Ministry of Higher Education
And scientific Research
Al Muthanna University
College of veterinary medicine

Assessing cow health condition by using the recent Cowdition Smartphone App and its correlation with vital clinical parameters

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Year 5

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Final year project submitted to College of veterinary medicine /

Al Muthanna University/ Iraq, as partial fulfillment of the requirements of the Bachelor degree in Veterinary Medicine and Surgery

April 2017

Dedication

الاهداء

الى من زرعو في طريقنا حب المثابرة والنجاح نهدي لهم هذا البحث كونهم اختاروا لنا الافضل

وجعلونا على طريق الصواب الى اباؤنا الكرام

الى العظيمات دائما وابدا الى امهاتنا الكرام اللواتي علمنا خط اول حرف

الى زميلنا العزيز نور جمعة

الى وطننا الحبيب العراق

الى كل اساتذتنا الافاضل

الى كل باحث عراقي

Acknowledgement

شكر وتقدير

كن عالما فان لم تستطع فكن متعلما ؛فان لم تستطع فاحب العلماء؛ فان لم تستطع فلا تبغضهم .

بعد رحلة بحث وجهد واجتهاد تكللت بانجاز هذا البحث

نحمد الله عز وجل على النعمة التي منَّ بها علينا

فهو العلي القدير كما لا يسعنا الا ان نخص عبارات الشكر والتقدير الى (الدكتورة كريمة عاكول الصالحي) لما قدمته لنا من جهد ونصح ومعرفة طيلة انجاز هذا البحث

كما نتقدم بالشكر الجزيل لكل من اسهم في تقديم يد العون لانجاز هذا البحث

تقدير الحالة الصحية للابقار باستخدام التطبيق الحديث للهاتف الذكي (الكاودشن) وعلاقته بالمعايير الحيوية السريرية

الخلاصة

تعاني الأبقارالحلوبة العالية الانتاجية من فقدان كبير ومتزايد في حالة الجسم عند الرضاعة المبكرة وتكون أكثرعرضة للاضطرابات الأيضية. يمُكن تحديد الوضع الصحي للحيوان باستخدام تطبيق الهاتف الذكي الحديث الكاودشن، والذي يسمى مؤشر درجات حالة الجسم (بي سي أس) . حيث يمكن تطبيقه بشكل مناسب لادارة حقول الابقار. ويساعد البي سي أس أيضا للتاكد من أن جميع المراحل السنوية للبقرة هي في حالة جيدة. وبالتالي ،إجراء التغييرات الغذائية المناسبة لمنع حدوث الامراض الايضية. تقاس درجة حرارة الجسم والنبض والتنفس بشكل روتيني وتعتبر من المؤشرات الحيوية المناسبة لتقييم صحة الحيوانات. لذلك ،صممت هذه الدراسة لتقديرحالة جسم الحيوان وعلاقتها بالمؤشرات الفسيولوجية الحيوية لتقييم صحة الحيوان. تم اختيار ثلاثين بقرة في مراحل تكاثر مختلفة في مزارع بمحافظة المثنى \ العراق. تم استخدام تطبيق البي سي أس من شركة باير لقياس درجة حالة الجسم بالاضافة الى ذلك تم قياس درجة الحرارة ,النبض والتنفس لكل بقرة. وتم ايجاد العلاقة بين هذه المؤشرات الفسيولوجية الحيوية وقراءات البي سي أس. كان المتوسط الكلي للبي سي أس هو 0.068 ± 3.9 وتراوحت بين 2.5 إلى 5 لاقل وأعلى قيمة على التوالي. وعلاوة على ذلك،أظهرت 63.33٪ (19 من أصل 30) بقرة المؤشرات القياسية للبي سي أس وتراوحت بين 3.25-3.75 , في حين اظهرت هذه الابقار مؤشرات سريرية حيوية طبيعية. وأظهرت 30٪ (9 من أصل 30) بقرة مؤشر السمنة وبقيم تراوحت بين 4-4.25 مصحوبة بتفاوت في المؤشرات السريرية الحيوية التي تزداد مع قيم البي سي أس العالية. واظهرت فقط 6.66٪ (2 من أصل 30) بقرة المؤشرات المتطرفة والتي كانت 2.5 و 5 للابقار المتوسطة والبدينة الجسم على التوالي مع اختلاف بالمؤشرات الفسيولوجية الحيوية.

في الخلاصة ،ولمعرفة الباحثين ،فان هذه الدراسة الأولى من نوعها في العراق والتي اسُتخدام فيها التطبيق الحديث للهاتف الذكي (الكاودشن) لتقييم صحة الحيوان لفهم العلاقة بين البي سي أس وفسيولوجية المؤشرات السريرية الحيوية (درجة حرارة الجسم، والنبض، ومعدلات الجهازالتنفسي)،لتقييم صحة جسم الابقار والتي تساعد في تحسين التغذية الحيوانية وتُجنب حدوث الأمراض الأيضية بالابقارالحلوبة العالية الانتاجية. يوصي الباحثون باستخدام تطبيق الكاودشن البي سي أس لاجراء دراسة أخرى مستقبلية وايجاد العلاقة بينها وبين الامراض الايضية . وعلاوة على ذلك ينصح الباحثين بتشجيع الاطباء البيطريين والمزارعين بالاستخدام الروتيني لهذاالتطبيق الذكي والذي يستخدم حاليا في جميع الدول المتقدمة لادارة حقول الابقار.

Abstract

Background

Highly productive milk cows suffer from increasing loss in body condition at early lactation and are more prone to metabolic disorders. Recent Cowdition smartphone application can determine animal health situation, and it is called body condition scoring (BCS) system. It can apply adequately for proper farming and management the animal performance. BCS is also helping to assure that all stages of annual cow cycle are in a good condition. Consequently, appropriate dietary changes can be done to prevent any deficiencies and metabolic diseases.

Materials and methods

Routinely, rectal body temperature and pulsation and respiratory rates are measured as suitable vital indicators for evaluation the health of the animals and recognize the clinical abnormalities. Therefore, this study intends to correlate between the animal body condition and the vital physiological parameters measurements to assess cow health. A total of 30 cows at different stages of the reproduction period, raised at various farms location in Al Muthanna Governorate/ Iraq were nominated animal material of the present study. For each cow, Bayer smartphone Application/ BCS Condition was used to measure the body condition, and at the same time, body temperature and pulse and respiratory rates also measured. Scores that collected from the Cowdition application system compared with physiological vital indicators parameters.

