THE RELATIONSHIP BETWEEN GLYCEMIC RESPONSE AND THE INCIDENCE OF OCD IN THOROUGHBRED WEANLINGS: A FIELD STUDY

JOE D. PAGAN
Kentucky Equine Research, Versailles, Kentucky, USA

Introduction

Hyperglycemia and hyperinsulinemia have been implicated in the pathogenesis of osteochondrosis (Glade et al., 1984; Ralston, 1995). More specifically, foals that experience an exaggerated and sustained increase in circulating glucose or insulin in response to a carbohydrate (grain) meal may be predisposed to development of osteochondrosis. In vitro studies with fetal and foal chondrocytes suggest that the role of insulin in immature cartilage may be to promote chondrocyte survival or to suppress differentiation and that hyperinsulinemia may be a contributory factor to equine osteochondrosis (Henson et al., 1997). Rutgers University was recently granted a United States patent for diagnosing a predisposition for equine osteochondritis dissecans (OCD) using an oral glucose tolerance test (United States Patent). This patent was based on the premise that foals exhibiting an exaggerated glycemic response to an oral glucose challenge were more susceptible to developing OCD. The purpose of the present study was to evaluate if there is a relationship between a glycemic response test and the incidence of OCD in Thoroughbred weanlings, and to determine if this test would be useful in identifying factors that may predispose young growing horses to OCD.

Materials and Methods

Two hundred eighteen Thoroughbred weanlings (average age 300 ± 40 d, average body weight 300 ± 43 kg) on six central Kentucky farms were studied during December 1999 and January 2000. A glycemic response test was conducted by feeding a meal that consisted of the weanling's normal concentrate at a level of intake equal to 1.4 g nonstructural carbohydrate (NSC)/kg body weight (BW). Two of the farms fed a pelleted concentrate, while the other four used a textured sweet feed mix. All of these concentrates were fortified with levels of protein and minerals deemed suitable for weanlings. The NSC content of the farms' feeds ranged from 40% to 50%, and the test meal size equaled 963 g ± 170 g. A single blood sample was taken 120 min post feeding for the determination of plasma

glucose and insulin concentrations. The test meal was fed between 7:00-8:00 a.m. and the weanlings had not received any other grain for at least 12 h. Weanlings on five of the six farms spent the night before the test on pasture, whereas one farm confined the weanlings in box stalls with access to grass hay throughout the evening.

The glycemic index (GI) of each feed was also determined using four mature Thoroughbred geldings at the Kentucky Equine Research (KER) farm. These feeds were again fed in a single meal at a level of intake equal to 1.4 g NSC/kg BW. Blood samples were taken immediately pre-feeding and at 30-min intervals for 4 hours post feeding. GI was calculated from the area under the glucose response curves (AUC) for each feed. The overall incidence of OCD on these farms was recorded until the horses were sold as yearlings in July or September at ages ranging from 16-20 months. For the purpose of this study, OCD was defined as osteochondrotic lesions occurring in the fetlock, hock, shoulder, or stifle that were treated surgically. These lesions were either diagnosed after the foal showed clinical signs of lameness or joint effusion, or after routine radiographic examinations that were performed in January and February of the foal's yearling year. Weanlings with no evidence of lesions or with lesions that were identified radiographically but that did not require surgery were considered unaffected.

Results

Twenty-five of the 218 weanlings (11.5%) had OCD lesions that were treated surgically. There was a wide range in the incidence of OCD among farms (Table 1). Plasma glucose and insulin 2 h post feeding were significantly higher in weanlings with OCD than in unaffected foals ($p < .05$). Insulin/glucose ratios, however, were not significantly different (Table 2). The incidence of OCD was significantly higher in foals whose glucose and insulin values were greater than one standard deviation above the mean for the entire population (both OCD and unaffected) in the study (Table 3). Elevated insulin/glucose ratios did not appear to be correlated with an increased incidence of OCD. Each weanling's body weight was measured at the time of the glycemic response test and expressed as a percentage of a reference set of body weights collected from 350 fillies and 350 colts raised in Kentucky (Pagan et al., 1996). Each body weight was compared to the same age and sex in the reference data set. Overall, there was no difference between unaffected foals and OCD foals in relative body weight. However, affected foals from farm 2, which experienced a 32% incidence of OCD, averaged 115% of the reference weight whereas unaffected foals averaged 106%. Conversely, foals from farm 1, which reported no OCD, averaged 97% of the Kentucky average body weight.

