

# SELENIUM AND THE ELECTROCARDIOGRAM IN THE DROMEDARY CAMEL (*Camelus dromedarius*)

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## ABSTRACT

Selenium (Se) is an essential trace element with well-established roles in antioxidant defense, redox regulation, and cardiovascular function. Both Se deficiency and excess have been associated with myocardial dysfunction and electrocardiographic (ECG) abnormalities in several animal species, yet limited data are available in the dromedary camel (*Camelus dromedarius*). The present study investigated the relationship between Se status and cardiac electrical activity in a cohort of apparently healthy adult female camels. Twenty camels (age  $9.8 \pm 0.3$  years; body mass  $406 \pm 7$  kg) were studied. Se concentrations were measured in hair and blood serum using inductively coupled plasma mass spectrometry. ECG recordings were obtained in a modified base-apex configuration under standardised conditions, and multiple ECG parameters were quantified, including PR, QRS, QT, corrected QT (QTc), ST and RR intervals, heart rate, and short-term heart rate variability. Mean Se concentrations were  $0.61 \pm 0.05$  mg kg<sup>-1</sup> in hair and  $133 \pm 10$  ng ml<sup>-1</sup> in serum, values consistent with previously reported reference ranges for camels. ECG analysis demonstrated considerable inter-individual variability in waveform morphology and interval duration, with a mean HR of  $54 \pm 3$  beats min<sup>-1</sup>. Occasional arrhythmias, including premature ventricular contractions and marked bradycardia, were observed in a small number of animals and excluded from summary analysis. Correlation analysis revealed no significant associations between Se concentrations in serum or hair and PR interval, QRS duration, QTc interval, or HR ( $|r| < 0.5$  for all comparisons). These findings indicate that, in apparently healthy adult female camels with Se concentrations within physiological range, Se status is not associated with alterations in resting ECG parameters. The results suggest that Se-related electrophysiological effects reported in other species may be context-dependent and become clinically relevant primarily under conditions of Se deficiency, excess, or additional metabolic or oxidative stress.

**Key words:** Camel (*Camelus dromedarius*), Electrocardiogram, Heart, Selenium

Selenium (Se) is an essential trace element that plays a critical role in antioxidant defense, immune function, reproduction, endocrine, neural and cardiovascular systems and metabolic regulation in animals, including the dromedary camel (*Camelus dromedarius*) (Faye and Seboussi, 2009; Fairweather-Tait *et al*, 2011; Rayman, 2012; Kieliszek, 2019; Abdelrahman *et al*, 2022a; Schomburg, 2022). There is a high correlation between serum Se concentration and blood glutathione peroxidase (GSH-Px) (Hamliri *et al*, 1990; Corbera *et al*, 2001; Seboussi *et al*, 2008). As a constituent of selenoproteins, such as GSH-Px, Se protects cells from oxidative damage and maintains tissue integrity (Hamliri *et al*, 1990; Corbera *et al*, 2001; Venardos *et al*, 2004; Seboussi *et al*, 2008). Se deficiency is associated with disorders including white muscle disease, cardiomyopathy, disturbances

in cardiac rhythm, impaired fertility and reduced disease resistance (Faye and Bengoumi, 1994; Al-Qarawi *et al*, 2001; El-Khouly *et al*, 2001; Gutierrez *et al*, 2001; Faye and Seboussi, 2009; Seboussi *et al*, 2009a; Seboussi *et al*, 2009b; Fantinato and Binanti, 2015; Özdemir *et al*, 2016; Ali *et al*, 2019; Kieliszek, 2019; Ali *et al*, 2021; Shahin *et al*, 2021; Abdelrahman *et al*, 2022a; Ardahanli and Ozkan, 2022). Long-term Se supplementation, combined with the use of angiotensin-converting enzyme inhibitor and beta blocker therapy, improved the survival of patients with chronic Keshan disease and congestive heart failure (Zhu *et al*, 2019). Dromedary camels, which are uniquely adapted to arid and semi-arid environments, are particularly vulnerable to Se imbalance due to low and variable soil and forage Se content (Abdelrahman *et al*, 2022a; Abdelrahman *et al*, 2022b; Abdelrahman

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*et al*, 2025). Dietary Se supplementation increases the Se concentration in blood and to varying extents in organs including kidney, lung, spleen, liver lung and hair (Seboussi *et al*, 2008; Faye and Seboussi, 2009; Seboussi *et al*, 2010). Excessive intake of Se can cause selenosis and systemic toxicity (Gasmi *et al*, 1997; Faye and Seboussi, 2009; Seboussi *et al*, 2009a). Recent studies in camels have characterised regional variations in Se status, tissue distribution, and physiological responses to deficiency and supplementation, demonstrating both beneficial and dose-dependent toxic effects (Faye and Seboussi, 2009; Seboussi *et al*, 2009a; Abdelrahman *et al*, 2022b; Bataa *et al*, 2022). These findings highlight the importance of optimised Se management to support camel health and productivity.