Results and discussion

The total average of BCS was 3.9±0.068 that range from 2.5 to 5 for lower and higher values respectively. Moreover, 63.33 % (19 out of 30) cows showed the standard BCS ranged between 3.25-3.75 and revealed normal vital clinical parameters. Also, 30% (9 out of 30) cows showed fat BCS values ranged between 4- 4.25 accompanied with variation in the vital clinical parameters that increase with high BCS values. Only 6.66% (2 out of 30) cows showed extremist BCS values which were 2.5 and 5 for moderate and grossly fat cow respectively. Moreover, these cows showed also variations in the vital clinical parameters.

Conclusions: In conclusion, for the authors' knowledge, this study represented for the first time in Iraq the adoption of smartphone BCS Cowdition system to evaluate the animal health. Besides, to understand the relationship between BCS and physiological vital clinical parameters values (body temperature, pulse, and respiratory rates), to evaluate and assess the cow body health that helps in the improving of animal nutrition and avoid the metabolic diseases that commonly occur in the highly productive cow. The authors recommend another future study that uses BCS Cowdition Smartphone Application and correlates it with the animal's metabolic diseases. Moreover, to encourage the veterinarian and farmers to routinely use of this simple smartphone application to evaluate the animal BCS.

CONTENTS

Introduction

Body condition is a term used to determine the quantity of stored energy that cow has it for future use. BCS can indicate the energy equilibrium and determine animal production and reproduction achievement. Body condition impacts both dam and calf performances. It is also affected on the general meanings of the animal such as health, breeding, production, reproduction and the longevity of the dairy cattle. The weakness (emaciation) or obesity (fatness) animal status that occur due to poor welfare herd organization can identify by regular assessment of their body condition. These procedures can help in the resolving the animal health complication that leads to raising both reproduction and production. Later on, high milk production cows conserve their longevity in the farm (kunkle *et al*., 1998; Roche *et al.,* 2007). Huge numbers of research were done to assess the animal body condition especially dairy and beef cows. These research pointed to the high drop rates in the body condition relating to weight loss. Accordingly, the measurement of body condition using the scoring system provide a good indication for the opportunity of the animal reproducibility (Roche *et al.,* 2007; Roche *et al.,* 2013). Moreover, the weakness in the nutritional substance and organization of the farm can enhance the development of fat cows that are prone to metabolic diseases such as milk fever, ketosis, and hematuria due to phosphorus deficiency. Besides, the rate of incidence of infectious diseases and struggling at, during and after calving time are increased. The over-conditioning usually begins during the last three to four months of lactation, when milk production has decreased, but the dietary energy and total nutrient levels have not been reduced accordingly. Other common causes of over-conditioning are prolonged dry periods or overfeeding during the dry period (Roche *et al.,* 2013). However, below-acclimatizing, or skinniness, can frequently decrease the output and concentrations of milk fat because of inadequate energy and protein store that need to sustain production. Skinny cows commonly do not display heat or conceive until they start to recover or at least preserve their body weight. In nurturing these animals, attention must be taken to keep production, while raising body reserves. The body condition scoring system also acts as a useful tool in dairy heifer feeding management. Skinny heifers probably no develop speedily enough to reach sexual maturity at the expected time. A number varieties of dilemmas and distress such as failure to reach the foreseen calving time can also occur when this young cow that called heifers have a minor BCS. These heifers also compensate the deficit that occurs during milk production by moving enough mass of their body weight. Moreover, fat heifers have been shown to be hard to breed, if they are fat, when they are close to calving. These cows also donate small milk quantity particularly when they were grossly fat at the period of sexual. Body condition scoring system is a vital method that offers an important value for the complications that occur from disturbances in the body energy reserves and lead to developing several metabolic diseases and reproductive traits (Roche *et al.,* 2013; Edmonson *et al.,* 1989; NRC ,1996). Diverse approaches are usually used globally to estimate the body condition score. The "6" point scoring system used by Lowman *et al.,* (1976) that extended between “0” and “5”. Another body condition system developed by Whitman (1975) with “9” point system. Later on, Holmes *et al.,* (1987) had also developed body condition score of “10” points. Variations in the body condition scoring system are

recognized and occur depending on the country and the animal to be the score. The more practiced system in Australia is "8" point system which developed by Earle, (1976). Meanwhile, New Zealand, USA, Canada, and the European Union have used "10", "1-9" and "1-5" by "0.5 steps" respectively (Grainger and Mcgowan, 1982).
Recently, BCS Cowdition smartphone application has developed to improve simple and precision body condition scoring for dairy cows. It is an accurate photographic and credible estimation of body fat reserves using a 5-point scale with 0.25-point increments. The scores are a subsidiary evaluation of energy equilibrium. A score of 1 means an actual skinny cow, while 5 means an extremely fat cow, and 3 is an average body condition. Estimation emphases on the rump (Hindquarters) and loin (flank); scales used in allocating BCS appear in Figure. (1).

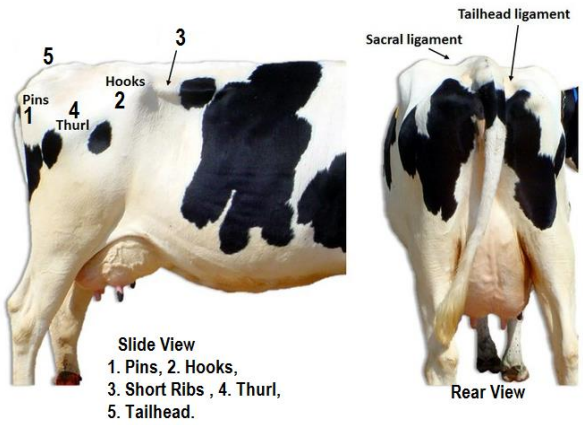

Figure.1: shows the animal view that uses for BCS evaluation

The body temperature of the animal is the result of the internal equilibrium between the heat production (the basic metabolism and muscular activities of the body) and heat lost from the body (Jeffrey and Michael, 2010). Pulsation and heart rates and rectal temperature are used as consistent indexes of short period physical stressful in livestock (Plyaschenko and Sidorov, 1987; Verstegen, 1987; Oladimeji *et al., 1996*; Ayo *et al.*, 1998).
Iraq is a distinct core for best common farm livestock species and has a large numbers varieties of farm animal species. According to 1978 estimation survey, there were 1.7 million cattle and 170.000 buffalo (Al salihi, 2012). However, these numbers changed according to 2009 FAO data estimation that revealed 1.6 million cattle and 275 000 buffaloes (http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Iraq/Iraq.html).