There were strong positive correlations between mean glucose ($r = .84$, $p < .01$; Figure 1) and insulin ($r = .93$, $p < .01$; Figure 2) response on each farm and the incidence of OCD. Much of the difference in glycemic response among farms was probably due to the GI of the feed since there was also a strong positive

correlation ($r = .88$, $p < .05$; Figure 3) between the GI of each farm's feed and the farm's weanling glucose response. GI was also positively correlated with the incidence of OCD on each farm ($r = .74$, $p < .10$; Figure 4).

Table 1. Incidence of OCD on individual farms.

Farm #	*Total foals (n)*	*OCD foals (n)*	*OCD (% of foals)*
1	24	0	0
2	19	6	32
3	27	2	7
4	51	4	8
5	74	9	12
6	23	4	17

Table 2. Plasma glucose, insulin, and insulin/glucose ratio two hours post feeding.

	Glucose (mg/dl)		*Insulin (pmol/l)*		*Insulin/Glucose Ratio*	
	OCD (n = 25)	Unaffected (n = 193)	OCD (n = 25)	Unaffected (n = 193)	OCD (n = 25)	Unaffected (n = 193)
Mean	150.1	134.2	130.3	106.0	0.846	0.779
SE	7.1	1.9	12.8	3.4	0.055	0.019
Significance	$p < .01$		$p < .05$		$p > .10$	

Table 3. Relationship between glucose, insulin, and insulin/glucose ratio and the incidence of OCD.

Standard deviations from mean	*Glucose*		*Insulin*		*Insulin/Glucose Ratio*	
	% Population	*% OCD*	*% Population*	*% OCD*	*% Population*	*% OCD*
< 1 SD	11.0	0.0	10.1	0.0	15.1	6.0
± SE	72.9	10.1	78.0	11.2	68.3	12.1
> 1 SD	16.1	25.7	11.9	23.0	16.5	13.9

Discussion

In this study, a high glucose and insulin response to a concentrate meal was associated with an increased incidence of OCD. Glycemic responses measured in the weanlings were highly correlated with each feed's GI, suggesting that the GI of a farm's feed may play a role in the pathogenesis of OCD. GI characterizes the rate of carbohydrate absorption after a meal and is defined as the area under the glucose response curve after consumption of a measured amount of carbohydrate

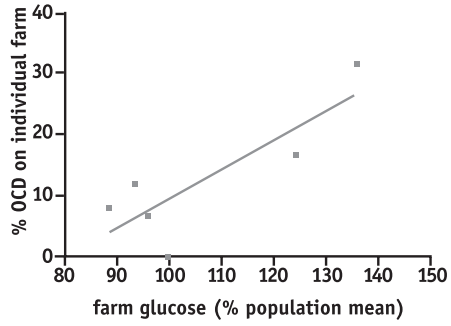

Figure 1. Relationship between farm glucose and incidence of OCD.

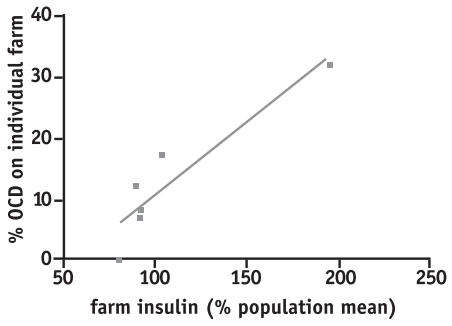

Figure 2. Relationship between farm insulin and incidence of OCD.

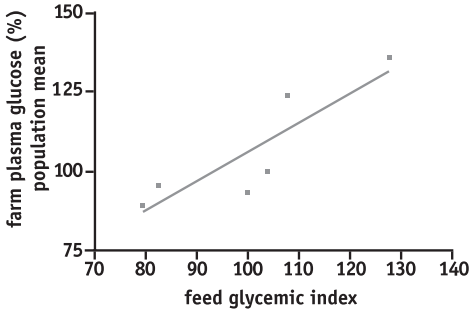

Figure 3. Relationship between glycemic index and farm glucose.

