

Blood Phosphorus and Magnesium Levels in 130 Elite Track and Field Athletes

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Abstract

Purpose: This study tested the clinical utility and relevance of serum phosphorus and magnesium as markers possibly useful to monitor training in athletes.

Methods: Phosphorus and magnesium serum concentrations of 130 elite track and field athletes (65 males and 65 females, age range 20-30 years) from the National Athletics Sports Medicine Center database in Thessaloniki, Greece were measured.

Results: Abnormal results were found in 61 (47%) athletes (32 men and 29 women). In male athletes, serum phosphate was higher than normal in 18% and decreased in 1.5%, whereas serum magnesium concentration was higher in 26%, and lower in 3%. Regarding female athletes, higher serum phosphate and magnesium levels were detected in 26% and 17% respectively, whereas decreased serum magnesium was found in 3%. The most common alterations were higher serum phosphate (29/61, 47%) and magnesium concentrations (28/61, 46%). Abnormalities of serum phosphorus and magnesium concentrations were detected in almost half of the athletes. Hyperphosphataemia and hypermagnesaemia were the most common abnormalities.

Conclusion: The reference intervals used for general population cannot be used for athletes. Given the lack of pathological manifestations, the physio-pathological significance of these findings is uncertain. Further studies on the interpretation of reported ion concentrations in athletes should take in account the type of sport practiced and also the possible variations during the training and competition season.

Key Words: Athletes; Hyperphosphataemia; Hypophosphatemia; Hypomagnesaemia; Hypermagnesaemia

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INTRODUCTION

Screening for biochemical parameters and their repeated assessment is widespread in elite sports medicine and exercise physiology. Several studies have assessed the clinical utility of screening for iron-related parameters in elite athletes, but there have been no studies on the clinical utility of other biochemical parameters [1-11]. Widespread screening is suggested not only to produce normal ranges for

elite athletes, but also to set a baseline for biochemical monitoring of training [3]. As biochemical monitoring is relatively expensive, and involves some discomfort and inconvenience, it is essential to prove that these potential applications are worthwhile [3]. The present study assessed the clinical utility of two electrolytes, magnesium (Mg) and phosphorus (P) and two biochemical parameters creatinine (Cr) and serum creatine kinase (CPK) in the blood of elite track and field athletes.

METHODS AND SUBJECTS

The serum values of phosphorus (P), magnesium (Mg), creatinine (CR), and CK as biomarkers of renal function and possible rhabdomyolysis were obtained from 130 elite track and field athletes (65 males and 65 females; age range, 20-30 years). All athletes were members of Greek Track and Field Athletics clubs, covering 12 different track and field events (100 m, 200 m, 100/110 m hurdles, 400 m, 800 m, 10000m, high jump, long jump, pole vault, discus throw, hammer throw, shot put and decathlon/heptathlon). The electrolyte values were taken from the athletes' medical records kept at the National Athletics Sports Medicine Center database in Thessaloniki (Greece). The study had the permission and approval of the ethic committee of the National Track & Field Centre. Criteria for inclusion in the study included the lack of any medical disorder or major muscle trauma during the 6 months preceding the assessment, and the presence in the case notes of at least 2 measures of the biochemical parameters in question, evaluated at the same interval time in all subjects. Biochemical blood test monitoring [for glucose, Ca, P, Mg, potassium, sodium, urea, CR, lactate dehydrogenase, CK, liver enzymes] has been routinely undertaken in our sports medicine clinic for the last 5 years in all elite athletes.

Blood samples were collected after an overnight fast before a training session during the pre participation screening after 24 hours of rest. A sterile, single-use, 20 gauge venous catheter (BD, Franklin Lakes, NJ) was inserted into an antecubital vein. A catheter was attached to a 3-way stopcock (Covidien, Mansfield, MA) via a short extension tubing. The vial blood was sealed and stored in a 6.0 mL lithium heparin Vacutainer (BD) placed into an ice bath until the last blood sample was collected. Blood samples were all analyzed in the same laboratory for electrolytes, glucose, serum urea nitrogen, lactate, ionized calcium, and ionized magnesium using a Vitros 250 Analyzer (VITROS 250, Ortho-Clinical Diagnostics, NY Rochester/United States).

