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Medicine ball throw test predicts arm power in rugby sevens players

Arremesso de medicine ball prediz potência de membro superior em jogadores de rugby sevens

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Abstract – The aim of this study was to develop an upper limb muscle power (PUL) prediction model using the Medicine Ball Throw Test (MBT) in rugby players. Eighteen amateur rugby players underwent the MBT test and the guided bench press exercise at 30, 40, 50 and 60% of 1. Myotest® accelerometer was positioned on the bench press bar to estimate muscle power. Linear regression was used to derive the upper limb muscle power prediction equation from the MBT distance. The residue analysis estimated the residual error of the predicted values using values obtained by Myotest®. Bland-Altman plots were used to verify agreement between actual and predicted upper limb muscle power, both in absolute Watts (W) and relative terms (W/kg of fat-free mass). There were significant correlations between actual and predicted upper limb muscle power (r = 0.834, 0.854, and 0.872) for intensities of 30%, 40% and 50%, respectively. Absolute bias of predicted values was -1.87 W (p <0.05). For muscle power predicted relative to fat-free mass, bias was 0.782 W/kg (p <0.05). Conclusion: The MBT test has high correlation with actual PUL values and it was found that the equation developed in this study has high accuracy to predict PUL in rugby players of both sexes.

Key words: Athletic performance; Muscle strength; Sports.

Resumo – *Objetivou-se verificar a concordância e predição da potência muscular de membros superiores (PMS) a partir da distância do teste de Arremesso de Medicine Ball (AMB) em jogadores de rugby. Participaram do estudo 18 jogadores amadores de rugby (11 homens) os quais realizaram o teste AMB e o exercício de supino reto na barra guiada com acelerômetro Myotest® nas intensidades de 30%, 40%, 50% e 60% de 1RM. A regressão linear foi utilizada para derivar a equação de predição da potência a partir da distância no AMB. A análise de resíduo estimou o erro residual dos valores preditos, utilizando os valores obtidos pelo Myotest® como referência. O método leave-one-out foi adotado para aferir o erro da equação em subconjuntos da amostra. O modelo de Bland-Altman verificou a concordância entre potência predita pelo AMB e valores obtidos do Myotest® de forma absoluta Watts (W) e relativa à massa isenta de gordura (W/kg). Foram encontradas correlações significativas entre os métodos (r=0,834, 0872 e 0,854) para as intensidades de 30%, 40% e 50% de 1RM, respectivamente. O viés de medida na análise absoluta foi de -1,87 W (p<0,05). Na análise relativa, foi verificado o viés de 0,782 W/kg (p<0,05). Pode-se concluir que o teste de AMB possui alta concordância com os valores reais da PMS e também verificou-se que a equação elaborada no estudo possui alta acurácia para predizer a PMS em jogadores de rugby de ambos os sexos.*

Palavras-chave: *Desempenho atlético; Esportes; Força muscular.*

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INTRODUCTION

Rugby is a sport practice on the rise and constitutes the third most practiced sport worldwide[1], and in Brazil, rugby has gained progressive adhesion of participants of both sexes as a result of good results obtained by male and female Brazilian teams in world championships in the last[2] years.

Similarly to other team sports of invasion, rugby requires wide variability of high-intensity motor actions[3]. In addition, the sport requires agility, speed, strength and muscle power, regardless of the position played in the field[4]. Among physical abilities, muscular power stands out as decisive in the performance of motor gestures during a match[5,6], especially in the upper limbs, as 50% of passes are of long distance[7].

In general, the improvement in muscle power is subject to sports training planning, taking into account the individual strength capacity[8]. Thus, the knowledge of training load is a necessary requirement for the development of muscle power [9,11]. Given the fluctuations in the capacity of individual power generation during a rugby championship, it is essential to carry out assessments of muscle power so that the best adjustments of specific training loads are applied[12].

Medicine ball throw (MBT) is the most widely known and indirect test used to evaluate the power of the upper limbs (PUL) in team sports[13,14]. However, the validity of the results provided by MBT to measure PUL in rugby players is unknown. Therefore, the aims of this study were: a) to compare anthropometry, body composition and performance on PUL tests between sexes; b) verify the correlation of MBT testing and the bench press bar with coupled accelerometer (ABS) in obtaining PUL; c) to elaborate equation to predict the power from the MBT test distance of amateur rugby sevens players of both sexes, and d) to verify the correlation between power predicted by the equation generated and power of the accelerometer.

