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The prevalence of irregularity in rhythm and heart sound in apparently healthy small ruminants

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Abstract

This study was conducted on 384 clinically healthy sheep and goats from farms around Tehran suburb. The animals were divided into two equal groups (according to species) and then assigned into three age groups, two gender groups and female animals into two groups: late pregnant and non-pregnant. Heart sounds were auscultated by two cardiologists and heart rate and probable murmurs were recorded. Using the base-apex lead, the electrocardiograms were taken. Three types of dysrhythmias including sinus tachycardia, sinus arrhythmia and atrial premature complex were observed. Regarding the incidence of dysrhythmias, there were significant statistical differences between the age and sex groups, but not between pregnant and non-pregnant animals. The mean heart rate of sheep and goats with sinus arrhythmia was significantly lower than those with regular cardiac rhythm (p<0.001). The prevalence of the murmurs in sheep and goats, which all were systolic, were 6.3% and 8.9%, respectively. Only one holosystolic murmur was detected in a sheep and the others were early to early-mid systolic murmurs. One murmur was detected with grade 3/5 in sheep and other murmurs were grade 1 and 2. The number of murmurs on the mitral valve was higher in age groups 1 (< 6 months) and 2 (6-12 months) compared to group 3 (> 12 months). But there was no significant relationship between the incidence of murmur and age, gender and pregnancy. The results of this study revealed that small ruminants have lower prevalence of dysrhythmias and murmurs compared to cattle and horses.

Key words: Dysrhythmia, Murmur, Sheep, Goat.

Introduction

Cardiac dysrhythmias (arrhythmias) are defined as variations of the cardiac rhythm from normal sinus rhythm defects in impulse formation and impairment of impulse conduction or both (Constable *et al*. 2017). In a healthy livestock, the rhythm and the heart rate are affected by the function of autonomic

nervous system, acid-base and electrolyte imbalances in the body (Constable *et al.* 2017). Electrocardiographic examination is the best method to detect cardiac dysrhythmia; however, in case of sheep and goats, the base- apex is the most common technique (Pugh & Baird, 2012). Auscultation is also the most basic method of assessing cardiac function. Heart murmurs are prolonged auditory vibrations originating within the heart that occur during a heartbeat cycle (Marr & Bowen, 2010). Generally, blood flow is laminar and without turbulence. Turbulence generation in blood may be created by an abrupt variation in diameter of vessel. In addition, turbulent flow occurs when blood flows at high velocity and an inverse relationship exists between flow rate and viscosity (Constable *et al.* 2017). Murmurs unrelated to cardiac disorders occur in large animals, especially the lactating dairy cows and the horses (Constable *et al*. 2017). Systolic murmurs occur any time between the first and second heart sounds (Marr & Bowen, 2010) and are categorized as early, late, holosystolic, or pansystolic according to duration in the time and their occurrence (Constable *et al*. 2017). Systolic ejection murmurs are produced by damage or dilatation of the vessel (vasodilation) behind the valve, ventricular outflow obstruction and increase in semilunar valves blood flow (Marr & Bowen, 2010). Functional dysrhythmias and murmurs are a common finding in horses (Kriz et al. 2000; Rezakhani *et al*. 2005; Zucca *et al*. 2010). Many attempts have been made to detect physiological dysrhythmias and murmurs in large ruminants (Frese *et al*. 2017; Reef, 1989; Ghadrdan Mashhadi *et al*. 2014; Rezakhani et al. 2004; Rezakhani & Zarifi, 2007b). The most important group of ruminants in Iran are sheep and goats. More than 28 distinctive breeds of sheep and 20 breeds of goats are in Iran and the population of goats and sheep are approximately 25 and 52 million heads, respectively. Although Functional dysrhythmias in specific breeds of sheep and goats have been reported (Pourjafar *et al*. 2012; Tajik *et al.* 2016; Samimi *et al.* 2015), a review of veterinary literature revealed no data available about the prevalence of functional murmurs in sheep and goats. The present study was conducted to find the prevalence of cardia dysrhythmias and murmurs based on gender, age and pregnancy in clinically healthy sheep and goats in the suburbs of Tehran.

