INTER-RELATIONSHIP BETWEEN CALCIUM, PHOSPHOROUS AND SERUM ALKALINE PHOSPHATASE IN APPARENTLY HEALTHY MALES AND FEMALES *

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Abstract

Two hundred apparently healthy males and females of various age groups were assessed for serum and urinary calcium, inorganic phosphorous and serum alkaline phosphatase.

Highest levels of mean serum calcium were found in the age group of 30 — 39 years in both sexes whereas mean inorganic phosphorous and alkaline phosphatase were highest in children of either sex. Urinary calcium and inorganic phosphorous are dependent on serum calcium and inorganic phosphorous concentration.

A reciprocal relationship existed between calcium and inorganic phosphorous whereas a direct correlation has been found between inorganic phosphorous and alkaline phosphatase (JPMA 29:236, 1979).

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* This project was supported by a grant from Pakistan Medical Research Council.

Introduction

Calcium and phosphorous are important not only for bones and teeth but also for normal nerve transmission, muscle contraction, blood clotting and the maintenance of cell membrane (Kenneth 1976). A pyrophosphatase enzyme, alkaline phosphatase present in osteoblast liberates from organic phosphate esters, the required inorganic phosphate to react with calcium to form insoluble calcium phosphate (Davidson and Henry, 1969). Increased calcium requirement may be due to reduced calcium absorption, impaired renal conservation of calcium and due to oestrogen deficiency in post menopausal women (Marshall et al., 1976).

Alterations in serum and urine calcium, phosphorous and serum alkaline phosphatase reflects bone disease, endocrine dysfunction, dietary intake and absorption of calcium (Davidson and Henry, 1969). An increase in inorganic phosphorous is accompanied by a decrease in calcium. An enhanced level of inorganic phosphorous is also observed in the late stage of nephritis due to decreased kidney function and resultant retention of phosphate (Levinson and Mcfate, 1969). Osteomalacia is associated with a depressed production of calcium and phosphorous (Chalmers et al., 1967). Hypophosphatasia expresses itself primarily as rickets and osteomalacia (Heaney, 1967; Lotz et al., 1968). Increased alkaline phosphatase activity is found in patients with Osteomalacia along with increase in urinary calcium (Kocher 1966). The highest levels of alkaline phosphatase are observed in patients with osteitis deformans where serum and urine calcium and phosphorous values are usually within normal limits (Davidson and Henry, 1969). The increased alkaline phosphatase activity in serum correlates well with the rate of bone growth and is due to an increased amount of bone isoenzymes in serum (Posen et al., 1965).

Material and Method

Two hundred blood and 24 hour urine samples of apparently healthy individuals of

both sexes were collected. The age and sex distribution is shown in table I.

Table I : Age and Sex Distribution

Age Range (yrs)	Males	Females	Total
0- 9	33	31	64
10-19	23	23	46
20-29	16	18	34
30-39	10	11	21
40-49	8	8	16
50-59	5	5	10
60-60+	5	4	9

These samples, as represent various age groups, and socioeconomic status as the nutritional needs of the human body differ with age, sex, height, weight, growth and physical activity.

Biochemical tests were done by the following methods :

1. Calcium : Serum and urinary calcium was estimated by clinton calcium kit.
2. Inorganic phosphorous : Serum and urinary inorganic phosphorous was measured by the method described by Gomori (1942).
3. Alkaline phosphatase : Serum alkaline phosphatase activity was determined by Bessey Lowry method modified by Gutman (1959).

Result

Tables II, III, IV, V, and VI represent serum and urinary calcium, inorganic phosphorous and serum alkaline phosphatase in apparently healthy males and females of various age groups.

Table II : Serum (mg%) in Apparently Healthy Males and Females of Various Age Groups

AGE RANGE	MALE			FEMALE		
(years)	Number	Mean ± S.D. ± S.E.	Range	Number	Mean ± S.D. ± S.E.	Range
0— 9	33	9.0 ±0.58±0.10	8.0—11.4	31	9.28±0.74±0.14	8.0—11.6
10—19	23	9.34±0.78±0.16	8.0—10.8	23	9.36±0.78±0.16	8.6—11.4
20—29	16	9.64±0.84±0.22	8.0—11.0	18	9.50±0.80±0.18	8.0—11.0
30—39	10	9.84±0.48±0.16	9.0—10.4	11	9.70±0.72±0.22	8.8—11.6
40—49	8	9.62±0.66±0.24	8.8—11.2	8	9.56±0.52±0.18	9.0—10.8
50—59	5	9.50±0.96±0.42	9.2—11.6	5	9.48±0.50±0.22	9.0—10.4
60—60+	5	9.40±0.90±0.40	8.6—11.2	4	9.40±0.16±0.10	9.2— 9.6

Table III : Urinary Calcium (mg/24hrs) in Apparently Healthy Males and Females of Various Age Groups

AGE RANGE	MALE			FEMALE		
(years)	Number	Mean ± S.D. ± S.E.	Range	Number	Mean ± S.D. ± S.E.	Range
0— 9	33	12.30± 9.2±1.6	2.0—36.0	31	8.94± 7.0±1.12	2.0—25.6
10—19	23	13.14± 9.8±2.04	2.0—40.0	23	14.90±10.2±2.14	2.0—40.0
20—29	16	16.18±10.0±2.54	2.8—38.0	18	15.28±10.4±2.46	4.0—38.0
30—39	10	17.43±10.8±3.42	4.2—39.2	11	17.06± 7.4±2.64	4.6—26.4
40—49	8	16.52± 7.8±2.6	8.0—32.0	8	15.42± 7.8±2.74	6.6—28.6
50—59	5	14.92± 9.6±4.32	5.6—32.0	5	13.92±10.4±4.6	4.8—33.6
60—60+	5	10.2 ± 7.6±3.4	2.8—24.0	4	12.46± 9.8±5.64	4.8—26.2