METHODOLOGICAL PROCEDURES

Sample selection

Thirty-four amateur rugby sevens players were invited to participate in this study. Inclusion criteria were: time of practice more than eight months; absence of musculoskeletal injuries; do not use ergogenic resources and / or thermogenic foods. The non-participation in all evaluations and tests was considered an exclusion criterion. Eighteen players participated in the study (11 men and 7 women). Participants were informed of the methodological procedures and signed the free and informed consent form to participate. The study was approved by the Ethics Research Committee of the Federal University of Triangulo Mineiro (protocol No. 2382/2012).

Measurements

Height, total body mass, perimeters and skin folds were measured. Prior to performing the tests, participants underwent familiarization sessions for

MBT, 1RM and ABS. Tests and evaluations were performed at the same time on day each, respecting 48-hour interval between them. Participants were instructed to keep feeding habits and avoid alcohol intake.

Anthropometry

Height was measured by stadiometer with accuracy of 1 mm (Estadiometer Personal Caprice ES2060 Sanny®, São Paulo, Brazil) and body weight was recorded with calibrated digital scale with accuracy of 0.1 kg (Wiso W939®, Florianopolis, Brazil). A caliper (Lange®, São Paulo, Brazil) was used to measure the skinfold thickness of triceps, suprailiac and thigh for women and triceps, abdomen and thigh for men, according to measurement protocol suggested by the International Society for the Advancement of Kinanthropometry. Body density was calculated using standard equation for men[15] and women[16], and these results were used to calculate body fat percentage using the equation of Siri[17]. Fat-free mass (FFM) was obtained by the difference between total body mass and fat body mass. Participants used the least amount of clothing possible during collections.

1 Repetition Maximum Test (1RM)

To evaluate the maximum strength of the upper limbs of participants and prescribe the external resistance for the ABS test, 1 MR test was performed on bench press guided bar in accordance with standardized protocol[18]. In addition, 2-3 series of warm-up exercises with 5-10 repetitions with approximately 40-60% of the load to be tested in the 1RM test were also performed. Then, all were instructed to perform one maximum repetition. The load was adjusted to ~ 10% for subsequent attempts until participant makes one movement with proper exercise technique. Maximum muscle strength was determined with maximum number of five attempts and intervals of 3-5 minutes of recovery between them.

Medicine Ball Throw Test (MBT)

The procedures adopted for the MBT test followed protocol proposed by Vossen et al.[19]. For the test, the participant remained sat on a bench (with adjustable height) stabilized on the ground with the back supported against the vertical back support with thighs horizontally supported, knees flexed at an angle of 90° and ankles fixed the ground. Participants were affixed to the seat with elastic straps placed around the trunk at the level of the mid chest under the armpit. This position was standardized in all throws to ensure greater stability and minimize movements of the trunk during performance.

For the throw, the three-kilo medicine ball (Dynamax Inc®. Dallas, TX) was positioned at the height of the sternum (A). The throw was held with both hands without movement of the trunk on the support, and if the individual fails to follow the established standards, the attempt was disregarded. The distance of the throw of the medicine ball from point A up to its first contact with the ground (B) was measured. Each participant performed three throws, with five-minute break between them and, for analysis, the best result among attempts was considered.

Throw of the bench press bar with coupled accelerometer (ABS)

PUL was measured by the Myotest® triaxial accelerometer (model S4P, Sion, Switzerland) in the bench press exercise with guided bar according to assessment procedures proposed by Comstock et al.[20]. The device was placed on the bar between the shoulder and thumb of the right hand, and held upright. Myostest measures power through estimated speed variation applied force and torque (concentric phase), considering the movement runtime.

Using 30%, 40%, 50% and 60% of 1RM test, participants performed three consecutive repetitions for each intensity, with passive break of five minutes between each intensity. Participants were instructed to hold the bar about 2-3 cm above the chest level (starting position of the movement) and, after audible signal emitted by the accelerometer, they pushed the bar upward at full speed up to full extension of the elbow.

The largest power value recorded in each of three attempts of each intensity percentage was used to calculate the average power of each participant. The mean power of each participant was calculated considering the absolute power in Watts (W) of the highest peak intensities tested (30% + 40% + 50% + 60% 1RM / 4).

