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Non-Genetic Factors Affecting some Colostrum Quality Traits in Holstein Cattle

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ABSTRACT

The aims of this study were to determine the effects of dry period length (DPL), average daily milk yield (ADMY), parity and calving season on some colostrum quality traits in Holstein cows. The material of the study consisted of 51 Holstein Friesian cows. The specific gravity of colostrum, fat, non-fat dry matter (NDM) and protein percentages were measured for colostrum produced at 2, 24, 48 and 72 h after birth. The specific gravity of colostrum (colostrum quality) was determined using a colostrometer. The effects of DPL, ADMY, parity and calving season on the specific gravity of colostrum (colostrum quality) were found to be significant at the 2nd h after birth. Colostrum quality of cows with ADMY low (Group 1) and high (Group 2) were found to be 1.065±0.0015 and 1.055±0.0016 g/ml, in postpartum 2nd h, respectively. Colostrum quality of cows with long DPL (1.064±0.0013 g/ml) was found to be higher than those with short DPL (1.054±0.0017 g/ml) at the 2nd h after birth. The effect of parity on the specific gravity was found to be significant at the 2nd h ($P<0.01$), 24th h ($P<0.001$) and 48th h ($P<0.05$) after birth. In addition, the effect of calving season on fat percentage was found to be significant at the 24th and 48th ($P<0.05$). The highest NDM and protein in colostrum were determined in cows with low ADMY while the least NDM and protein in colostrum were found in cows with short DPL.

INTRODUCTION

As is well known, colostrum is the first liquid secreted from the udder in mammals after birth. This unique liquid is quite different from normal milk in terms of color, odor, appearance and content (Erdem and Atasever, 2005; Angulo *et al*., 2015; Le Cozler *et al*., 2016). After birth, the first milk which is obtained from the cow is defined as colostrum. However, it is reported that the milk between the first six and ten milkings is termed colostrum by many researchers (Genc, 2015; Hoyraz *et al*., 2015; Okuyucu and Erdem, 2018). Colostrum is a liquid rich in respect to many nutrients and non-nutrients, such as protein, fat, lactose, vitamins, minerals, immunoglobulin (Ig), lactoferrin, transferrin and growth factors required for the calf after birth. It is reported that in the first milking of colostrum after birth especially Ig and growth factors are at the highest level, but these substances decrease rapidly in subsequent milking (Blum and Hammon, 2000; Jaster, 2005; Piccione *et al*., 2009; Zarcula *et al*., 2010). The Ig and specific antibodies are important components necessary for the development of immune systems of calves. However, it is not guaranteed to transfer Ig and specific antibodies from mother to calf during pregnancy because of the placental structure of cows. Calves gain passive immunity (colostral immunity) by taking these antibodies via colostrum after birth (Hoyraz *et al*., 2015). Therefore, it is very important for livability, adequate passive immunity and growth performance of calves before and after weaning to drink colostrum in sufficient quantity and good quality of calves within the shortest time after birth (Goncu *et al*., 2014; Mellado *et al*., 2017; Phipps *et al*., 2017).

The amount of Ig in the colostrum is an important criterion that determines the quality of colostrum (Erdem and Atasever, 2005; Hoyraz *et al*., 2015). The colostrum quality of cattle is influenced by many factors, such as breed, age, parity, dry period length (DPL), milk yield, calving season, nutritional status, difficulty in calving, live weight and nutritional status during the dry period (Kehoe *et al*., 2007; Indra *et al*., 2012; Angulo *et al*., 2015). However, some of these factors can be controlled with herd management practices. One of these factors, the DPL (mean 6-8 weeks) is an important period for cows in terms of renewal of the milk secretion tissue that wears off during lactation, the preparation for next lactation, completion of fetus development and colostrum production with high Ig levels after birth (Annen *et al*., 2004; Collier *et al*., 2012; Kok *et al*., 2017). In addition, it was reported by Barrington *et al*. (2001) and Collier *et al*. (2012) that the colostrum started to be secreted in the last 15-20 days of the dry period and biochemical changes in this fluid continued until birth. In the studies conducted by Lori *et al*. (1991) and Kaygisiz and Kose (2007) in

