Literature review of the serum potassium, sodium and calcium levels in healthy individuals

Authors

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Introduction

The human body is made up of 24 elements, among them mineral elements, which include major and trace elements and constitute ca. 0.7% of total atoms [1]. The most common mineral elements include calcium (Ca^{2+}), sodium (Na^{+}) and potassium (K^{+}). Current report summarizes the literature gathered data reporting the total serum concentration of these ions in healthy individuals.

Assumptions

Publicly available scientific literature was chosen as the only source of data, reported either directly in the text or in the form of graphs and figures, which were digitized using specialized software [Sourceforge.net http://digitizer.sourceforge.net/]. Mean serum concentration expressed in mM was chosen as the analyzed endpoint. Dispersion was described using the standard deviation (SD). If different units were reported, the gathered values were recalculated to mM and SD, respectively. There was no publication date

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restriction and it was assumed that all measurement methods used in the analyzed studies were equally precise and sensitive. However, information about the measurement method was collected whenever possible and is reported below. Additional reported data include: the sex ratio, mean age in years (presented either as a mean value with the dispersion measure [SD] or range, depending on the studied report), height (cm) and weight (kg), which were collected whenever possible.

Literature analysis and collected data processing

Main Scopus, Medline and Google Scholar searches were performed. The key phrases used during the searches were: "potassium serum concentration", "calcium serum concentration", "sodium serum concentration", AND "healthy volunteers" or "control" either in the article title, keywords or abstract. To find articles describing circadian variation, the following terms were used: "circadian", "diurnal" and "rhythm". Every available English-language paper was carefully evaluated and the results were noted down in two Excel spread sheets, separately for static (time of the measurement not reported) and dynamic values (circadian rhythm, with the time of measurement reported).

Data

Table 1 presented below contains data records chosen for further analysis for potassium, sodium and calcium, respectively. Demographic and physiological parameters include gender and age. The mean serum ionic concentration is a dependent parameter. The number of individuals in all studies was also reported. Table 1 presents also the serum ions concentration means weighted by the study-specific sample sizes and overall standard deviations around the overall mean. The two sample t-test indicated statistically significant differences between males and females for all ions. All p-values were below 0.001.

Table 1. Serum potassium, sodium and calcium concentration derived from the healthy volunteers studies. Weighted means of the serum ions concentration.

Author	Year	Gender	n	Age [years]		K^+ [mM]				
				Mean	SD	Concentration	SD	Total n	Mean weighted concentration	SD
Chun	2008	Female	59	23.8	4.6	4.06	0.31	328	4.09	0.45
			49	23.5	4.2	4.02	0.35			

Luft	1979		115	32.7	15.0	4.25	0.32			
			35	28.5	10.0	4.14	0.35			
Hallen	1992		6	21.0	0.5	4.25	0.29			
Martinerie	2010		47	31.9	4.2	3.70	0.7			
Heenan	2003		17	27.1	5.8	4.20	0.41			
Federenko	2011	Male	10	24.0	7.5	4.14	0.02	496	4.21	0.35
			10	24.0	7.5	4.15	0.02			
McKenna	1997		6	21.2	1.5	4.40	0.25			
Miller	2009		9	25.0	2.0	4.40	0.30			
Karakoc	2005		10	18.4	1.3	4.10	0.30			
Krapf	1991		4	28.1	3.6	4.50	0.40			
			5	28.1	3.6	4.60	0.45			
Pearson	2010		11	21.0	2.0	4.00	0.33			
Chun	2008		52	22.9	4.3	4.13	0.36			
			39	22.1	3.7	4.04	0.31			
Luft	1979		145	28.9	13.3	4.30	0.36			
			42	30.7	11.7	4.24	0.32			
Bonfils	2010		27	68.0	3.1	4.00	0.20			
Jartti	1998		6	24.0	0.0	4.00	0.24			
			6	24.0	0.0	4.20	0.24			
Afshar	2009		18	18.9	0.9	4.20	0.30			
Zorbas	2001		10	25.0	7.7	4.16	0.12			
			10	24.5	8.0	4.12	0.14			
			10	23.9	6.7	4.12	0.11			
Zorbas	2001		10	24.7	6.8	4.20	0.30			
			10	23.9	7.0	4.00	0.50			
			10	25.4	5.6	4.10	0.20			
Zorbas	1998		10	23.8	4.2	4.70	0.11			
			10	25.4	3.0	4.50	0.13			
			10	24.9	3.0	4.60	0.13			
Laso	1990		6	21.6	0.5	3.80	0.12			

