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Predictability of adult Show Jumping ability from early information: Alternative selection strategies in the Spanish Sport Horse population

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A B S T R A C T

The purpose of this study was to estimate the genetic parameters and to evaluate whether performance results of young horses are good predictors for later sport performance, in order to propose alternative selection strategies to assess adult show jumping (SJ) ability. The data included 84,600 performance records from 4011 Spanish Sport Horses. Two different bivariate animal models with genetic groups were compared, using rankings of young and adult horses as the dependent variables. The models included the age as covariate, and gender, event, type of penalty scale and competition level as fixed effects. The horse*rider interaction and the animal permanent environment random factors were tested to find the most suitable model (A vs B, respectively). The heritability values obtained were in the low range, between 0.11 ± 0.01 in adult horses and 0.17 ± 0.01 in young horses. The results also showed high genetic correlations (≥0.84 ± 0.04) between results early and later on in life. With model A, the prediction of the adult SJ ability was higher (Pearson correlation between predicted and real data: 0.33 ± 0.01) than with model B (0.31 ± 0.01). The implementation of alternative strategies, such as two-stage selection, could increase the expected genetic gain significantly (over 50%) compared to other strategies. This strategy could promote genetic progress, without any loss of accuracy and little additional cost.

1. Introduction

In horse breeding programs, carrying out an effective performance test for young horses as a basis for early selection would allow us to make greater genetic progress (Ström and Philipsson, 1978; Hugason et al., 1987). This kind of test would be useful to predict the breeding values of young sport horses more accurately (Olsson et al., 2007), and thus lead to genetic advances (Thorén-Hellsten et al., 2006). Accordingly, in 2004 the Spanish Ministry began recording results of young horse performances in the main sport horse disciplines (dressage, eventing and show jumping) held throughout Spain. Now, 10 years later, the time has come to evaluate these results.

The Spanish Sport Horse (CDE; www.ancades.com) was established as a breed in 2002, with the aim of competing in the different Olympic equestrian disciplines (show jumping, eventing and/or dressage) (Bartolomé et al., 2011), and with the main focus on show jumping. At the present time, it is considered one of the Spanish horse breeds with the highest potential for this discipline (Bartolomé et al., 2013). Furthermore, genetic evaluation of the CDE breed is carried out by direct selection on young and adult horses using univariate animal models (www.ancades.com).

Many studies based on show jumping data have been carried out to evaluate the relationship between performance traits scored early in life and the same traits scored as adults, especially in Sweden (Wallin et al., 2003; Thorén-Hellsten et al., 2006; Olsson et al., 2007; Viklund et al., 2010a). Medium to high genetic correlations (over 0.50) have been obtained for most of the traits studied, suggesting that performance as a young horse is useful as a genetic predictor for later performance of the same horse as an adult. This could potentially increase the breed's genetic response for show jumping.

In addition, validation of genetic models is useful in order to achieve previously-set breeding objectives. In the equine industry, considerable amounts of time and money are invested in horses in order to obtain the maximum performance potential from the animal during their long, productive life. Therefore, accurate prediction of adult' performances to achieve continuous genetic progress over the years requires that the assumptions made with the genetic model match exactly the performance data (Viklund et al., 2010b).

Moreover, an efficient breeding program can only be set up if the genetic progress of the population and affecting factors (i.e. rider or environmental permanent effects) are studied (Viklund et al., 2011). Some strategies such as direct selection may also not be physically or

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economically viable to carry out with the entire group of potential candidates. This requires alternative, practical and cost-effective methods, such as two-stage selection, for example (Jopson et al., 2004).

The rider is one of the most relevant environmental factors that could influence horse performance (particularly in young horses; Bartolomé et al., 2013). Considering the rider effect in horse genetic evaluations provides more accurate estimations (Bartolomé et al., 2013; Sánchez et al., 2014). Moreover, the importance of the permanent environment effect on sport horse genetic evaluations has also been reported (Kearsley et al., 2008; Sánchez et al., 2014). Therefore, ignoring the rider or the permanent environmental effects in genetic models would produce an overestimation of genetic parameters in the main equestrian disciplines (Kearsley et al., 2008; Bartolomé et al., 2013; Sánchez et al., 2014).

Thus, the aims of this study were: first, to analyze the genetic relationship between sport results obtained earlier in life and those obtained later in life for CDE horses participating in Show Jumping (SJ) competitions, comparing two different models (with focus on the rider and on the permanent environmental effects); second, to compare the predictive ability of a bivariate vs. a univariate model, discussing whether young horse competitions are good predictors for adult SJ ability considering alternative selection strategies in the CDE population.

2. Materials and methods

2.1. Animals

SJ competition results were available for 4011 animals of the CDE breed (2424 males and 1587 females) aged between 4 and 22 years old. The whole data set comprises a total of 84 600 performance records, collected between 2004 and 2014 at either young (422 SJ events) or adult (350 SJ events) sport horse competitions.

For the young animal's database, a total of 20,157 registries from 2090 animals (1190 males and 900 females) between 4 and 6 years old were available. The average number of animals per penalty scale class was 4.74 and per competition level class was 4.15, showing a global average of 9.67 participating records per horse. 42.06% of the riders have competed with different horses, and 51.92% of the horses have competed with different riders.