Materials and Methods

The study design

The study was performed on 384 clinically healthy Iranian sheep and goats in the suburbs of Tehran. All animals receiving standard diet and hairs free access to water, underwent a general clinical examination and were proved to be clinically healthy. In order to minimize the effects of endoparasites on cardiovascular system, sheep and goats received albendazole at doses of 7.5 and 10 mg/kg respectively, in order to minimize ectoparasite effects on cardiovascular system the topical cypermethrin (1 ml per 10 kg-1) was administered to all animals. They were divided into two equal groups (n=192) and then assigned into three age groups (as: 1: up to six months, 2: higher than six months old and less than one-year-old, and 3: higher than one-year-old) and two gender groups (male and female). Each group consisted of 37 animals, except for two male age groups older than one year of age (Rams=7, Bucks=7). To further investigate the impact of pregnancy on heart rate, dysrhythmias and murmurs, female animals were divided into two groups: late pregnant (female sheep=10, female goat=7) and non-pregnant (female sheep=27, female goat=30). Ultrasonographic technique with a 5 MHz linear-array transducer was used for pregnancy examination.

Record of heart rate and murmurs

Cardiac auscultation was performed by two specialists first with stethoscopes of 3M Littmann Classic II S.E. and then with Littmann electronic model 4000. Prior to cardiac auscultation, the apex beat was determined through axillary region palpation. The stethoscope was then placed on the cardiac region in which apex beat was heard clearly; careful auscultation focused on detection of 1^{st} and 2^{nd} heart sounds, and heart rate was recorded within 1 minute. After that, the stethoscope was placed on the pulmonary, aortic, tricuspid and mitral valve location. The right side of axillary region was also auscultated. The two examiners were unaware of the results. After completion of the auscultation, both clinicians reviewed the results with each other. Heart murmurs were graded as follows: A grade 1 murmur is a faint murmur and can be heard only by careful auscultation; A grade 2 murmur is a soft one and is clearly heard after only a few seconds of auscultation; A grade 3 murmur is

a loud murmur readily detected on auscultation and is heard over a large area without a palpable thrill murmur; A grade 4 murmur is loud one associated with a palpable thrill; A grade 5 murmur is a loud murmur with a thrill, that can be heard with the stethoscope partially off the chest (Smith, 2015). In this study, each murmur that was audible with a stethoscope was recorded.

Obtaining an electrocardiogram

A portable single-channel ECG machine (Fukuda 501B-III, JAPAN) was used for electrocardiography. The machine was calibrated at 1mV=10 mm and paper speed of 25 mm/sec and the electrodes which *were* fixed to alligator clips were attached to the body to record the based apex electrocardiogram for at least 2 minutes. Recording of ECG was performed in a quiet standing position. The positive electrode (left arm) was attached to the apex of heart in the fifth left intercostal space at the elbow level, the negative electrode (right arm) was attached to the left jugular groove at the cardiac base top, and the ground electrode was placed on site away from the heart (Constable et al., 2016). In this study, the higher heart rate above 90 and 120 was known as tachycardia in animals over 1-year-old and younger, respectively.

Statistical analysis

Statistical analyses were done by SPSS software, version 20.0. The data were described by Mean±SEM. To compare means, a t-test was used and the categorized data were analyzed by a Chi-Square test. A $p<0.05$ was considered statistically significant.

Results

Heart rate

The heart rate of the sheep ranged from 70 to 191 beats/min with an average of 109.7±1.87 and the heart rate of the goats ranged from 68 to 170 beats/min with an average of 111.9±1.86. There was a significant difference between the heart rate with age groups ($P<0.001$), gender ($P<0.001$) and pregnancy ($P<0.001$) in sheep (Tables 1&2). There was a significant negative correlation between the heart rate and age (r=-0.612, $p<0.001$). Also, the statistical analysis in goats revealed a significant difference between the heart rate with pregnancy ($p=0.016$), age ($p<0.001$) and gender ($p<0.001$) (Tables 1&2). Pearson's correlation coefficient test determined a moderate and negative reversal correlation

between the heart rate and age in goats (r=0.539, p<0.001).