Author	Year	Gender	n	Age [years]		Na^+ [mM]				
				Mean	SD	Concentration	SD	Total n	Mean weighted concentration	SD
Chun	2008	Female	59	23.8	4.6	137.8	2.30	322	138.17	4.40
			49	23.5	4.2	137.8	2.10			
Luft	1979		115	32.7	15.0	140.3	4.29			
			35	28.5	10.0	139.3	2.37			
Martinerie	2010		47	31.9	4.2	132.3	4.80			
Heenan	2003		17	27.1	5.8	140.0	1.65			

McKenna	1997	Male	6	21.2	1.5	139.7	1.00	553	140.10	3.02
Miller	2009		9	25.0	2.0	141.0	1.00			
Karakoc	2005		10	18.4	1.3	142.0	3.80			
Krapf	1991		4	28.1	3.6	141.5	1.00			
			5	28.1	3.6	139.3	1.60			
Pearson	2010		11	21.0	2.0	139.0	3.32			
Chun	2008		52	22.9	4.3	137.9	2.16			
			39	22.1	3.7	137.9	1.87			
Luft	1979		145	28.9	13.3	141.3	3.61			
			42	30.7	11.7	139.9	2.59			
Bonfils	2010		27	68.0	3.1	139.0	1.90			
Afshar	2009		18	18.9	0.9	136.7	3.10			
Zorbas	2001		10	25.0	7.7	139.1	0.60			
			10	24.5	8.0	140.3	1.00			
			10	23.9	6.7	142.3	0.40			
Zorbas	2001		10	24.7	6.8	140.0	0.50			
			10	23.9	7.0	138.0	0.70			
			10	25.4	5.6	137.0	0.50			
Zorbas	1998		10	23.8	4.2	143.0	0.80			
			10	25.4	3.0	142.0	1.10			
			10	24.9	3.0	141.0	1.50			
Sothern	1996		21	51.3	8.7	140.3	0.96			
			14	41	7.2	140.3	0.20			
Miller	2010		10	25.4	0.7	138.6	2.21			
			10	25.4	0.7	139.3	1.90			
Zorbas	1994		10	25.5	7.6	143.0	0.10			
			10	24.9	9.7	140.0	0.13			

Author	Year	Gender	n	Age [years]		Ca^{+2} [mM]				
				Mean	SD	Concentration	SD	Total n	Mean weighted concentration	SD
Goldberg	1973	Female	271	48.0	12.8	2.375	0.13	1783	2.31	0.14
Horwitz	2010		15	58.0	8.1	2.325	0.10			
			10	57.0	7.0	2.325	0.08			
			10	55.0	5.1	2.375	0.08			
			6	60.0	7.3	2.45	0.06			
Lorentzon	2001		69	17.0	1.2	2.14	0.08			
Schlemmer	1999		11	24.0	5.0	2.31	0.03			
			11	24.0	5.0	2.33	0.07			
Yan	2002		48	30.9	3.2	2.46	0.30			
			48	66.9	2.7	2.63	0.14			

