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A comparison of an automated body condition scoring system from DeLaval with the manual, non-automated, method.

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Abstract
The aim of this study was to determine the accuracy of an automated body condition scoring (BCS) system of DeLaval compared to the manual, non-automated, method. Data was collected from a research dairy farm with 500 cows in a loose housing system. The DeLaval system was situated in the pathway to the milking parlour and in the voluntary milking system. Delaval recorded the average BCS of each cow milked every day using a 0 to 5 scale with 0,1 intervals. Cows were manually measured for BCS by the same two persons, the farm veterinarian and an employee, every week using a 0 to 5 scale with 0,1 intervals. This data was compared using visual representations. The DeLaval system shows a regression to the mean during the whole lactation and the average BCS is higher in comparison with the manual BCS. However, the DeLaval BCS system could be used for recording changes of BCS over time.

Keywords
Body condition score, DeLaval, Manual, Hooks, Pins, Dairy cow, Body condition score camera

Introduction
Body condition scoring (BCS) is a subjective method to assess the amount of fat and muscle on a cow. According to Wright and Russel (Wright & Russel, 1984), the BCS is related to proportion of fat in the live weight. Weight alone is not a good measurement of the cow's condition, since weight is strongly related to the size of the cow, udder filling and feeding. BCS is a better indicator for the degree of fitness and condition of dairy cows (Wildman et al., 1982).

The BCS of dairy cows is an important factor regarding the health and production of the animal, as well as the fertility (Buckley et al., 2003, Roche & Berry, 2006, Bewley & Schutz, 2008). Dairy cows rely on body reserves and feed intake to produce great amounts of milk. Changes in BCS and absolute BCS, especially at calving, both influence fertility, health and milk production (Bewley & Schutz, 2008). Cows with a low BCS during the transition period are more likely to develop endometritis and lameness (Kadivar et al., 2013, Randall et al., 2015). A loss of BCS has a negative impact on reproduction rates and development of ketosis (van Straten et al., 2009, Lacetera et al., 2005). It is also shown that fluctuation in BCS throughout the transition period is negatively correlated to milk yield (Buckley et al., 2003). Extreme BCS may indicate management shortcomings and result in health issues which affect the animal's well-being negatively. So, BCS has implications for overall farm profitability. (Bewley & Schutz, 2008). Therefore, BCS is a tool for dairy farmers to make management and nutrition adjustments.

The method commonly used is scoring each individual animal by hand using palpation and visual observation. Scores are based on appearance and palpation of the back and hind quarters and the system has a 1 to 5

scale using 0,25-unit increments, with 1 being emaciated and 5 obese (Wildman et al., 1982). Specifically, transverse processes, spinous processes, spinous transverse processes, tailhead region, tuber coxae and tuber ischii are inspected. Tuber coxae and tuber ischii are the so-called hooks and pins respectively. The area between the hooks and pins is observed and they are also observed relative to each other (Edmonson et al., 1989). This method is time consuming and therefore often not measured frequently.

Technology could reduce human faults and inconsistent scoring of BCS. An automated BCS system has been developed which provides 3D imaging of the caudal dorsal part of the cow, from the short ribs to the tail, and scores automatically based on this image (DeLaval). The 3D camera is linked to a radio-frequency identification (RFID) system and is recording continuously. Whenever the system recognizes movement from a cow passing underneath, the camera selects the best image of the cow in the video sequence of that moment. A light coding technology is used, and it works by projecting a pattern of IR dots on the rear part of the back of the cow. To create an accurate 3D image of the back, the distance between the dots is measured, and then an algorithm is applied converting the information into a BCS. Cows are scored multiple times a day, depending on the location of the camera, and the average is recorded in the database system (Hallén Sandgren & Emanuelson, 2016).

Research goal

The goal of this research is to determine the accuracy of the automated BCS from DeLaval compared to the manual, non-automated, method.

Material and methods

The data collected is from a research dairy farm with over 500 cows in a loose housing system. The lactation stage varied between 0 and 477 days in milk with a median of 64 days. There is a milking parlour and a voluntary milking system where the cows are milked. The cows are housed in groups with different feeding regimes, but they all get concentrates while milking and in the food stations. Data was collected from July to December 2017.

The automated BCS system that provides the data is from the brand DeLaval. It is situated in the pathway to the milking parlour and in the voluntary milking system. The average day score from the observations is recorded in the data system using a 0 to 5 scale with 0,1 intervals. The BCS of the cows were also manually measured by the same two persons, the farm veterinarian and an employee, every week using a 0 to 5 scale with 0,1 intervals.