Cardiac dysrhythmias

The prevalence of cardiac dysrhythmias in clinically healthy sheep and goats is shown in Figures 1&2. In this study, three types of cardiac dysrhythmias, including sinus arrhythmia (Figure 3A), sinus tachycardia and atrial premature complex (APC) (Figure 3B) were detected. APC was observed in one 3 years old goat. In addition, the prevalence of cardiac dysrhythmias based on gender and different age groups in studied animals are shown in Table 3. The Chi-square test did not show any significant difference between frequency of dysrhythmias with pregnancy (p>0.05) in sheep and goats. There was a significant difference between dysrhythmias with gender (p=0.004) and different age groups (p<0.001) in sheep and dysrhythmias with gender (p=0.003) and different age groups (p<0.001) in goats. Further analysis with an independent-samples t-test revealed that the heart rate of sheep and goats with sinus arrhythmia was significantly lower than the heart rate of sheep and goats with normal cardiac rhythm (p<0.001). In studied animals, there was no significant relationship between the frequency of sinus arrhythmia and pregnancy (P>0.05).

Cardiac murmurs

Results showed that the prevalence of cardiac murmurs in sheep and goats was 6.3% (12 of 192) and 8.9% (17 of 192), (Tables 4 & 5). All murmurs found in the sheep and goats were systolic. Only one holosystolic murmur was detected in a sheep and the other murmurs in both sheep and goats were early to early-mid systole. One murmur was detected with grade 3/5 in sheep and other murmurs in sheep and goats had the loudness of grade 1 and 2. The intensive murmurs (grades 4/5 and 5/5) and late-systolic or pansystolic murmurs were not heard in this study. The point of maximal intensity (PMI) of sheep murmurs was over the pulmonic, mitral and aortic valves 66.7%, 25% and 8.3%, respectively and the PMI of goats murmurs was over the pulmonic, mitral, and tricuspid valves 76.5%, 17.6% and 5.9%, respectively. The number of murmurs on the mitral valve was higher in groups 1 (< 6 months) and 2 (6-12 months) compared with group 3 (> 12 months). The only holosystolic murmur in our study was over mitral valve with grade 1 in intensity. The statistical analysis using chi-square and fisher's exact

tests in both sheep and goats did not show any significant relationship between murmurs with gender, pregnancy and different age groups.

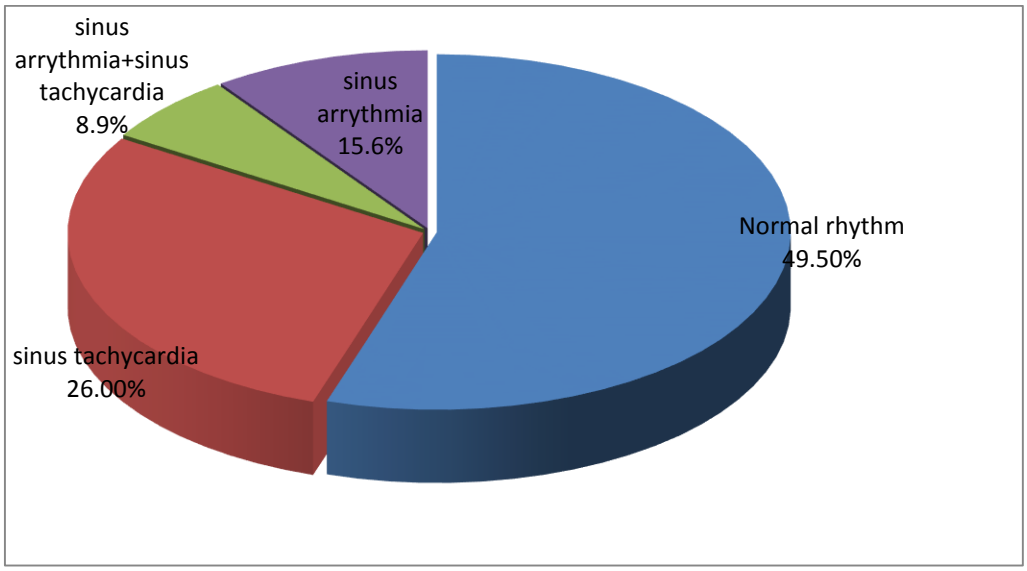

Figure 1: The prevalence of cardiac dysrhythmias in clinically healthy sheep in the suburbs of Tehran

