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point of view

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Using the medicine ball throw test to predict upper limb muscle power: validity evidence

Teste do arremesso de bola medicinal para predizer potência muscular de membros superiores: evidências de validade

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Abstract – Muscle power is the product of muscle force and velocity, which translates into the ability to produce force in a short time interval. Periodic evaluations of strength and power, coupled with training strategies for these capacities, are of great value to athletes and multi-sports coaches, since they are key determinants for team success. Specifically, in rugby, where passing is a predominant and determinant element of sporting success, few field tests are available for assessing upper limb muscle power. The purpose of this point of view is to correct the upper limb power prediction equation previously published by our group and to highlight its concepts and applicability in sports, especially in rugby.

Key words: Athletic performance; Sports; Muscle strength; Reproducibility of results.

Resumo – *Potência muscular é o produto entre força e velocidade, que se traduz na capacidade de produzir força em um curto intervalo de tempo. Avaliações periódicas de força e potência, combinadas a estratégias de treinamento para essas capacidades, são de grande valor para atletas e treinadores multi-esportivos, pois são determinantes para o sucesso da equipe. Especificamente no rugby, onde o passe é elemento predominante e determinante do sucesso esportivo, poucos testes de campo estão disponíveis para avaliar força muscular de membro superior. O objetivo deste ponto de vista é corrigir a equação de predição de potência do membro superior previamente publicada pelo nosso grupo e destacar seus conceitos e aplicabilidade nos esportes, especialmente no rugby.*

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

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INTRODUCTION

Sport coaches are usually interested in increasing and optimizing the performance of their athletes using precise and efficient strategies. In high performance sports, strength and power represent essential physical abilities and are determinants for team success in various modalities, such as track and field, combat sports, American football, basketball, rugby, among others. The generation of muscle power, independent of the sport modality, is important for different sports gestures, like sprints, changes of direction, kicks, blows, launches, jumps and passes.

In rugby, as in other contact sports, athletes need to perform a variety of high intensity motor actions[1]. Thus, muscle power stands out as the primary physical capacity in motor gestures during a rugby game[2]. Although many studies focus on strategies for increasing lower limb muscle power[3], we highlight the need to specifically optimize muscle power of upper limbs (PUL) in rugby. Rugby players on average perform 106 passes per game[4], up to 50% of which are long distance[5] with the objective of, at a given moment, create numerical advantage in the attack[2].

The development and maintenance of muscular strength is fundamental during the sports season[6]. Thus, its periodic evaluation is necessary for the prescription of optimal loads for training muscle power[3,6,7]. The training planning for high-performance athletes should consider that the development of muscle power lies on the application of force at high speeds and that, for most sports, what really matters is not the maximum strength, but rather the rate of force development applied within the sporting gesture. The lack of resources for the acquisition of devices and inertial sensors for power evaluation and identification of optimal loads constitutes one of the main limitations in amateur teams[8].

Recently, we proposed a low-cost strategy for indirect determination of PUL in rugby athletes[9]. More specifically, we developed and validated a regression equation for predicting PUL in rugby athletes from the medicine ball throw test (MBT). This equation has great applicability in the sporting context, as it may serve to monitor training progress in rugby, as well as in other modalities in which PUL is preponderant. However, in the original article[9], the predictive equation was published with errors, precluding the accurate prediction of PUL based on MBT. In this Point of View, we would like to reinforce the validation process of our predictive model and to carry out the correction of our previously published equation.

VALIDITY EVIDENCE AND CORRECTION OF THE PREDICTION EQUATION

In novice athletes, strength training results in the increased ability to produce force by improving the relation of activation and inhibition of agonist and antagonist muscles. On the other hand, in experienced athletes, strength training alone may be insufficient to improve muscle power, thus demanding more specificity in the training process. Therefore, power training should be as specific as possible regarding the sporting gesture. The working muscles must be the same as those used in the sport modality, and even the resistance of the exercise must resemble that of the motor action of interest[10], optimizing the skill transfer to the actual sport.

