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Deepak Biradar
M.V.Sc Scholar,
Department of Livestock Production Management, College of Veterinary and Animal Sciences, Pookode, Wayanad, Kerala, India

John Abraham
Professor and Head,
Department of Livestock Production Management, College of Veterinary and Animal Sciences, Pookode, Wayanad, Kerala, India

Balusami C
Professor, Department of Livestock Production Management, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Corresponding Author:
Deepak Biradar
M.V.Sc Scholar,
Department of Livestock Production Management, College of Veterinary and Animal Sciences, Pookode, Wayanad, Kerala, India

Ergonomic assessment of different milking systems in crossbred dairy cattle

Deepak Biradar, John Abraham and Balusami C

Abstract
Milking is the most important daily operation in a dairy farm. Despite the development in mechanization majority of the animals are still being hand milked. Which is adversely affecting the workload and increased risk of Musculo-skeletal disorders among milkers due to poor body postures and hand movements. This study was conducted to compare and evaluate electrical milking machine (T_1), hand milking (T_2) and manual milking machine (T_3), on the physiological parameters of the milker. Fifteen freshly calved crossbred dairy cows were randomly selected and allotted to three different treatment groups adopting switch-over design. The cows were milked for 60 days both in the morning and evening sessions. The physiological parameters of the milker (Blood Pressure, Heart Rate and Respiratory Rate) compared before and after milking revealed that, the stress undergone by the milker was higher in T_2 compared to T_1 and T_3. The study revealed that, hand milking caused much stress to the milker. The Electric milking machine was found to be superior in terms of ergonomics of milking and relatively less work stress was observed compared to other milking systems. However, Manual milking machine, intermediate in terms of ergonomics, can be recommended for small holder dairy farmers.

Keywords: Ergonomics, milking systems, physiological parameters, manual milking machine

1. Introduction
Dairying in India is mainly a small holder enterprise. Dairy producers in India are mainly rural based small producers and account for about 70 million of the total population (Report, 2021) [1]. Many small, marginal and landless farmers are involved in it as a subsidiary or supplementary occupation (Sekhon *et al*., 2008) [2]. The mean average herd size of cattle in the country is limited to two cows (Douphrate *et al*., 2013) [3]. Almost 90 per cent of animals in India are still hand milked as majority of farmers cannot afford the costly electrical milking machine (Muehlhoff *et al*., 2013; Park and Haenlein, 2013) [4, 5]. As per the 20th livestock census 2019, (Report, 2020) [6], it is evident that the cattle population is showing a constantly decreasing trend from past few decades, whereas, the production performance of the herd and herd size, is showing an increasing trend. This shows an obvious increase in the productivity indices of the cattle. As a consequence, it is challenging for the farmers to manage the dairy animals efficiently. This has resulted in the farmers finding difficulty in providing time to spend per cow, to ensure efficient milking. It is both practically and economically difficult to find skilled labour for milking a small herd of cows especially by a small farmer which necessitates the use of advanced milking machines. Nearly 70 per cent of the work force in this sector is contributed by women, which causes back pain, shoulder pain, finger fatigue and allergic reactions to them (Douphrate *et al*., 2009; Hwang *et al*., 2010) [7, 8]. They are also exposed to occupational hazards like cow kicking and tail lashing (Patil *et al*., 2010) [9]. Hence, this study was conducted to study the impact of different milking systems on the operator efficiency and ergonomics related to the work stress on the milker involved.

2. Material and Methods
The present study was conducted to assess the work stress of milkers during milking in the dairy farms of the Instructional Livestock Farm Complex (ILFC), College of Veterinary and Animal Sciences, Pookode. The experiment was carried out on freshly calved fifteen crossbred dairy cows of uniform parity and body condition, which were chosen randomly from the farm. The lactating animals, so selected, were randomly allotted into three treatments adopting switch-over design, where in which, all the three treatments would be studied upon the same animal alternately, with an adaptation period of three days between the treatments. The treatment effects were studied five days post calving up to two months of lactation of the cows.

In T_1, the animals were milked by using DeLaval® bucket type milking machine i.e. floor mounted milking machine with six can cluster assembly. Animals under T_2 were hand milked and animals under T_3 were milked with Rocker type manual milking machine, (Indian Patent No. IN 401547) [10].

All the animals were milked twice daily at 05.00 A.M and 02.00 P.M and data collected. Physiological parameters such as Respiratory Rate (RR), Blood Pressure (BP) and Pulse Rate (PR) of the milkers were recorded before and after milking of the animals. The respiratory rate of the milker was recorded manually by placing the hand in front of the nostrils before and after milking and counting the expirations per minute. Heart rate (Pulse rate) of milker was recorded using OMRON® digital Automatic BP monitor and the Blood Pressure of the milker was recorded as Systolic and Diastolic pressure separately using OMRON® digital Automatic BP monitor before and after the milking.

Work stress was evaluated using the work related body part discomfort score card given to the milkers as per Borg (1982) [11]. The panel consisted of fifteen labours, involved in milking of animals, during the experimental period. Different milking systems adopted by these panelists were questioned for the pain perceived by them during each milking system. The panelists were asked to evaluate the milking systems and record a score on a 7-point scale (0= comfortable, 7 = extreme pain). The pain perception score card is as presented in table (1) and the means were analysed by Kruskal-Wallis ANOVA.