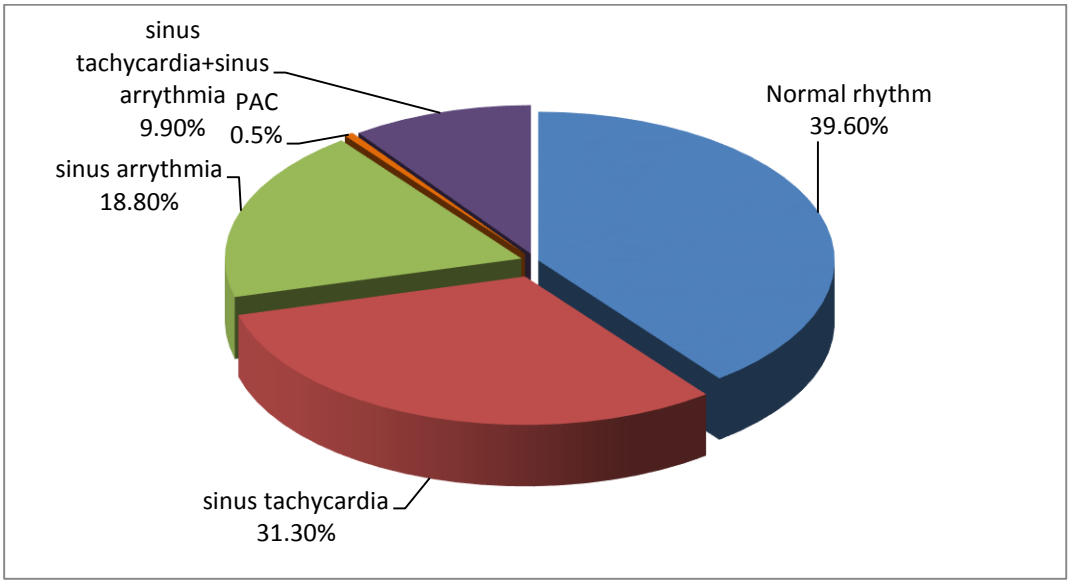

Figure 2: The prevalence of cardiac dysrhythmias in clinically healthy goats in the suburbs of Tehran

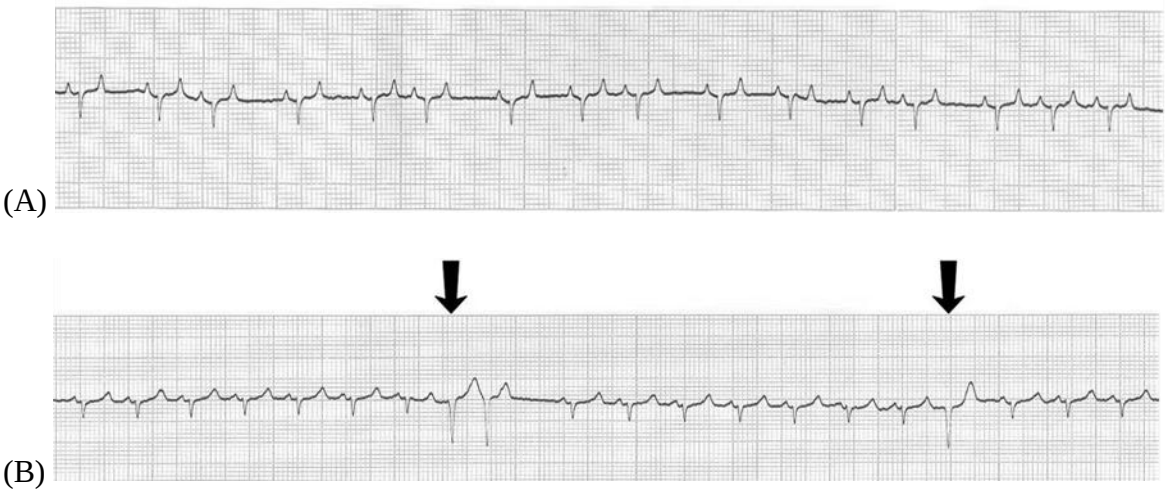

Figure 3: Base–apex electrocardiograms (ECGs) of sheep and goat with dysrrhythmias. All ECGs were recorded at 25 mm/s and 10 mm = 1 mV. (A) Sinus arrythmia in a 2 years old goat. (B) Sinus tachycardia & premature atrial complex in a 3 years old goat.