Data analysis

Data normality was checked by the Shapiro-Wilk test. All variables were expressed as mean ± standard deviation. Student's t test for independent samples was used to compare anthropometric variables, strength of 1RM, PUL and MBT distance between sexes. Mixed-model ANOVA with Bonferroni correction for multiple comparisons was employed to verify the effects of PUL (30%, 40%, 50% and 60% 1RM), sex and interaction (PUL * sex). The Pearson test was used to verify the correlation of values between MBT and ABS at different intensities (30%, 40%, 50% and 60%) of 1RM. The correlation (r) was classified as weak (0.10-0.30), moderate (0.40-0.60), strong (0.70 to 0.9) and perfect (1)[21]. Regression linear analysis was performed for deriving the power prediction equation (watts) based on the distance (m) from MBT. The equation was established taking into account the distance obtained in the MBT and sex as independent variables. In order to verify the existence of differences between predicted power and power measured at 30%, 40%, 50% and 60% of 1RM, the residual error was calculated as the average of distances between each predicted value and the line of best fit of the regression. The leave-one-out method was applied to validate the equation[22]. The Bland-Altman analysis was used to verify the agreement between power predicted by the power equation and power measured by Myostest® accelerometer, absolutely and relatively to the total body weight and the fat-free mass, respectively. The calculation of the intraclass correlation coefficient (ICC) was performed to verify the reliability of the equation to predict PUL. Analyses were performed using the GraphPadPrism Software® 6.0 Inc. (California, USA). Significance level of 5% was adopted for all analyses.

RESULTS

Anthropometric characteristics, body composition and performance on PUL tests are shown in Table 1. Women had lower ($p < 0.05$) stature, BW, FFM, 1RM, MBT distance and average PUL compared to men. ANOVA revealed significant main effect of gender [$F_{(1,17)} = 29.83$; $p < 0.001$, effect size = 0.637] and power [$F_{(1,17)} = 5.981$; $p = 0.007$, effect size = 0.260]. PUL at 60% of 1RM was lower compared to 40% and 50% of 1RM, but not in relation to 30% of 1RM. There was no significant difference among PUL at 30%, 40% and 50% of 1RM. There was no interaction effect [$F_{(1,17)}$ = 2.112; $p < 0.139$, effect size = 0.111].

Table 1. Anthropometry, body composition and performance on PUL tests in rugby sevens players according to sex

Variables	Total (n=18) Mean ± SD	Men (n=11) Mean ± SD	Women (n=7) Mean ± SD
Age (years)	23.2 ± 5.4	24.6 ± 6.7	21.3 ± 1.5
Stature (cm)	171.8 ± 9.2	177.9 ± 5.3	*163.4 ± 6.9
BW (kg)	79.4 ± 15.8	88.3 ± 12.7	*67.1 ± 11.4
Σ skinfolds (cm)	146.9 ± 51.4	126.8 ± 44.1	172 ± 56
FFM (kg)	70.21 ± 15.0	76.98 ± 13.9	*59.57 ± 9.7
1RM supine (kg)	69.6 ± 32.4	90.9 ± 25.8	*40.3 ± 7.3
MBT distance (m)	3.8 ± 1.1	4.6 ± 0.8	*2.8 ± 0.5
Average PUL (W)	441.8 ± 273.1	621.3 ± 223.9	*195.0 ± 48.7
	Mean ± MSE	Mean ± SD	Mean ± SD
PUL at 30% 1RM (W)	420.4 ± 47.3[ab]	639.2 ± 259.6	201.6 ± 70.8
PUL at 40% 1RM (W)	432.5 ± 46.2[b]	660.4 ± 256.4	204.7 ± 49
PUL at 50% 1RM (W)	424.2 ± 39.3[b]	648.2 ± 217.4	200.3 ± 48.6
PUL at 60% 1RM (W)	355.3 ± 28.5[a]	537.3 ± 156.7	173.4 ± 40.2
Main effects		ANOVA p-value	
Sex		0.001	
PUL		0.007	
Interaction (PMS*sex)		0.139	

* significant difference (p <0.05) between sexes by Student t test; BW = body weight; FFM = fat free mass; Σ SF = sum of skin folds; MBT = medicine ball throw; PUL = power of the upper limbs; SD = standard deviation; SEM = standard error of the mean; [ab] significant difference after Bonferroni adjustment for multiple comparisons.

