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Araştırma Makalesi ***Research Article***

Electrocardiographic Indices in Clinically Healthy Iranian Najdi Goats in Different Ages: A Reference Study

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Abstract

The cardiovascular system develops along with growing the animals. Information regarding the alterations of electrocardiographic parameters during aging can provide the basis to evaluate the development of cardiovascular system. Hence, the present study was performed to clarify the effect of aging on electrocardiographic alterations in Iranian Najdi goats. The electrocardiograms were recorded on a bipolar base apex lead from 172 clinically healthy Iranian Najdi does into 9 age groups, including 15-day-old (n=18), 2 (n=18), 6 (n=19), 9-month-old (n=21), 1 (n=20), 2 (n=22), 3 (n=19), 5 (n=18) and 7-year-old (n=17). All electrocardiograms were examined to evaluate normal electrocardiographic parameters and cardiac arrhythmias. Finally changing of the electrocardiographic parameters during aging was statistically determined. P, S and T durations were increased significantly during aging. Furthermore, the significant increases were seen in RR, QT and ST intervals. Sinus tachycardia and sinus arrhythmia were the most common cardiac arrhythmias in studied animals. The proportion of cardiac arrhythmias in under 1-year-old kids was significantly higher than other groups. It may be concluded that aging can affect electrocardiographic parameters in Iranian Najdi goats.

Özet

Klinik Yönden Sağlıklı İran Najdi Keçilerinin Farklı Yaşlarda Elektrokardiyografik Endeksleri: Temel Çalışma

Kardiyovasküler sistem hayvanların büyümesi ile birlikte gelişir. Yaşlanma süresinde elektrokardiyografik parametrelerdeki değişikliklere yönelik bilgiler kardiyovasküler sistemin gelişimini değerlendirebilmek için temel oluşturabilir. Bu nedenle bu çalışma İran Najdi keçilerinde yaşlanmanın elektrokardiyografik değişiklikler üzerindeki etkisini ortaya koymak için yapılmıştır. Elektrokardiyogramlar klinik yönden sağlıklı 172 Iran Najdi keçisinden bir bipolar baz apeks kutup üzerine kaydedildi; keçiler 15 günlük (n=18), 2 aylık (n=18), 6 aylık (n=19), 9 aylık (n=21), 1 yaşında (n=20), 2 yaşında (n=22), 3 yaşında (n=19), 5 yaşında (n=18) ve 7 yaşında (n=17) olmak üzere 9 grupta toplanmıştı. Tüm elektrokardiyogramlar normal elektrokardiyografik parametreleri ve kardiyak aritmileri değerlendirebilmek için incelendi. Son olarak, yaşlanma sırasında elektrokardiyografik parametreleri değiştirme istatistiksel yönden belirlendi. Yaşlanma sırasında P, S ve T süreleri anlamlı olarak arttı. Ayrıca, RR, QT ve ST entervallerinde anlamlı artışlar görüldü. İncelenen hayvanlarda en yaygın kardiyak aritmiler sinus taşikardisi ve sinus aritmisiydi. Kardiyak aritmilerin oranı 1 yaş altı keçilerde daha yaşlı gruplara oranla anlamlı olarak daha yüksekti. Netice itibariyle, İran Najdi keçilerinde yaşlanmanın elektrokardiyografik parametreleri etkileyebildiği sonucuna varılabilir.

Introduction

Electrocardiography as a non-invasive procedure, can record heart electrical activities over a period of time. Depolarization and repolarization of the myocardium, as electrical impulses, cause heart beats which are detectable by electrocardiography to record and produce electrocardiograms (ECGs). ECG in large animals can be used to evaluate the heart rate and rhythm, size of cardiac chambers, myocardial damages and drugs side effects (Radostits et al., 2007).