Table 1: The heart rate (mean± SE) based on sex and different age groups in apparently healthy sheep and goats in the suburbs of Tehran

	Age groups	< 6 months	Months 6-12 months	> 12 months
sheep	Male	129.86 ± 3.74*	108.64 ± 3.18*	110.85 ± 3.84
	Female	125.62 ± 4.04*	102.18 ± 3.08*	82.29 ± 2.34*
Goats	Male	128.83 ± 3.34*	115.75 ± 3.99*	121.42 ± 9.20
	Female	126.56 ± 3.02*	100.48 ± 3.55*	86.18 ± 2.76*

The * in each row indicates significant difference ($p<0.05$).

Table 2 : The heart rate (mean± SE) based on pregnant and non-pregnant in apparently healthy sheep and goats in the suburbs of Tehran

	Sheep	Goats
Pregnant	97.50 ± 6.08	105.71 ± 7.32
Non-pregnant	76.66 ± 1.09	81.63 ± 2.31

Table 3: The prevalence of cardiac dysrhythmias based on gender and different age groups in apparently healthy sheep in the suburbs of Tehran

	Type of cardiac arrhythmias										
		Normal sinus rhythm		Sinus tachycardia		Sinus arrhythmia		Sinus tachycardia& Sinus arrhythmia		Premature atrial complex	
	Age groups	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
sheep	<6 months	9	16	21	12	3	4	4	5	0	0
	6-12 months	22	21	6	5	7	9	2	2	0	0
	>12 months	0	27	4	2	0	7	3	1	0	0
	Total	31	64	31	19	10	20	9	8	0	0
Goats	<6 months	9	10	18	20	4	4	6	3	0	0
	6-12 months	13	22	10	5	9	9	5	1	0	0
	>12 months	0	22	5	2	0	10	2	2	0	1
	Total	22	54	33	27	13	23	13	6		1

Table 4 : The prevalence of cardiac murmurs and their characteristics based on gender and different age groups in apparently healthy sheep in the suburbs of Tehran

Male sheep	Age groups	< 6 months			Months 6-12 months			> 12 months			
	Timing	Early	Early-med	Holo	Early	Early-med	Holo	Early	Early-med	Holo	
		0	2	0	0	0	0	1	0	0	
	Intensity	1/5	2/5	3/5	1/5	2/5	3/5	1/5	2/5	3/5	
		1	1	0	0	0	0	0	1	0	
	PMI	P	M A	T	P	M A	T	P	M A	T	
		1	1 0	0	0	0 0	0	1	0 0	0	
Female sheep	Age groups	< 6 months			Months 6-12 months			> 12 months			
	Timing	Early	Early-med	Holo	Early	Early-med	Holo	Early	Early-med	Holo	
		3	0	0	3	0	0	2	0	1	
	Intensity	1/5	2/5	3/5	1/5	2/5	3/5	1/5	2/5	3/5	
		1	2	0	1	2	0	1	1	1	
	PMI	P	M A	T	P	M A	T	P	M A	T	
		1	2 0	0	3	0 0	0	2	0 1	0	

A: aortic, M: mitral, P: pulmonic, T: tricuspid

Table 5: The prevalence of cardiac murmurs and their characteristics based on gender and different age groups in clinically healthy goats in the suburbs of Tehran

Male	Age groups	< 6 months				Months 6-12 months				> 12 months		
	Timing	Early	Early-med		Holo	Early	Early-med		Holo	Early	Early-med	Holo
		2	0		0	1	1		0	0	0	0
	Intensity	1/5	2/5		3/5	1/5	2/5		3/5	1/5	2/5	3/5
		0	2		0	2	0		0	0	0	0
	PMI	P	M	A	T	P	M	A	T	P	M	A	T
		2	0	0	0	2	0	0	0	0	0	0	0
Female	Age groups	< 6 months				Months 6-12 months				> 12 months		
	Timing	Early	Early-med		Holo	Early	Early-med		Holo	Early	Early-med	Holo
		2	2		0	4	0		0	4	1	0
	Intensity	1/5	2/5		3/5	1/5	2/5		3/5	1/5	2/5	3/5
		2	2		0	3	1		0	2	3	0
	PMI	P	M	A	T	P	M	A	T	P	M	A	T
		3	1	0	0	3	1	0	0	3	1	0	1