Aims of study

Review of literature revealed no published BCS for Iraqi cattle or buffalo. In Iraq, there are different species and breeds of cattle. These cattle are local, cross or imported. The estimation of body condition in cattle of the Iraqi farm are necessary to evaluate its reproduction annual cycle and to design the nutritional program to prevent the most important metabolic diseases. Consequently, this study intends for the first time in Iraq, to implement BCS Cowdition smartphone application to measure the cow body condition and to correlate its scores with vital parameters measurements to assess cow health.

Review of literature

Body Condition Scoring Scale

Reproduction is the most important factor in determining profitability in a cow calf enterprise. To maintain a calving interval of 365 days, a cow must re-breed in 80 to 85 days after calving. Many cows need a higher level of condition at calving and breeding to improve reproductive performance (Alic, 2012). Poor reproductive performance is directly linked to the percentage of body fat in beef cows. Body condition scoring (BCS) is an easy and economical way to evaluate the body fat percentage of a cow ((kunkle *et al.,* 1998; Roche *et al.,* 2007). Cows can then be sorted and fed according to nutritional needs. Body condition scoring can be an effective tool for cattle producers who cannot weigh cattle, and it may be an even better measurement of cow condition and reproductive performance than weight (Bewley & Schutz, 2008). Most studies show that body condition decreases at a faster rate than weight loss. Therefore, body condition scoring can estimate the probability of re-breeding. Beef cattle have nutrient requirements in priority order for body maintenance, fetal development, lactation, growth and breeding. The nutrient intake is distributed in the body of the cow to fill these nutrient requirements. As each requirement is filled, the available nutrient is shifted to the next lower priority. The reverse shift is also obvious in beef cows. As nutrient requirements exceed intake, nutrients are shifted from the lower priority requirements to be sure that higher priority requirements are filled. Dairy and beef cattle store excess nutrients as body fat. The fat stores are mobilized when the nutrient demands exceed the available intake. In times of severe nutrient restriction, muscle tissue is mobilized once fat and other nutrient stores have been depleted. Researchers have determined that a certain amount of body fat is required for the reproductive system to function. Inadequate nutrition is most often the cause of poor reproductive performance. Developing a nutrition program is easier and more cost effective when all cows on the farm can be managed in a similar manner. This is especially true when all cows on a farm are managed in a single herd, which is often the case with small production units. Calving year around will make it very difficult to maintain adequate body condition on all cows at the critical times (Bewley *et al.,* 2010).

Importance of Body Condition Scoring

Body condition affects both cow and calf performance. Poor body condition is associated with reduced income per cow, increased post-partum interval, weak calves at birth, low quality and quantity of colostrum, reduced milk production, increased dystocia, and lower weaning weights. Increasing post-partum interval will result in a younger, smaller calf at weaning the next year and will result in lower incomes if sold at weaning. Weak calves at birth may not get adequate colostrum and are more susceptible to disease, reduced weaning weights, reduced feedlot performance, and less desirable carcass traits. Research clearly shows that cows in moderate body condition will have a shorter interval from calving to first estrus than cows in thin condition. This supports the conclusion that BCS is one of the most important factors in determining subsequent reproductive performance. Body condition scoring in dairy cattle is a visual and tactile evaluation of body fat reserves using a 5-point scale with 0.25-point increments. Body condition scores (BCS) are an indirect estimate of energy balance. A

score of 1 denotes a very thin cow, while 5 denotes an excessively fat cow, and 3 is an average body condition (Battiato *et al.*, 2010; Bayer, 2015).

BCS Related Research

Research demonstrates the classical relationship of body condition to dry matter intake, milk production, reproduction, and health. Figure 2 shows the relationships between body condition and the production cycle of dairy cows (Bayer,2015).

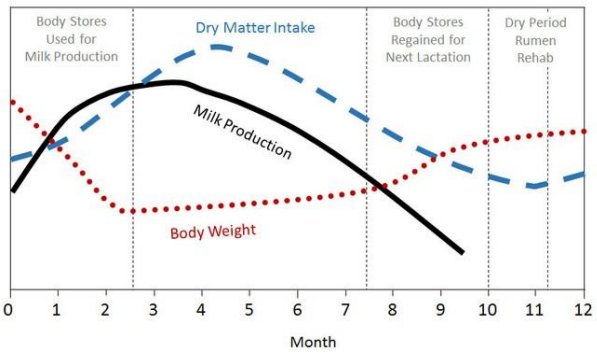

Figure 2. Changes in body weight, dry matter intake, and milk production over a single lactation (Bayer, 2015).

Dry Matter Intake

Body condition score generally is negatively related to dry matter intake. This means that cows carrying excess condition before calving have a greater risk for low feed intake in the critical transition period around the time of calving. This can lead to loss of body condition and deepen the negative energy balance cows experience after calving (Berry *et al.*, 2007). Reduced dry matter intake has obvious effects on milk production and can contribute to ketosis, a displaced abomasum, or other metabolic and production consequences of nutritional stress.

