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Clinical utility of calf front hoof circumference and maternal intrapelvic area in predicting dystocia in 103 late gestation Holstein-Friesian heifers and cows

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ABSTRACT

The objective of this study was to determine the clinical utility of measuring calf front hoof circumference, maternal intrapelvic area, and selected morphometric values in predicting dystocia in dairy cattle. An observational study using a convenience sample of 103 late-gestation Holstein-Friesian heifers and cows was performed. Intrapelvic height and width of the dam were measured using a pelvimeter, and the intrapelvic area was calculated. Calf front hoof circumference and birth weight were also measured. Data were analyzed using Spearman's correlation coefficient (r_s), Mann–Whitney *U* test, and binary or ordered logistic regression; $P < 0.05$ was significant. The calving difficulty score (1–5) was greater in heifers (median, 3.0) than in cows (median, 1.0). Median intrapelvic area immediately before parturition was smaller in heifers (268 cm^2) than in cows (332 cm^2), whereas front hoof circumference and birth weight of the calf were similar in both groups. The calving difficulty score was positively associated with calf birth weight in heifers ($r_s = 0.39$) and cows ($r_s = 0.24$). Binary logistic regression using both dam and calf data indicated that the ratio of front hoof circumference of the calf to the maternal intrapelvic area provided the best predictor of dystocia (calving difficulty score = 4 or 5), with sensitivity = 0.50 and specificity = 0.93 at the optimal cutpoint for the ratio (>0.068 cm/cm^2). Determining the ratio of calf front hoof circumference to maternal intrapelvic area has clinical utility in predicting the calving difficulty score in Holstein-Friesian cattle.

1. Introduction

Dystocia remains a major problem in the dairy industry as it increases cow and calf mortality [1,2], decreases milk yield [3], delays uterine involution [4], and decreases reproductive performance [5], ultimately resulting in substantial financial loss. Fetopelvic disproportion is the most common cause of dystocia in dairy cattle [6]. Primiparous animals have a higher incidence of fetopelvic disparity and dystocia than multiparous dairy cattle because of their smaller stature [5,7–9] and late maturation of pelvic dimensions [10]. Other causes of dystocia in dairy and beef cattle include uterine inertia (10% [11]), uterine torsion (5%–10% [12,13]), and fetal malpresentation (13% [14]; 20%–30% [15]). Accurate prediction of dystocia allows early and appropriate intervention, thereby decreasing morbidity and mortality of the dam and fetus, improving animal welfare, and reducing economic losses.

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Calf birth weight, particularly from first-calving heifers, and morphologic measurements of the dam such as thoracic circumference, height at the withers, and body weight are positively associated with the incidence of dystocia in dairy cattle [16–18]. Calf birth weight is also positively associated with morphologic measurements of the calf, including thoracic circumference, height at the withers or sacrococcygeal region [19], front hoof circumference [20,21], and circumference of the carpus, tarsus, or fetlock [10,22]. Of these calf morphologic measurements, front hoof circumference is easily measured during stage II of parturition and consequently has the greatest clinical potential to predict calf birth weight and therefore the likelihood of dystocia. Linear equations have been developed for beef calves relating calf birth weight (kg) to the circumference of the front hoof at the coronary band (cm), such that weight = 4.96 × circumference − 51.4 for heifer calves [20,23,24] and weight = 3.63 × circumference − 29.4 for bull and heifer calves [21]. These equations vary numerically and were developed for beef cattle but predict similar calf body weights for front hoof circumferences of 16 to 18 cm. A commercially available tape measure, calibrated using the first equation, accurately predicted body weight in Holstein-Friesian and Jersey calves weighing between 31 and 45 kg [25]. However, the clinical utility of front hoof circumference in predicting the likelihood of dystocia in Holstein-Friesian cattle is unknown.