Engel	2010		1272	56.9	6.4	2.29	0.10			
Brandi	2002		6	40.5	13.5	2.33	0.05			
			6	28.0	16.2	2.32	0.03			
Blanchard	2001	Male	5	35.0	17.9	2.25	0.06	475	2.42	0.20
			4	33.0	4.0	2.26	0.08			
			48	31.1	3.4	2.66	0.14			
			50	68.9	2.9	2.44	0.16			
Goldberg	1973		248	48.7	12.8	2.425	0.18			
Zorbas	2001		10	25.0	7.7	2.27	0.06			
			10	24.5	8.0	2.25	0.06			
			10	23.9	6.7	2.27	0.08			
Zorbas	2001		10	24.7	6.8	2.14	0.01			
			10	23.9	7.0	2.15	0.02			
			10	25.4	5.6	2.15	0.03			
Zorbas	1994		10	25.5	7.6	2.29	0.30			
			10	24.9	9.7	2.29	0.15			
			10	25.2	8.5	2.31	0.25			
Zorbas	1998		10	23.8	4.2	2.5	0.07			
			10	25.4	3.0	2.55	0.06			
			10	24.9	3.0	2.55	0.10			

Circadian data

The full set of collected data describing circadian rhythm of the serum concentration of the three studied ions is presented in Table 2.

Table 2. Circadian rhythm of the serum concentration derived from the available literature sources.

Author	Year		Age	SD	Sex M/F	Time of day	Ion					
							K^+	SD	Na^+	SD	Ca^{2+}	SD
Williams	1972	[51]	22.5	3.0	4/2	10:00	4.50	0.13	141.00	2.45		
						14:00	4.47	0.19	141.00	4.90		
						17:00	4.48	0.23	140.00	4.90		
						23:00	4.10	0.28	139.00	1.23		
Jubiz	1972	[52]	22-32		8/2	08:00					2.60	0.05
						10:00					2.63	0.08
						12:00					2.63	0.05
						14:00					2.60	0.05
						16:00					2.60	0.05
						18:00					2.63	0.08
						20:00					2.70	0.08

						22:00					2.63	0.05
						00:00					2.58	0.05
						02:00					2.55	0.08
						04:00					2.53	0.05
						06:00					2.55	0.03
						08:00					2.60	0.05
Morisson	1979	[53]	19-30		9/11	08:30	4.10	0.26	140.70	1.64	2.37	0.08
						12:30	4.07	0.23	140.20	1.65	2.40	0.08
						16:30	3.95	0.26	140.80	1.72	2.39	0.08
Pocock	1989	[54]	40-59		603/0	9:00-10:00	4.39	0.35				
					1041/0	10:00-11:00	4.42	0.25				
					947/0	11:00-12:00	4.41	0.27				
					847/0	12:00-13:00	4.38	0.28				
					426/0	13:00-14:00	4.26	0.33				
					317/0	14:00-15:00	4.26	0.45				
					735/0	15:00-16:00	4.26	0.29				
					918/0	16:00-17:00	4.25	0.25				
					912/0	17:00-18:00	4.26	0.25				
					863/0	18:00-19:00	4.26	0.29				
Rittig	2006	[55]	13.2	0.8	6/4	08:00	4.12		142.20			
						14:00	4.12		141.90			
						20:00	4.16		141.40			
						23:00	3.95		142.60			
						02:00	3.92		141.60			
						05:00	4.15		141.60			
						08:00	4.29		142.10			
Solomon	1991	[56]	37	7	2/6	12:00	4.10	0.20				
						16:00	4.14	0.28				
						20:00	4.00	0.28				
						00:00	3.98	0.20				
						04:00	4.12	0.25				
						08:00	4.13	0.17				
						12:00	4.07	0.28				
						16:00	4.10	0.25				
Rejnmark	2002	[57]	58	50-71	0/12	10:00					2.43	0.07
						08:00					2.36	0.03
Sothern	1996	[17]	51	8.65	21/0	19:00			140.50	1.70		
						22:00			139.90	1.33		
						01:00			139.80	1.01		
						04:00			140.10	1.05		
						07:00			138.60	2.25		