Milk Production

Mobilization of stored body fat provides a source of long-chain fatty acids for milk fat production and an energy source for body tissues in early lactation. Often BCS and milk production curves are mirror images, with cows producing the most milk experiencing the greatest change in body condition and the lowest BCS in early lactation. However, the effect of BCS on milk production is not a linear relationship. Cows with a BCS of 3.0 to 3.5 at calving produce more milk than those calving either at a lower or higher score. This relationship may be due to an increase in the energy available from body stores up to a BCS of 3.5 and negative effects of BCS on dry matter intake after that point (Edmonson *et al.*, 1989; Grainger and McGowan,1982). Cows can typically be expected to lose some condition score in the first 60 days after calving. We now generally recommend that cows loose as little BCS as possible after calving; no more than 0.5 to 1.0 point in score, with a maximum of 1.5 units of condition score. The 2001 Nutrient Requirements of Dairy Cattle include calculations that describe how

much milk production can be supported by the mobilization of stored body fat. For example, if a cow weighing 1433 pounds with a BCS of 4.0 at calving loses 1 BCS unit, 417 Mcal of NE_L are produced. This is enough energy to support 1,230 pounds of 4% fat-corrected milk production.

Reproduction

Energy balance plays a very important role in reproductive performance, and both current and past energy status influence a cow's ability to reproduce. Greater change in BCS between calving and first breeding and lower BCS at the first breeding consistently are associated with reduced pregnancy rates. However, multiple studies have found that diet changes were not able to overcome BCS loss in early lactation, which means that the primary way to control BCS at breeding is to manage BCS at calving. A Cornell study published in 1989 provides a good example of the impact of BCS on reproduction. In the study three groups of dry cows were monitored to determine the effect of body condition during the dry period on subsequent reproductive performance. Cows with the highest BCS at calving lost the most body condition in the first 5 weeks of lactation. These cows had a longer interval to first ovulation, a higher number of days to first heat and conception, and the lowest first-service conception rates (Table 1). Losing body condition during early gestation has also been associated with increased embryonic losses. For the farmer, these factors mean lost dollars (Butler and Smith, 1989).

Table 1. Relationship between BCS loss in first 5 weeks after calving and reproduction. (Butler and Smith, 1989; Journal of Dairy Science 72:767-783).

Item	Body Condition Loss < 0.5	Body Condition Loss 0.5 to 1.0	Body Condition Loss > 1.0
Means in a row with different superscripts differ *P* < 0.05 Butler and Smith, 1989; Journal of Dairy Science 72:767-783.			
# Cows	17	64	12
BCS at Calving	3.7	4.1	4.5
Days to first ovulation	27[a]	31[a]	42[b]
Days to first heat	48[ab]	41[a]	62[b]
Days to first service	68[a]	67[a]	79[b]
First service conception rate, %	65[a]	53[a]	17[b]
Services per conception	1.8	2.3	2.3
Pregnancy rate, %	94	95	100

Health

Body condition at calving and in early lactation is associated with the incidence of important metabolic disorders in dairy cows, particularly ketosis. The risk of ketosis has been shown to be two times greater for cows calving at BCS > 3.5 compared to

those calving at BCS 3.25, and the rate of both clinical and subclinical ketosis is greater in cows with high BCS. Milk fever may also be related to BCS. One study found cows with BCS < 2.5 or > 3.5 were 13% or 30% respectively more likely to suffer milk fever than cows with BCS of 3.0. Fat cows mobilize more energy from body reserves, which tends to reduce dry matter intake and increase milk production; both factors contribute to metabolic disease risk. Often, studies investigating the relationship between BCS and health problems have reported inconsistent results (Huseyin and Zahid, 2015). Metritis risk tends to be increased in cows with low BCS or those that lose body condition during the dry period. Cows losing condition during the dry period may have increased risk of dystocia, and a New Zealand study (Holmes *et al.*, 1987) of nearly 77,000 BCS records from 1,172 cows found that the amount of body weight lost between calving and conception affected the proportion of cows that gave birth to male calves, which could increase the risk of dystocia due to size differences between male and female calves. Cows with high BCS at calving or excessive loss of condition in early lactation have been shown to be more likely to experience a displaced abomasum. Retained placenta has been found to be more common in cows with excess body condition. More recent research has determined that cows with BCS greater than 3.5 are more sensitive to oxidative stress and more likely to have suppressed immune function, which likely contributes to increased disease risk in these cows. Lameness has been associated with both fat and thin cows. In cows that are over conditioned at dry-off, lameness may arise due to stress from carrying extra weight or from reduced dry matter intake at calving that leads to excessive BCS loss as lactation progresses (Hoedemaker *et al.*, 2009). Cows with BCS < 2.0 are more likely to suffer from lameness, which is possibly due to a thinner digital cushion that leads to greater incidence of sole ulcers and white line disease.

Table 2. Suggested Body Condition Scores for Cows by Stage of Lactation.(Bayer, 2015).

Stage of Lactation	DIM	BCSGoal	BCS/ Min	BCS/ Max
Calving	0	3.50	3.25	3.75
Early Lactation	1 to 30	3.00	2.75	3.25
Peak Milk	31 to 100	2.75	2.50	3.00
Mid Lactation	101 to 200	3.00	2.75	3.25
Late Lactation	201 to 300	3.25	3.00	3.75
Dry Off	> 300	3.50	3.25	3.75
Dry	- 60 to -1	3.50	3.25	3.75

Target Scores for Stages of Lactation

Changes in body condition are to be expected as a cow moves through the stages of lactation and gestation (Table 2). For most cows, BCS decreases from calving to about 100 days in milk and then increases through dry-off. A few efficient, high-producing cows may not experience large changes in BCS, and some inefficient, low producing cows may continually increase in BCS over a lactation. However, when cows accumulate too much or too little condition or changes occur too rapidly, health and performance can be affected. Generally speaking, the goal is to manage body condition

such that the extremes of over- or under conditioning are avoided. Nutritional strategies to manage body condition change as cows progress through lactation (Bayer, 2015).