Comparison between the two systems could be made on twenty-five days in the period from July to December. The number of cows looked at manually was not equal for each of these days and it were not the same cows every observation moment. If on a day cows only had an automated score they were removed from the study. Equally, the BCS of dry cows was measured manually but not by the DeLaval system due to limitations of the camera positioning. In total 857 comparisons could be made of which 737 the lactation stage was also known. The management system sometimes saved incorrectly and hence created missing data.

For descriptive statistics of the scores, the analytics platform Tableau was used. Other statistics, such as correlation, were performed by using Microsoft Office Excel and were used to determine the statistical dependence between the DeLaval system and manual BCS scoring.

Results

In this chapter the manual BCS data is compared with the DeLaval BCS data using visual data analysis.

Figure 1 shows the distribution of the BCS obtained manually. Figure 2 shows the distribution of the BCS obtained with the DeLaval system. Although both methods use a 0.1 interval it can be seen that the manual scores were mostly measured with 0.2 intervals. The mean of the manual BCS measured was 2,9 with the lowest score being 1,2 and the highest 4,8. The median of the manuals BCS was 3. The mean of the automated BCS measured was 3,2 with the lowest being 1,9 and the highest 4,1. The median of the automated BCS was 3,2. In order to find an association between the BCS manually and BCS DeLaval a scatterplot was made and shown in figure 3. A positive linear correlation is shown in this figure (R2 0,5). The correlation between the two systems is 0,7 (*P*-value <0,05). Moreover, the DeLaval BCS are on average 0,3 points higher. Most records of the DeLaval system range between 2 and 4, whereas this range is between 1 and 5 for the manual scores. Figure 4 also shows a high correlation between the manual and automated BCS system in time over the lactation. The top part of the figure shows the evolution of BCS of the cows during lactation for the DeLaval and manual records. Both show approximately the same evolution but the DeLaval BCS are consistently higher than the manual BCS. Therefore, it shows an overestimation of the BCS of the cows by the automated system.