There was a positive and strong correlation between PUL at intensities of 30%, 40% and 50% of 1RM and the distance from the MBT (Table 2).

Figure 1 shows the scattering among averages of PUL (30%, 40%, 50%) of 1RM and the distance obtained in the MBT test. Data demonstrate low dispersion of values in the fit line, showing strong correlation ($r = 0.881$) among variables analyzed.

Table 2. Correlation between distance of the medicine ball throw and power in the bench press bar with coupled accelerometer with different intensities of 1RM

Variables	Power at 30% 1RM	Power at 40% 1RM	Power at 50% 1RM
Throw distance MB	0.834*	0.872*	0.854*
Power at 30% 1RM		0.970*	0.982*
Power at 40% 1RM			0.972*

Pearson correlation test: RM = repetition maximum; MB = medicine ball; * (P <0.01).

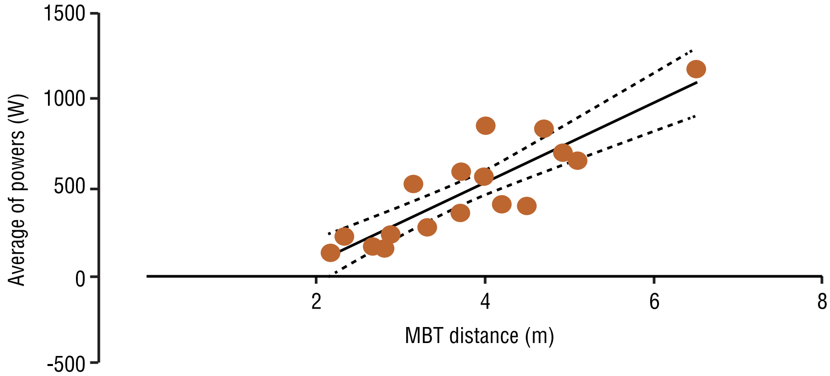

Figure 1. Linear regression of the average of powers and medicine ball throw.
Linear regression test: MBT = medicine ball throw; r = 0.881; r^2 = 0.776 (p <0.01).

The following equation proposes predicting PUL based on the MBT distance and sex:

$$PUL\ (watts) = -17{,}897 + (182{,}025 * AMD) + (1134{,}563 * sex)$$

Where: PUL = power of the upper limbs; AMD = medicine ball throw distance in meters; Sex, male = 1; female = 2

There was no difference between averages of powers obtained by the Myostest® accelerometer and power predicted by the equation (p <0.05).

The residue analysis was applied among values of powers at 30%, 40% and 50% of 1RM and the average value predicted by the equation. The results demonstrate that the average distance of various points analyzed and fit line based on the residual error are low (p <0.01) (Figure 2).

The Bland-Altman concerning the analysis of power produced in absolute terms of body mass (Figure 3A) and relative to fat-free mass (Figure 3B) between values predicted by the equation and those obtained through Myotest®. The measure bias obtained in relation to the power produced in absolute terms to the total body mass was -0.001 W and the upper and lower limits of agreement (95%) were -256.64 256.64 and W, respectively (Figure 3A). When adjusted to fat-free mass, a bias of 0.06 Watts / kg was observed and the upper and lower limits of agreement (95%) were -3.69 and 3.58 W / kg, respectively (Figure 3B).