The clinical utility of using maternal intrapelvic dimensions to predict dystocia remains controversial in beef cattle and has been minimally investigated in dairy cattle with the exception of a study published more than 30 years ago [26]. Intrapelvic dimensions are most commonly measured in beef heifers before the start of the breeding season or during the first and second trimesters when palpation per rectum is used for pregnancy diagnosis. Heifers with exceptionally small intrapelvic dimensions for their body weight or abnormal intrapelvic shape are culled or mated to “easy-calving” bulls because of their increased risk of dystocia. The ability of intrapelvic measurements measured at breeding time or early in gestation to accurately predict dystocia in beef heifers is questionable [27–29]. This is because extrapolation of intrapelvic dimensions obtained during the first service or the first or second trimester leads to unacceptably high 95% confidence intervals for the predicted intrapelvic dimensions at parturition [28] and does not accurately predict dystocia in primiparous beef cattle [29]. A second area of concern is that a strong positive genetic association exists between intrapelvic area and calf birth weight [30]. The selection that is done on the basis of intrapelvic dimensions is not likely to impact the incidence of dystocia caused by fetopelvic disproportion because such a strategy also selects for higher calf birth weights [16,29,31]. As a consequence, the ability of intrapelvic dimensions to predict dystocia is improved when they are indexed to the dam’s body weight [32–34]. Third, increased plasma estradiol and relaxin concentrations at parturition [35,36] and abdominal straining during fetal expulsion may transiently increase intrapelvic dimensions [37–39], particularly the intrapelvic height [40]. A fourth area of concern in using maternal intrapelvic dimensions to predict dystocia is whether the measures have adequate intraobserver and interobserver repeatability [28,38,40–43]. Despite these concerns, measurement of intrapelvic dimensions is believed to be of value in predicting dystocia in dairy cattle [8,26]. A preliminary recommendation is that the prepartum pelvic area should be greater than 270 cm^2 in Holstein-Friesian heifers to minimize the incidence of dystocia [15,44]. Selected external measurements such as heart girth, height at the withers, and horizontal distance between the tuber coxae and horizontal distance between tuber ischia (interischial distance or pin width) could potentially be used in adult cattle as proxies for intrapelvic dimensions [45–48]. However, these measurements appear to be weakly associated with the calving difficulty score [38].

On the basis of the aforementioned facts, we hypothesized that the measurement of calf front hoof circumference, maternal intrapelvic and selected morphologic dimensions in late gestation, and an estimate of the dam’s body weight would be predictive of the calving difficulty score in dairy cattle as previously documented for primiparous beef cattle [32]. We also hypothesized that the ratio of calf front hoof circumference to maternal intrapelvic area or width has clinical utility to predict dystocia in dairy cattle, as these ratios directly reflect the magnitude of fetopelvic disproportion which is the most common cause of dystocia in cattle [6,15,38]. Support for our hypothesis is provided by studies conducted in beef and dairy cattle that demonstrate the ratio of calf birth weight to maternal intrapelvic area or body weight was positively associated with the calving difficulty score [15,17,29,41,49–51]. We also hypothesized that the ratio of maternal intrapelvic area to body weight would be negatively associated with the calving difficulty score in dairy cattle. Therefore, the objectives of this study were to (1) determine the repeatability of measuring intrapelvic width, height, and area in late-gestation dairy cattle, and front hoof circumference in calves; (2) determine the clinical utility of measuring intrapelvic dimensions, selected morphometric measurements, age, and calculated body weight in late-gestation dairy cattle, and front hoof circumference of calves to predict dystocia; and (3) determine whether the ratio of calf front hoof circumference to maternal intrapelvic area and the ratio of maternal intrapelvic area to calculated body weight would be negatively associated with the calving difficulty score in dairy cattle.

2. Materials and methods

All methods were approved by the Purdue University Institutional Animal Care and Use Committee.

2.1. Animals, housing and feeding

An observational study using a convenience sample of 103 late-gestation nonlactating Holstein-Friesian cattle (34 primiparous, 69 multiparous) from the Purdue University Dairy Research and Education Center was performed over a 10-month period between May 29, 2012 and March 29, 2013. Cattle were housed outside in a dry lot and fed an acidogenic total mixed ration (dietary cation–anion difference = −10 mEq/100 g of dry matter, where dietary