Calving to Peak Milk

Cows should calve with adequate, but not excessive, body fat reserves and a BCS between 3.25 and 3.75. Dry matter intake should be managed closely for close-up and fresh cows to limit negative energy balance in early lactation. The early lactation ration must encourage maximum intakes and provide adequate energy and protein levels to support peak milk production and encourage a return to normal reproductive cycles. Cows in early lactation enter a negative energy balance and mobilize body fat to support milk production. The amount of energy a cow can draw from her body reserves depends on her weight and body composition. High-producing cows can lose 100 to 150 pounds of body weight during the first 60 to 80 days of lactation. This is typically the equivalent of 1 BCS unit and occurs at a rate of 1 to 2 pounds per day. If weight loss is higher (3 to 4 pounds per day), the risk of metabolic disorders and reduced fertility becomes higher. Mobilized body tissue can often support 1,000 to 1,300 pounds of 4% fat-corrected milk production (Kunkle *et al.*, 1998; Rae, 1993). The goal is to minimize weight loss by encouraging intake of high quality, highly palatable forage dry matter at a rate of 1.8 to 2.0% of body weight per day, with grain supplemented to support milk production. Early lactation cows that are thin but not high producers are not getting enough energy. Be sure that all nutrients are balanced properly and that dry matter and water intakes are adequate. Cows in early lactation with BCS > 3.25 and lower milk production than expected are likely not getting enough protein. In addition, confirm that mineral, vitamin, and water intakes are adequate.

Mid-Lactation

After cows reach their peak milk production they should start replenishing body fat reserves, and it becomes more efficient to add body condition. If regaining body condition is delayed past 80 to 120 days, cows will often have reduced fertility. The nutritional program should encourage moderate weight gain (0.75 to 1 pound per day) that will support milk production and fertility, but avoid excessive weight gain. If cows have BCS > 3.25, energy intake should be reduced to avoid over conditioning.

Late Lactation

Late lactation is the optimum time to manipulate body condition. Cows should be in a positive energy balance and confirmed pregnant by this time, and changes in body condition can be made very efficiently. If cows have BCS < 3.0, increase energy intakes. Failure to replenish energy reserves will limit milk production during the next lactation. If BCS exceeds 3.75, energy intakes are too high and should be reduced to avoid excessive fattening. Extended calving intervals may also contribute to high BCS in late lactation.

Dry Period

The goal of the dry period is to prepare cows for their next lactation by maintaining body condition. Separate dry cows from the milking herd and feed them a low energy ration with adequate, but not excessive, protein, minerals, and vitamins. If cows are too fat at dry-off (BCS > 3.75) it is best to keep them from losing BCS during the dry period. Thin cows (BCS < 3.0) may benefit from extra energy in the first three weeks of the dry period. If cows consistently enter the dry period with BCS < 3.25, energy intake should be increased for cows in late lactation. If cows are consistently at BCS > 3.75 at dry-off, reduce the energy intake late lactation cows and/or address issues contributing to extend calving intervals. To keep dry cows in proper condition, ensure that forage dry matter intake is a minimum of 1.8 to 2.0% of body weight per day. Forage should provide 85 to 88% of the total ration dry matter. If necessary, control feed intake to hold dry matter intake to 2% of body weight (Roche *et al.*, 2007; Roche *et al.,* 2013).

Heifers

Table 3 presents recommended BCS for heifers throughout the rearing period. Feed balanced rations that provide adequate levels of all nutrients so that heifers can grow properly and maintain BCS in a normal range. If young heifers are allowed to become too thin, they will not grow at the proper rate and may have reproductive problems that delay their first calving. Failure to provide adequate feed to older heifers may limit their ability to support milk production. On the other hand, overconditioning of bred heifers can increase calving difficulty and have negative repercussions on the health of both the heifer and her calf. Overfeeding younger heifers, particularly between weaning and puberty, leads to greater fat infiltration of the mammary gland and increased breeding difficulty. When these heifers freshen, they will not produce to their full genetic potential.

Table 3. Suggested Body Condition Scores for Growing Heifers by Age in Months (Roche *et al.*, 2007).

Events	Age (months)	BCS Goal	BCS Min	BCS Max
	0 to 4	2.25	2.00	2.50
	4 to 10	2.50	2.25	2.75
Pre-Breeding	10 to 12	2.75	2.50	3.00
Breeding	12 to 15	3.00	2.50	3.25
Bred	15 to 20	3.25	3.00	3.50
Calving	> 20	3.50	3.50	3.75

Troubleshooting

Regular monitoring of BCS can be useful in tracking changes over the lactation and in troubleshooting nutrition and health problems in the herd. Within a herd, Researcher can expect a few cows, about 5 to 10% at most, that either never put on much flesh or usually tend to be obese. Signals that body condition is not where it should be may include an increase of 5 to 10% in the incidence of metabolic diseases or a failure of cows to maintain lactation persistency or peak at expected levels. When animals are

not in proper condition, the first thing to check is the feeding program. Focus first on dry matter intake, especially of forage. Forage should account for at least 45% of a cow's total dry matter intake. Determine that the feeding sequence, fiber levels, feeding frequency, and ration palatability are in order. If these items are adequate, evaluate protein, energy, mineral, and vitamin levels in rations to be sure they are adequate. Test forages and re-balancing rations for each group of cows as needed. Be sure to analyze for bound protein in hay-crop silages and adjust the ration accordingly. Examine feed quality, including particle size of forage and grain, and smell and pH of silages and wet commodity feeds.Check rations for amounts of bypass and soluble protein and for levels of starch, fats, and oils. Feed extra energy in early lactation to offset negative energy balance. Added fat from oilseeds should comprise no more than 5% of total ration dry matter. Rumen-protected (bypass) fats can provide an additional 2% of ration dry matter. Total fat in the ration should not exceed 7%. When oils and fats are added to the ration, increase calcium, magnesium, and phosphorus by 10% on a dry matter basis. Once the cause of the problem has been determined, the next step is to keep it from reoccurring. Avoid rapid fluctuations in body condition. Pay close attention to cows during lactation, especially the later part, and during the dry period. When large amounts of forage are consumed or if grain is not fed properly, animals may become overconditioned and are more susceptible to health problems. In dry cow rations these factors are more often overlooked (Bayer, 2015).

Materials and methods

Cows

This study conducted at different locations in Al Muthanna Governorate/ Iraq. A total of 30 cows randomly selected, were used in this evaluation and considered as the animal material of this study. The cows were in different stages of annual reproduction cycle.