There are several electrocardiographic lead systems in large animals to record ECGs contain bipolar (I, II, III, base-apex, X, Y and Z of the orthogonal lead system) and unipolar leads (aVF, aVR, aVL, thoracic). But the recorded waves by these leads in each animal's breed, size, body type and sex are different from others and these factors should not affect the ECGs (Reef and McGuirk, 2009). Base apex lead in large animals has not the complications in other leads and can record the clear and large waves and animal movement has a minimum

effect on the recording (Radostits et al., 2007; Santamarina et al., 2001).

There are several electrocardiographic studies in clinically healthy small ruminants (Pourjafar et al., 2011a; 2011b; Pourjafar et al., 2012) and some literature reported the normal electrocardiographic parameters in different breeds of apparently healthy goats tracing by leads other than base apex (Ahmed and Sanyal, 2008; Mohan et al., 2005). Changing the electrocardiographic parameters has been studied during aging in Holstein cattle (Chalmeh, 2014) and dromedary camels (Chalmeh et al., 2013), but according to the author's knowledge, the comprehensive study on normal electro-cardiographic parameters and cardiac arrhythmias during aging of clinically healthy Iranian Najdi goats is lacking. Hence, the present study was performed to clarify the effect of aging on electrocardiographic findings in this breed tracing by standard base apex lead system.

Materials and Methods

This study was performed after being approved by the Ethics Committee of the School of Veterinary Medicine, Shiraz University. The present study was accomplished in October 2013 on 172 clinically healthy Iranian Najdi does around Shiraz, Fars province, southwest of Iran. These female goats had been assigned into 9 age groups, including 15-day-old (n=18), 2 (n=18), 6 (n=19), 9-month-old (n=21), 1(n=20), 2 (n=22), 3 (n=19), 5 (n=18) and 7-year-old (n=17). All goats were grazing in a green pasture with free access to water and shade. The animals were examined prior to ECG recordings and proved to be clinically healthy. None of the goats used in this study had any clinical signs of heart diseases (edema, jugular distension or pulsation and cardiac murmurs), coughing and exercise intolerance. The ECGs were recorded on a bipolar base apex lead, using limb lead I. Animals were kept standing without any sedation and minimum restraint also. When animals got calm (decreased panting behavior and muscle tremors), the ECGs were recorded, using alligator-type electrodes which were attached to skin after cleaning it with ethanol and applying electrocardiographic jelly to improve skin contact. The positive electrode (left arm) was placed over cardiac apex in the fifth left intercostal space at the level of the elbow, the negative electrode (right arm) was placed in the left jugular furrow at the top of heart base, the neutral electrode (right foot) was used on the skin of thoracic inlet and the ground was placed on the dorsal spine or another site away from the heart (Radostits et al., 2007). All ECGs were obtained in a single channel electrocardiographic machine (Kenz-line EKG 110, Suzuken Co., Ltd., Japan) with paper speed of 25 mm/sec and calibration of 10 mm equal to 1 mV. The precision of duration was 0.02 second and amplitude was 0.05 mV. All ECGs were examined to evaluate normal electrocardiographic parameters and cardiac arrhythmias. Finally changing the electrocardiographic parameters during aging was determined, statistically.

Mean and standard deviation (SD) were calculated for all studied electrocardiographic parameters in different age groups. Repeated measures ANOVA was used to determine the changing pattern of each parameter during aging. Fisher's exact test was used to evaluate the differences among proportion of arrhythmias in the studied groups. All data were analyzed using SPSS software (SPSS for Windows, version 20, SPSS Inc, Chicago, Illinois). $P<0.05$ was considered statistically significant.

Results

Normal electrocardiographic parameters in each age are shown in Table 1. The changing patterns of each parameter during aging are presented in Figures 2 to 4. P, S and T durations were increased significantly during aging ($P<0.05$; Figure 2). There were no significant changing patterns in amplitudes (Figure 3). Furthermore, the significant increases were seen in RR, QT and ST intervals ($P<0.05$) but the increasing pattern of PR interval was not significant during aging ($P>0.05$; Figure 4).