						10:00			140.20	2.06		
						13:00			141.50	1.74		
						16:00			141.70	1.83		
Statland	1973	[58]			3?/0	08:00	5.35		140.50		2.58	
						11:00	4.74		141.90		2.57	
						14:00	4.34		140.00		2.60	
Schlemmer	1999	[47]	24	5	0/11	08:00					2.33	0.07
						11:00					2.32	0.07
						14:00					2.28	0.05
						17:00					2.30	0.03
						20:00					2.29	0.05
						23:00					2.31	0.08
						02:00					2.30	0.07
						05:00					2.32	0.07
						08:00					2.31	0.07
Markowitz	1985	[59]	17-35		13/0	09:30					2.32	
						10:30					2.32	
						11:30					2.32	
						12:30					2.31	
						13:30					2.30	
						14:30					2.29	
						15:30					2.28	
						16:30					2.28	
						17:30					2.27	
						18:30					2.26	
						19:30					2.26	
						20:30					2.26	
						21:30					2.25	
						22:30					2.25	
						23:30					2.24	
						00:30					2.23	
						01:30					2.22	
						02:30					2.22	
						03:30					2.21	
						04:30					2.21	
						05:30					2.21	
						06:00					2.21	
						06:30					2.21	
						07:30					2.23	
						08:30					2.31	
						09:00					2.31	

Even	2007	[60]	12.6	1.8	5/3	20:00					2.25	0.12
						00:00					2.17	0.13
						02:00					2.18	0.08
						08:00					2.25	0.16

Summary

The collected data are intended to be used as the source of information about physiological variability during the modelling and simulation of the drug-triggered left ventricular wall electrophysiology disruption [30].

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References

1. Vander A, Sherman J, Luciano D. Human physiology - The Mechanisms of Body Function, 8th edn, McGraw-Hill, Boston 2001.
2. Ronco C, Bellomo R, Kellum JA. Critical Care Nephrology: Expert Consult. Saunders/Elsevier, Philadelphia 2009.
3. Singer GG, Brenner BM. Fluid and electrolyte disturbances. In : Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL. Eds. Harrison's Principles of Internal Medicine, 16th Edition. New York. McGraw Hill, 258–26, 2005.
4. Copp DH, McPherson GD, McIntosh HW. Renal excretion of calcium in man: estimation of Tm-Ca. Metabolism 1960; 9: 680–685.
5. Ceriotti F, Henny J, Queraltó J, Ziyu S, Özarda Y, Chen B, Boyd JC, Panteghini M; IFCC Committee on Reference Intervals and Decision Limits (C-RIDL); Committee on Reference Systems for Enzymes (C-RSE): Common reference intervals for aspartate aminotransferase (AST), alanine aminotransferase (ALT) and γ-glutamyl transferase

(GGT) in serum: results from an IFCC multicenter study. Clin Chem Lab Med 2010; 48: 1593–1601.

6. Giebisch G. Renal potassium transport: mechanisms and regulation. Am J Physiol 1998; 274: 817-833.
7. Brandi L, Egfjord M, Olgaard K. Pharmacokinetics of 1,25(OH)(2)D(3) and 1alpha(OH)D(3) in normal and uraemic men. Nephrol Dial Transplant 2002; 17: 829–842.
8. Parfitt AM. Calcium homeostasis. In Physiology and Pharmacology of Bone, ed. Mundy GR, Martin TJ, pp. 1–66. Springer-Verlag, Berlin 1993.
9. Bonfils PK, Damgaard M, Taskiran M, Goetze JP, Norsk P, Gadsbøll N. Impact of diuretic treatment and sodium intake on serum volume in patients with compensated systolic heart failure. Eur J Heart Fail 2010; 12: 995–1001.
10. Ganong WF (2003): Review of Medical Physiology, 20th edn, McGraw-Hill, New York
11. World Health Organization., & Food and Agriculture Organization of the United Nations. Vitamin and mineral requirements in human nutrition. Geneva: World Health Organization 2004
12. Chun TY, Bankir L, Eckert GJ, Bichet DG, Saha C, Zaidi SA, Wagner MA, Pratt JH. Ethnic differences in renal responses to furosemide. Hypertension 2008; 52: 241–248.
13. Dibner C, Schibler U, Albrecht U. The mammalian circadian timing system: organization and coordination of central and peripheral clocks. Annu Rev Physiol 2010; 72: 517–549.
14. Bernardi M, DePalma R, Trevisani F, Capani F, Santini C, Baraldini M, Gasbarrini G. Serum potassium circadian rhythm. Relationship with aldosterone. Horm Metab Res 1985; 17: 695.
15. Ekmekcioglu C, Touitou Y. Chronobiological aspects of food intake and metabolism and their relevance on energy balance and weight regulation. Obes Rev 2011; 12: 14–25.
16. Kanabrocki EL, Scheving LE, Halberg F, Brewer RL, Bird TJ. Circadian variations in presumably healthy men under conditions of peace time army reserve unit training. Space Life Sci 1973; 4: 258–270.
17. Sothern RB, Vesely DL, Kanabrocki EL, Bremner FW, Third JL, McCormick JB, Dawson S, Ryan M, Greco J, Bean JT, Nemchausky BM, Shirazi P, Scheving LE. Circadian