A: aortic, M: mitral, P: pulmonic, T: tricuspid

Discussion

Syme and Elphick (1983) determined that heart rate can act as an indicator for social stress in individual groups of sheep (Andersson, 2016; Syme & Elphick, 1982). Vandenheede and Bouissou (1993) found rams less fearful than ewes, while in the current study rams had higher heart rate than ewes. A possible explanation is that the studied male animals have had less previous contact with humans and were used only in breeding seasons; thus, they could be considered fearful of people. In addition, Romeyer and Bouissou (1992) found that within the sight of an unfamiliar human the sheep were less active and had more stress. It has been shown that pregnancy increases heart rate (Hall *et al.* 2011; Nagel *et al.* 2011; Olsson *et al*. 1998; Samimi *et al*. 2018; Trenk *et al*. 2015). Our results also revealed that sheep and goats in late pregnancy period had significantly higher heart rate compared with non-pregnant animals. This result is in agreement with Samimi *et al.* (2015) and is also confirmed by previous findings (Olsson *et al.* 1998; Olsson *et al*. 2001). Sinus tachycardia is an elevated heart rate initiated by the sinoatrial (SA) node. Some factors like exercise, hyperthermia, excitement, pain, anemia, or the use of adrenergic drugs could be responsible for this dysrhythmia. Generally, physiologic sinus tachycardia is predominantly catecholamine driven, but there is synergistic vagal inhibition (Yusuf & Camm, 2005). More recent evidence (Pourjafar *et al. 2011)* reveals that sinus tachycardia is the most common dysrhythmia in Iranian fat-tailed newborn lambs (Pourjafar *et al*. 2011). Also, sinus tachycardia also has been reported in 15-day-old apparently healthy Iranian Najdi goats. Sinus arrhythmia is a normal physiological phenomenon that occurs at slow heart rates especially when the animal is at rest. The dysrhythmia is also related to variation in the rate of SA node discharge and vagal activity (Constable *et al*. 2017). In this study, the mean heart rates of sheep and goats with sinus arrhythmia were significantly lower than the mean heart rates of sheep and goats with normal cardiac rhythm ($p<0.001$). It has been hypothesized that high vagal tone could cause sinus arrhythmia in low mean heart rate (Rezakhani *et al*. 2004). The onset of sinus arrhythmia is clinically more common in the young of all species, tame sheep and goats and is in synchrony with respiration. Sinus arrhythmia is usually present in animals with

sinus bradycardia (Constable *et al.* 2017). This dysrhythmia has been reported in different sheep and goats breeds by various researchers (Pourjafar et al., 2011; Samimi *et al*. 2015; Tajik *et al*. 2016). Rezakhani *et al.* (2004) reported sinus arrhythmia as the most common arrhythmia in cattle. In horses, sinus arrhythmia is relatively uncommon at rest; nevertheless, this dysrhythmia is an usual post exercise phenomenon when there is an altered sympatho-vagal tone (Marr & Bowen, 2010). The incidence of sinus arrhythmia decreases with age, probably as a result of age-related reduction in carotid distensibility and baroreceptor reflex sensitivity. Sinus arrhythmia is usually benign and rarely requires treatment (Marr & Bowen, 2010). Reports of other dysrhythmias in sheep and goats are uncommon (Pugh & Baird, 2012). Atrial premature complexes (APCs) are more frequent in cattle with gastrointestinal tract disease also, their presence should be expected when there is a change in the first heart sound intensity with or without irregularities in the heart rhythm. Simultaneous sympathovagal discharges were observed to precede premature atrial contractions (Chen *et al*. 2014). APCs can lead to atrial fibrillation in cases where there is increase in the tone of the vagus. Atrial premature beats are frequently observed in human newborns and they likely occur even more often in fetal life (Wren, 2012). The persistent APCs were observed in one pair of twin lambs (Koether et al., 2015). In a study conducted by Rezakhani *et al.* (2004), the age of all cows with APCs was above 36 months. The only goat in our study with APC was 3 years old. Constable *et al.* (1990) showed 14 out of 16 APCs had gastrointestinal disorders. It has also been shown that cathecolamine application induced APCs in dogs (Sharifov *et al*. 2004). In another study, APCs had greater prevalence in ponies more than 15 years of age (Rezakhani *et al*. 2010). More recent evidence suggests that APCs are the most common dysrhythmias in cattle (Frese *et al*. 2017). APCs commonly have no clinically specific meaning and do not need treatment (Wren, 2012). The innocent or functional murmur may be distinguished from a pathologic murmur by being of lower and variable intensity, peaking in early to mid- systole, ending well before the second heart sound, and having no radiation (Smith, 2015). In human beings, heart murmurs are heard commonly in healthy newborns, children, and adults (Biancaniello, 2005;