Table IV : Serum Inorganic Phosphorous (mg%) in Apparently Healthy Males and Females of Various Age Groups

AGE RANGE	MALE			FEMALE		
(years)	Number	Mean ± S.D. ± S.E.	Range	Number	Mean ± S.D. ± S.E.	Range
0— 9	33	4.30±0.92±0.16	2.7—6.6	31	4.90±0.84±0.15	2.3—6.2
10—19	23	4.30±1.04±0.22	2.4—6.6	23	4.58±0.93±0.19	2.4—5.9
20—29	16	3.82±1.16±0.29	1.5—6.0	18	3.54±1.40±0.33	0.3—5.2
30—39	10	3.52±0.78±0.25	2.3—5.0	11	3.34±1.03±0.31	1.1—5.7
40—49	8	3.25±1.53±0.54	2.1—6.6	8	3.28±1.16±0.41	2.1—5.8
50—59	5	2.92±0.39±0.17	2.5—3.6	5	3.02±0.33±0.15	4.5—5.2
60—60+	5	2.84±0.40±0.18	2.3—3.5	4	3.0±0.86±0.50	4.0—5.0

Table V : Urinary Inorganic Phosphorous (gm/24hr) in Apparently Healthy Males and Females of Various Age Groups

AGE RANGE	MALE			FEMALE		
(years)	Number	Mean±S.D.±S.E.	Range	Number	Mean±S.D.±S.E.	Range
0— 9	33	0.66±0.18±0.08	0.3 —0.8	31	0.59±0.16±0.05	0.2 —0.76
10—19	23	0.66±0.25±0.09	0.3 —0.9	23	0.49±0.22±0.08	0.23—0.9
20—29	16	0.59±0.23±0.08	0.33—0.9	18	0.45±0.18±0.04	0.3 —0.9
30—39	10	0.59±0.12±0.04	0.35—0.8	11	0.36±0.13±0.06	0.2 —0.5
40—49	8	0.56±0.23±0.06	0.25—0.9	8	0.35±0.20±0.04	0.17—0.9
50—59	5	0.46±0.23±0.05	0.17—0.9	5	0.32±0.08±0.05	0.21—0.38
60—60+	5	0.34±0.18±0.03	0.1 —0.9	4	0.29±0.14±0.03	0.1 —0.64

Table VI : Serum Alkaline Phosphatase (IU/litre) in Apparently Healthy Males and Females

AGE RANGE	MALE			FEMALE		
(years)	Number	Mean±S.D.±S.E.	Range	Number	Mean±S.D.±S.E.	Range
0— 9	33	63 ± 8.4±1.4	42 —77	31	60 ±12.6±2.3	40.6—78.8
10—19	23	53 ±11.2±2.8	39 —59	23	54 ±12.4±2.6	42 —61.6
20—29	16	40 ± 9.8±2.8	31 —45	18	38 ± 9.8±2.3	28.0—44.8
30—39	10	35 ±11.2±3.0	28 —42	11	33 ±11.0±3.2	25.2—39.2
40—49	8	21 ± 8.4±2.9	17 —35	8	22 ± 5.6±3.6	19.6—25.2
50—59	5	15 ± 9.8±4.2	11.2—17	5	15.4± 2.8±0.7	8.4—19.6
60—60+	5	14 ± 8.4±3.0	8.4—17	4	14.0± 5.6±3.0	7.0—17.0

Discussion

Prolonged negative mineral balance depletes the body stores and may be detrimental to health. Adaptation to low intake is followed by a low plasma concentration and a subsequent low urinary excretion.

Serum calcium is maintained by parathyroid hormone, calcitonin and vitamin D where-as urinary excretion is affected by afore mentioned hormones, dietary intake of calcium, percentage of protein binding, the glomerular filteration rate and the influence of other ions (Kenneth 1976). Serum calcium concentration regulates urinary calcium loss. With an increased concentration of serum calcium the renal loss of calcium increases proportionally and vice versa (Davidson and Henry, 1969). This is in accordance with our findings. Table II represents a gradual increase in serum calcium concentration from children of 0-9 years to adults of 30-39 years. After that a gradual decrease is observed in both the sexes. Similar observations have been made in the renal calcium excretion (Table III).

The normal phosphate concentration can be estimated from the normal relation between plasma and urinary phosphate (Robertson 1976). Serum phosphorous concentration governs the renal loss of phosphate which in turn regulates phosphorous concentration in serum. Higher serum phosphorous levels are observed in growing children (Davidson and Henry, 1969). Similar findings have been observed in the present study. Table IV depicts a decrease in serum phosphorous concentration from children to adults. Urinary phosphorous losses follow the same pattern (Table V). A reciprocal relationship seems to exist in blood between the concentration of calcium and phosphorous. A higher calcium level is usually associated with a low phosphorous level and vice versa. This observation corresponds with the findings of Levinson and Mcfate (1969).

Measurement of alkaline phosphatase reveals a distribution presented in table VI. Elevated levels are observed in growing children as has previously been reported by Clark and Back (1950). The elevation continues upto adolscence, after that a decrease is observed. From table IV and VI it is postulated that a direct correlation exists between serum inorganic phosphorous and serum alkaline phosphatase activity.

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