Technique

Each cow of the animal material was left to rest and acclimatized for a short time before evaluation. The body temperature and pulse and respiratory rates were also measured and recorded. Bayer smartphone Application/ BCS Cowdition was acquired to measure the body condition (Figure. 3). The cow photographed from both side and rear views. Moreover, all data regarding each cow inserted in the program including cow number or name; date of birth; Herd; Breed and Calving date and history. Later on, the program system was requested to analyze all data to identify the cow's BCS. Scores that collected from the Cowdition application system were compared with vital indicators parameters.

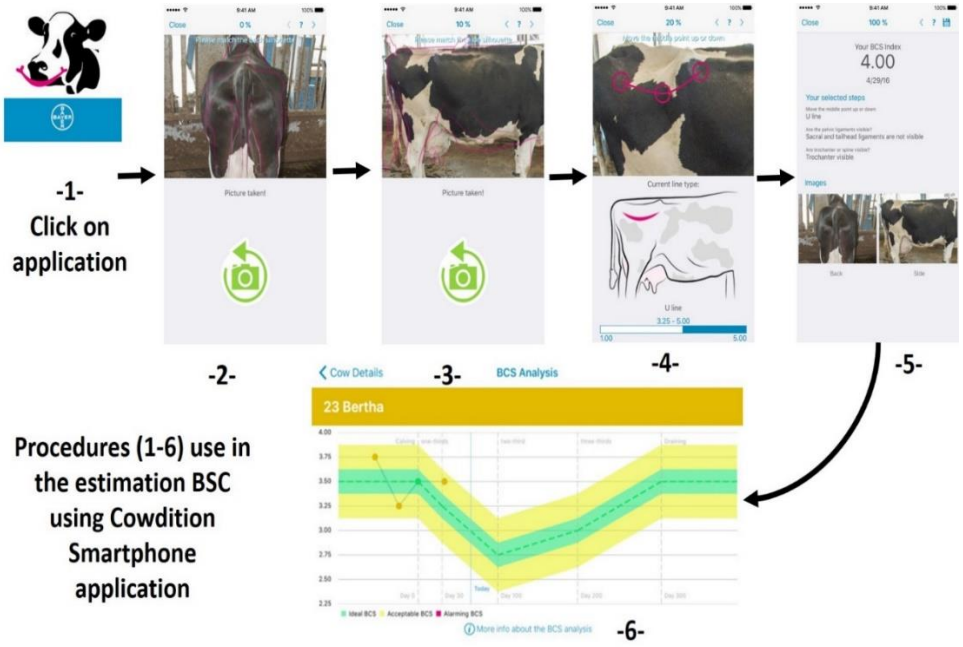

Figure. 3: Shows the procedures use in the estimation of cow's BCS using Bayer smartphone Application/ BCS Cowdition system

Results

The overall means of BCS were 3.9 ±0.068 and range from 2.5 to 5 for minimum and maximum values respectively (Table 4 & Figure 4 A&B). Moreover, 19 out of 30 cows showed the standard BCS ranged between 3.25-3.75 and revealed typical vital clinical parameters (Figure. 5). Also, 9 out of 30 cows showed fat BCS values ranged between 4- 4.25 accompanied with variation in the vital clinical parameters that increase with high BCS values (Figure.6). Only 2 out of 30 cows showed extremist BCS values which were 2.5 and 5 for moderate and grossly fat cow respectively (Figure. 7). Moreover, these cows showed also variation in the vital clinical parameters (Figure.8).

No	BCS	Temperature	Respiration	pulse	Photo
1	**3,5**	37.8	24	81	
2	3,5	38.4	24	60	
3	3,25	38.8	27	45	
4	4,25	38.9	21	65	
5	3,25	37.3	33	43	
6	**5**	37.6	40	56	
7	4,5	36.8	20	58	
8	3,75	37.8	29	50	
9	3,5	39	50	34	
10	4,25	38	28	61	
11	3,5	38.5	35	64	
12	3,25	37	25	76	
13	3,5	38.7	28	65	
14	3,5	36.6	23	62	
15	4	37.4	32	53	
16	**2,5**	37.2	24	76	
17	4	39.6	38	68	
18	3,5	39.1	75	84	
19	3,5	38.5	22	69	
20	3,5	36.6	31	55	
21	3,75	37.2	43	68	
22	**4,5**	37.8	21	46	
23	3.5	38.1	26	78	
24	3.5	37.6	33	67	
25	4.25	37	44	34	
26	3.75	37.8	28	58	
27	4	39.1	32	41	
28	3.5	38.3	60	66	
29	3.75	38.6	43	56	
30	4.25	37.5	78	69	
Average	3.9	37.9	34.5	59.9	

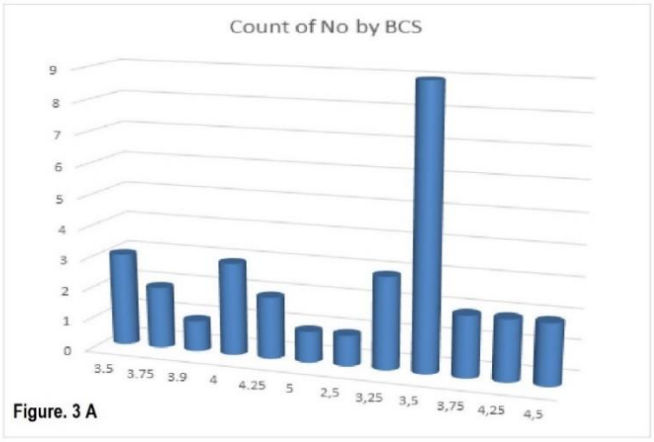

Figure. 3 A

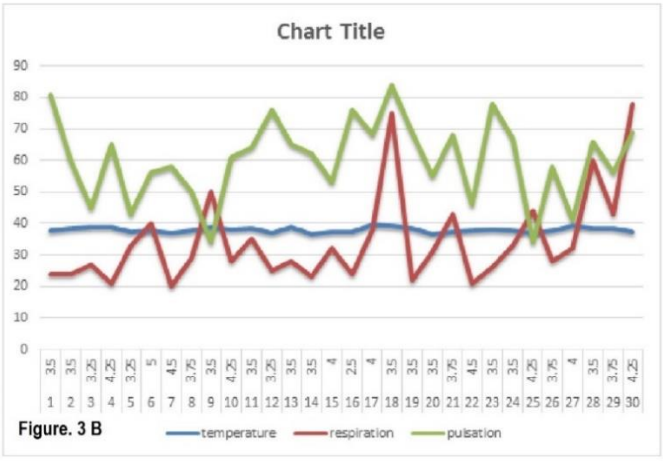

Figure. 3 B

Table.4: Shows BCS, Temperature, Pulsation and respiratory rates of the cows nominated for measurement their body condition