For the adult animal's database, a total of 64,443 registries from 2772 animals (1756 males and 1016 females) ≥7 years old were available. The average number of animals per penalty scale class was 6.20 and per competition level class was 7.05, with a global average of 23.25 participating records per horse. 45.71% of the riders have competed with different horses, and 47.53% of the horses have competed with different riders. Moreover, 851 animals had performances in SJ events in both subsets, as young and adults.

Pedigree information for genetic evaluation was traced back to all known generations for the participants (4 equivalent complete generations with a maximum of 11 not complete generations), including a total of 17 771 animals. The CDE studbook includes animals born in Spain with different breed origins (Bartolomé et al., 2011). Thus, to consider a model of genetic groups based on breed lineages, 5 clusters were formed according to the influence of different breed lines: Warmblood lineage (Belgian, Dutch, German and Irish breeds), CDE lineage (1 generation of pure matings CDE x CDE), Selle Français lineage (Anglo Arab, Arab or Selle Français), Thoroughbred lineage, and other non-specialized (minority) breed lineages (Lusitano, Pura Raza Español, San Fratelano, Trotter and undefined horses).

2.2. Estimation of genetic parameters and breeding values

The genetic parameters (heritabilities and genetic correlations) were obtained for two different bivariate animal models with genetic groups, including weighted rankings of young 4–6 years old) and adult horses (≥7 years old) as the dependent variables. Horse weighted rankings were calculated on a positive points scale by assigning a value of 100 to the first classified animal (within the same event, penalty scale and competition level) and a value of 0 to the last. The rest of the participating animals were assigned an equivalent value according to the punctuation obtained in the exercise (Foran et al., 1995).

The genetic models included age as covariate, with gender, event, type of penalty scale (punctuation of the faults committed during the test, according to Spanish Equestrian Federation rules) and competition level (assigned according to the obstacles height of the competition) as fixed effects. The horse*rider interaction (in model A) and the animal permanent environment (in model B) were tested as random effects in order to find the most suitable model. The following bivariate animal model was used:

$$\begin{pmatrix} Y_1 \\ Y_2 \end{pmatrix} = \begin{pmatrix} X_1 & 0 \\ 0 & X_2 \end{pmatrix}\begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} + \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix}\begin{pmatrix} p_1 \\ p_2 \end{pmatrix} + \begin{pmatrix} G_1 & 0 \\ 0 & G_2 \end{pmatrix}\begin{pmatrix} a_1 \\ a_2 \end{pmatrix} + \begin{pmatrix} e_1 \\ e_2 \end{pmatrix}$$

where Y_1 is dependent variable 1 (rankings of young horses) and Y_2 is dependent variable 2 (rankings of adult horses). Vector (β1'β2')' contains the covariate effect of age (in years), and the fixed effects of gender (2 levels: male, or female), event ($X_1 = 422$ levels and $X_2 = 350$ levels), penalty scale ($X_1 = 9$ levels and $X_2 = 11$ levels) and competition level ($X_1 = 16$ levels and $X_2 = 24$ levels). Vector (p1'p2')' contains the random effects of horse*rider interaction (Model A) and the animal permanent environment (Model B). The **X**, **P** and **G** matrices are incidence matrices relating the observations to the fixed and random effects, respectively; **p** is the vector of random effects, **a** is a vector of additive genetic effects of the horses, and **e** is a vector of random residuals:

$$\begin{pmatrix} p \\ a \\ e \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} P \otimes I_n & 0 & 0 \\ 0 & G \otimes A & 0 \\ 0 & 0 & R \otimes I_n \end{pmatrix}\right],$$

where **P** is the random covariance matrix with the following components:

$$\mathbf{P} = \begin{pmatrix} \sigma^2_{p_1} & \sigma_{p_1,p_2} \\ \sigma_{p_1,p_2} & \sigma^2_{p_2} \end{pmatrix},$$

where **G** is the additive genetic covariance matrix with the following components:

$$\mathbf{G} = \begin{pmatrix} \sigma^2_{a_1} & \sigma_{a_1,a_2} \\ \sigma_{a_1,a_2} & \sigma^2_{a_2} \end{pmatrix},$$

⊗ is the Kronecker product, **A** is the additive genetic relationship matrix and **R** is the residual dispersion matrix with the following components:

$$\mathbf{R} = \begin{pmatrix} \sigma^2_{e1} & 0 \\ 0 & \sigma^2_{e2} \end{pmatrix},$$

where σ^2_{e1} is the residual variance for variable 1 (data from young horses with no data from adult horses); σ^2_{e2} is the residual variance for variable 2 (data from adult horses with no data from young horses). Because a horse can not have observations from both periods at the same time (a temporary environmental effect at a given event will be independent of the same temporary effect in an event measured later on), residual covariances are not estimable and were set to zero.

To compare the predictive ability of a bivariate vs. a univariate model and evaluate whether performance results of young horses are good predictors for later sport performance, a univariate analysis (using whole data set) was performed considering the same effects (model A and B) of the bivariate analysis.

VCE 6, v.6.0 software (Groeneveld et al., 2008) was used to estimate the genetic parameters.