Sinus tachycardia and sinus arrhythmia were the most common cardiac arrhythmias in studied animals. There were no normal sinus rhythms in 15-day-, 2-and 6-month-old kids. In these groups, sinus arrhythmia and sinus tachycardia were seen. The proportion of cardiac arrhythmias in under 1-year-old kids was significantly higher than other groups ($P<0.05$; Figure 5).

Discussion

Electrocardiography is the clinical method of choice to evaluate cardiac problems associated with the initiation and conduction of waves of depolarization and repolarization (Santamarina et al., 2001). Compared with the numerous data available in the caprine ECG traced by different electrocardiographic leads (Ahmed and Sanyal, 2008; Mohan et al., 2005), studies on the base apex lead system have been scarcely touched and little information is available on electrocardiography in Iranian Najdi goats. Furthermore, the data in basic parameters of the standard base apex caprine ECG in different ages which could be used as reference values are absent in the consulted literatures. Furthermore, there were no studies on changing the normal electrocardiographic parameters and cardiac arrhythmias during aging of Iranian Najdi goats. There are independent studies which covered the normal

different ECG parameters in healthy goats at distinct age in electrocardiographic lead systems other than base apex lead such as standard bipolar (I, 11, 111), augmented unipolar (aVR, aVL, aVF) limb leads and unipolar V10 (Ahmed and Sanyal, 2008; Mohan et al., 2005). The present study incorporated a range of different ages of Iranian Najdi goats in a single wide study to clarify the effect of age on normal ECG parameters and cardiac arrhythmias.

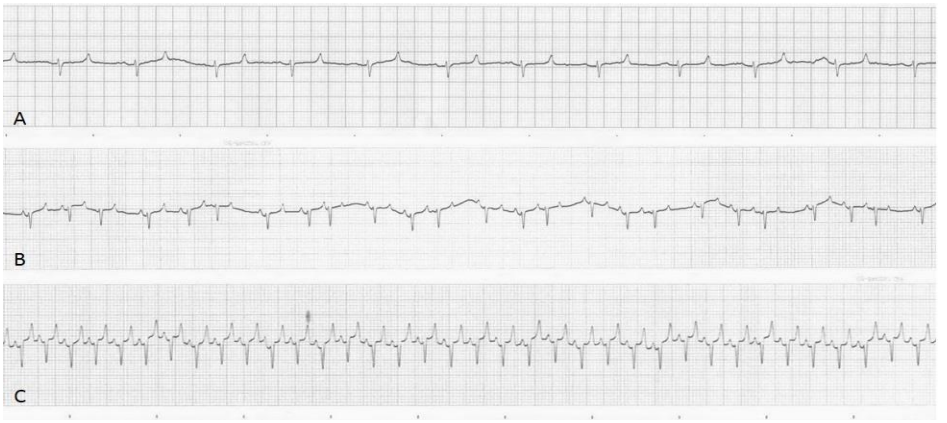

Figure 1. ECG records in clinically healthy Iranian Najdi goats at different ages (base apex lead system; paper speed 25 mm/s, sensitivity 10 mm/mV). A: Normal sinus rhythm in 7-year-old doe (heart rate=65 beats/min); B: Sinus tachycardia and respiratory sinus arrhythmia in 6-month-old kid (heart rate=150 beats/min; R-R interval=0.36 sec, connected with inspiration; and period with R-R interval=0.52 sec, connected with expiration); C: Sinus tachycardia in 9-month-old goat (heart rate=200 beats/min).