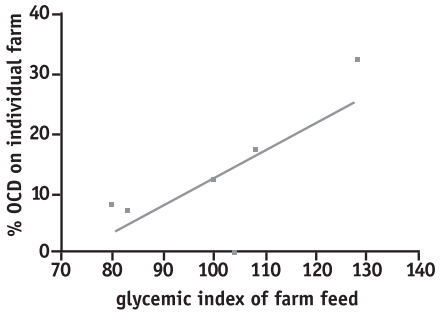

Figure 4. Relationship between feed glycemic index and incidence of OCD.

from a test feed divided by the area under the curve after consumption of a reference meal (Jenkins et al., 1981). In rats, prolonged feeding of high GI feed results in basal hyperinsulinemia and an elevated insulin response to an intravenous glucose tolerance test (Pawlak et al., 2001). In foals, hyperinsulinemia may affect chondrocyte maturation, leading to altered matrix metabolism and faulty mineralization, or altered cartilage growth by influencing other hormones such as thyroxine.

Within each farm, there was no significant difference in glycemic response between horses that had lesions and normal individuals. Therefore, using this type of glycemic response test in older weanlings to identify individuals that may be predisposed to OCD does not look promising. Perhaps diet-induced hyperglycemia or hyperinsulinemia predisposes every weanling to OCD, but other factors such as biomechanical stress or trauma are needed to produce a clinically relevant lesion. Body weight may have been a factor affecting the very high and low incidence of OCD in farms 2 and 1, respectively.

Based on the results of this study, it would be prudent to feed foals concentrates that produce low glycemic responses. More research is needed to determine if a glycemic response test using a more standardized oral glucose challenge (i.e., dextrose) can be used to identify younger individuals that are predisposed to OCD. This study was entirely funded by Kentucky Equine Research, Inc. which is the licensee of the patent (#5,888,756) discussed in this article. The authors wish to thank the owners and managers of the farms that participated in this study for allowing access to their weanlings. Also, thanks go to Dr. Rhonda Rathgeber of Hagyard-Davidson-McGee Assoc. for assisting in blood sampling, Dr. Sarah Ralston of Rutgers University for performing insulin assays, and KER interns Amanda Prince, Catherine Hudson, and Sonya Gardner for assistance with glucose assays and GI determinations.

This paper was first published as Pagan, J.D., R.J. Geor, S.E. Caddel, P.B. Pryor, and K.E. Hoekstra. 2001. The relationship between glycemic response and the incidence of OCD in thoroughbred weanlings: A field study. In: Proc. Amer. Assn. Equine Practnr. 47:322-325.

References

Glade, M.J., S. Gupta, and T.J. Reimers. 1984. Hormonal responses to high and low planes of nutrition in weanling Thoroughbreds. J. Anim. Sci. 59:658-665.

Henson, F.M., C. Davenport, L. Butler, et al. 1997. Effects of insulin and insulin-like growth factors I and II on the growth of equine fetal and neonatal chondrocytes. Equine Vet. J. 29:441-447.

Jeffcott, L.B., and F.M. Henson. 1988. Studies on growth cartilage in the horse and their application to aetiopathogenesis of dyschondroplasia (osteochondrosis). Vet. J. 156:177-192.

Jenkins, D.J., T.M. Wolever, R.H. Taylor, et al. 1981. Glycemic index of foods: A physiological basis for carbohydrate exchange. Amer. J. Clin. Nutr. 34:362-366.

Pagan, J.D., S.G. Jackson, and S. Caddel. 1996. A summary of growth rates of Thoroughbreds in Kentucky. Pferdeheilkunde 12:285-289.

Pawlak, D.B., J.M. Bryson, G.S. Denyer, et al. 2001. High glycemic index starch promotes hypersecretion of insulin and higher body fat in rats without affecting insulin sensitivity. J. Nutr. 131:99-104.

Ralston, S.L. 1995. Postprandial hyperglycemica/hyperinsulinemia in young horses with osteochondritis dissecans lesions. J. Anim. Sci. 73:184 (Abstr.).

United States Patent #5,888,756. Diagnosing a predisposition for equine osteochondrosis dissecans. Inventor: Sarah L. Ralston, Jackson, NJ; Assignee: Rutgers, The State University of New Jersey, New Brunswick, N.J.; Licensee: Kentucky Equine Research, Inc., Versailles, KY 40383.