Table 1: Pain intensity score card

Score	Subjective feeling
0	Comfortable
1	Uncomfortable
2	Pain starts
3	Slightly painful
4	Moderately painful
5	Highly painful
6	Very highly painful
7	Extremely painful

3. Results and Discussions

The parameters, were recorded on the milkers during morning and evening sessions of milking are presented in the Tables 2 & 3. The percentage change in BP, HR and RR revealed that the variation was higher in T_2 as compared to T_1 and T_3. The average changes in systolic pressure, diastolic Pressure, HR and RR during morning were +2.35, +1.86, +2.94 and +1.45, respectively, for electric milking machine (T_1); +11, +7.86, +7.57 and +6.61, respectively, for hand milking (T_2); and +6.28, +2.97, +4.00 and +1.77, respectively, for manual milking machine (T_3). The variation was higher in T_2 as compared to T_1 and T_3.

Le-Blanc (1957) [12] observed a linear relationship between heart rate and the amount of physical workout. The physiological stress shot up at an increasing rate along with an increase in the rate of body movement. Weybrew (1997) [13] reported that the physiological response, in any kind of work could be conveyed in terms of cardio-respiratory response. Tomlinson (1970) [14] reported that, in excessively heavy exercise, a secondary upsurge of heart rate may also take place, which can be related to the results obtained under hand milking. Groborz *et al*. (2011) [15] reported that the activities like udder washing, connecting the milking machine, along with massaging of the udder and disconnecting the milking machine were performed under squat position, which could be categorised as a high risk factor for Musculo-Skeletal Disorders (MSD's) under bucket type machine milking system. Pinzke *et al*. (2001) [16] reported that the tasks like "attaching, holding the milk claw unit" and drying of udders exerted highest load on biceps and flexor muscles, respectively. The analysis of the BP, HR and RR revealed that hand milking caused maximum stress to the milkers with highest increase in BP, HR and RR. While electric milking machine caused least stress to the milker and less change in BP, HR and RR. Manual milking machine was intermediate between these two milking systems.

The results of the work stress in terms of pain perception upon milking with different milking systems are presented in Table 4. The mean score for the pain perceived was 0.13 ± 0.09, 3.87 ± 0.17 and 2.67 ± 0.21, in T_1, T_2 and T_3. Which were significantly (p <0.001) different from each other. The analysis of pain perception revealed that, the work stress was highest in hand milking followed by Rocker type manual milking machine and was least in electric milking machine. Therefore, the stress undergone by the milker in hand milking can be accredited to the abnormal ergonomic squat position and repetitive motion of hand which imposed more stress which might lead to Musculo-skeletal Disorders. This observation was supported by Pinzke *et al*. (2001), Groborz *et al*. (2011), Kolstrup (2012) and Hayati *et al*. (2015) [16, 15, 17, 18].

Table 4: Pain perception under different milking systems

Treatment	T_1	T_2	T_3	Chi-square value	P-value
Score mean	0.13 ± 0.09	3.87 ± 0.17	2.67 ± 0.21	36.265**	<0.001**

Means with ** differ significantly at p <0.01

Table 2: Physiological parameters of milker before and after milking (morning)

Parameters	T_1			T_2			T_3		
	Before	After	% change	Before	After	% change	Before	After	% change
Systolic Pressure (mm Hg)	120.56±0.65	122.91±0.89	+2.35	119.25±0.64	130.25±0.73	+11	121.87±0.88	128.15±0.76	+6.28
Diastolic Pressure (mm Hg)	76.69±0.72	78.55±0.91	+1.86	76.76±0.78	84.62±0.91	+7.86	79.47±0.61	82.44±0.56	+2.97
Pulse Rate (per min)	91.81±1.61	94.75±1.27	+2.94	88.90±1.62	96.47±1.45	+7.57	86.79±2.34	90.79±2.67	+4.00
Respiratory Rate (per min)	21.67±0.29	23.12±0.57	+1.45	21.23±0.10	27.84±0.44	+6.61	21.16±0.10	22.93±0.30	+1.77

Table 3: Physiological parameters of milker before and after milking (evening)

Parameters	T_1			T_2			T_3		
	Before	After	% change	Before	After	% change	Before	After	% change
Systolic Pressure (mm Hg)	118.43±0.74	121.56±1.17	+3.13	118.90±0.82	129.47±1.06	+10.57	115.98±0.95	122.15±1.29	+6.17
Diastolic Pressure (mm Hg)	74.83±0.98	76.84±0.67	+2.01	74.65±0.83	82.50±1.17	+7.85	73.58±1.11	76.49±1.23	+2.91
Pulse Rate (per min)	97.74±1.94	99.53±1.45	+1.79	93.44±1.42	100.76±1.32	+7.32	90.61±1.87	94.25±2.11	+3.64
Respiratory Rate (per min)	21.58±0.27	23.36±0.57	+1.78	20.88±0.08	27.36±0.41	+6.48	21.11±0.08	23.40±0.29	+2.21

4. Conclusions

Hand milking exerts greater stress on the milker and requires skilled labour to milk the animals. Whereas, Electrical milking machine is ergonomically superior but, it is not affordable to the small holder dairy farmers under economic perspective. Manual milking machine being an intermediary among all the three milking systems, can be recommended to small holder milk producers. It can be used by ladies and children, without any skill for milking and considerably exerts lesser stress than hand milking.

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