Şekil 1. Klinik yönden sağlıklı İran Najdi keçilerinde EKG kayıtları (baz apeks kutup sistemi; kağıt hızı 25 mm/s, hassasiyet 10 mm/mV). A: 7- yaşındaki keçilerde normal sinus ritmi (kalp hızı = 65 atım/dak); B: 6-aylık keçide sinus taşikardisi ve solunum sinus aritmisi (kalp hızı = 150 atım/dak; R-R aralığı =0,36 saniye, nefes alış ile bağlantılı; ve R-R aralığı ile süre= 0.52 san, nefes veriş ile bağlantılı); C: 9-aylık keçide sinus taşikardisi (kalp hızı= 200 atım/dak).

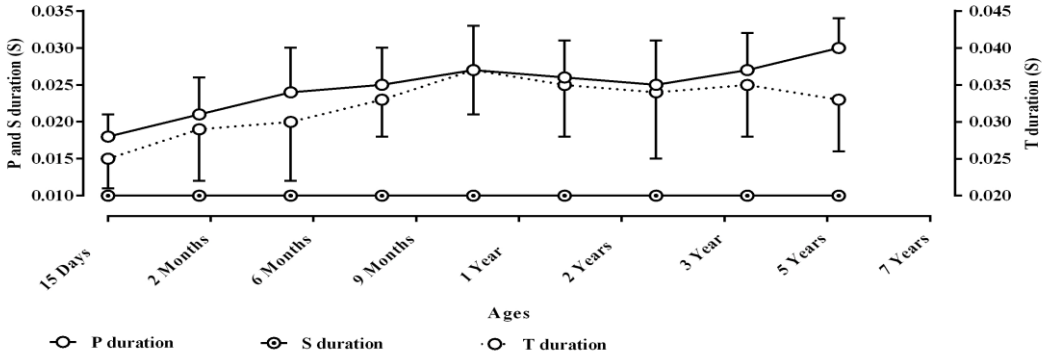

Figure 2. Changing patterns of electrocardiographic wave's durations during aging of clinically healthy Iranian Najdi goats (base apex lead, paper speed 25 mm/sec, sensitivity 10 mm/mV).

Şekil 2. Klinik yönden sağlıklı İran Najdi keçilerinde yaşlanmayla elektrokardiyografik dalgaların sürelerinin değişen patternleri (baz apeks kutbu, kağıt hızı 25 mm/san, hassasiyet 10 mm/mV).

Table 1. The duration (sec), interval (sec) and amplitude (mV) values of standard electrocardiographic parameters (Mean±SD) of base apex lead in different age groups of clinically healthy Iranian Najdi goats (base apex lead, paper speed 25 mm/sec, sensitivity 10 mm/mV).

Tablo 1. Farklı yaş gruplarındaki klinik yönden sağlıklı İran Najdi keçilerinin baz apex kutuplarının standart elektrokardiyografik parametrelerin süresi (sn), aralığı (sn) ve amplitüdü (mV) değerleri (ortalama ± standart sapma).