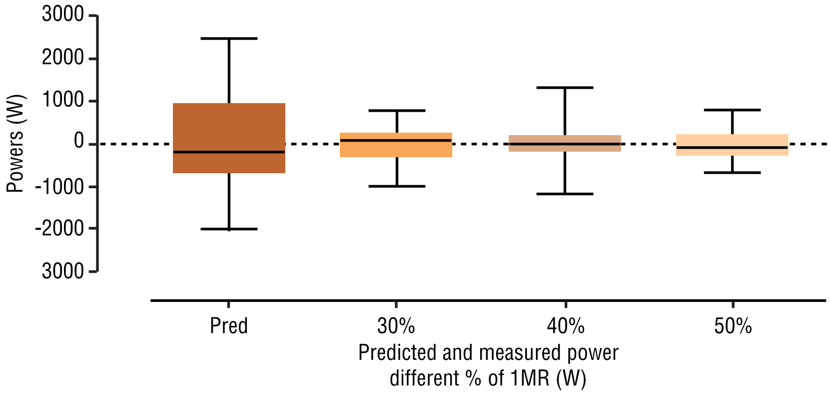

Figure 2. Residue analysis of power values obtained by equation (Pred) and measured at Myostest® in different percentages of 1RM. Pred (r^2 = 0.796); 30% of 1RM (r^2 = 0.983); 40% of 1RM (r^2 = 0.976); 50% of 1RM (r^2 = 0.984); MB = medicine ball; All variables were significant (p <0.01); The predictive model obtained correlations of r = 0.868, r = 0.902, r = 0.885 respectively at intensities of 30%, 40% and 50% of 1RM. The residual error was ± 99.5 W.

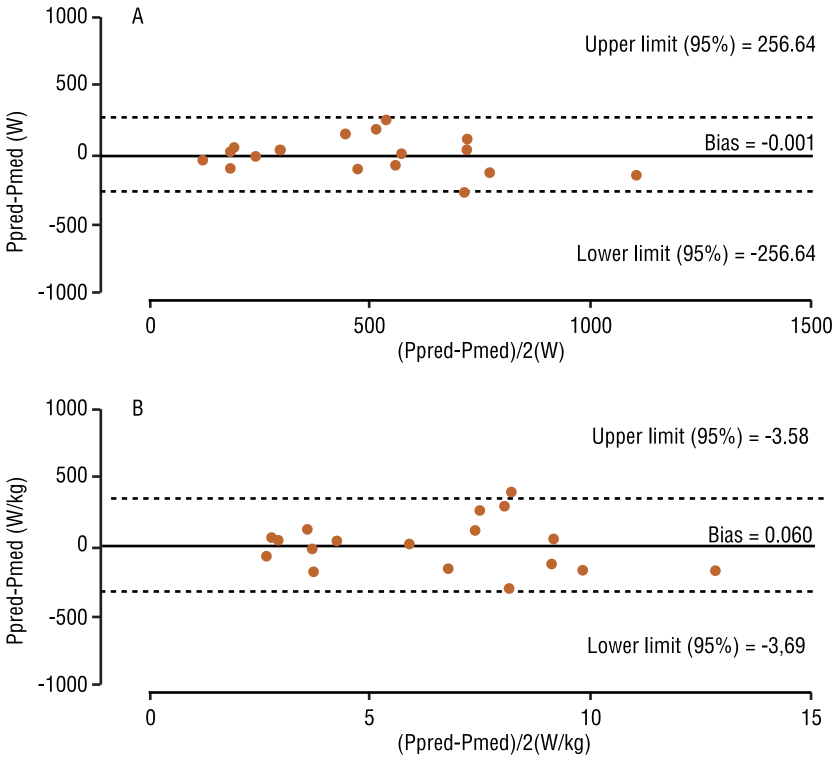

Figure 3. A. Bland-Altman analysis between power predicted by the equation and power of the accelerometer in absolute terms to body weight; B. Bland-Altman test between power predicted by the equation and power of the accelerometer in relative terms to the fat-free mass (W / kg); Ppred: Power predicted by the equation; Pmed: Power measured by the accelerometer; The axis of ordinates denotes overestimated and underestimated values of the prediction and the axis of abscissa refers to the average between Ppred and Pmed values.

In the ICC analysis, it was found that power predicted by equation exhibited high reliability among individuals (ICC: 0.861; p <0.01), calculated based on powers developed at different percentages of 1RM.

DISCUSSION

In this study, the distance (m) in the MBT test showed strong correlation with PUL obtained by accelerometry. In addition, the equation proposed from the distance (m) of the MBT test proved to be useful to quantify absolute and relative power to fat-free mass (W / kg) for both sexes. The MBT test is an efficient tool for coaches of rugby sevens players due to its easy application, accessibility and low cost.