Considering all theoretical conclusions, we verified the agreement and prediction of PUL from the distance in the MBT in rugby players[9]. The experimental design included the following steps: 1) measurement of maximum strength (1RM) in the bench press (horizontal push); 2) MBT performed after 48h of the bench press; and 3) Direct PUL measurement using a Myotest® triaxial accelerometer (model S4P, Sion, Switzerland) coupled to a guided barbell during the bench press exercise, which was performed 48h post MBT. Loads corresponding to 30%, 40%, 50% and 60% of the 1RM test were used for the PUL test. Each participant performed three consecutive repetitions for each intensity. All protocols were based on tests validated in the literature.

The initial results indicated a positive and strong correlation between PUL at 30%, 40% and 50% of 1RM and the distance in the MBT. This allowed us to develop a regression equation to predict PUL from MBT. The intensity of 60% of 1RM presented lower PUL value in relation to 40% and 50% of 1RM, yet no difference in relation to 30% of 1RM. On the other hand, there were no differences between PUL when using 30%, 40% and 50% of 1RM, which possibly denotes that real maximum power was achieved between 30-50% of 1RM in our sample. In our study, we also observed that sex (male or female) was related to differences in MBT distance. Thus, this variable was also considered a predictor variable for PUL.

Based on the abovementioned observations, we used a linear regression to verify the associations of MBT, sex, and PUL ($r^2 = 0.776$, $p < 0.01$). This allowed us to develop a PUL prediction equation, which uses MBT distance and sex as predicting variables. This equation was applied to MBT distance from all participants and their predicted PUL values were compared with the criterion test (Myotest). This comparison indicated no significant differences between PUL measured by the Myostest accelerometer and PUL predicted by our equation ($p < 0.05$). To verify the dispersion of predicted values, a residual analysis was performed, which verified a residual error of approximately ± 99.5 W. The Bland-Altman method was then used to identify the prediction bias (-0.001 W) with its corresponding upper and lower limits of agreement (256.64 and -256.64 W, respectively, at 95% CI). The Bland-Altman was also applied to verify prediction bias when PUL values were adjusted for fat free mass. In this case, prediction bias for PUL was 0.06 W/kg of lean mass, with upper and lower limits of agreement (95%) of 3.58 and -3.69 W/kg of lean mass.

We observed low bias in the application of the equation by sex, absolute mass and fat free mass adjustments. For reliability testing, an inter-class coefficent (ICC) test was also performed. The ICC test indicated that PUL predicted by the equation presented high reliability among individuals

(CCI: 0.861; $p < 0.01$) for power in the different percentages of 1RM. It is important to highlight that we used the leave-one-out method to verify the model performance in terms of accuracy and precision. By adopting this method of cross validation, the accuracy of the proposed equation is tested in a theoretically independent sample, making it possible to estimate the true performance of the equation.

We have recently observed that researchers and scholars have begun to use our PUL prediction equation. Some of these researchers have reported that the PUL values predicted by our equation were much higher than what would be expected. We, therefore, rechecked the equation[9] and verified that the latter was published with some errors in its second and third terms (see below). These errors render PUL values that are not feasible. Therefore, we would like to take this opportunity to make the appropriate corrections. Below we present the previously published[9] incorrect equation and the corrected version.

Incorrect equation published in Leite et al.[9]

PUL (Watts) = -17.897+ (182.025 * MBT) + (1134.563 * sex)

Correct equation:

PUL (Watts) = -17.897+ (182.055 * MBT) + (- 134.563 * sex)

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

We hope that this corrected equation can serve as a tool for assessing PUL in male and female rugby players as well as in other modalities in which PUL is key to high levels of sport performance. In this sense, the equation has high feasibility for field use by coaches and physical trainers for determinations of PUL of their athletes.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – University Federal do Triângulo Mineiro and the protocol (no. 2382/2012) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: MAFJL and ELM Performed the experiments: MAFJL and ELM. Analyzed the data: MAFJL; JES; CLML; HRZ; GRM and ELM. Contributed reagents/materials/analysis tools: MAFJL; JES; CLML; HRZ; GRM and ELM. Wrote the paper: MAFJL; JES; CLML; HRZ; GRM and ELM.

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