Se concentrations in camel blood have been reported in many studies with values varying according to age, sex, and study population (Hamliri *et al*, 1990; Zongping, 2003; Faye *et al*, 2005; Barri and Al-Sultan, 2007; Seboussi *et al*, 2010; Acosta-Dacal *et al*, 2025; Meligy *et al*, 2024).

Experimental studies using isolated heart preparations have demonstrated that Se supplementation markedly improves post-ischemic recovery of mechanical performance and reduces lipid peroxidation and metabolic indicators of myocardial damage, underscoring its cardioprotective potential under conditions of acute oxidative stress (Sinci *et al*, 1998). Abnormal electrocardiograms (ECGs) have been reported in rats and lambs fed a low Se diet (Godwin, 1965; Godwin and Fraser, 1966). Ultrastructural defects, hemodynamic alterations and ECG disturbances have been reported in rats fed Se restricted diet (Wildman *et al*, 1994). Se has protective effects against experimentally induced myocardial infarction in rats (Dallak, 2017). Hearts from Se deficient rats were more susceptible to ischemia-reperfusion injury (Venardos *et al*, 2004) and addition of Se to reperfusion solutions improved cardiac functional recovery and decreased postischemic myocardial injury in isolated guinea pig heart (Sinci *et al*, 1998). Sodium selenite causes a contracture state both in Langendorff perfused rat hearts and isolated papillary muscles (Ugur and Turan, 2001). Gender dependent effects of toxic concentrations of sodium selenite on the ECG and left ventricular pressure have been demonstrated in perfused rat heart (Ayaz *et al*, 2007). Neonatal rats fed a Se deficient diet showed a high incidence of ECG abnormalities including sinus arrhythmia and extrasystole and there was also left ventricular hemodynamic dysfunction (Okamoto *et*

*al*, 1999). Studies in non-diabetic hearts have shown that chronic Se administration can alter the kinetics of L-type  $\text{Ca}^{2+}$  and  $\text{K}^{+}$  currents, reduce inward rectifier  $\text{K}^{+}$  current density, and shift myocardial redox balance toward oxidation, changes that may increase susceptibility to electrical instability when Se exposure exceeds physiological requirements (Ayaz *et al*, 2005). Diets deficient in Se and Vitamin E impairs L-type  $\text{Ca}^{2+}$  current responses to isoproterenol in rat ventricular myocytes as a result of a defect in the  $\beta$ -adrenoceptor-adenylate cyclase pathway (Sayar *et al*, 2000). Notably, Se deficiency alone, in the presence of adequate vitamin E, does not appear to induce significant electrophysiological or mechanical abnormalities in the healthy rat heart, suggesting that the effects of Se are highly context-dependent and become more pronounced under conditions of oxidative or metabolic stress (Ringstad *et al*, 1988). Collectively, these findings highlight Se as a critical yet tightly regulated modulator of cardiac redox state, ionic currents, and calcium homeostasis.