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Holstein cows, DPL showed a statistical difference in the quality of the colostrum produced after birth, whereas Morin *et al*. (2001), Watters *et al*. (2008), Shoshoni *et al*. (2014) and Genc (2015) found the effect of DPL to be insignificant. Le Cozler *et al*. (2016) reported that there was a positive correlation (R^2 = 0.22; P<0.01) between DPL and colostrum Ig level. In addition, Collier *et al*. (2012) reported that milking continuously in cows had a negative effect on the quality of colostrum. Thus, colostrum components are secreted several weeks before birth (Dunn *et al*., 2017a), but milking continuously in cows eliminates these substances with milk. Therefore, the DPL of dairy cows is thought to be an important environmental factor in terms of the quality of the colostrum produced after birth.

Different results were obtained in studies conducted to determine the effect of parity and calving season on the quality of colostrum in Holstein cows. In studies carried out by Godden (2004), Kaygisiz and Kose (2007), Liu *et al*. (2009), Kehoe *et al*. (2011), Conneely *et al*. (2013), Angulo *et al*. (2015), Bartier *et al*. (2015) and Phipps *et al*. (2017), parity was found to significantly affect the quality of the colostrum, whereas this effect was found to be statistically insignificant by Genc (2015) and Hoyraz *et al*. (2015). The mean dry matter (DM), fat and protein percentage in colostrum were determined as 22.6%, 5.6% and 12.7%, respectively by Morrill *et al*. (2012), and the increase of parity affects only the fat percentage of colostrum components (P<0.05). In addition, the average colostrum specific gravity 1.060 g/ml, DM 23.32%, fat 3.40% and protein 15.32% in Holstein cows were determined by Wojtas and Zachwieja (2016).

In the investigations, it has been reported that the colostrum quality and constituents were affected by the calving season as well as by the parity. Colostrum quality of cows calved in summer months was found to be lower than those calved in autumn months (Morin *et al*., 2001). However, Gulliksen *et al*. (2008) stated that the quality of colostrum produced by cows calved in the winter months (December, January, February) is lower than those obtained in the other seasons. In contrast to the results obtained by Gulliksen *et al*. (2008), Genc (2015) reported that colostrum quality was lower in cows calved in the summer months. In addition, the effect of calving season on colostrum quality was found to be statistically insignificant by Kaygisiz and Kose (2007).

Many studies have investigated the effect of calving season and parity on colostrum quality. The results of these studies are thought to be different due to the different genetic structure and breeding conditions of the cows. However, reports on the effects of DPL and average daily milk yield (ADMY) on the quality of colostrum in Holstein cattle are still limited. Therefore, further studies have been required to reveal the effect of DPL and ADMY on colostrum quality of this breed.

The objectives of this study were to determine the effects of DPL, ADMY, parity and calving season on the specific gravity and components of colostrum (fat, NDM and protein) at the 2^{nd}, 24^{th}, 48^{th} and 72^{nd} h after birth in Holstein cows.

MATERIALS AND METHODS

The study was carried out on Holstein cows (51 heads) in a breeding-intensive condition at a private dairy farm in Konya, Turkey. Data were collected during the first 4 days after birth between September and August. During the investigations, DPL, calving seasons, ADMY and parities of cows were recorded regularly. During the dry period, the cows were fed with wheat straw, alfalfa hay, corn silage and concentrate feed. In addition, the cows in the dry period were fed the same ration throughout the experiment.

At the 2^{nd}, 24^{th}, 48^{th} and 72^{nd} h after birth, approximately 0.5 liters of colostrum samples were collected before the calves sucked their mothers. Colostrum samples were taken by mixing the total-colostrum homogeneously after the milking process was completed. Moreover, colostrum samples were stored in the deep freeze at approximately–20°C (Okuyucu and Erdem, 2018). Frozen colostrum samples were brought to the laboratory for specific gravity and component analysis, and these samples were analyzed after heating to 20–22 °C in a hot-water bath. Colostrum quality was determined using a colostrometer, which is based on the relationship between the amount of Ig in the colostrum and specific gravity (Kaygisiz and Kose, 2007). In addition, colostrum components (fat, NDM and protein percentage) were determined in the colostrum taken at different periods, and a Funke Gerber Lactostar milk analyzer was used in the analyses.