Age groups	P-duration (sec)	P-amplitude (mV)	PR-interval (sec)	RR-interval (sec)	T-duration (sec)	T-amplitude (mV)	QT-interval (sec)	R-amplitude (mV)	S-amplitude (mV)	ST-interval (sec)	S-duration (sec)
15-days (n=18)	0.018±0.003	0.055±0.010	0.035±0.005	0.166±0.004	0.025±0.004	0.094±0.067	0.059±0.014	0.033±0.017	0.219±0.086	0.047±0.014	0.010±0.001
2-months (n=18)	0.021±0.005	0.052±0.016	0.045±0.008	0.203±0.032	0.029±0.007	0.100±0.057	0.071±0.014	0.054±0.012	0.300±0.089	0.060±0.014	0.010±0.001
6-months (n=19)	0.024±0.006	0.058±0.014	0.050±0.007	0.221±0.027	0.030±0.008	0.092±0.055	0.085±0.014	0.044±0.015	0.240±0.088	0.073±0.014	0.010±0.001
9-months (n=21)	0.025±0.005	0.052±0.011	0.054±0.006	0.241±0.030	0.033±0.005	0.122±0.048	0.087±0.012	0.045±0.015	0.271±0.090	0.075±0.011	0.010±0.001
1-year (n=20)	0.027±0.006	0.047±0.014	0.058±0.011	0.262±0.037	0.037±0.006	0.152±0.059	0.090±0.016	0.045±0.015	0.300±0.084	0.078±0.014	0.010±0.001
2-years (n=22)	0.026±0.005	0.051±0.011	0.058±0.009	0.270±0.030	0.035±0.007	0.137±0.053	0.097±0.011	0.052±0.012	0.295±0.090	0.084±0.012	0.010±0.001
3-years (n=19)	0.025±0.006	0.055±0.013	0.058±0.007	0.278±0.045	0.034±0.009	0.122±0.054	0.104±0.017	0.059±0.015	0.280±0.078	0.090±0.048	0.010±0.001
5-years (n=18)	0.027±0.005	0.064±0.015	0.060±0.007	0.269±0.030	0.035±0.007	0.151±0.063	0.101±0.013	0.060±0.011	0.275±0.099	0.090±0.014	0.010±0.001
7-years (n=17)	0.030±0.004	0.068±0.011	0.060±0.008	0.274±0.021	0.033±0.007	0.185±0.023	0.109±0.015	0.051±0.011	0.220±0.101	0.098±0.016	0.010±0.000

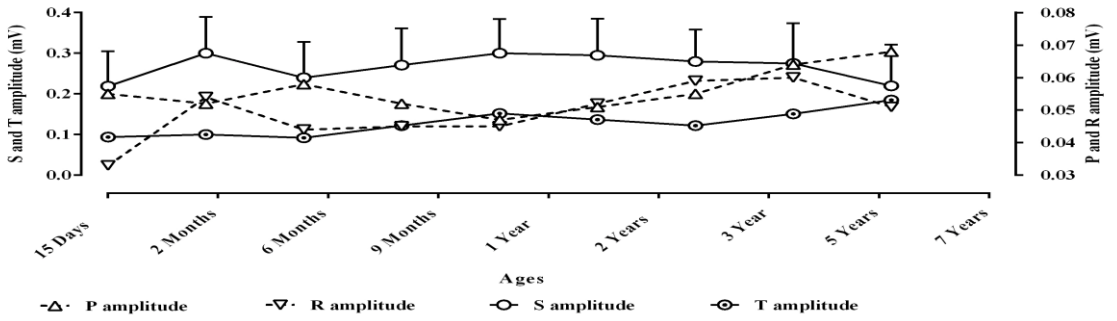

Figure 3. Changing patterns of electrocardiographic wave's amplitudes during aging of clinically healthy Iranian Najdi goats (base apex lead, paper speed 25 mm/sec, sensitivity 10 mm/mV).

Şekil 3. Klinik yönden sağlıklı İran Najdi keçilerinde yaşlanmayla elektrokardiyografik dalgaların amplitüdlerinin değişen paternleri (baz apeks kutbu, kağıt hızı 25 mm/san, hassasiyet 10 mm/mV).