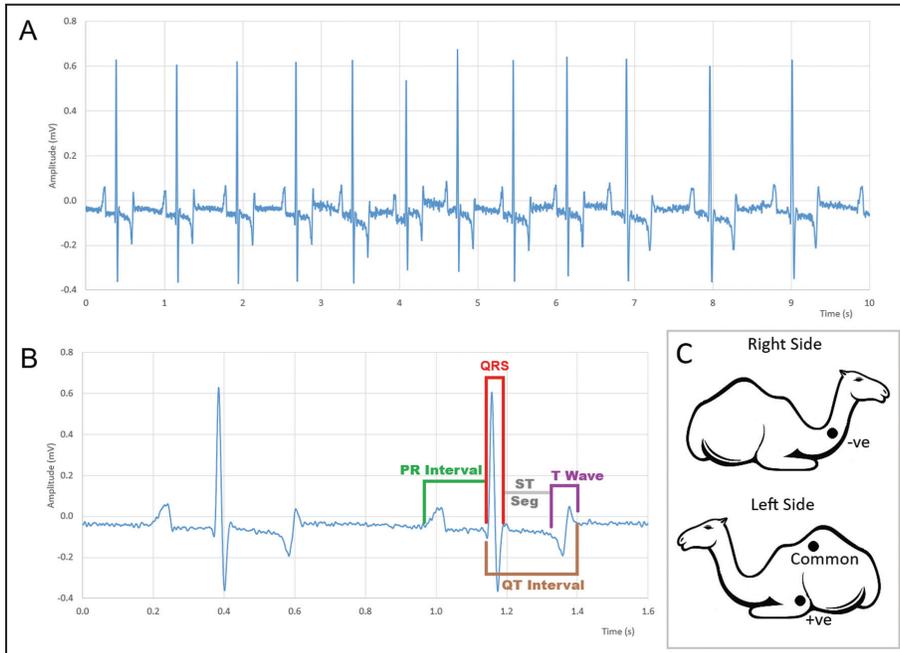
Several studies have reported ECG derived heart rate (HR) measurements in camels, demonstrating considerable variation with age and body size. Braun *et al* (1958) recorded a resting pulse rate of 24-30 beats per minute (bpm) in a 265-kg adult male camel. Age-related changes in HR were described by Pourjafar *et al* (2011), who reported mean HRs of 89 bpm in camels younger than 6 months, 69 bpm in camels aged 7-9 years, and 56 bpm in those aged 13-15 years. Samimi and Sanjarinejad (2021) reported HRs of 80 bpm in 5-year-old male camels, while Howarth *et al* (2025) documented a mean HR of 69 bpm in 9.5-year-old female camels.

The aim of this study was to measure Se concentrations in hair and blood serum, and to measure a range of electrocardiographic parameters in a group of apparently healthy adult female camels, in order to investigate potential associations between Se status and cardiac electrical activity.

