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ScienceDirect
Livestock Science 104 (2006) 173–181
LIVESTOCK SCIENCE
www.elsevier.com/locate/livsci

The influence of mineral supplementation on skeleton formation and growth in Lusitano foals

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Received 5 July 2005; received in revised form 10 April 2006; accepted 18 April 2006

Abstract

Diets traditionally used in the horse industry are very often imbalanced in mineral composition, mainly in what concerns Ca, P, Mg and Ca/P ratio. The main objective of this study was to evaluate the effect of calcium, phosphorus and magnesium supplementation of traditional diets, on bone formation and growth in Lusitano breed foals, from weaning to 1 year old. Two homogenous groups of eight colts each received for 140-day *iso*-energetic and *iso*-proteic diets, which differed only on Ca, P and Mg levels (respectively, 0.26%, 0.27% and 0.12% vs. 0.56%, 0.43% and 0.18%). Throughout the experiment, blood samples were periodically collected for evaluation of total calcium, inorganic phosphorus, magnesium, copper, zinc, intact parathyroid hormone, bone alkaline phosphatase and osteocalcin concentrations. Animals were weighed and measured (wither height, hip height, girth and cannon circumference) for body growth evaluation. No significant differences were observed between treatments, with respect to growth, plasmatic concentrations of analysed minerals or biochemical markers. The linearity of growth in both groups is in agreement with studies reported for other light breeds. The observed results could be explained by the fact that calcium, phosphorus and magnesium levels in the base diet were close to supply the animal needs for a moderate growth. Further studies concerning the relationship between bone biochemical markers and mineral nutrition, in the growing horse, should consider the evaluation of bone mineral density and content.

Keywords: Lusitano foals; Growth; Mineral supplementation; Parathyroid hormone; Bone alkaline phosphatase; Osteocalcin

1. Introduction

Functionality and behavioural characteristics of Lusitano horses make possible their use in very

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doi:10.1016/j.livsci.2006.04.014

demanding equestrian disciplines, for a long period of their productive life. Since progressive training and learning submit the skeleton to considerable strengths, it is required to provide all the conditions that promote a normal bone and cartilage development. Besides genetics and exercise, nutrition has been implicated as a major factor for an adequate skeletal development in horses (Trillaud-Geyl et al., 1986; Bigot et al., 1987; Ott and Asquith, 1989; INRA, 1990). Diets traditionally used in the horse breeding are very often imbalanced in mineral composition, mainly in the Ca/P ratio.

Calcium deficiencies may, to a certain extent, limit the rate at which bone can be remodelled. When adequate amounts of this mineral are not present, the body removes calcium from bone resulting in an overall weakened skeletal system, due to homeostatic mechanisms that keep plasmatic calcium concentrations within a narrow range (Nielsen et al., 1998a). Parathyroid hormone (PTH) plays a key role on this homeostatic mechanism. It increases blood calcium levels by stimulating bone resorption and renal calcium reabsorption (Breslau, 1996).

A large percentage of magnesium in the body is in the skeleton. Apparently, bone acts as a magnesium reservoir, but its mobilization from this tissue is slow (Swenson, 1989). In horse nutrition, copper and zinc are frequently referred as limitative trace minerals for an adequate skeletal development, high quality of bone and cartilaginous tissue (Ott and Asquith, 1989, 1995; Hurtig et al., 1993). Copper is required for the enzyme lysyl oxidase, which is essential for the synthesis and maintenance of cross-links between collagen molecules (Cymbaluk and Smart, 1993). Additionally, zinc deficiency is related with growth impairment of cartilage cells, disrupting keratogenesis (Swenson, 1989).

Bone turnover in animals occurs throughout two different processes, modeling and remodeling, both involving the action of osteoclasts and osteoblasts (Allen, 2003). In the skeletally mature animals, bone resorption and bone formation are balanced but the rate of bone formation tends to exceed that of resorption, during growth (Fraher, 1993).

Previous experimental research in the horse has shown the metabolic activity of the osteoblasts can be assessed by biochemical markers like bone alkaline phosphatase (BALP) or osteocalcin (OC) (Lepage et al., 1990, 1991, 1997, 1998; Price et al., 1995, 2001; Black et al., 1999).

Bone alkaline phosphatase is a cell-membrane-associated enzyme, synthesized and secreted by osteoblasts that constitutes a large percentage of total serum alkaline phosphatase (Toquet et al., 2001). It is mostly increased in the newborn foal and has an inverse relationship with age (Price et al., 1995).

Osteocalcin, also known as bone Gla-protein, is a non-collagenous protein, predominantly synthesized by osteoblasts and incorporated into the extra cellular matrix of bone (Lepage et al., 2001). Since osteocalcin is not released from bone during resorption, serum levels of this protein accurately reflect the synthetic activity of the osteoblasts (Allen, 2003).

The main objective of this study was to evaluate the effect of Ca, P and Mg supplementation of traditional diets, on growth and bone formation in Lusitano breed foals, from weaning to 1 year old, by assessment of some biometrical parameters and two biochemical markers (BALP and OC).

2. Materials and methods

2.1. Experimental design and management of animals

Two homogenous groups (A and B) of eight colts each (258-day average age), received for 140 days (between December and April), *iso*-energetic and *iso*-proteic diets, that differed only on Ca, P and Mg levels (respectively, 0.26%, 0.27% and 0.12% vs. 0.56%, 0.43% and 0.18%).

Base diet consisted of traditional feeds (oat, horse bean and oat hay). It was formulated to provide energy and protein requirements according to INRA recommendations for a moderate growth and for a predicting adult body weight of 500 kg (INRA, 1990). Oat hay was group fed in the parks at a rate of 2.6 kg/100 kg BW daily, divided into 2 equal feedings. Concentrate feeds (oat and horse bean) were also provided in the average amount of 2 kg and 1 kg per foal, respectively.

Both groups (A and B) were supplemented with trace minerals and vitamins, by adding a premix to the concentrate, but only group B was supplemented with Ca, P and Mg. All foals received a diet with no macro-