Serum phosphorus levels were expressed as phosphorus mass (mg/dL). The normal laboratory adult range was 2.5-4.5 mg/dL (0.6-1.45 mmol/L). Hyperphosphatemia was defined as a serum phosphate

value above 4.5 mg/dL. Hyperphosphatemia is considered clinically significant when levels are greater than 5 mg/dL in adults. Hypophosphatemia was categorized as mild (2.0-2.5 mg/dL), moderate (1-2 mg/dL), or severe (<1 mg/dL). The normal laboratory adult magnesium serum reference range was 1.5-2.5 mg/dL (0.62-1.03 mmol/L). Hypermagnesemia was defined as serum magnesium level greater than 2.5mg/dL and hypomagnesemia as a serum magnesium level below 1.5 mg/dL.

Serum creatinine was expressed as mg/dL. The normal laboratory adult range was 0.7-1.5 mg/dL (62-133 μ mol/L) in males and 0.6-1 mg/dL (53-88.4 μ mol/L) in females. A serum CK below 195 U/L was considered normal.

Descriptive statistics of serum P, Mg, creatinine and CK were calculated. Associations between variables were determined using the Chi square test.

RESULTS

The descriptive statistics of serum P, Mg, CR and CK are outlined in Table 1. Abnormal results were found in 47% of athletes (61/130 athletes, 32 males and 29 females). Among male athletes, hyperphosphatemia was present in 18% (12/65), hypophosphatemia in 1.5% (1/65), hypermagnesemia in 26% (17/65), hypomagnesemia in 3% (2/65), higher CR in 24% (16/65), and higher CK in 15% (10/65). In the male group, hyperphosphatemia correlated with and showed a statistically significant association with higher levels of CK ($P=0.03$) and CR ($P=0.03$), whereas hypermagnesemia showed a statistically significant association with higher CR ($P=0.0001$). Among female athletes, hyperphosphatemia was present in 26% (17/65), hypermagnesemia in 17% (11/65), hypomagnesemia in 3% (2/65), higher CR in 9% (6/65) and higher CK in 3% (2/65). No evidence of a statistically significant association between biochemical variables was noted in females ($P=0.08$). Neither serum phosphorus nor magnesium showed a statistically significant association with age, in both genders. Given the limited number of athletes, it was

Table 1: Descriptive results of phosphorus, magnesium, creatinine and creatine kinase in all athletes

	Male N=65	Female N=65
Creatinine [Mean (SD)]	1.04 (0.01)	0.87 (0.01)
Creatine kinase [Mean (SD)]	288 (26)	148 (10)
Phosphorus [Mean (SD)]	4.05 (0.06)	4.05 (0.08)
Magnesium [Mean (SD)]	2.27 (0.05)	2.09 (0.04)
↑ Creatinine [n (%)]	16 (24%)	6 (9%)
↑ Creatine kinase [n (%)]	10 (15%)	2 (3%)
↑ Phosphorus [n (%)]	12 (18%)	17 (26%)
↑ Magnesium [n (%)]	17 (26%)	11 (17%)
↓ Creatinine [n (%)]	-	-
↓ Creatine kinase [n (%)]	-	-
↓ Phosphorus [n (%)]	1 (1.5%)	-
↓ Magnesium [n (%)]	2 (3%)	2 (3%)

SD: Standard Deviation

not possible to identify a statistically significant association between serum levels and type of track, or field event. In conclusion, hyperphosphatemia and hypermagnesemia, observed in 22% (29/130) and 21% (28/130) of patients respectively, were the most commonly altered variables in these elite athletes.

DISCUSSION

All our athletes were apparently healthy, but many showed results were out of the “normal” laboratory range. In males, serum phosphate was higher than normal in 18% and serum magnesium in 26%. For what concerns female athletes, higher phosphate and magnesium was found in the plasma in 36% and 17% of them, respectively. Therefore, as the athletes had no signs of impaired health, these observations mean that reference levels for serum phosphorus and magnesium in the general population may not apply to elite athletes.