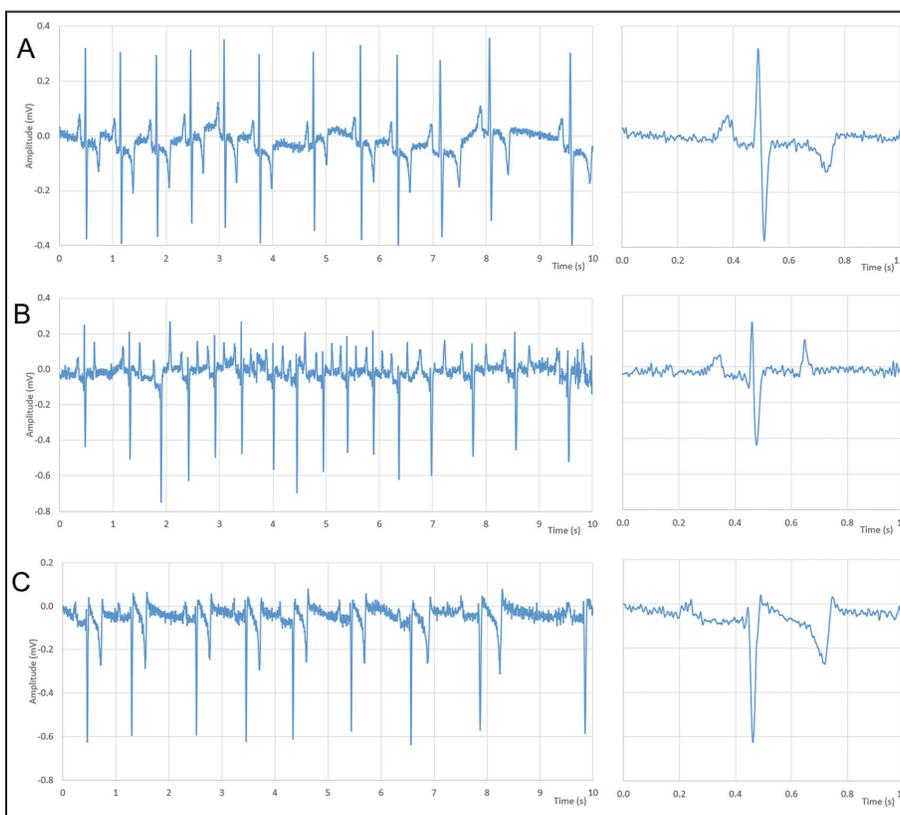
## Materials and Methods

Twenty female dromedary camels, aged  $9.8 \pm 0.3$  years and weighing  $406.5 \pm 6.6$  kg, accommodated at the Camel Research Centre, Al Ain were used in this study. All the camels used in this study were apparently healthy. Animals were weighed before measurement of the ECG. Ethical approval for the project was obtained from the UAE University Animal Ethics Committee.

**Measurement of Se in hair and blood:** Hair samples were collected from the withers area of



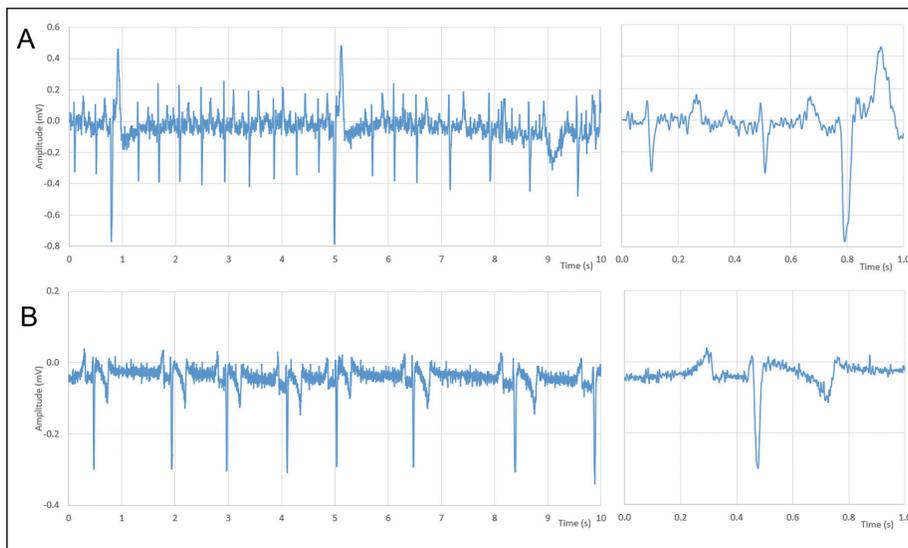
**Fig 1.** Electrocardiographic recording. (A) ECG of camel 2, an adult, 9-year-old female camel displaying positive P Wave with biphasic QRS and T Wave deflections, (B) One cycle on an expanded scale with indicated wavelet intervals. Recordings were made in modified base-apex lead configuration as displayed in (C).



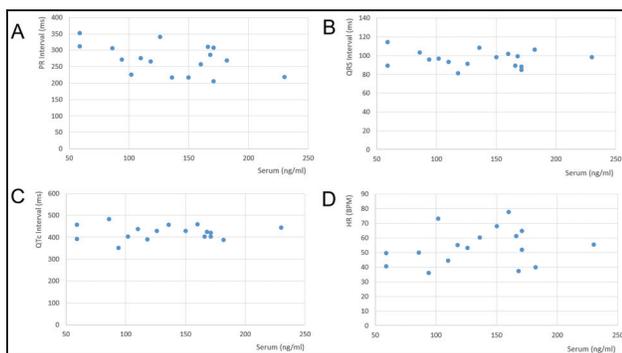
**Fig 2.** Typical ECG traces showing varying configuration of P, QRS and T waves. Sample 10 sec strip on the left and 1 sec expanded scale on the right. (A) P wave +ve, QRS biphasic, T wave -ve, (B) P wave +ve, QRS biphasic, T wave +ve and (C) P wave +ve, QRS -ve, T wave biphasic.

camels, placed in sterile collection tubes, and stored at 4°C. After measuring the ECG a sample of blood was collected from the jugular vein using vacutainer blood collection tubes (Yellow top, BD Vacutainer) for serum analysis. The blood sample tubes were centrifuged at 4000 rpm for 5 min at room temperature (Rotofix 32A, Hettich Zentrifugen). Supernatants were transferred to Eppendorf tubes (Microtubes, Tube-170-C, 1.5 ml, Extragene) and stored at -80°C. Hair samples were washed 3 times with Milli-Q water and placed in an oven at 50°C for 24 hrs to dry thoroughly. Weighed hair samples were digested in 8 ml of nitric acid (Sigma-Aldrich, 30709) and 1 ml hydrochloric acid (Univar, 1367) in a microwave (CEM, Model MARS 6). Serum samples were diluted (25X) with 1% nitric acid (Sigma-Aldrich, 30709) and 0.001 % Triton X (BDH, 30624). Measurement of Se was performed by inductively coupled plasma mass spectrometry (ICPMS, Agilent, 7850). The system was calibrated with a standard calibration solution (Merck, 70350.0100).