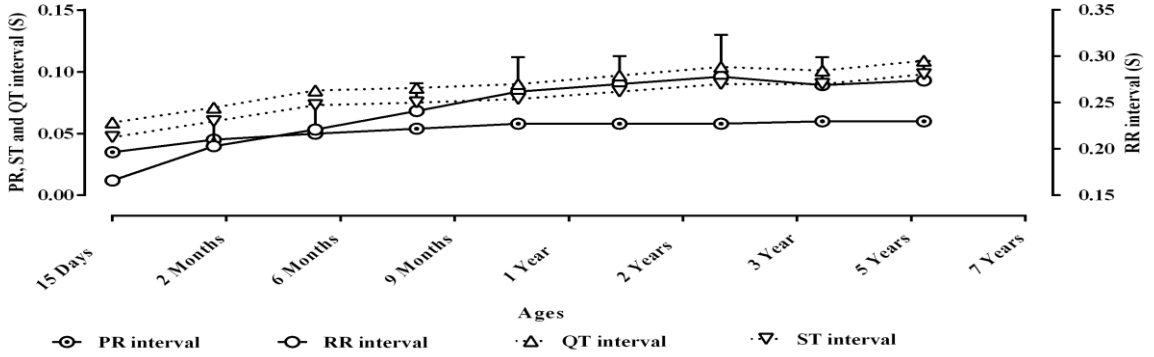

Figure 4. Changing patterns of electrocardiographic wave's intervals during aging of clinically healthy Iranian Najdi goats (base apex lead, paper speed 25 mm/sec, sensitivity 10 mm/mV).

Şekil 4. Klinik yönden sağlıklı İran Najdi keçilerinde yaşlanmayla elektrokardiyografik dalgaların aralıklarının değişen paternleri (baz apeks kutbu, kağıt hızı 25 mm/san, hassasiyet 10 mm/mV).

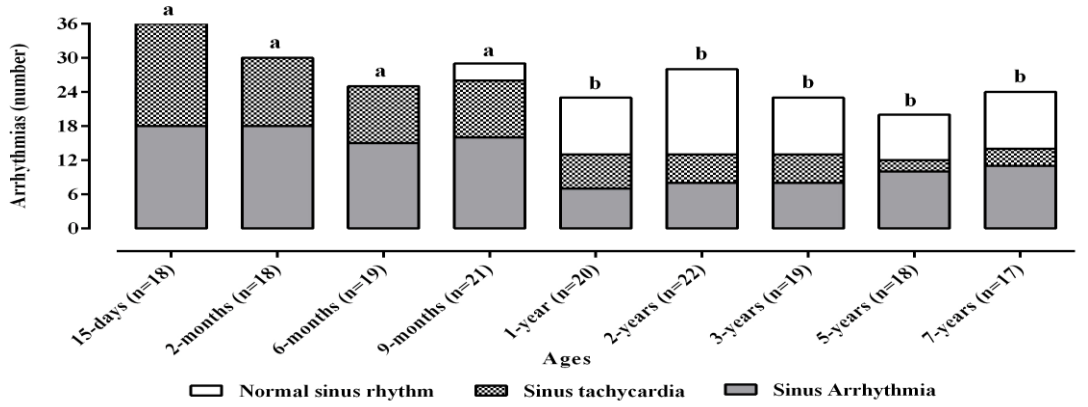

Figure 5. The proportion of cardiac arrhythmias in different ages of clinically healthy Iranian Najdi goats.
Different letters above each columns indicate significant differences among proportion of cardiac arrhythmias in studied groups (P<0.05).

Şekil 5. Klinik yönden sağlıklı İran Najdi keçilerinde değişik yaşlardaki kardiyak aritmilerinin oranı.
Her sütunun üstündeki farklı harfler incelenen gruplardaki kardiyak aritmilerinin oranları arasındaki anlamlı farklılıkları göstermektedir (P<0,05).

The base apex lead appears to be most useful in measuring conduction times (i.e., durations of component deflections, intervals, and segments) because the origins and terminations of deflections could be identified easily (Santamarina et al., 2001). It has been reported that the base apex lead gave the least variable ECG tracings in all the animals; furthermore, the P waves, QRS complexes, and T waves in the base apex lead had the highest mean amplitude of all the leads recorded (Santamarina et al., 2001). It seems that our study on goat's ECG parameters in base apex lead system may be helpful in standardizing this lead in various ages of Iranian Najdi goats in a comprehensive study in comparison with the previous studies.

The conductive properties of the body mass of ruminants, attributable to the volume of the gastrointestinal tract, influence the distribution of body surface potentials comprising the ECG (Santamarina et al., 2001). This may explain the differences among different ECG parameters between the different ages in our study (Table 1). The gradual development of body mass may cause difficulty in reaching the waves to the body surface due to relative electrical insulation by increasing body mass and decrease of amplitude in adults (Kellerová et al., 2010).

