***Artificial neural networks improve estimation of horse body weight using morphometric measurements***

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***Key words:*** horse, body weight, morphometric measures, artificial neural networks

***Application***

Accurate estimation of horse body weight using morphometric measurements and artificial neural networks could provide a reliable and accessible method for equine practitioners, veterinarians and nutritionists to monitor equine health and adjust management practices. The proposed Artificial Neural Network (ANN) architecture will serve as the underpinning for a mobile application, ensuring practicality and portability. This will be particularly useful in situations where scales are not available, enabling more accurate medication dosing, nutritional planning and overall health assessment of horses.

***Introduction***

Accurate estimation of body weight (BW) in horses is essential for several aspects of equine management, including health monitoring, medication dosing and nutritional planning. Traditional methods based on morphometric measurements such as height at withers, chest girth and body length have been widely used, but are often inaccurate due to variations in breed, age and body composition. Recent studies have investigated more advanced approaches that integrate multiple morphometric variables and sophisticated statistical techniques to improve prediction accuracy. ANN have shown potential for improving the accuracy of BW estimation compared to conventional multiple linear regression models (Angeles-Hernandez et al., 2022). Therefore, the aim of the present study is to compare the fitting performance of traditional multiple linear regression and ANN for estimating horse BW based on a comprehensive set of morphometric measurements.

***Material and methods***

*Data base*

A database was constructed based on registers of BW and morphometric measurements of a total of 142 horses (88 females and 54 males) over 2 years of age. The horses were located in three different states of Mexico: State of Mexico, Nuevo Leon and Mexico City. BW (kg) was recorded for each animal using a digital scale (model S3, TRU-TEST) in conjunction with the following morphometric measurements: height at withers (HW), chest girth (CG), neck circumference (NC) and body length (BL). Age and body condition score (BCS) were also recorded. Morphometric measurements were obtained with the animals standing and using a flexible measuring tape.

*Multiple linear regression*

A multiple linear regression (MLR) model was constructed using the glm() function in R, with BW as the dependent variable. The independent variables included HW, CG, NC, BL, BCS and age.

*Model training of ANN*

The ANN incorporates identical inputs to those used for MLR. Data normalisation was critical due to different ranges and units. A supervised learning approach was used to train a two-layer ANN with seven hidden structures: 5-5, 5-10, 10-5, 10-10, 10-15, 15-10 and 15-15 neurons. Inputs were transferred to the hidden layer multiplied by weight W using a tangent sigmoid activation function. The data set was randomly divided into 70% for training and 30% for testing. A globally convergent algorithm based on resilient backpropagation computed the ANN with a maximum training step of 1x107 using the *neuralnet* package (Fritsch et al., 2019) in R software (R core team, 2022).

*Goodness of fit*

To compare the fitting performance of RLM and ANN, the following criteria and goodness of fit statistics were used: r, correlation between actual and predicted values; r2, coefficient of determination; MSPE, mean square prediction error; RMSPE, root mean square prediction error; AIC, Akaike's Information Criterion; BIC, Bayesian's Information Criterion. The best models were those with the lowest AIC, BIC, RMSE and the highest r and r2.

***Results***

Table 1 shows a comparison between MLR and different architectures of ANN for predicting BW in horses. In general, all models show good performance, with coefficients of correlation and determination higher than 0.90 and 0.82, respectively, confirming that morphometric measurements are good predictors of BW in horses. According to the RMSPE values, MLR had a mean prediction error in BW estimation of 24.29 kg. On the other hand, ANN consistently outperformed the MLR model in all evaluated criteria. The 15-15 ANN architecture shows the best performance in all aspects (r = 0.99, r² = 0.97) and a mean prediction error of 9.78 kg, a reduction of 60% compared to MLR. This model also has the lowest information criteria AIC (657.62) and BIC (672.40), indicating a higher prediction accuracy and a better balance between fit and complexity. These results suggest that ANN, especially with more complex configurations, are more effective tools than MLR for predicting BW in horses.

***Conclusion***

ANN demonstrated superior accuracy and reliability compared to MLR models for predicting horse BW based on morphometric measurements. This approach provides an effective and accessible tool for equine management, particularly in the absence of scales.

**Table 1.** Evaluation of goodness of fit of full multiple linear model and artificial neural networks to predict body weight in horses.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model** | **r** | **r2** | **MSPE** | **RMSPE** | **AIC** | **BIC** |
| MLR | 0.91 | 0.82 | 622.55 | 24.29 | 1132.6 | 1356.2 |
| Hidden\* |  |  |  |  |  |  |
| 5-5 | 0.93 | 0.87 | 491.69 | 22.17 | 980.09 | 904.87 |
| 5-10 | 0.93 | 0.87 | 498.63 | 22.33 | 892.08 | 906.86 |
| 10-5 | 0.94 | 0.89 | 413.60 | 20.33 | 865.53 | 880.31 |
| 10-10 | 0.93 | 0.87 | 471.21 | 21.71 | 839.21 | 853.99 |
| 10-15 | 0.94 | 0.87 | 424.20 | 20.50 | 869.13 | 883.91 |
| 15-10 | 0.95 | 0.90 | 373.77 | 19.33 | 851.16 | 865.93 |
| 15-15 | 0.99 | 0.97 | 95.65 | 9.78 | 657.62 | 672.40 |

MLR, multiple lineal regression; -786.59 (53.79\*\*\*) + 0.94 (0.43\*) × HW + 1.50 (0.40) × BL + 3.61 (0.42\*\*\*) × CG + 1.35 (0.33\*\*\*) × NC + 0.87 (0.55) × AGE + 23.56 (7.01) × BCS. r, correlation between actual and predicted values; r2, coefficient of determination; MSPE mean square prediction error; RMSPE, root mean square prediction error; AIC, Akaike´s Information Criterion; BIC, Bayesian´s Information Criterion.

**Figure 1.** Architecture of used ANN with two-layers and 15 neurons to estimate horse body weight based in morphometric measurements



***References***

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