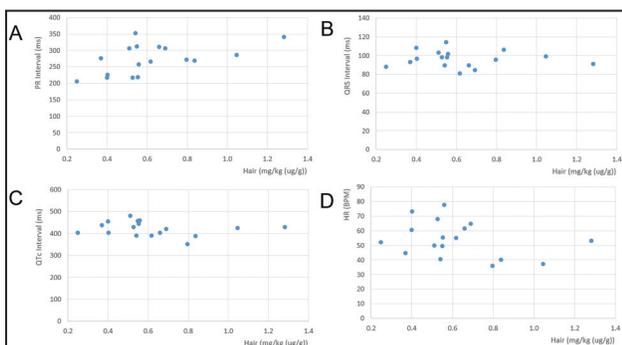
**Electrocardiographic recording:** ECG recording was performed according to previously described techniques (Howarth *et al*, 2025). Typical recordings of ECG are shown in Fig 1A and two cycles on an expanded scale are shown in Fig 1B. In brief, camels were seated in a sternal recumbency



**Fig 3.** Examples of ECG arrhythmia. (A) PVC contractions with tachycardia. (B) Varying diastole associated with bradycardia.



**Fig 4.** Charts displaying no correlation between camel Se measured in serum and PR Interval, QRS Interval, QTc Interval, and HR. (A) PR Interval vs. serum Se, (B) QRS Interval vs. serum Se. (C) QTc Interval vs. serum Se and (D) HR vs. serum Se.



**Fig 5.** Charts displaying no correlation between camel Se measured in hair and PR Interval, QRS Interval, QTc Interval, and HR. (A) PR Interval vs. hair Se, (B) QRS Interval vs. hair Se. (C) QTc Interval vs. hair Se and (D) HR vs. hair Se.

position as shown in Fig 1C. Hair was removed from the electrode locations with an electronic razor followed by a hand razor. The area was cleaned

with ethanol. A small bead of electrocardiographic gel (Konix) was placed on each of three disposable electrocardiographic adhesive button electrode pads (Sino-K, X0024ZRZRN). The electrode pads were then attached to the hide. Electrodes were placed in a modified apex-base configuration as shown in Fig 1C. The negative electrode was placed on the right side of the neck, in the jugular groove, about one-third the distance from the mandible to the thoracic inlet (Fig 1C). The positive

electrode was placed on the left side of the thorax, just caudal to the olecranon, the point of the elbow, and slightly above the cardiac apex (Fig 1C). The ground electrode was placed on the withers, the highest point of the shoulders (Fig 1C). Electrodes were connected via cables to a PowerLab 26T (ADInstruments, ML856). The PowerLab was connected to a laptop computer. ECG data was acquired at a sampling rate of 2k/sec with LabChart 7 software (v7.3.8, ADInstruments). Data acquisition was continued for a period of three minutes.

The LabChart datafiles were saved in MATLAB format (R2024a) and filtered using a high order, FIR low pass filter with a 75Hz cutoff frequency in order to reduce baseline noise. Each wave was then processed by the BIOPAC Systems analysis application to identify P wave start, QRS complex, and T wave parameters. From the identified parameters, the PR Interval, QRS Interval, ST Segment, QT Interval, T Wave duration, and RR Interval times (ms) were measured for each beat. Next, outlier detection and removal were implemented using the interquartile range method. Specifically, for each set of measurements, the 25<sup>th</sup> percentile, 50<sup>th</sup> percentile (median), and 75% percentile are determined. The interquartile range (IQR) is defined as the difference between the 75% percentile and 25% percentile values. Outliers are identified as any values in the set of measurements that is greater than the median + 1.5\*IQR or less than the median - 1.5\*IRQ. With the outliers removed from the measurement set, the summary statistics were completed for each electrogram parameter of

each camel and are shown in Table 2. Secondary measures included corrected QTc interval, HR and short-term Heart Rate Variability (HRV) values. QTc was determined using the Bazett's formula where QTc is computed as the QT interval divided by the square root of the associated RR interval. The HR was determined from the RR Interval and standard deviation of the normal RR Interval (SDNN) was used to determine the short-term HRV.