relationships between circulating atrial natriuretic peptides and serum sodium and chloride in healthy humans. Am J Nephrol 1996; 16: 462–470.

18. Jartti TT, Kuusela TA, Kaila TJ, Tahvanainen KU, Välimäki IA. The dose-response effects of terbutaline on the variability, approximate entropy and fractal dimension of heart rate and blood pressure. Br J Clin Pharmacol 1998; 45: 277–285.
19. Common Terminology Criteria for Adverse Events v 4.03. U.S. Department of health and human services 2009.
20. Sourceforge. http://digitizer.sourceforge.net/ (accessed 02-05-2013).
21. Ebert SN, Liu XK, Woosley RL. Female gender as a risk factor for drug-induced cardiac arrhythmias: evaluation of clinical and experimental evidence. J Womens Health 1998; 7: 547–557.
22. Kawasaki R, Machado C, Reinoehl J, Fromm B, Baga JJ, Steinman RT, Lehmann MH. Increased propensity of women to develop torsades de pointes during complete heart block. J Cardiovasc Electrophysiol 1995; 6: 1032–1038.
23. Yang PC, Clancy CE. In silico Prediction of Sex-Based Differences in Human Susceptibility to Cardiac Ventricular Tachyarrhythmias. Front Physiol 2012; 3: 360.
24. Kratz A, Lewandrowski KB. Normal reference laboratory values. N Engl J Med 1998; 339: 1063.
25. Krapf R, Beeler I, Hertner D, Hulter HN. Chronic respiratory alkalosis. The effect of sustained hyperventilation on renal regulation of acid-base equilibrium. N Engl J Med 1991; 324: 1394–1401.
26. Kratz A, Ferraro M, Sluss PM, Lewandrowski KB. Case records of the Massachusetts General Hospital. Weekly clinicopathological exercises. Laboratory reference values. N Engl J Med 2004; 351: 1548–1563.
27. Reidenberg MM, Gu ZP, Lorenzo B, Coutinho E, Athayde C, Frick J, Alvarez F, Brache V, Emuveyan EE. Differences in serum potassium concentrations in normal men in different geographic locations. Clin Chem 1993; 39: 72–75.

