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Genetic parameters for osteoarthrosis, radiographic changes of the navicular bone and sidebone, and their correlation with osteochondrosis and osteochondral fragments in Hanoverian warmblood horses

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ABSTRACT

In the present study, results of radiographic examinations were used for estimation of genetic parameters for osteoarthrosis (OA) in distal interphalangeal joints, proximal interphalangeal joints, fetlock, hock and stifle joints, radiographic changes in the navicular bones of the forelimbs (RCNB) and sidebone in 7396 Hanoverian Warmblood horses. Radiographic changes were recorded as ordinal traits in dependence of the number of joints affected or, in case of RCNB, of their severity score. In addition, their genetic correlations with osteochondrosis (OC) and osteochondrosis dissecans (OCD) in fetlock, hock and stifle joints as well as palmar/plantar osteochondral fragments (POFs) and dorsodistal osteochondral fragments in fetlock joints were determined. The prevalence for OA in hock joints was 21.4%, for OA in fetlock joints 7.4%, for RCNB 33.6% and for sidebone 9.6%. Horses with OA in most cases were affected at only one limb while RCNB and sidebone in most cases were found bilaterally. The heritabilities estimated in a linear animal model and transformed onto the liability scale were at 0.17 for OA in fetlock joints, 0.40 for OA in hock joints, 0.19 for RCNB and 0.59 for sidebone. Additive genetic correlations among OA in fetlock joints, OA in hock joints, RCNB and sidebone were moderate ($r_g = -0.19$ to $r_g = 0.18$). The highest additive genetic correlations were found between OA in fetlock joints and OC in fetlock joints ($r_g = 0.71$) as well as OCD in fetlock joints ($r_g = 0.62$). RCNB showed positive genetic correlations with OC and OCD in the different joints as well as with OFs in hock and stifle joints. POFs and RCNB were genetically negatively correlated. The size of the heritability estimates for OA in fetlock joints, OA in hock joints, RCNB and sidebone seems to be sufficient high that breeding measures can be recommended in order to reduce their prevalence.

1. Introduction

The presence of radiographic changes in the context of a pre-purchase examination has a significant effect on the market value of horses (van Hoogmoed et al., 2003). Osteoarthrosis (OA) (Oliver et al., 2008), radiographic changes in the navicular bones (RCNB) (Stock and Distl, 2006a) and the ossification of the cartilages of the distal phalanx of the forelimbs, also called sidebone (Ruohoniemi et al., 1993; Willms et al., 1999) are common findings in the limb joints of horses. Osteochondrosis (OC) and osteochondrosis dissecans (OCD) are most prevalent in growing horses and these conditions prone horses to increased risk of developing orthopaedic problems later in life (Distl, 2013). OA may lead to lameness (Gough and Munroe,

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1998) and reduced performance (Stock and Distl, 2006b). RCNB are not necessarily associated with navicular disease, but in affected horses are often more severe (Dik et al., 2001). The clinical relevance of sidebone remains to be clarified (Ruohoniemi et al., 2003; Verschooten et al., 1996).

Inheritance seems to play an important role for the occurrence of OC, OCD, OA, RCNB and sidebone (Axelsson et al., 2001; Bos et al., 1986; Distl, 2013; Ruohoniemi et al., 2003; Stock and Distl, 2006a). Heritability estimates for OA in Warmblood horses ranged between 0.16 and 0.31 (KWPN, 1994; Stock and Distl, 2006a), for RCNB in Hanoverian Warmblood horses between 0.09 and 0.40 (Stock and Distl, 2006c) and for sidebone in Finnhorses between 0.31 and 0.50 (Ruohoniemi et al., 2003). Heritability estimates for OC and OCD in warmblood horses were at 0.06–0.32 in fetlock joints, at 0.19–0.46 in hock joints and at 0.02–0.23 in stifle joints and for trotters between 0.21 and 0.45 (Distl, 2013; Hilla and Distl, 2014).

To achieve genetic progress for orthopedic health traits, the size of the heritability of the target traits in the selection index and their genetic correlation structure have to be taken into account. The aim of this study was to estimate genetic parameters for OA, RCNB and sidebone in a large sample of Hanoverian Warmblood horses and to analyse their correlations with osteochondrosis (OC) and osteochondrosis dissecans (OCD) in fetlock, hock and stifle joints as well as with palmar/plantar osteochondral fragments (POFs) and dorsodistal osteochondral fragments (DOFs) in fetlock joints. This is the first report on additive genetic correlations of OA, RCNB and sidebone with OC, OCD, POFs and DOFs. The results of the present analysis should help to define a set of traits to be included in a merit index for orthopedic health in warmblood horses.

