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A new peak-power estimation equations in 12 to 14 years-old soccer players

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Abstract

The aim of this study was to develop an age and soccer-specific regression equation to estimate the peak power of children aged 12–14 from the height of their vertical jumps using a large sample (n = 188). This study included 188 male soccer players (age, 12.6 ± 0.55; height, 153.31 ± 8.38 cm; and body weight, 43.65 ± 7.58 kg). Their actual peak power values obtained from vertical jumps were recorded using a force platform. The body weights of the participants were measured using Tanita. A regression model was developed using body weight and vertical jump values. All data were analyzed with the IBM SPSS (version 21) statistical analysis program. A multiple linear regression model was used to generate the best estimation of peak power. In this regression model, Power = −1714,116 + [(47.788 * body weight (kg)] + [(58,976 * Countermovement jump height (cm)]. Actual peak power is highly predictable for 12–14-year-old football players. In line with the new model, the actual peak power values obtained in this study were close to the estimated peak power values obtained with the Tufano formula. This may be because of the larger sample size and the same branch used for both equation models.

Abbreviations: BFP = body fat percentage, BMI = body mass index, BW = body weight, CMJ = countermovement jump, LBM = lean body mass, VJH = vertical jump height, W = watts.

Keywords: force platform, peak power, power prediction, soccer, vertical jump

1. Introduction

Football is one of the most popular games in the world, played in 196 countries. This popularity makes football an activity for all ages.[1] Football requires technical, tactical and physical skills, as well as high-intensity maximal repetitive movements.[2,3] In many sports, including football, the ability to generate power is a key element of success.[4,5] Anaerobic muscle strength, or explosive power, is an important component of different motor tasks, sports activities or physical performance.[6] Muscle strength is positively correlated with athletic performance parameters that require explosive movement, such as maximal running speed and jumping.[7–9] Lower body strength plays an important role in a footballer's performance on the field.[10] In many studies, lower body strength has been found to be associated with speed performance and the speed of change of direction.[11,12] Therefore, improving strength is a top priority for many athletic-performance coaches.[13] The evaluation of muscle strength and power is important in many sports areas.[14] Several methods have been developed to measure power. Force platforms are commonly used to assess power in laboratory environments, and methods that involve their use provide a precise and direct measurement of power.[7,15] However, various jump tests are also used, especially in the assessment of power. Given all this, there is a need for a more practical method that coaches and sports clubs can use.

Several equations have been developed, in the literature, for estimating average and peak power using jump height and body weight via various methods.[7,16,17] However, there are methodological differences in the development of these equations. In studies employing peak-power prediction equations, separate jump tests were used to determine vertical jump height and peak power, rather than using values derived from the same test.[18,19] In these studies, the jump height was measured using the Sargent jump test, while peak power was determined using a force platform.[18,19] The use of the Sargent jump test to determine the height of a jump is a problematic method in itself, as it is more likely to interfere with the jump technique than a jump test carried out using a force platform.[7] Sayers et al's[19] study involved a heterogeneous group of male and female participants from various athletic backgrounds; since there are differences in coordination between the sexes and between athlete and non-athlete groups in terms of jump technique,[20–23] the study of a more homogeneous group would be necessary to fully confirm their equations. Canavan and Vescovi, (2004)[7] specifically stated that countermovement jumps (CMJs) should be used when evaluating athletes; however, they used the squat jump method. Harman et al[18] reported that the prediction equation obtained using CMJs gave more accurate results than the prediction

Editor: Mohammed Nader Shalaby.

The authors have no funding to disclose.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the present study are available from the corresponding author on reasonable request. All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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How to cite this article: Gülü M, Akalan C. A new peak-power estimation equations in 12 to 14 years-old soccer players. Medicine 2021;100:39(e27383).

Received: 25 June 2021 / Received in final form: 10 September 2021 / Accepted: 11 September 2021

http://dx.doi.org/10.1097/MD.0000000000027383

equation obtained using squat jumps. Sayers et al[19] reported that these factors may contribute to the variability of regression models, which, in turn, increase the accuracy of peak-power estimates.

Either performance levels or normative reference data are required to assess performance variables in a population. There are normative data for vertical jump and leg power for adolescents and adults.[24] Most of the models previously developed by means of the vertical leap have been based on college-age or young individuals.[7,25,26] However, there is no equation that can be used to predict leg power in 12 to 14-year-old male soccer players. The aim of this study is to develop an age- and football-specific regression equation to estimate peak power from the vertical jump height of children playing football at the ages of 12–14 using a large sample (n = 188).