In the present study the electrocardiographic durations and intervals were increased significantly during aging (Figures 2 and 4). The transition time of heart electrical impulses produces durations and intervals. It may be stated that the smallest cardiac size and more superficial purkinje fibers in younger goats in comparison with older animals can create lowest durations and intervals in younger ones. It could be suggested that as the mass of heart in larger animals became larger in the process of growth, the duration of transfer of cardiac electrical activity also increases (Schmidt-Nielsen, 1997). In our study the lowest P and T durations, PR, RR, QT and ST-intervals were seen in 15-day-old kids and these parameters were gradually increased along with aging.

The amplitude of P, R, S and T waves recorded in the studied goats were not followed a specific pattern during aging. The changing of amplitudes presumably could be due to a high degree of synchronized ventricular polarization passing in any given direction. Furthermore, alterations between heart situation and attached positive electrode can change amplitudes. This may be also due to the presence of high degree of synchronization of depolarization of individual myocardial fibers.

Respiratory sinus arrhythmia, either transient or persistent, is the most common arrhythmia observed in all examined groups by different number and proportion (Figure 1B; Figure 5). The observation of ECGs revealed that sinus arrhythmia is associated with respiration. Sinus arrhythmia is a normal physiological arrhythmia that occurs at slow resting heart-beating rate and is connected with variation in the rate of discharge from the sinoatrial node which is related to variation in the intensity of vagal stimulations. It highly correlates with respiration so that discharge rate and heart rate increase and decrease during inspiration and expiration, respectively. Respiratory sinus arrhythmia is more clinically obvious in tamed sheep and goats (Radostits et al., 2007). This arrhythmia has been reported in cattle which have been deprived of food or anorectic due to some gastrointestinal problems (Gentile et al., 1992). None of the animals with respiratory sinus arrhythmia in this study had clinically obvious systemic problems or suffered from anorexia. High vagal tone is supposed to be the cause of arrhythmia in these animals (Rezakhani et al., 2004). It may be possible to link the genesis of sinus tachycardia and respiratory sinus arrhythmia in apparently healthy kids to the increased load imposed on the heart or the fluctuation of sympathetic or parasympathetic tone associated with excessive exertion during birth stage (Machida et al., 1993).

The proportion of sinus tachycardia in the four youngest age groups was significantly higher than other ages (Figure 1B, C; Figure 5). Sinus tachycardia causes an increase in heart rate initiated by sinoatrial node. The term sinus tachycardia has been used to describe an increase in heart rate caused by factors such as pain, excitement, exercise, hyperthermia, fall in arterial blood pressure and administration of adrenergic drugs (Radostits et al., 2007). The heart rate returns to normal when factors are removed or relieved. The results of this examination proved that all of 15-day-old kids had sinus tachycardia. It may be suggested that higher heart rate of kids might be due to stress and excitation caused by isolation of kids from their dams, however, it is unlikely to be the origin for higher heart rate since the animals were kept in a quiet state. Because there were no clinical signs of cardiac problems (oedema, jugular distension or pulsation) in examined animals, this irregular cardiac rhythm could be categorized as physiologic arrhythmias. Pourjafar et al. (2011a) reported that sinus tachycardia is the most common cardiac arrhythmia in newborn Iranian fat-tailed lambs. The physiological properties of fetal and neonatal myocardium make it intrinsically more vulnerable to high heart rates (Rudolph, 2009).

Finally, it is obvious that these data will provide a good basis for judging the ECGs in base apex lead system from different age groups of Iranian Najdi goats. It could be stated that aging can affect electrocardiographic

findings. Furthermore, it was concluded that cardiac arrhythmias observed in clinically healthy goats in this study could be regarded as physiological arrhythmias, therefore treatment was not necessary.

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