**Statistical analysis:** The ECG and Se data from 20 camels were analysed using IBM SPSS (Version 31.0.1.0. (49). The mean, standard deviation (STD), standard error (SE), maximum, minimum values, median, range and interquartile range were analyzed. Camels 7, 17, and 19 were removed from the summative analysis due to excessive pre-ventricular contractions (PVC), excessive baseline noise, and excessive bradycardia, respectively, for a total n = 17.

## Results

The cohort of camels included a group of apparently healthy adult female animals weighing  $406 \pm 7$  kg (n=20) and aged  $9.8 \pm 0.3$  yrs (n=20). Se was measured in blood serum and hair and the results are shown in Table 1. Se content of hair was  $0.61 \pm 0.05$  (n=20) and ranged from 0.25 to 1.28 mg/kg. Se content of blood serum was  $133 \pm 10$  ng/ml (n=20) and ranged from 59 to 230 ng/ml (Table 1).

Electrocardiographic measurements included interval measurements of the P wave, QRS wave and T wave and also HR and HRV are shown in Table 2. HR was  $54 \pm 3$  BPM (n=17) and HRV was  $141 \pm 21$  ms (n=17). Configuration of the P, QRS and T varied. Deflection of the P wave was always +ve. Deflection of the QRS complex was -ve or bidirectional. Deflection of the T wave was +ve, bidirectional or -ve (Table 2 and Fig 2). The ECGs displayed various arrhythmias, some of which are displayed in Fig 3.

The correlation coefficient for all comparison was determined using the Pearson's r method, where  $|r| = 1$  implies a perfect correlation. For each comparison, there was no observable correlation in the scatter graphs (Figs 4 and 5) and the absolute correlation coefficient,  $|r|$ , was less than 0.5. Specific comparisons include PR Interval vs. serum Se (Fig 4A), QRS Interval vs. serum Se (Fig 4B), QTc Interval vs. serum Se (Fig 4C), HR vs. serum Se (Fig 4D), PR Interval vs. hair Se (Fig 5A), QRS Interval vs. hair Se (Fig 5B), QTc Interval vs. hair Se (Fig 5C) and HR vs. hair Se (Fig 5D).

## Discussion

This study examined the relationship between Se status and ECG parameters in a cohort of apparently healthy adult female dromedary camels. The principal finding is that, within the physiological range of Se concentrations observed in serum ( $133 \pm 10$  ng/ml) and hair ( $0.61 \pm 0.05$  mg/kg), there were no significant associations with key ECG indices, including PR interval, QRS duration, QTc interval, or HR. These findings indicate that normal variation in Se status does not influence resting cardiac electrical activity in healthy camels.

**Table 1.** Camel ID, weight (kg) age (years) and selenium level measured in hair and blood serum. Summative statistics include animal count, mean, standard deviation, standard error, maximum, minimum, median, range, and interquartile range (IQR).

Camel ID	Weight (kg)	Age (yrs)	Hair Se (mg/kg)	Serum Se (ng/ml)
1	400	10	1.045	168
2	410	9	0.617	118
3	405	12	0.689	171
4	400	10	0.659	166
5	480	10	0.400	136
6	450	9	0.249	171
7	375	8	0.426	131
8	410	9	0.837	182
9	426	10	0.369	110
10	397	10	0.553	230
11	450	10	0.527	150
12	428	12	0.402	102
13	403	10	1.282	126
14	379	9	0.559	160
15	395	10	0.549	59
16	382	10	0.541	59
17	386	9	0.535	64
18	350	8	0.511	86
19	393	9	0.563	184
20	410	12	0.795	94
<b>Count</b>	20	20	20	20
<b>Average</b>	406	9.8	0.61	133
<b>STD</b>	29	1.2	0.24	47
<b>SE</b>	7	0.3	0.05	10
<b>Max</b>	480	12.0	1.28	230
<b>Min</b>	350	8.0	0.25	59
<b>Median</b>	402	10.0	0.55	134
<b>Range</b>	130	4.0	1.03	171
<b>IQR</b>	23	1.0	0.18	69

**Table 2.** Camel number, weight (kg) age (years), electrocardiographic interval measurements and deflections of the P Wave, QRS Wave, and T Wave. Summative statistics include animal count, mean, standard deviation, standard error, maximum, minimum, median, range, and interquartile range (IQR). Camels 7, 17, and 19 were removed from the summative analysis due to excessive pre-ventricular contractions (PVCs), excessive baseline noise, and excessive bradycardia.