28. Lang T, Prinsloo P, Broughton AF, Lawson N, Marenah CB. Effect of low protein concentration on serum sodium measurement: pseudohypernatraemia and pseudonormonatraemia! Ann Clin Biochem 2002; 9: 66–67.
29. Lorentzon M, Lorentzon R, Lerner UH, Nordström P. Calcium sensing receptor gene polymorphism, circulating calcium concentrations and bone mineral density in healthy adolescent girls. Eur J Endocrinol 2001; 144: 257–261.
30. Vesely DL, Sothern RB, Scheving LE, Bremner FW, Third JL, McCormick JB, Dawson S, Kahn S, Augustine G, Ryan M, Greco J, Nemchausky BA, Shirazi P, Kanabrocki EL. Circadian relationships between circulating atrial natriuretic peptides and serum calcium and phosphate in healthy humans. Metabolism 1996; 45: 1021–1028.
31. Luft FC, Grim CE, Fineberg N, Weinberger MC. Effects of volume expansion and contraction in normotensive whites, blacks, and subjects of different ages. Circulation 1979; 59: 643–650.
32. Hallén J, Gullestad L, Sejersted OM. K+ shifts of skeletal muscle during stepwise bicycle exercise with and without beta-adrenoceptor blockade. J Physiol 1994; 477: 149–159.
33. Martinerie L, Pussard E, Foix-L'Hélias L, Petit F, Cosson C, Boileau P, Lombès M. Physiological partial aldosterone resistance in human newborns. Pediatr Res 2009; 66: 323–328.
34. Heenan AP, Wolfe LA, Davies GA, McGrath MJ. Effects of human pregnancy on fluid regulation responses to short-term exercise. J Appl Physiol 2003; 95: 2321–2327.
35. Federenko YF, Deogenov VA, Kakuris KK, Yerullis KB. Muscle potassium and potassium losses during hypokinesia in healthy subjects. Biol Trace Elem Res 2011; 143: 668–676.
36. McKenna MJ, Heigenhauser GJ, McKelvie RS, MacDougall JD, Jones NL. Sprint training enhances ionic regulation during intense exercise in men. J Physiol 1997; 501: 687–702.
37. Miller KC, Mack G, Knight KL. Electrolyte and serum changes after ingestion of pickle juice, water, and a common carbohydrate-electrolyte solution. J Athl Train 2009; 44: 454–461.
38. Karakoc Y, Duzova H, Polat A, Emre MH, Arabaci I. Effects of training period on haemorheological variables in regularly trained footballers. Br J Sports Med 2005; 39: e4.

39. Pearson J, Low DA, Stöhr E, Kalsi K, Ali L, Barker H, González-Alonso J. Hemodynamic responses to heat stress in the resting and exercising human leg: insight into the effect of temperature on skeletal muscle blood flow. Am J Physiol Regul Integr Comp Physiol 2011; 300: 663–673.
40. Afshar R, Sanavi S, Jalali Nadooshan MR. Urinary sodium and potassium excretion following karate competitions. Iran J Kidney Dis 2009; 3: 86–88.
41. Zorbas YG, Kakurin VJ, Afonin VB, Kuznetsov NA. Electrolyte changes in serum and urine of athletes during acute and rigorous bed rest and ambulatory conditions. Biol Trace Elem Res 2001; 79: 49–65.
42. Zorbas YG, Kakurin VJ, Denogratov SD, Yarullin VL, Deogenov VA. Urinary and serum electrolyte changes in athletes during periodic and continuous hypokinetic and ambulatory conditions. Biol Trace Elem Res 2001; 80: 201–219.
43. Zorbas YG, Kakurin AG, Kuznetsov NK, Federov MA, Yaroshenko YY. Magnesium loading effect on magnesium deficiency in endurance-trained subjects during prolonged restriction of muscular activity. Biol Trace Elem Res 1998; 63: 149–166.
44. Laso FJ, González-Buitrago JM, Martín Ruiz C, de Castro S. Hormonal regulation of potassium shifts during graded exhausting exercise. Eur J Appl Physiol Occup Physiol 1991; 62: 292–296.
45. Zorbas YG, Federenko YF, Naexu KA. Calcium loading and renal function in trained subjects during restriction of muscular activity and chronic hyperhydration. Biol Trace Elem Res 1994; 41: 137–156.
46. Goldberg DM, Handyside AJ, Winfield DA. Influence of demographic factors on serum concentrations of seven chemical constituents in healthy human subjects. Clin Chem 1973; 19: 395–402.
47. Schlemmer A, Hassager C. Acute fasting diminishes the circadian rhythm of biochemical markers of bone resorption. Eur J Endocrinol 1999; 140: 332–337.
48. Yan L, Prentice A, Zhou B, Zhang H, Wang X, Stirling DM, Laidlaw A, Han Y, Laskey A. Age- and gender-related differences in bone mineral status and biochemical markers of bone metabolism in Northern Chinese men and women. Bone 2002; 30: 412–415.