The data are divided into two groups; parity (≤3^{rd} and ≥4^{th} lactation) and calving season (Autumn–Winter and Spring–Summer). In addition, a single value was obtained by taking the arithmetic means of DPL (day) and ADMY (liter) values of the cows that constitute the experimental material. The arithmetic means of these parameters were found to be 58.41±1.05 days for DPL and 22.84±0.48 L for ADMY. Those with values lower than these averages were classified as the first group (Group-1) and the high values were taken to the second group (Group-2). Colostrum specific gravity and the components in the sampling period were analyzed statistically by grouping according to parity, calving season, DPL and ADMY.

The effects of calving season, parity, DPL and ADMY on the components and specific gravity of colostrum in different colostrum periods were determined. Statistical analysis was performed with the *t*-test using SPSS 20.0 for Windows package program.

RESULTS

In this study, the average specific gravities of colostrum were determined as 1.059±0.0013, 1.041±0.0013, 1.032±0.0006 and 1.027±0.0005 g/ml, at the 2nd, 24th, 48th and 72nd h after birth, respectively (Table I). It is seen that these values tended to decrease rapidly as a function of time.

As seen in Table I, DPL of cows affected positively the specific gravity of colostrum (colostrum quality) only produced in the 2nd h after birth (P<0.001). The specific gravity of colostrum in the cows with long DPL was higher than ones with short DPL. In addition, the specific gravity of colostrum at the 2nd h after birth for cows with low ADMY (Group-1) was higher than those with high ADMY (Group-2). The specific gravities of colostrum for cows with low and high ADMY were determined as 1.065±0.0015 and 1.055±0.0016 g/ml, respectively (P<0.001) (Table I). Based on these findings, it can be said that high milk yield had a negative effect on colostrum quality (Table I).

Changes of colostrum specific gravity of cows by calving season and parity of cows in this research are presented in Table I. It was determined that the parity of the cows affects the colostrum specific gravity positively in the 2nd (P<0.01), 24th (P<0.001) and 48th h (P<0.05) after birth. Namely, the quality of colostrum in the cows with ≥4th parity was higher than cows with ≤3rd parity.

The calving season was found to be effective (P<0.001) on the quality of colostrum produced in the 2nd h after birth, while the effect in other colostral periods was statistically insignificant (Table I). It was determined that colostrum specific gravity of cows that calved in Spring–Summer months (1.052± 0.0017 g/ml) was lower than those calved in Autumn–Winter months (1.064± 0.0013 g/ml).

In this research, the mean fat percentage of colostrum at 2nd, 24th, 48th and 72nd h after birth were 5.64±0.298%, 4.46±0.240%, 3.97±0.204% and 3.68±0.189%, respectively (Table II). In addition, it was determined that the colostrum fat percentage of cows calving in the Spring–Summer months was lower than those calving in the Autumn–Winter months at the 24th and 48th h (P < 0.05).

In the study, the mean percentage of non-fat dry matter (NDM) in the colostrum produced at the 2nd, 24th, 48th and 72nd h after birth were found to be 21.20± 0.638%, 13.46± 0.612%, 9.75± 0.299% and 9.03± 0.369%, respectively. These parameters rapidly decreased in the hours after birth (Table III). While the cow's DPL had a positive effect on the percentage of NDM in the colostrum produced at the 2nd h after birth (P<0.01), the effect on other colostrum periods was not statistically significant (Table III).

The NDM percentage in the colostrum of the cows with long DPL was found to be 22.85±0.631%, while this parameter was determined as 19.34±1.039% in cows with short DPL. The ADMY had a negative effect on the NDM percentage in the colostrum produced at the 2nd h postpartum (P<0.001). In the cows with low and high ADMY, colostrum NDM percentage was found to be 23.36±0.619% and 19.58±0.909%, respectively. The parity affected the NDM percentage of colostrum produced only at the 24th h (P<0.001). In addition, it was determined that NDM percentage in the colostrum of cows calved in Autumn–Winter months was higher than those calved in Spring–Summer months (P<0.001).