Camel Idx	Weight (kg)	Age (yrs)	PR Int (ms)	QRS Int (ms)	T Int (ms)	QT (ms)	QTc (ms)	ST (ms)	RR (ms)	HR (BPM)	HRV (ms)	P Wave Def	QRS Def	T Wave Def
1	400	10	286	99	195	548	425	254	1673	37	319	↑	↓	↓
2	410	9	266	81	122	405	390	202	1089	55	52	↑	↓	↓
3	405	12	307	85	133	394	420	180	924	65	67	↑	↓	↑
4	400	10	311	89	86	403	403	226	978	61	41	↑	↓	↑
5	480	10	217	108	121	453	456	223	981	60	94	↑	↓	↓
6	450	9	206	88	136	431	404	203	1158	52	94	↑	↓	↓
8	410	9	269	106	134	471	389	223	1506	40	141	↑	↓	↓
9	426	10	276	93	175	488	438	211	1383	45	254	↑	↓	↓
10	397	10	219	98	128	462	445	234	1083	55	88	↑	↓	↓
11	450	10	217	98	107	404	430	196	880	68	47	↑	↓	↓
12	428	12	226	97	92	362	403	167	810	73	82	↑	↓	↑
13	403	10	340	91	121	469	430	252	1115	53	164	↑	↓	↓
14	379	9	258	102	136	399	459	157	770	78	142	↑	↓	↓
15	395	10	312	114	149	512	457	254	1207	50	131	↑	↓	↓
16	382	10	352	89	125	484	392	264	1478	41	271	↑	↓	↓
18	350	8	306	103	179	534	482	251	1134	50	150	↑	↓	↓
20	410	12	271	96	138	455	351	219	1672	36	262	↑	↓	↓
<b>Count</b>	17	17	17	17	17	17	17	17	17	17	17			
<b>Mean</b>	410	10	273	96	134	451	422	218	1167	54	141			
<b>STD</b>	30	1.1	45	9	29	53	33	32	283	12	87			
<b>SE</b>	7	0.3	11	2	7	13	8	8	69	3	21			
<b>Max</b>	480	12.0	352	114	195	548	482	264	1673	78	319			
<b>Min</b>	350	8.0	206	81	86	362	351	157	770	36	41			
<b>Median</b>	405	10.0	271	97	133	455	425	223	1115	53	131			
<b>Range</b>	130	4.0	146	33	109	186	131	107	903	42	278			
<b>IQR</b>	29	1.0	81	12	16	80	42	49	404	17	81			

The measured Se concentrations in serum were comparable to values previously reported in camels from similar geographical regions and management systems. Hamliri *et al* (1990) performed a study in male and female camels between 3 and 16 years of age. In camels aged 10-15 years the whole blood Se concentration was 112.9±15.2 ng/ml. Zongping (2003) performed a study in male and female camels 2-13 years of age. Se concentrations were 0.29±0.09 mg/kg in blood and 0.22±0.15 mg/kg in hair. Faye *et al* (2005) performed a study in male and female camels between 2 and 10 years of age. In camels greater than 7 years of age Se serum concentration was 12.4 µg/100 ml and was higher in female (22.9 µg/100 ml) compared to male (13.6 µg/100 ml) camels. Seboussi *et al* (2008) performed a study in