The equation was developed taking into account only the mean PUL value at 30%, 40% and 50% of 1RM, the distance reached in the MBT test and sex. The higher the concentric muscle action speed, the lower the resistance that counteracts the movement and the greater the resistance to be overcome, the lower the speed achieved [23]. Thus, strong players develop more power at higher loads, while faster ones develop more power at lower loads[24]. In this study, the peak power was tested at intensities of 30%, 40%, 50% and 60% of 1RM in order to meet individual differences. Intensity of 60% of 1RM was not used in the development of the equation because it showed the lowest PUL compared to 40 and 50% of 1RM, but not over 30% of 1RM. On the other hand, there was no difference for PUL at intensities of 30%, 40% and 50% of 1RM, which possibly present value closer to the actual maximum power to be used in further analysis. The difference of PUL between sexes justifies the consideration of sex proposal by the equation.

In the study of Cormie et al.[10] conducted with trained athletes, it was observed that loads ranging from 27% to 42% of 1RM produced major powers in squat jump and squat exercises. The wide range of 1RM intensity reported to obtain the peak power can induce the development of training sessions that do not meet the principle of specificity and thus result in failure to achieve the expected explosive force result. In this sense, we adopted the value of the average of powers of the variable load protocol in order to identify the most accurate corresponding intensity in predicting the highest peak power in rugby sevens players.

The power values estimated by the equation were strongly correlated with powers measures at 30%, 40%, 50% of 1RM measured by Myotest® accelerometer, r = 0.868, r = 0.902, r = 0.885, respectively. Furthermore, there was no difference between power predicted by the equation and the average of measured powers, i.e., the equation seems to be valid for quantifying the power from the MBT distance, regardless of intensity (load) applied in the test (30 %, 40% and / or 50% of 1RM). The residual error obtained by the root mean square error (RMSE) was only ± 99.5 watts compared the average value of measured powers, namely the elaborate equation has low estimates of underestimating or overestimating the real PUL values of rugby sevens players.

Forwards are characterized by the production of sharp force and higher body topography in relation to backs, who are players of high aerobic capacity and low body fat percentage[25-27]. In addition to the body weight difference among positions, there is a difference in body composition between sexes; additionally, fat-free mass has higher correlation with power, since force is more correlated to fat-free mass than to total body mass[28].

However, both the prediction of power in absolute terms to body mass as the equation adjusted for fat-free mass (W / kg), it was possible to identify good agreement to the direct test and also low errors in the estimation of PUL using accelerometer (absolute bias: -0.001 W; relative bias: 0.06 W). There was no significant difference between absolute and relative prediction because sex differences were considered in the equation itself.

Previous studies have described equations for power prediction[29,30], especially for lower limbs. Harman et al.[29] developed lower limb prediction equation (MMII) from the height reached by vertical jump vs. values obtained by the jump test on the force platform as a reference. Lara et al.[30] developed the equation for predicting power of the lower limbs using the same methodology, comparing with results with other equations and concluded that the developed equation was more efficient for predicting power of lower limbs in the research sample. Although this study has adopted similar methodology for power prediction, the comparability of results is limited, since both studies mentioned above used MMII as target muscles, while this study used upper limbs.

To our knowledge, this is the first study to propose predictive equation of PUL for rugby sevens players. Therefore, the leave-one-out method (cross-validation) was use to verify the accuracy and precision of the model developed. Adopting this cross validation method, the equation proposed is less likely to show discrepant actual power values.

This study has some limitations. First, the lack of standardization of the angle of evaluated limbs during indirect MBT test may have influenced the distance achieved by the medicine-ball; however, although MBT test does not adopt a standard regarding the angle of elbows, we adopted the throw of the medicine ball in front of the sternum, and in the case of non-compliance, the attempt was rejected. Second, sample size is relatively low, which can reduce the statistical power of results; however, the number of participants of each sex in this sample is the reality a rugby sevens team. Moreover, this study adds to rugby a simple and inexpensive tool which uses the MBT distance test for accurate prediction of PUL. Using this equation will enable monitoring the PUL development throughout the season in order to allow adjustments of the team or individual training. Although the MBT test is widely used to predict PUL, future studies should be focused on the validation of equations from tests that simulate specific motor actions of the sport, for example, a medicine-ball throw test in simulation to lateral pass.

CONCLUSION

Male rugby players have higher power compared to women in all tested intensities. The MBT test shows strong correlation with the criterion measure, as well as the developed equation can be used to predict PUL in rugby sevens players of both sexes, regardless of intensity (30%, 40%, 50% of 1RM).

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