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Technical note: The use of an accelerometer for measuring step activity and lying behaviors in dairy calves

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ABSTRACT

Calf behaviors such as step activity, lying bouts, and lying time may be an indicator of calf health and welfare. To reduce time-consuming visual observations, the use of behavioral monitoring systems have been developed to capture these data. Previous studies have validated lying behaviors using an accelerometer (HPG; HOBO Pendant G data logger, Onset Computer Corp., Bourne, MA) in calves. However, the HPG does not measure step activity. The objectives of this study were to (1) validate step activity, lying bouts, and lying time of AfiTag II (AT2; AfiTag II, Afimilk Ltd., Kibbutz Afikim, Israel) to observations from video, and (2) to compare the behavioral data from AT2 to the HPG. Calves (n = 5) were group housed with an automatic calf feeder. Video cameras were installed at both sides of the pen, and observations were analyzed for 7 h/calf. The AT2 and the HPG were both attached to the lateral side of the right rear leg of 5 calves, and data were recorded for 10 d. The full 10-d data set was used to examine correlations for lying bouts and lying time between AT2 and the HPG. The HPG was set at a 60-s sampling interval and the output was analyzed both unfiltered as well as utilizing a 1-min event filter to remove potentially erroneous readings. The AT2 recorded step activity, lying bouts, and lying time, and summarized these behaviors in 15-min periods. The AT2 recorded lying time in 3-min intervals, which were then automatically summarized in 15-min periods. The correlations of step activity, lying bouts, and lying time between video recordings and AT2 were 0.99. For the second objective, correlations between AT2 and the HPG were 0.99 for lying time and 0.93 for lying bouts. The 1-min event filter resulted in a 0.03 improvement in correlations for lying bouts between the HPG and AT2. The high correlation between video recordings and AT2 suggest that this device can be used to measure step activity, lying time, and lying bouts in unweaned dairy calves housed in groups.
Key words: validation, calf, lying behavior, activity

Technical Note

As herd size continues to increase in the dairy industry, many producers have turned to technology to assist with daily management tasks (Khanal et al., 2010). Triaxial accelerometers have grown in popularity in part due to their usefulness in estrus detection (Dolecheck et al., 2015), but more recently research has shown value in disease detection (Alsaaod et al., 2012; Fogsgaard et al., 2015; Itle et al., 2015). In dairy cattle, accelerometers have been used to detect behavioral changes around calving and disease events (Alsaaod et al., 2012; Jensen, 2012; Fogsgaard et al., 2015; Itle et al., 2015). Early detection of these events can allow for timely intervention, potentially reducing the negative effect on the cow. In dry cows, a significant increase in standing times either during the week before calving or on the day of calving was indicative of clinical ketosis (Itle et al., 2015). In addition, cows close to calving showed an increase in step activity and lying bouts 6 h before calving and a decrease in lying time 24 h before calving, allowing for the development of calving alerts (Jensen, 2012). Furthermore, lameness in lactating dairy cattle housed in freestalls can be found with 76% accuracy utilizing deviations from a baseline for lying behaviors and step activity (Alsaaod et al., 2012). Lastly, mastitic cows were more restless for 10 d after initial infection date, exhibiting an increased frequency in lying bouts and step activity, and decreased lying time (Fogsgaard et al., 2015).

Research in calves has shown promise in identifying disease through behavioral changes. When low doses of *Escherichia coli* endotoxin (0.025 or 0.05 μg of LPS/kg of BW) were injected IV, calves were less active while lying, and total lying time was unaffected (Borderas et al., 2008). In another study, calves inoculated with *Mannheimia haemolytica* to experimentally induce pneumonia showed a significant decrease in step activ-

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ity after inoculation (Hanzlicek et al., 2010). In studies examining social housing, calves were found to be more active when housed in pairs or groups and exhibited an increase in time spent standing (Jensen et al., 1998; Chua et al., 2002). Lying behavior has also been shown to be affected by different housing systems, flooring types, and pen sizes in dairy calves (Webster et al., 1985; Bokkers and Koene, 2001; Hänninen et al., 2005; Færevik et al., 2008). These studies have demonstrated that behavioral measurements can provide quantitative evidence of calf welfare.