12 healthy female camels 6 to 12 years of age. The mean value of Se content in plasma was 275.1±125.7 ng/ml and varied between 91.6 and 596.6 ng/ml. Elrayah *et al* (2010) performed a study in 500 male and female camels in age groups ranging from less than 5 years to greater than 10 years of age showing differences by geographic location and age. Se in serum of >10 year old camels was 128±5.97 ng/ml. Seboussi *et al* (2010) performed a study in 8 young female camels exposed to different levels of dietary Se. Se concentration was measured in blood and different organs. In blood serum Se was increased significantly in Se supplemented groups with an average of 176.3±18 ng/ml in the control group, rising to 382.7±107.6 ng/ml in the group receiving 2 mg Se, 519.8±168.4 ng/ml in the group receiving 4 mg Se,

and  $533.4 \pm 158.6$  ng/ml in the group receiving 8 mg Se daily. In hair the Se concentrations were  $80.7 \mu\text{g}/\text{kg}$  in control group, 163.6 in the group receiving 2 mg Se, 563.2 in the group receiving 4 mg Se and  $1130.7 \mu\text{g}/\text{kg}$  in the group receiving 8 mg Se supplementation. Abdelrahman *et al* (2022) reported regional and seasonal variations in Se.

Considerable inter-individual variability in Se status was evident, consistent with known influences of soil Se content, forage composition, dietary supplementation, age, and sex. Despite this variability, ECG parameters remained within established reference ranges for camels, suggesting that Se levels in the present cohort were adequate to maintain normal myocardial electrophysiological function.

Experimental studies in rodents and other species have demonstrated clear electrophysiological disturbances associated with both Se deficiency and Se excess, including alterations in ECG, action potential duration, repolarization abnormalities, and increased susceptibility to arrhythmias (Godwin, 1965; Godwin and Fraser, 1966; Wildman *et al*, 1994; Ayaz *et al*, 2007). These effects are largely attributed to impaired antioxidant defense, disrupted redox regulation, and direct modulation of cardiac ion channels and calcium-handling proteins (Sayar *et al*, 2000; Ayaz *et al*, 2004; Ayaz *et al*, 2005; Okatan *et al*, 2013). However, many of these effects have been observed under conditions of metabolic stress, ischemia, diabetes, or experimentally induced Se imbalance. In contrast, studies in healthy animals with sufficient antioxidant reserves have reported minimal electrophysiological consequences of isolated variation in Se intake (Ringstad *et al*, 1988). The absence of correlation between Se status and ECG parameters in the present study is therefore consistent with the concept that Se-related cardiac electrical effects are highly context-dependent.

Marked variability in ECG waveform morphology was observed, particularly in QRS and T wave configurations. Similar variability has been reported in previous camel ECG studies and is likely attributable to species-specific cardiac anatomy, heart orientation within the thorax, electrode positioning, and body size rather than biochemical influences (Howarth *et al*, 2025). Occasional arrhythmias, including premature ventricular contractions and pronounced bradycardia, were identified in a small number of animals; however, these cases were not associated with extreme Se concentrations and were therefore unlikely to be Se-mediated.

Hair Se measurement provided an index of longer-term Se exposure, complementing serum

measurements that reflect more recent intake. The lack of association between hair Se and ECG parameters further supports the conclusion that chronic Se status, within the observed physiological range, does not affect resting cardiac electrophysiology in healthy camels.

Several limitations should be acknowledged. The study was limited to adult female camels and to resting ECG recordings, and it did not include animals with confirmed Se deficiency or selenosis. Based on the literature review, the electrocardiogram can be affected by Se deficiency, which was not observed in this study. It is possible that Se-related electrophysiological effects may become apparent during exercise, physiological stress, ischemia, or disease states. In addition, subtle cellular or molecular effects of Se on cardiac ion channels may not be detectable using surface ECG recordings alone.

In conclusion, this study demonstrates that in apparently healthy adult female dromedary camels, physiological variation in Se status is not associated with alterations in standard ECG parameters. These findings support the view that Se-related cardiac electrophysiological effects are primarily evident under conditions of nutritional imbalance or pathological stress, rather than during normal physiological homeostasis.

## Conclusion

In the group of apparently healthy adult female camels there were no associations between blood serum Se and a range of electrocardiographic parameters including serum Se and PR interval, QRS interval, QTc interval and HR.

## Acknowledgements

The authors would like to acknowledge the support of the technical and handling staff at the Camel Research Centre, Al Ain.

## Funding

The project was supported by a SURE+ Grant from UAE University and a Project Grant from the College of Medicine and Health Sciences.

## Ethical Statement

This study was done according to the guidelines of the Declaration of Helsinki.

## Data Availability

The data generated during the study can be requested from the corresponding author.

## Conflict of Interest

The authors declare no conflict of interest.

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