In the present study, the protein percentage of colostrum was found to be 17.40±0.622%, 11.21±0.584%, 8.12±0342% and 7.59±0.440% for all colostrum periods, respectively. While the DPL of cows had a positive effect on colostrum protein percentage at the second hour after birth (P<0.05), the effect on the 24th, 48th and 72nd h was statistically insignificant. (Table IV). The protein content of colostrum at the 2nd h after birth was found to be higher in long DPL cows (18.70±0.577%) compared to those with short DPL (16.00±1.077%). As in the case of DPL, ADMY affected protein percentage of colostrum at the 2nd h colostrum period (P<0.01), but this effect was negative. In other words, protein content is lower in colostrum of cows with higher milk yield in the previous lactation. The amount of protein in colostrum produced at the 2nd and 24th h after birth was affected by parity (P<0.05). As the parity increased, the protein content in these colostrum periods increased. In addition, it was determined that colostrum protein percentage of cows calved in Autumn–Winter months was higher than those calved in Spring–Summer months at the 2nd h after birth (P<0.001).

DISCUSSION

As seen, non-genetic factors have a significant effect on colostrum quality. While the colostrum specific gravity in the Holstein cows was found to be 1.055–1.057 g/ml at the 2nd h after birth by Nowak *et al.* (2012), it was determined as 1.060±0.010 g/ml by Wojtas and Zachwiega (2016) for the same period. The findings obtained in this study are similar to results acquired by Nowak *et al.* (2012) and Wojtas and Zachwiega (2016). In addition, in this investigation, the specific gravity of colostrum at the 24th h after birth is similar to the results obtained by Wojtas and Zachwieja (2016) (1.039±0.010 g/ml)

Table I. Specific gravity values of colostrum at different periods according to the dry period length, average daily milk yield, parity and calving season (±SE).

Factor	Colostral period (g/ml)							
	2nd h		24th h		48th h		72nd h	
	n	Mean± SE	n	Mean± SE	n	Mean± SE	n	Mean± SE
Dry period length		***						
Group-1	24	1.05±0.001	19	1.04±0.002	18	1.03±0.001	16	1.02±0.0005
Group-2	27	1.06±0.001	25	1.04±0.001	23	1.03±0.001	22	1.02±0.0007
Average daily milk yield		***						
Group-1	22	1.06±0.001	20	1.04±0.001	19	1.03±0.0008	18	1.02±0.0006
Group-2	29	1.05±0.001	24	1.04±0.00	22	1.03±0.001	20	1.02±0.0007
Parity		**		***		*		
≤3	27	1.05±0.001	22	1.03±0.001	19	1.03±0.0008	17	1.02±0.0004
4≤	24	1.06±0.001	22	1.04±0.0016	22	1.03±0.0009	21	1.02±0.0008
Calving season		***						
Fall-Winter	31	1.06±0.001	28	1.04±0.001	26	1.03±0.0008	25	1.02±0.0007
Spring- Summer	20	1.05±0.001	16	1.03±0.002	15	1.03±0.0010	13	1.02±0.0005
Mean	51	1.05±0.001	44	1.04±0.001	41	1.03±0.0006	38	1.02±0.0005

*P<0.05; **P<0.01; *** P<0.001

Table II. Fat percentages according to dry period length, average daily milk yield, parity and calving season in different colostrum periods (±SE).

Factor	Colostral period (%)							
	2nd h		24th h		48th h		72nd h	
	n	Mean± SE	n	Mean± SE	n	Mean± SE	n	Mean± SE
Dry period length								
Group-1	24	5.49±0.43	18	4.43±0.47	14	4.07±0.41	10	3.90±0.46
Group-2	27	5.77±0.41	26	4.48±0.25	20	3.89±0.19	16	3.54±0.11
Average daily milk yield								
Group-1	22	5.48±0.47	20	4.29±0.29	15	3.68±0.24	12	3.35±0.11
Group-2	29	5.76±0.38	24	4.60±0.36	19	4.19±0.30	14	3.96±0.32
Parity								
≤3	27	5.33±0.31	22	4.27±0.32	13	3.76±0.30	10	3.90±0.36
4≤	24	5.99±0.52	22	4.65±0.36	21	4.09±0.27	16	3.54±0.21
Calving season				*		*		
Fall-Winter	31	5.95±0.41	30	4.74±0.32	22	4.24±0.29	19	3.83±0.24
Spring-Summer	20	5.15±0.38	14	3.85±0.24	12	3.46±0.14	7	3.25±0.15
Mean	51	5.64±0.29	44	4.46±0.24	34	3.97±0.20	26	3.68±0.18

*P<0.05

and Kaygisiz and Kose (2007) (1.043±0.0013 g/ml). According to the results obtained, the colostrum specific gravity was decreased rapidly depending on time. For this reason, calves should be given a sufficient amount of colostrum in a short time after birth to obtain adequate immunity.