49. Blanchard A, Jeunemaitre X, Coudol P, Dechaux M, Froissart M, May A, Demontis R, Fournier A, Paillard M, Houillier P. Paracellin-1 is critical for magnesium and calcium reabsorption in the human thick ascending limb of Henle. Kidney Int 2001; 59: 2206–2215.
50. Engel P, Fagherazzi G, Boutten A, Dupré T, Mesrine S, Boutron-Ruault MC, Clavel-Chapelon F. Serum 25(OH) vitamin D and risk of breast cancer: a nested case-control study from the French E3N cohort. Cancer Epidemiol Biomarkers Prev 2010; 19: 2341–2350.
51. Williams GH, Tuck ML, Rose LI, Dluhy RG, Underwood RH. Studies of the control of serum aldosterone concentration in normal man. 3. Response to sodium chloride infusion. J Clin Invest 1972; 51: 2645–2652.
52. Jubiz W, Canterbury JM, Reiss E, Tyler FH. Circadian rhythm in serum parathyroid hormone concentration in human subjects: correlation with serum calcium, phosphate, albumin, and growth hormone levels. J Clin Invest 1972; 51: 2040–2046.
53. Morrison B, Shenkin A, McLelland A, Robertson DA, Barrowman M, Graham S, Wuga G, Cunningham KJ. Intra-individual variation in commonly analyzed serum constituents. Clin Chem 1979; 25: 1799–1805.
54. Pocock SJ, Ashby D, Shaper AG, Walker M, Broughton PM. Diurnal variations in serum biochemical and haematological measurements. J Clin Pathol 1989; 42: 172–179.
55. Rittig S, Matthiesen TB, Pedersen EB, Djurhuus JC. Circadian variation of angiotensin II and aldosterone in nocturnal enuresis: relationship to arterial blood pressure and urine output. J Urol 2006; 176: 774–780.
56. Solomon R, Weinberg MS, Dubey A. The diurnal rhythm of serum potassium: relationship to diuretic therapy. J Cardiovasc Pharmacol. 1991; 17: 854–859.
57. Rejnmark L, Lauridsen AL, Vestergaard P, Heickendorff L, Andreasen F, Mosekilde L. Diurnal rhythm of serum 1,25-dihydroxyvitamin D and vitamin D-binding protein in postmenopausal women: relationship to serum parathyroid hormone and calcium and phosphate metabolism. Eur J Endocrinol 2002; 146: 635–642.

58. Statland BE, Winkel P, Bokelund H. Factors contributing to intra-individual variation of serum constituents. 1. Within-day variation of serum constituents in healthy subjects. Clin Chem 1973; 19: 1374–1379.
59. Markowitz ME, Rosen JF, Mizruchi M. Circadian variations in serum zinc (Zn) concentrations: correlation with blood ionized calcium, serum total calcium and phosphate in humans. Am J Clin Nutr 1985; 41: 689–696.
60. Even L, Bader T, Hochberg Z. Nocturnal calcium, phosphorus and parathyroid hormone in the diagnosis of concealed and subclinical hypoparathyroidism. Eur J Endocrinol 2007; 156: 113–116.
61. Horwitz MJ, Tedesco MB, Garcia-Ocaña A, Sereika SM, Prebehala L, Bisello A, Hollis BW, Gundberg CM, Stewart AF: Parathyroid hormone-related protein for the treatment of postmenopausal osteoporosis: defining the maximal tolerable dose. J Clin Endocrinol Metab 2010; 95: 1279–1287.