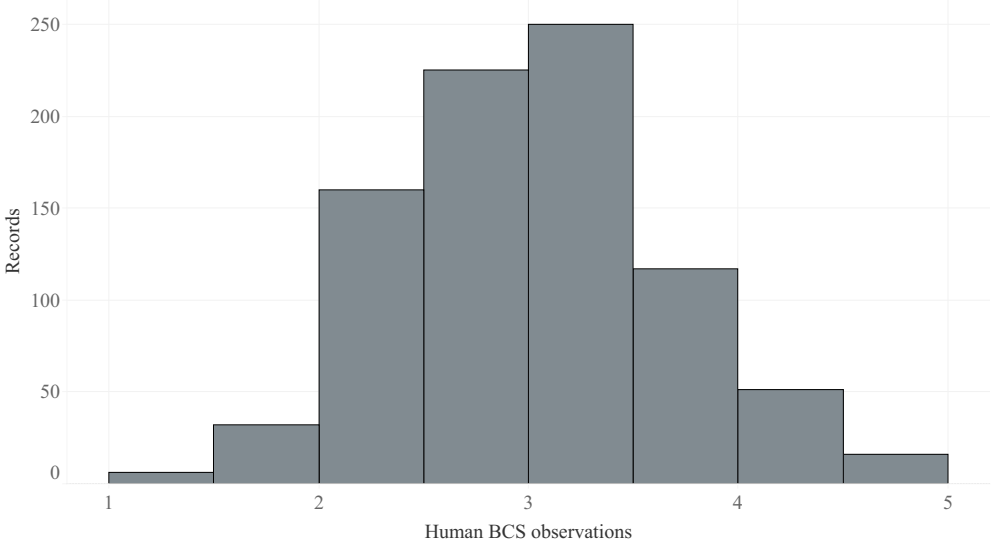

Figure 1 – Distribution of BCS manually

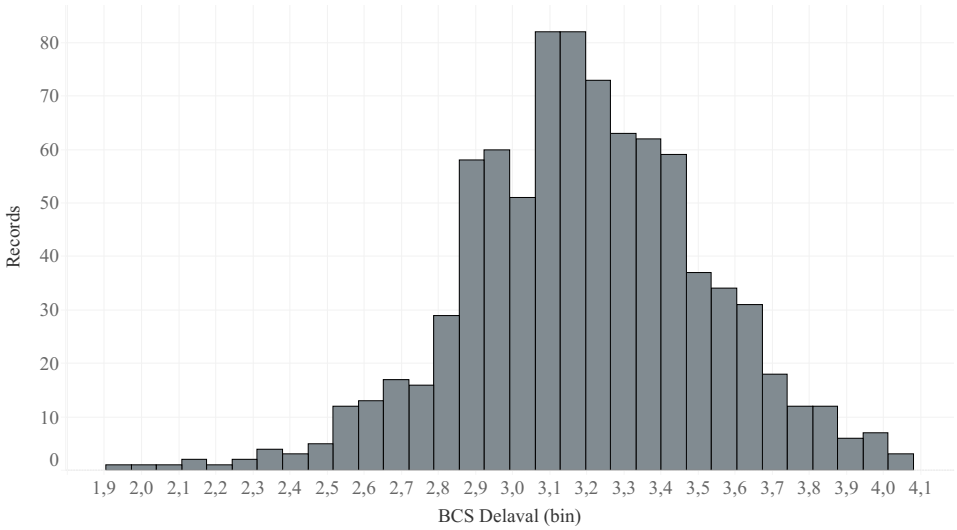

Figure 2 – Distribution of BCS DeLaval

What strikes is that the difference between the two measure methods gets smaller further ahead in lactation days. Although the DeLaval system collects data every day during lactation of the cows, the collection of manual BCS data happened on predefined farm visits. Furthermore, they focused on cows early in lactation, mid lactation (150 – 250 days) and before drying off. This resulted in peaking comparison records at these three moments in lactation. As seen in the bottom halve of figure 4 there are large counts of records (>100) early in lactation. Furthermore, there is a fair amount (<30) of records around 200 days in lactation and around 300 days. So, dividing the data into three lactation groups is an obvious step to make.

A Bland-Altman plot was made to further analyze the collected data. A Bland-Altman plot is a graphical method to compare two measurement methods and identifies any systematic difference between them. Evaluation of a bias between the mean differences can be made and with that an estimation of an agreement interval. This plot shows that low BCS are often overestimated by de automated camera system. When BCS are higher (>3,5) the difference between DeLaval and manual

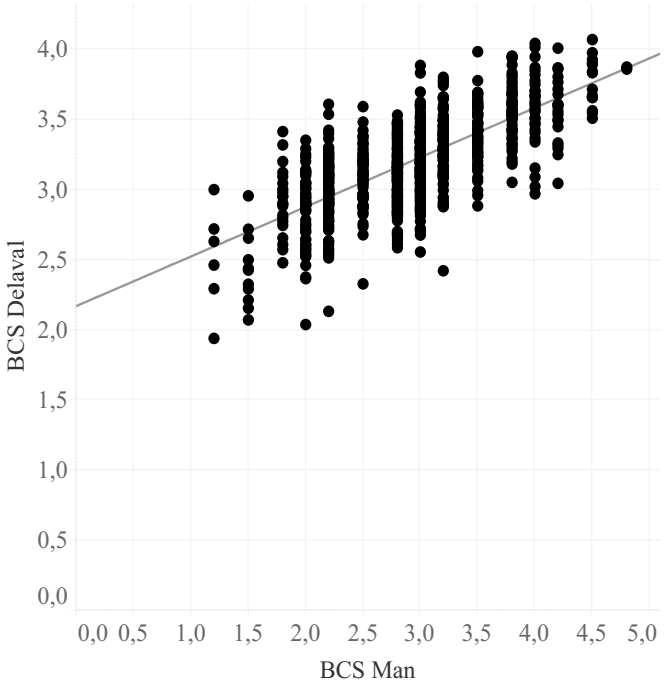

Figure 3 - Scatterplot from the BCS manually and the BCS DeLaval

gets smaller. It seems that the DeLaval scores show a regression to the mean. There are few extreme high or low scores recorded by the camera whereas the manual BCS data does show scores beneath 2 and above 4.