Table III. Non fat dry matter percentage according to dry period length, average daily milk yield, parity and calving season in different colostrum periods (±SE).

Factor	Colostral period (%)							
	2nd h		24th h		48th h		72nd h	
	n	Mean± SE	n	Mean± SE	n	Mean± SE	n	Mean± SE
Dry period length								
Group-1	23	19.34±1.03	18	13.68±1.12	14	9.81±0.57	10	9.50±0.78
Group-2	26	22.85±0.63	26	13.30±0.70	20	9.72±0.32	16	8.73±0.35
Average daily milk yield		***						
Group-1	21	23.36±0.61	20	13.49±0.77	15	9.92±0.30	12	8.84±0.42
Group-2	28	19.58±0.90	24	13.43±0.93	19	9.63±0.48	14	9.19±0.59
Parity				**				
≤3	25	20.03±0.91	22	11.73±0.69	13	9.06±0.42	10	8.74±0.29
4≤	24	22.42±0.82	22	15.18±0.87	21	10,18±0.38	16	9.20±0.57
Calving season		***						
Fall-Winter	30	23.41±0.60	30	13.84±0.68	22	10.15±0.38	19	8.99±0.48
Spring- Summer	19	17.71±0.88	14	12.63±1.25	12	9.02±0.40	7	9.11±0.47
Mean	49	21.20±0.63	44	13.46±0.61	34	9.75±0.29	26	9.03±0.36

** P<0,01; *** P<0,001; SE, Standard error.

Table IV. Protein values according to dry period length, average daily milk yield, parity and calving season in all colostrum periods (±SE).

Factor	Colostral period (%)							
	2nd h		24th h		48th h		72nd h	
	n	Mean± SE	n	Mean± SE	n	Mean± SE	n	Mean± SE
Dry period length								
Group-1	24	16.00±1.07	18	11.80±1.11	14	8.26±0.63	10	8.29±0.84
Group-2	26	18.70±0.57	26	10.81±0.62	20	8.02±0.39	16	7.15±0.47
Average daily milk yield		***						
Group-1	22	19.33±0.52	20	11.23±0.69	15	8.14±0.44	12	7.18±0.56
Group-2	28	15.89±0.94	24	11.21±0.91	19	8.10±0.51	14	7.94±0.66
Parity		*		*				
≤3	26	16.24±0.78	22	9.89±0.74	13	7.69±0.47	10	7.78±0.43
4≤	24	18.67±0.92	22	12.53±0.82	21	8.39±0.46	16	7.47±0.67
Calving season		***						
Fall-Winter	30	19.40±0.65	30	11.31±0.69	22	8.46±0.46	19	7.44±0.56
Spring-Summer	20	14.40±0.85	14	11.00±1.11	12	7.50±0.41	7	7.98±0.63
Mean	50	17.40±0.62	44	11.21±0.58	34	8.12±0.34	26	7.59±0.44

*P<0,05; ** P<0,01; ***P<0.001; SE, Standard error.

In this study, the specific gravity of colostrum in the cows with long DPL was found to be higher than those with short DPL. This investigation is consistent with results obtained by Lori *et al*. (1991), Kaygisiz and Kose (2007) and Le Cozler *et al*. (2016). However, the effect of DPL on colostrum quality (specific gravity of colostrum) was also found to be insignificant by Morin *et al*. (2001), Watters *et al*. (2008), Shoshoni *et al*. (2014) and Genc

(2015). Briefly, to acquire quality colostrum after birth, it is necessary to supply cows with optimum DPL (Indra *et al*., 2012).

It is determined that colostrum specific gravity at the 2nd h after birth was 1.065±0.0015 g/ml for cows with low ADMY (Group-1), while 1.055±0.0016 g/ml for those with high ADMY (Group-2). Unlike the results obtained in this study, Le Cozler *et al*. (2016) reported that previous lactation performance did not affect colostrum quality. As the milk yield of cows increases, colostrum quality decreases. There is a negative correlation between colostrum quality and high milk yield (Table I). This condition may arise from deformation of milk secretion tissues in the cows with high milk yield and throw out more nutrients from the body together with milk during lactation.