Figure. 4: A; Shows the distribution of cows according to BCS

B. The correlation between the body condition scores and the vital physiological indicators

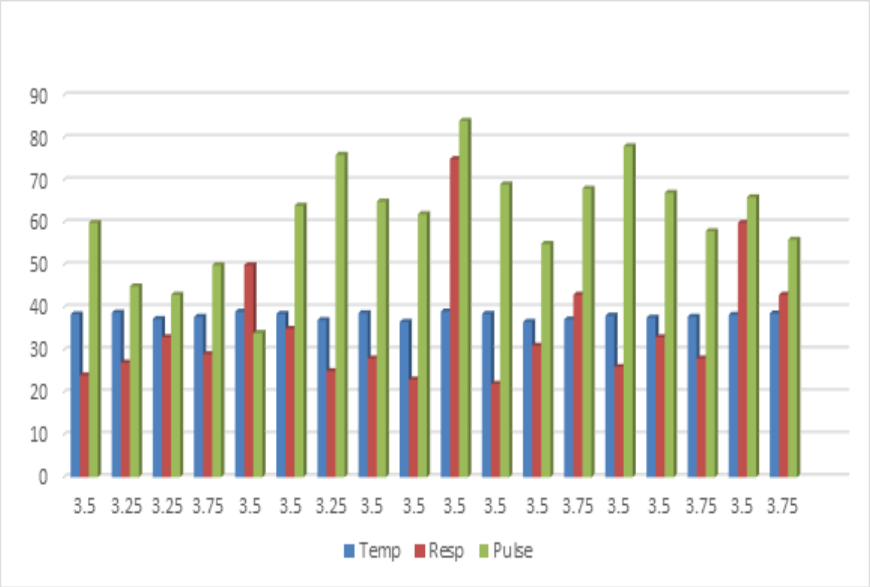

Figure. 5: Shows the distribution of body condition concerning physiological vital clinical indicators for the group with good BCS

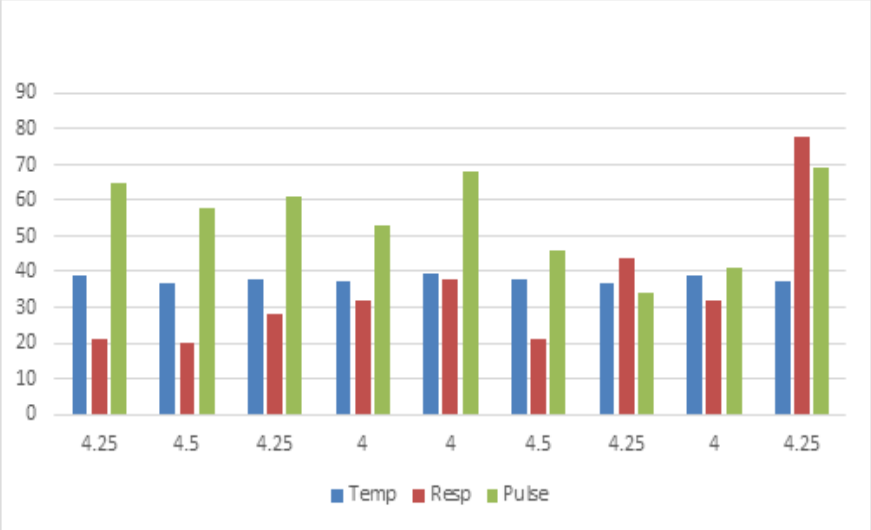

Figure. 6: Shows the distribution of body condition concerning physiological vital clinical indicators for the group with Fat BCS

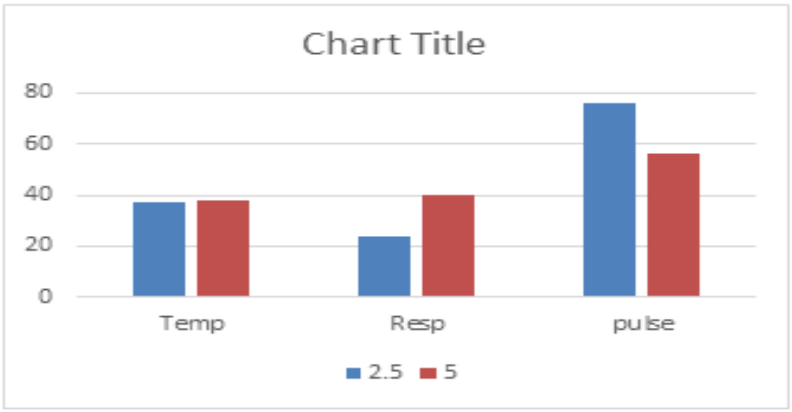

Figure. 7: Shows the distribution of body condition concerning physiological vital clinical indicators for the groups with moderate (BCS=2.5) and grossly fat (BCS=5) BCS

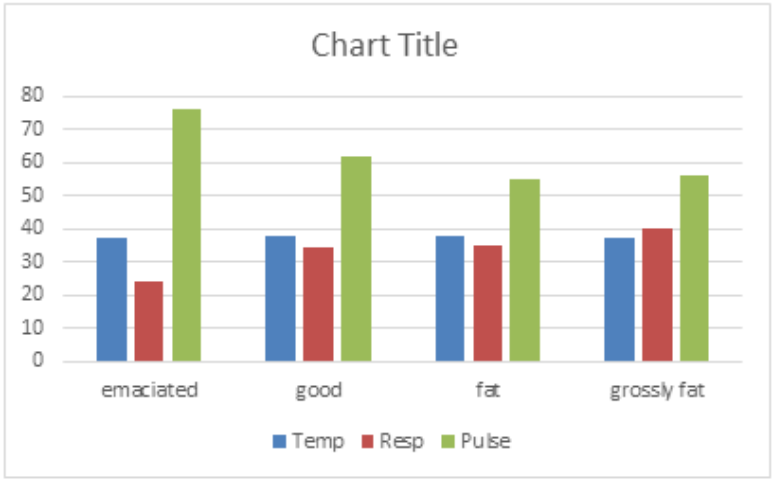

Figure. 8: Shows the variation in the physiological vital signs parameters between different BCS groups