2. Methods

2.1. Participants and procedure

This study was designed as a cross-sectional study with the aim of developing a new equation for predicting muscle strength from vertical jumps in 12–14-year-old soccer players. The sample group consisted of 188 soccer players aged 12–14 who had played licensed football in football clubs for at least 1 year. The sample number of the study was determined according to the results of the power analysis.[27] The criterium for inclusion in the study was that the participant had not suffered any injuries in the previous six months. The jump technique was shown to each participant and a standard warm-up consisting of jumping and stretching was performed. Each participant performed a maximum of 3 CMJs, each followed by 1 min breaks. A peak-power estimation model was developed using real peak muscle power, which we obtained from 188 soccer players using the hand-on-hip CMJ and free-arm CMJ jumping techniques performed on a force platform, along with measurements of body weight and vertical jump height. The research was developed based on the ethical standards and was approved with the decision of No. 09 702 19 by the Ankara University Faculty of Medicine Ethics Committee in accordance with the Declaration of Helsinki.

2.2. Height measurement

To determine their height (H), the participant was asked to stand barefoot and upright, with their feet held close together at the heels and their eyes looking forward; the highest point of the head was measured, with an accuracy of 1 mm, while the participant held their breath after a deep inspiration. The measurement was taken with a Seca stadiometer (Seca, 213, Hamburg Germany), in cm.

2.3. Body weight measurement

Body weight and body composition measurements were determined by a Tanita (Tanita, USA) analyzer. After we entered the information about the participant such as age, gender, and physical activity level into the Tanita system, the participant was asked to stand on the platform barefooted and wearing only shorts. The data entered into the system were displayed on the screen; then, the electrodes were attached to the hands of the participant, and their arms were stretched out to approximately 30° on both sides. The measurements were taken for 10 s. The values of body weight (BW), body fat percentage (BFP), lean body mass (LBM), and body mass index (BMI) of all participants were recorded.

2.4. Peak muscle strength and jump height measurement

Using an Accupower 2.0 portable force platform system (Accupower 2.0, USA), muscle strength (in watts (W)) and vertical jump height (VJH) (in centimeters (cm)) were measured during the vertical jumps. The measurement frequency of the device was set to 500 Hz. The jumping protocol was explained to all participants in a standardized manner. It was stated, to each participant, that that they should jump freely, keeping their hands on their hips during the jump. After hearing a sound from the computer, participants were asked to start a downward movement and to immediately jump as high as possible. Participants were informed that both feet should be on the platform, and after the experiment, they were told to wait motionless on the platform until the computer beeped. Each participant performed 3 trial jumps. The best values were used for analysis.

2.5. Countermovement jump

Two different jumping techniques were used in the measurements. In the hand-on-hip countermovement jumps, the participants made a steady movement with the hip region without waving their arms to an upright position. A countermovement jump consists of a rapid downward movement, followed by a rapid upward vertical movement—as high as possible. The same method was performed in free-arm CMJs, with the difference being that participants did not have to keep their hands on their hips.

2.6. Statistical analysis

All data were analyzed in the IBM SPSS (version 21) statistical analysis program. Before performing any statistical analysis, the data were examined in terms of normality, homogeneity and missing values in order to assess whether there were any problems in the dataset. In this study, the regression model based on the obtained test results was used in the statistical analysis. To determine the significance of the models, F tests were conducted. As a result of the F tests, it was seen that the models and the variables representing the models were significant. The multiple regression method was used to generate the best estimate of peak power. The accuracy of the regression equations was determined using a correlation coefficient, adjusted R^2 value, and standard error of estimation of peak power between measured and predicted peak power. An alpha level of less than or equal to 0.05 was set for statistical significance.

3. Results

The aim of this study is to develop an age-specific and football branch-specific regression equation to predict the peak power of 12 to 14-year-old soccer players from the vertical jump height, using a large sample (n = 188). Participants were informed about the tests before the measurements. Then, vertical jump heights were determined by means of anthropometric measurements and use of a force platform, as required for our model. Participants were asked to use two different jumping techniques. First, they

Table 1

ANOVA Results of the model.

	Model	Sum of Square	S.D.	Mean square	F	*P*-değeri
1	Regresyon	3,089	2	1544	652,96	.000
	Residual	4375495,49	185	23651,33		
	Total	3,526	187			

Table 3

Regression analysis results of the model.

Estimate	Unstandardized coefficient	Std. Error	*t*	*P*-değeri
Constant	−1714,116	104,485	−16,405	0.000
Body weight	47,788	1,530	31,228	0.000
Arms-Free CMJ	58,976	2,322	25,395	0.000

were asked to perform hand-on-hip CMJs and then free-arm CMJs. Jumps were repeated three times, and their best values were recorded. Every participant was allowed a 5-minute break between each jump. Our best peak power regression model created for the obtained data, Power = −1714,116 + [(47,788 * body weight (kg)] + [(58,976 * Vertical jump height (cm)] (cm), had a prediction rate of (R^2) 0.876. The model built with free-arm countermovement jump height and body weight data. In this model, free-arm countermovement jumping was performed as a jumping technique. A prediction model was created based on the jump height value and body weight value.

As can be seen in Table 1, an analysis of the ANOVA table to check the statistical significance of the regression model with the regression analysis method was performed; the resulting model was found to be statistically significant at the 95% confidence level ($P = .000 < \alpha = 0.05$).