In the present research, the effect of parity was statistically significant for the specific gravity of colostrum at the 2nd, 24th and 48th h after birth. The findings obtained in the research are similar to results obtained by Liu *et al*. (2009), Kehoe *et al*. (2011), Angulo *et al*. (2015), Bartier *et al*. (2015), Phipps *et al*. (2017). It was determined that colostrum specific gravity (colostrum quality) in these periods was also increased by the increase in the parity. The quality of colostrum in the cows with ≤3 parities was found to be lower than those with ≥4 parities. Similarly, Gulliksen *et al*. (2008) reported that colostrum qualities of cows with 4 or more parities were higher. This situation is interpreted that cows have more Ig synthesis with advancing parity.

In this study, it was determined that the specific gravity of colostrum was affected by calving season. The results found by Morin *et al*. (2001) and Genc (2015) support the results of this study. In addition, Gulliksen *et al*. (2008) and Zarei *et al*. (2017) reported that colostrum Ig levels of cows calved in winter are higher than those calved in other seasons. However, Kaygisiz and Kose (2007) and Yaylak *et al*. (2017) reported that the quality of colostrum was not affected by calving season. In studies conducted, it is thought that the differences in the results achieved may be due to differences in the conditions of feeding and breeding. Thus, the feeding conditions of the dairy farms can change in different seasons.

In this study, the mean fat percentage was determined as 5.64% in the colostrum produced at the 2nd h after birth. In the studies conducted by Morrill *et al*. (2012), Nowak *et al*. (2012), Hoyraz *et al*. (2015), Zarei *et al*. (2017) and Dunn *et al*. (2017b), average fat percentage in colostrum was found to be 5.6%, 5.69–7.27%, 6.99%, 4.6% and 6.4%, respectively. The variation of our findings with similar study results might also be derived from differences in the genetic structure of the cows and application of care-feeding practices of the farms. DPL, ADMY and parity did not affect the percentage of colostrum fat in all four periods. However, the fat percentage of colostrum at the 24th and 48th h after birth was affected by calving season (P<0.05). Colostrum fat percentage of cows calving in Autumn–Winter seasons was found to be higher than those calving in Spring–Summer seasons. The results obtained here might mainly be caused by differences in metabolism, water and feed consumption in the Spring and Summer seasons. This fact is supported also by West (2003) and Sucu *et al*. (2015).

The results obtained from this research indicate that DPL, ADMY and parity of cows have effects on NDM percentage in colostrum after birth. Moreover, the effect of calving season was significant statistically for NDM percentage of colostrum at the 2nd h after birth in this research. However, unlike our findings, Zarei *et al*. (2017) reported that calving season has no effect statistically on the total DM percentage of colostrum produced after birth.

In this study, the mean protein percentage of the colostrum produced in the 2nd h after birth is lower than that obtained in results by Zarei *et al*. (2017). However, our findings are higher than reported by Nowak *et al*. (2012) and Hoyraz *et al*. (2015).

CONCLUSION

Finally, the specific gravity of the colostrum, fat, NDM and protein percentages decreased rapidly from the 2nd h to the 72nd h postpartum. In this study, non-genetic factors (DPL, ADMY, parity and calving season) mostly affected colostrum quality traits at the 2nd h after birth. However, no significant effect of non-genetic factors on colostrum quality at the 72nd h after birth was observed. At the 72nd h, the colostrum composition approaches the normal milk levels in terms of other components except total protein. Therefore, feeding with high-quality colostrum of calves immediately after birth is required to obtain adequate passive immunity.

The presented data indicate that DPL of cows had effects on colostrum quality after birth. In particular, DPL can be controlled by herd management applications. Therefore, dry-cow management is an important factor in terms of the production of good quality colostrum. Moreover, the results showed that colostrum quality is lower with high milk yield. Colostrum quality being negatively correlated with the milk yield of cows might be explained by deformation in milk secretion tissues during lactation in the cows with high milk yield. Further comprehensive research is needed to determine the effect of DPL and ADMY on colostrum quality.

Statement of conflict of interest
The authors declare no conflict of interest.

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