Discussion

Body condition scoring (BCS) system has the ability to distinguish the alterations in the dietary requirements for a cow in the flock. It is a numeric scoring system that use to assess body energy reserve in the cow. A strong relationship was approved by research between cow reproductive performance and her body condition (Deniz, 2016; Bayer HealthCare, 2014; Roche *et al.,* 2007; Berry *et al.,* 2007). Observing body condition using BCS system is an essential professional method to defect the productivity failure and then able to take a rapid action to correct it (John *et al.,* 2009). The results of the current study revealed that the whole average of cows BCS was 3.9 ± 0.068. Moreover, 63.33 % (19 out of 30) of cows showed the standard BCS ranged between 3.25-3.75 and shown normal vital clinical parameters. These results are located within the range of good BCS that ranged (3 - 4), based on Bayar Company that released and created the Cowdition system. According to Bayer interpretation, the cow that reveals the score (3-4), these scores means good BCS. The cow in this score shows tail head with fat cover over the whole area and smooth skin, but pelvis can be felt. Moreover, Loin, end of horizontal process can only be felt with pressure and only slight depression in loin. These results are compatible with results previously reported worldwide by other research on cow BCS (Roche *et al.,* 2004; Bewley &Schutz., 2008; Bewley *et al.,* 2010; Battiato *et al.,* 2010).

The result of the current study also showed cow located at fat BCS. There were 30% (9 out of 30) of cows showed fat BCS values ranged between 4- 4.25 accompanied with variation in the vital clinical parameters that increase with high BCS values. According to Bayer interpretation, these scores (4-5), means the fat BCS, which the cow revealed tail head – completely filled and folds and patches of fat evident. Moreover, the Loin – cannot feel processes and will have a completely rounded appearance. Only 6.66% (2 out of 30) cows showed extreme BCS value. These extremist BCS were 2.5 and 5 for emaciated and grossly fat cow respectively. Moreover, these cows showed also variation in the vital clinical parameters. And according to Bayer interpretation, the score 2.5 is located at the moderate body condition, where the cow reveals the Tail head – shallow cavity but pin bones prominent; some fat under skin and Skin supple. While, Loin – horizontal processes can be identified individually with ends rounded. These results are in agreement with records of other research (Sablik *et al.,* 2014; Soares and Dryden, 2011). Moreover, some research (Vasseur *et al.,* 2013; Alic, 2012) found that BCS < 2.5 and 4.0 > BCS of cows is highly diminishing the animal well-being. These variations of BCS may initiate from different reasons such as dietary levels and well-planned ration. Nonetheless, this BCS alteration and conversion of animal tissues occur in highly productive animal.

It is worth to mention the body condition target scores during different stages of cow's annual reproduction cycle. According to Bayer, there are acceptable BCS (Table. 5) for each stage (Bayer Health Care, 2015). The variations in BCS are to be likely as a cow passes via the steps of milk production (lactation) and pregnancy. Majorities of cows revealed decline BCS from calving and around the first100 days of milk production, later on rises over dry-off. Only scarce proficient, high producing cows may not practice huge variations in BCS, and some incompetent, low producing cows may constantly rise in BCS over a lactation. However, when cows collect too much or too

little condition, or alterations occur too rapidly, well-being and performance can be affected.

Suggested Body Condition Scores for Cows by Stage of Lactation.				
Stage of Lactation	**DIM**	**BCS Goal**	**BCS Min**	**BCS Max**
Calving	0	3.50	3.25	3.75
Early Lactation	1 to 30	3.00	2.75	3.25
Peak Milk	31 to 100	2.75	2.50	3.00
Mid Lactation	101 to 200	3.00	2.75	3.25
Late Lactation	201 to 300	3.25	3.00	3.75
Dry Off	> 300	3.50	3.25	3.75
Dry	- 60 to -1	3.50	3.25	3.75

Table. 5: Shows the suggested target BCS during different stages of lactation

The results of the current study also showed a good relationship between the BCS and the vital normal physiological signs. The average of body temperature, pulse rate, and respiratory rate, were 37.9, 34.6 and 62.1 respectively for the majority (63.33%) of the animal study that revealed 3.25-3.75 BCS. Moreover, the averages of these physiological parameters were 38.01, 34.1 and 55 for temperature, respiratory rate and pulse rate respectively, for the study animals that showed 4- 4.25 BCS. However, the physiological parameter for the cows with moderate (2.5) and grossly fat (5.0) BCS values were 37.2, 37.6; 24, 40 and 76, 56 for temperature, respiratory rate and pulsation rate respectively. Although no variation appeared between different BCS regarding the body temperature, changes were seen in pulsation and respiratory rates. These results are in agreement with Kubkomawa *et al.*, (2015) who mentioned that weak BCS could negatively affect the animal rectal temperature, and pulsation and respiratory rates. These physiological parameters related to cattle production per cow, elevation in the postpartum pause, pathetic calves at birth, low value and capacity of colostrum, low milk production, high incidence of dystocia, and lesser weaning masses. The correlation among BCS and health difficulties have frequently described inconsistent results in different investigation studies. The threat of various health problems such as metritis has a tendency to be amplified in cattle with low BCS or those that drop body condition throughout the dry period. Moreover, these cows may have raised the threat of dystocia (Grainger and McGowan, 1982).

Conclusions

In conclusion, this study offered for the first time in Iraq the adoption of smartphone BCS Cowdition application to evaluate the animal health. Besides, to understand the

relationship between BCS and vital clinical parameters values (body temperature, pulse and respiratory rates), to evaluate and assess the cow body health that helps in the improving the animal nutrition and avoid the metabolic diseases that commonly occur in the highly productive cow. The authors recommend another future study that uses BCS Cowdition Smartphone App and correlates it with metabolic diseases that occur in the animals.

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