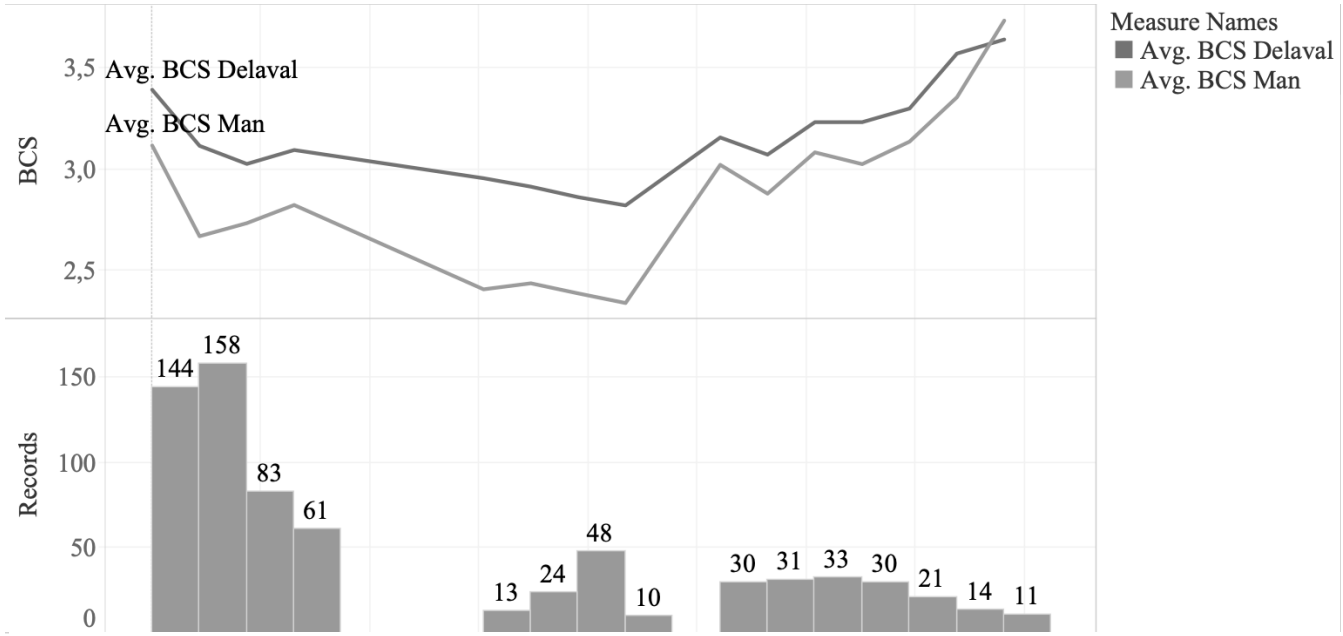

Figure 4 - Distribution of days in milk with a minimum of 10 records. The view is filtered on sum of number of records, which range from 10 – 158