2. Material and methods

Data of 7396 Hanoverian Warmblood horses that were presented for radiographic examinations in 2005–2012 was included in the present study. These horses took part in pre-selection for sale at auction as riding horses by the Association of Hanoverian Warmblood breeders in Verden (Aller), Germany, ($n=4259$), were pre-selected for stallion licensing during the same time period ($n=865$) or were presented for other reasons, particularly for pre-purchase veterinary examination including a radiographic examination ($n=2272$). Of these horses, 4480 were male and 2916 were female. The mean age of the horses was 3.9 years, with 776 horses aged less than 3 years, 4923 aged 3–4 years and 1698 aged more than 4 years. More details on the horses and the radiographic examination can be found elsewhere (Hilla and Distl, 2013, 2014).

Pedigree information was provided from the unified animal ownership database (Vereinigte Informationssysteme Tierhaltung w.V., vit) in Verden/Aller, Germany. The horses were offspring of 675 sires, with a mean of 11 progeny per sire, ranging from 1 to 317, and of 5712 dams with a mean of 1.3 progeny per dam, ranging from 1 to 6.

All horses underwent a standardized radiographic examination, with a minimum of twelve x-rays of the limbs, including laterolateral projections of the front and hind digits, dorsoproximal–palmarodistal projections of the region of the navicular bone of the forelimbs according to Oxspring (1935), 45° and 115° projections of the hock joints and 90° projections of the stifle joints.

According to McIlwraith (1982), changes of the contour of the joint by periarticular osteophytes or exostoses and narrowing or loss of the joint space were classified as signs of OA. Their presence was recorded in distal interphalangeal joints (DIJ) and proximal interphalangeal joints (PIJ), fetlock, hock and stifle joints. Diagnostic criteria for RCNB were shape, symmetry, contour and structure of the navicular bone as well as form, size, number and location of the canales sesamoidales (Brunken, 1986; Diesterbeck et al., 2007; MacGregor, 1986; Stock and Distl, 2006a; Ueltschi, 2001). In addition, the presence of sidebone was regarded.

Criteria for diagnosis of OC and OCD included all radiographic findings consistent with OC and OCD at the specific predilection sites (Distl, 2013; van Weeren, 2006). These sites were in fetlock joints the dorsoproximal part of the sagittal ridge of the third metacarpal or metatarsal bone, in hock joints the sagittal ridge of the distal tibia, the lateral and medial malleolus of the tibia, the lateral and medial trochlea and the basis of the talus, and in stifle joints the lateral and medial trochlea of the femur, the sulcus intertrochlearis and the patella (van Weeren, 2006; van Grevenhof et al., 2009). Only those osteochondral fragments were classified as OCD that were within one of these predilection sites. A distinction has to be made to other osteochondral fragments, such as those palmar or plantar in fetlock joints and at the attachment sites of the short sesamoidean ligaments on the proximal phalanx (POFs) (Carlsten et al., 1993; Sandgren et al., 1993) or those dorsodistal in fetlock joints (DOFs). In fetlock joints, we distinguished between the traits OC, OCD, DOFs and POFs (Hilla and Distl, 2013, 2014).

2.1. Statistical analysis

OA in DIJ, PIJ, fetlock, hock and stifle joints, just as sidebone, were analysed as ordinal traits in dependence of the number of joints affected. The score ranged from 0 to 4 (0=free from radiographic changes for the specific condition, 1 to 4=radiographic changes at a particular localisation in one, two, three or four limbs). RCNB were classified into a severity score from 0=free from radiographic changes to 3=severe radiographic changes. Few conical canales sesamoidales or slight alterations of the contour of the navicular bone were classified as slight, deformed canales sesamoidales or changes of the structure of the navicular bone as moderate and branched or bulb-ended canales sesamoidales as severe radiographic changes of the navicular bone (Diesterbeck et al., 2007; Stock and Distl, 2006a).

Prevalences of OA in DIJ, PIJ, fetlock, hock and stifle joints, sidebone and RCNB were analysed using the procedure FREQ of SAS, version 9.4 (SAS, 2013).

Analysis of variance was employed to evaluate the influences of gender, month of birth, age group, year of examination and reason for radiographic examination on the prevalence of OA, RCNB and sidebone. The analyses were performed using the procedure MIXED of SAS.

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