McConnell & Branigan, 2008). Functional ejection murmurs are audible in almost 50% of fit horses and should not be mistaken for evidence of valvular disease (Constable *et al*. 2017). Moreover, in mature dogs, murmurs are frequently indicative of pathological conditions (Bélanger & Côté, 2010). The prevalence of murmurs was 47.7% in a population of three hundred clinically healthy Holstein cattle (Rezakhani & Zarifi, 2007a). There is little documentation in the literature regarding abnormal heart sounds in sheep and goats (Smith & Sherman, 2011). There are uncommon reports of cardiac congenital defects in sheep and goats. Cardiac murmur could be heard in cases of congenital heart diseases (Smith, 2015). Systolic murmurs derive from blood turbulence by incompetent atrial-ventricular valves or as blood flows by the valves of semilunar. The prevalence of systolic murmurs is significantly higher than diastolic murmurs in dairy cattle (Rezakhani & Zarifi, 2007a). All of the murmurs in our study were systolic. In goats with enzootic calcinosis, systolic murmurs with different features have been reported both in Austria and Switzerland in association with the consumption of Golden Oat grass (Trisetum flavescens) and in the prodromal phase of plant poisoning in goats caused by the family *Rubiaceae,* (gousiekte) (Smith and Sherman, 2011). In this study, the point of maximal intensity (PMI) of sheep and goats cardiac murmurs over pulmonic valve area was 66.7% and 76.5% respectively. Rezakhani and zarifi (2007a) reported 52.4% of murmurs over the pulmonic area in dairy cattle. The only holosystolic murmur in our study was over mitral valve with grade 1 in intensity. Holosystolic murmurs are common in foals, best heard on the left side of the thorax over the pulmonic or aortic valve area and are most likely a normal physiological phenomenon. Because murmurs over the mitral valve were early to mid-systolic, low in intensity (1/5,2/5) and localized over mitral valve area without any palpable thrill or radiation to other valves, we considered them as functional murmurs. Murmurs on the mitral valve was higher in groups 1 (months 6<) and 2 (months12<X<6) compared with group 3 (months12>). One possible hypothesis for this finding could be failure to develop heart structures in younger ruminants. Because the cardiovascular physiology of neonates and young animals is different from adults. (Koether *et al*. 2015). In cattle, the prevalence of cardiac murmurs

under 1 year of age was significantly higher than over 1 year old (Rezakhani & Zarifi, 2007a). Shekarforoush *et al.* (2006) also suggested that the presence of blood and serous cysts could cause heart murmurs in cattle under one year of age. There are reports of mitral regurgitations and audible murmurs due to blood and serous cysts in human medicine (Grimaldi *et al*. 2012; Kurtoğlu *et al*. 2005; Lopez-Pardo *et al*. 2008; Madhavan *et al.* 2015). Perhaps the presence of these cysts in sheep and goats at the younger age causes heart murmurs; however, the review of veterinary literature revealed few data on blood and serous cysts in sheep and goats (Kojouri *et al*. 2005). A cardiac murmur may also be heard in cases of endocarditis. For instance, a case of endocarditis has been reported in a pygmy goat with clinical signs of continuous murmur (Smith & Sherman, 2011). Previous exposure to the bacterial disease may lead to valvular insufficiency and murmur (Buczinski & Bélanger, 2010; Haskell, 2011). Nevertheless, Scott (2015) believed that vegetative endocarditis in sheep does not commonly present with an audible murmur.

Conclusion

The results of this study suggest that sheep and goats have low prevalence of cardiac murmurs and dysrhythmias compared to cattle and horses and accordingly the information obtained from this study could be used in animal model experiments.

Conflict of Interest Statement

The authors have not conflict of interest statement.

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