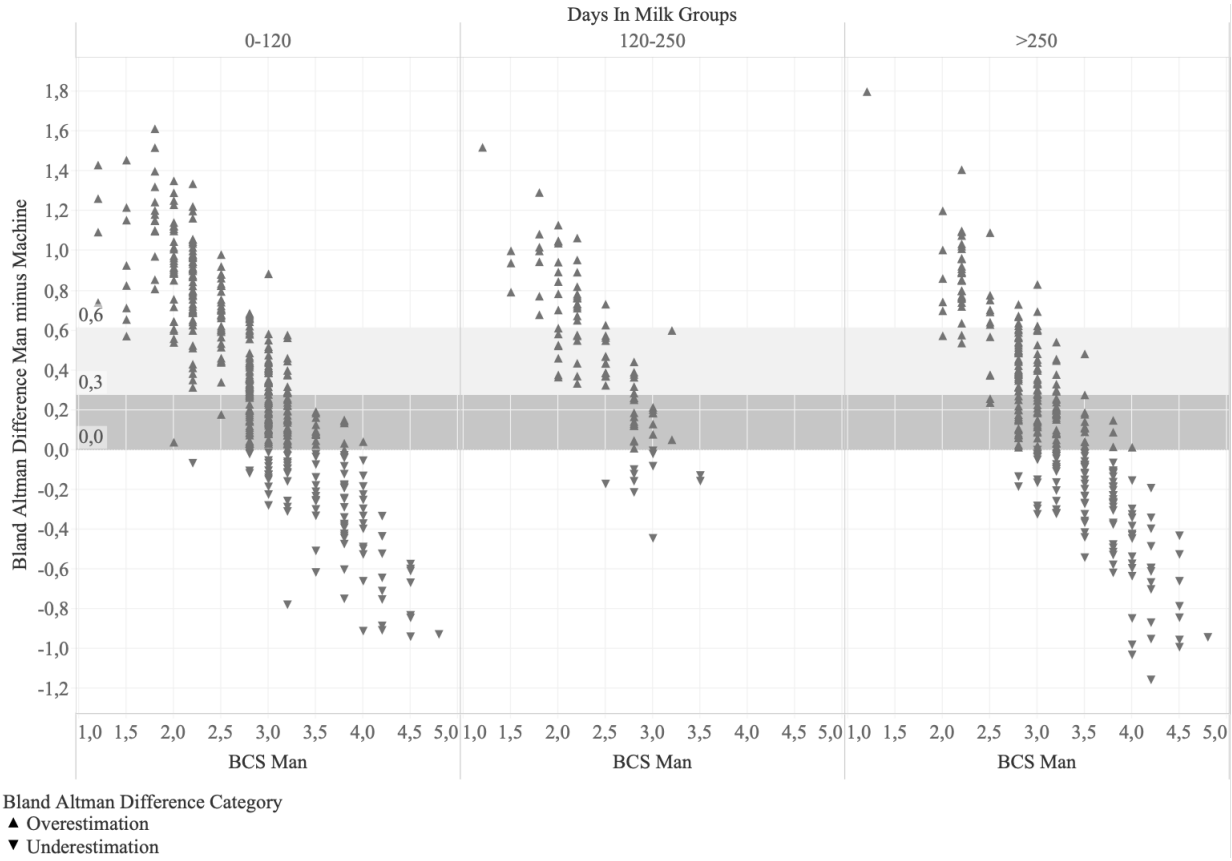

Figure 5 – Bland Altman Plot of BCS between manual BCS scoring (Man) and automated BCS scores (Machine).

Discussion

The main goal of this study was to determine if an automated BCS system is accurate when compared to manually scoring of BCS. Data of BCS on a dairy research facility recorded manually and automatically was compared. The correlation between the manual and automated BCS in this study was 0,7. This is similar to a study using the DeLaval camera and to another study using a 3D Kinect camera, respectively 0,78 and 0,76 (Mullins et al., 2019; Weber et al., 2014). However, a different study with a thermal imaging technique showed a correlation of 0,31, which is lower compared to the correlations mentioned above (Halachmi et al., 2013). A study of Weber et al. (2014) compared manual BCS with the same thermal imaging technique and found a higher correlation of 0,94 (Weber et al., 2014). A higher correlation of 0,84 between a DeLaval system and manual scoring was found by Anglart (2010).

A consistent difference was found between the two methods. The DeLaval system scores BCS on average 0,3 higher in comparison with the manual BCS. However, in a study of Mullins et al. (2019) the automated system was reliable for cows scored within the range of 3,00 to 3,75. Outside of this range the automated system also on average scored higher BCS in comparison with the manual BCS in that study (Mullens et al., 2019).

The BCS of cows high in condition was scored lower by the automated system in comparison with the BCS measured manually. Similarly, the cows low in condition were scored higher in BCS by the automated system. Cows with a low BCS are not correctly detected by the 3D camera (Krukowski, 2009). The Delaval system does not seem to pick up extremes in BCS

nor does the 3D camera in the study of Krukowski(2009).

It is known that lactation stage affects BCS of dairy cows (Wildman et al., 1982). In early lactation (<120 days) overestimations of the DeLaval system were found. This can also be seen end lactation (<250 days) where more underestimations of the DeLaval system were found, which can be associated with the increasing BCS of cows near the end of lactation.

We could also question if the manual method is the golden standard. It is questioned how reliable manual observations are. A study showed that an automated 3D camera system was sometimes more accurate than the manual BCS and that manual scoring can be inconsistent. Repeatability seemed to be higher in the scoring of the system than in the manual scoring (Hansen et al., 2018). Even though BCS is a frequently used measurement it could be questioned if this is the best representation of the actual energy reserves in the cow. Fat can also be stored abdominal and therefore is not visible when measuring BCS. Cows with a low BCS could have a high abdominal fat score and vice versa (Hostens, 2012).

Conclusions

This study shows that the DeLaval BCS system can be used for recording changes of BCS over time and making management and nutrition decisions during lactation based on that information. However, the DeLaval system shows a regression to the mean and the average BCS is higher in comparison with the manual BCS. Therefore, absolute BCS of a cow recorded by the DeLaval system is not accurate.

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