Mg is a ubiquitous element that plays a fundamental role in many cellular reactions [12]. More than 300 metabolic reactions require Mg as a cofactor. The normal serum level is 1.5-2.5 mEq/L [13]. Hypermagnesemia occurs when serum magnesium is more than 2.5 mEq/L. Sports related causes of

hypermagnesemia include rhabdomyolysis and ingestion of magnesium containing substances such as vitamins, antacids or cathartics [13]. On the other hand, hypomagnesemia occurs when serum magnesium levels are less than 1.5 mEq/L [14]. Hypermagnesemia is rare compared to hypomagnesemia [14-16]. In athletes, hypomagnesemia is possibly caused by excessive sweating while training. This probably reflects a transient redistribution of Mg in body compartments, indicating a release from one storage area to be used at an active site. Mg levels, though, return to normal values within 24 hours after exercise [15]. Another cause of decreased serum Mg is inadequate food intake, especially in athletes attempting to maintain low body weights [14]. However, in our study the outcome regarding hypermagnesemia is in discordance with these results. As higher Mg levels could not be attributed to rhabdomyolysis (CK was elevated only in 3 of the hypermagnesemic athletes), the underlying cause may well be magnesium supplementation.

Magnesium participates in many cellular activities and metabolic pathways operating during exercise [17-18]. On the other hand, phosphorus plays an important role in different biochemical reactions, mostly related to energy production. P levels are expressed in terms of serum phosphate mass (mg/dL). The normal adult range is 2.5-4.5 mg/dL [19]. Hyperphosphatemia occurs when serum P mass is above 4.5 mg/dL and is considered significant when levels are greater than 5

mg/dL. Trauma, rhabdomyolysis and use of nutritional supplements are sports related causes of hyperphosphatemia [20]. Hypophosphatemia is defined as mild when P is 2-2.5 mg/dL, moderate when P is 1-2mg/dL and severe when P is above 1mg/dL. Given the wide availability of P in food, studies on athletes have generally shown that diets are adequate in P [19]. The exception to this are athletes who are attempting to maintain low body weights. In our study, 47% of the reported athletes present a mild increase in serum P. It is also noticeable that hyperphosphatemia in the male group correlates positively with higher level of CR.

The concentration of CR in serum has long been the most widely used and commonly accepted measure of renal function in clinical medicine [21]. In sports medicine, creatinine is widely used to evaluate the general health status of athletes, particularly in events where hydroelectrolytic balance is crucial. Moreover, the urinary concentration of creatinine is used to validate antidoping tests [22]. The common reference range used for creatinine in the general population is 0.7–1.3 mg/dL [22]. Definition of the behavior of creatinine and its reference ranges in athletes is important to prevent misinterpretation of laboratory data in sportsmen. High training workload and psychophysical stress may modify athletes' homeostasis, inducing apparently pathological values [22]. The origination of creatinine from creatine may explain this correlation and also the higher concentrations and the positive correlation with higher P levels in men than women [21]. Creatine supplementation was not used in the teams we studied, although personal uncontrolled use of creatine by single athletes cannot be excluded.

Another biochemical parameter affected by the total skeletal muscle fibers is CK. Plasma CK is higher when muscles are damaged because of repeated and intense contractions [7]. Athletes seem to have higher

CK levels than non-athletes, whether they are male or female, juvenile or adult. So, comparing the values of athletes to the normal values established in non-athletes is pointless [9]. CK levels in men and women of comparable fitness levels are significantly lower in the latter [23]. This is in agreement with our own findings. High CK in men is also positively associated with hypermagnesemia.

CONCLUSION

In our athletes, most P and Mg serum alterations were close to the upper limits of a normal non athletic population. It is extremely difficult to establish true resting values in elite athletes who train for several hours every day. New reference limits should be established for biochemical variables in elite athletes, whose hydration, nutritional, and fasting status are difficult to ascertain, and probably at variance from the normal non-athletic population. The interpretation of reported concentrations in athletes should take in account the type of sport practiced, their body mass index (BMI), and also the possible variations during the training and competition season. The reference intervals for the general population may not be valid for elite athletes.

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Conflict of interests: None

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