Lying behaviors and activity in dairy calves are typically collected via video or direct observation (Webster et al., 1985; Bokkers and Koene, 2001; Hänninen et al., 2005). However, these methods are time consuming. Lying behaviors have been validated in lactating dairy cattle and calves utilizing an accelerometer (**HPG**; HOBO Pendant G data logger, Onset Computer Corporation, Bourne, MA; Ledgerwood et al., 2010; Bonk et al., 2013). However, the HPG does not measure step activity. Therefore, the objectives of this study were to (1) validate the use of an accelerometer (**AT2**; AfiTag II, Afimilk LTD., Kibbutz Afikim, Israel) in dairy calves by comparing step activity, lying bouts, and lying time to the gold standard of video recordings, and (2) to compare the behavioral data from AT2 to the HPG.

The current study was conducted during October 2015 at the Virginia Tech dairy farm. Five unweaned female calves (2 Jersey and 3 Holstein; age 44.6 ± 3.2 d) were housed in a group pen on a sawdust pack, which contained a concrete feed alley with an automatic calf feeder and a feed bunk for grain. Calves had access to 12 L/d of a 22% CP, 20% crude fat milk replacer (Amplifier Max, Land O'Lakes Animal Milk Products Co., Shoreview, MN) via an automatic calf feeder (FA Förster-Technik GmbH, Engen, Germany), as well as access to a 22% CP calf starter (Intensity 22% Textured Calf Starter Medicated, Southern States, Richmond, VA).

Video cameras (Canon HF M52, Canon USA Inc., Melville, NY) with 32 GB of internal memory were installed at both sides of the pen. Video was recorded for a 7-h period during daylight hours for analysis. For each calf, the same 7-h period of video was analyzed using behavioral analysis software (The Observer XT, Version 12.0, Noldus Information Technology, Leesburg, VA). Video was analyzed continuously by one observer. Using correlations in Excel (Microsoft Corp., Redmond, WA), intra-observer reliabilities (n = 3 calves for 2 h per calf) were found to be 1.00 for both lying time and lying bouts, and 0.93 for step activity. Step activity was defined as the right rear leg lifted off the floor while the calf was standing. A lying bout was defined as the transition from standing to lying, whereas lying time was defined as minutes per period spent lying.

Both AT2 and the HPG were attached to the lateral side of the right rear leg above the metacarpophalangeal joint. For 10-d, the HPG recorded the *g*-force and tilt of the x-, y-, and z-axes at 60-s intervals, and they were wrapped in gauze to provide cushioning and attached to the leg using Vet Wrap (Co-Flex, Andover Healthcare, Salisbury, MA). Output from the HPG was downloaded using graphing and analysis software (HOBOware Lite, Onset Computer Corp., Bourne, MA), and then downloaded to spreadsheets. The AT2 continuously recorded acceleration in the x-, y-, and z-axes and automatically transmitted these data as step activity and lying behaviors in 15-min intervals to herd management software (AfiAct II, Afimilk Ltd., Kibbutz Afikim, Israel). The AT2 data are cumulative; therefore, the output from AT2 was summarized to match the 24-h segments from the HPG, as well as the 7-h video recordings. The AT2 recorded a lying bout when the calf spent a minimum of 3-min lying down. The AT2 also recorded lying time to the nearest minute, and reported this behavior in 3-min intervals. Lying times not divisible by 3 min had the remainder added to the next lying bout. The HPG recorded the degree of the y-tilt, which is used to determine standing or lying behaviors, with less than 60° indicating standing, and greater than or equal to 60° indicating lying. Using Excel, degrees of y-tilt were converted to either a lying or standing minute, and the change from a standing minute to a lying minute was used to denote a lying bout. Output was also edited to examine the effect of using a 1-min event filter to remove potentially erroneous readings of lying or standing events (Ledgerwood et al., 2010; Bonk et al., 2013). This filter converted behaviors of a 1-min duration back to the original behavior that preceded it. Previous studies in calves have shown an improvement in correlations between the HPG and direct observation for lying time and lying bouts when single lying and standing events were removed, justifying the use of a 1-min event filter (Bonk et al., 2013).

For the first objective, data from the video period were used to determine the accuracy of AT2 and the HPG (PROC REG, SAS 9.4, SAS Institute Inc., Cary, NC) to identify video lying bouts and lying time, and AT2 to identify video steps. Because video was only 7 h, a mixed model containing device and calf was used to determine differences between the HPG, AT2, and video results for lying bouts and lying time, using a Dunnett test with video as the control (PROC GLIMMIX, SAS). A mixed model was also used to determine differences between AT2 and video for step activity. For the second objective, correlations for ly-

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