From Table 2, we can see that the multiple correlation coefficient, which is the square root of the determination coefficient, was 0.936 for the model, while the coefficient of determination of the model (R^2) was 0.876 and the adjusted coefficient of determination of the model (R^2) was 0.875.

According to the results of the regression analysis in Table 2, it can be seen that the model, as a whole, is statistically significant at the 5% significance level ($P < .05$). The explanatory power of the model ($R^2 = 87.6\%$) is high. Accordingly, it can be inferred that 87.6% of the changes in the dependent variable are explained by the independent variables.

As a result of the regression analysis, a statistically significant relationship was found between the peak power variable obtained from free-arm CMJs and the variables of body weight and free-arm CMJs. Looking at the direction of the relationship, it can be seen that the peak power dependent variable obtained from CMJs and the independent variables of body weight and free-arm CMJs had a positive relationship. According to the results of the regression analysis, Power = −1714,116 + (47,788 * body weight (kg) + (58,976 * vertical jump height (cm).

4. Discussion

Research studies have determined that the peak-power prediction equations developed for adult populations may not be suitable for predicting peak power in children and young people.[28] In this context, it was determined that a new estimation equation, using the data obtained from a force platform, is needed in order to develop suitable peak-power prediction tools for people in this population. The aim of this study was to develop an age- and football branch-specific regression equation to predict peak power of 12–14-year-old soccer players from their vertical jump height using a large sample (n = 188). The formula created in this study, Power = -1714.116 + [(47.788 * Body weight (kg)] + [(58.976 * vertical jump height (cm)], predicts peak power ($R^2 = 87.6\%$) for soccer players in the 12 to 14 age group. The results obtained from this study contribute to the improvement of athletes' performances and the follow-up of sport-specific performances while also supporting the suggestion that it is necessary to develop regression equations in more homogeneous samples.[22]

Although there are several difficulties in assessing actual peak power, several models have been developed using body weight and vertical jump height, but some models have become controversial over the years.[7,17,18,29–33] When using a particular equation developed from the study of different groups, such an equation depends on various factors, i.e., age, sex, activity level, etc., relative to the population studied. Depending on the type of jump used to measure vertical jump height, significant estimation errors are expected (for example, using hand-on-hip or free-arm CMJs may be the cause of some differences).[7,17,18,29,30] As a matter of fact, in this study, free-arm CMJs provided a higher power output and higher prediction rate in the created model than hand-on-hip jumps. In line with this, Viitasalo[34] determined that having free arms during jumping increased the explosive power output in children aged 10–12. In this regard, our findings support Viitasalo's[34] findings. Differences among jump types have been discussed in more detail in more recent studies. The Lewis formula used to be widely employed in the past,[35] but this model was later marked as incorrect by Harman et al[18]; they stated that the formula did not measure peak power from the jump but instead created an indirect prediction model based on the calculation of the average force of gravity on the falling object. As a result, Harman et al[18] in their study, developed a new regression model based on a young population of 17 people, which was then cross-validated in a larger population that included men and women.[19]

Accurately estimating peak power is important when setting up and evaluating power and conditioning programs in soccer. Therefore, more comparable examples are needed to test the validity of the estimated peak-power equations in future studies. There is also a need for sports scientists to develop sport-specific regression equations to predict the highest peak-power values among athlete groups in general.

The limitations of this study can be heightened by the measurement error originating from the use of a force platform to estimate jump height and muscle power.[8] Measuring jump height with a force platform is not as common as traditional area-based jump height measurements. However, some field-based measurements have given different results for jump height when compared with the jump height obtained using force platforms in the laboratory. Specifically, the jump height measured using the Vertec device was on average 2.4 cm lower than the jump height measured using a force platform.[36] This may result in an

Table 2

Summary of the regression model.

Model	R	R^2	Adjusted R^2	Std. Error of Estimates
1	0.936	0.876	0.875	153.78

underestimation of peak power in field-based studies. However, measuring jump height with a force platform does not reduce the utility and accuracy of our prediction equation, since the jump height values we obtained using a force platform are commonly found in the literature,[7,16,26,29,30,32,33,37] except for three papers where different prediction equations were published.[17,19,38]

5. Conclusions

The muscle power estimation equation we developed provides accurate results when used to predict muscle strength in the 12 to 14-year-old soccer-player population. Trainers and teachers can measure muscle power with this method, especially during the talent-selection phase, which can help form more accurate branches. This study was conducted on 12–14-year-old soccer players. Future studies may develop different models for other sports branches that require explosive features, such as basketball, volleyball and athletics. In addition, there is a need to develop new models on athlete and non-athlete populations and on different age groups.

Acknowledgments

This study was produced from a doctoral thesis. We express our sincere thanks to all participants for following all our recommendations for testing during the study. The research was developed based on the ethical standards and was approved with the decision of No. 09 702 19 by the Ankara University Faculty of Medicine Ethics Committee in accordance with the Declaration of Helsinki.

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