGS (r = 0.696)[32]. All the PhA values obtained from the studies abovementioned were similar to the present study, which appears that PhA is a reliable measure to assess the strength performance of athletes.

Considering the Basketball modality (Figure 2), it was noted through the probabilities that this sport did not show discrimination in relation to the measured PhA when considering the age range, since the R software used perform a confounding variable between the Intercept parameter and the first categorical variable (in the present study it was Basketball). That is why it was not possible to calculate the odds ratio for Basketball.

According to practice similarities of Soccer and Futsal, our findings showed that Soccer and futsal players presented 2.20 and 2.13 more chances of presenting a PhA above 7.7º, mainly in the age ranges starting from 16 years (Figures 3 and 4). It appears that a subject who becomes a Soccer player has more probability of having a higher PhA value, and a better functional muscle structure.

In fact, we found some studies where young soccer players presented results close to our predetermined PhA cut-off point, particularly PhA mean values of 7.12º±0.7 [33], 7.08º±0.7 [8], and 7.4º±0.6 [34], respectively. In a study with Portuguese male futsal athletes (age = 23.8±5.3 years), participants were divided into tertiles, starting from the level of VO2max, since those with lower VO2max (tertile 1) presented higher absolute (kg) and relative (%) body mass and fat mass than the other groups (tertiles 2 and 3). In addition, the athletes included in tertile 1 had a lower percentage of muscle mass (tertile 1 = 41.6%±6.8; tertile 2 = 43.8%±3.9; tertile 3 = 48.3%±7.5) and PhA (tertile 1 = 6.9º±0.4; tertile 2 = 7.2º±0.4; tertile 3 = 7.5º±0.5) than the tertile 3 group. These findings may also suggest that individuals who practice futsal may have a higher PhA when they have a greater amount of muscle mass (favorable to better performance in SJ, CMJ and HGS) and also a higher VO2max [35].

With respect to the handball modality (Figure 5), it can be seen through the probabilities that this sport does not show a clear discrimination in relation to the PhA measured, when considering the age range. Although it presented a characteristic of relevant physical contact during practice and also high mean values in strength tests (when compared to other modalities), we observed the existence of practitioners throughout the age group with low and high probabilities of occurrence. Thus, handball practitioners have a probability of 1.78 of presenting a PhA higher than the median of the present study. PhA values of 7.5º±0.5 were found for the sample in a study with 19 male handball athletes (age = 16.5±0.6) for the U17 level [36], where the authors suggested sex, chronological age, and selection of an intense routine based on physical training may determine the specificity of BIA properties in handball players.

When considering the rugby modality, it was observed that most players have a probability of 2.01 to generate a PhA greater than 7.7º, mainly for the age group above 16 years, which can be explained by the average results of the strength tests (i.e., SJ, CMJ, and HGS), which are superior to those of the other modalities. In addition, this sport has greater attention to strength training since it is characterized by intense physical contact.

In the study conducted by Campa et al. [30] reference PhA percentiles were created for players from different sports, including team sports (i.e., basketball, soccer, handball, and rugby). The mean PhA value proposed was 7.7º±0.8, and were organized by modalities and percentiles, namely: basketball (50th: 7.6º; 95th: 9.0º), handball (50th: 7.7º; 95th: 9.0º), soccer (50th: 7.6º; 95th: 9.0º), and rugby (50th: 7.6º; 95th: 9.0º). These results may suggest that team invasion players had more chances to develop a higher PhA.

Our findings, strongly suggest that higher PhA values obtained through the logistic regression equation developed will reflect in a better cellular integrity and greater muscle mass, predisposing the athletes to express greater strength during jumping and handgrip tests.

## V. CONCLUSIONS

The present study showed that higher PhA values predisposed the Soccer, Futsal and Rugby players to express greater strength performance during jumping or handgrip tests, mostly explained by the probability of PhA values higher than the cut-off point determined as a function of other variables (i.e., age, time of practice and strength). Therefore, and considering the advantage of using PhA as a marker of a healthy body composition profile, the magnitude of these probabilities to reach PhA higher values of strength performance in young athletes may depend on the sport modality practiced and their exposure to specific training.

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