

## Serum creatine kinase in marathon runners

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**Summary.** Serum creatine phosphokinase (CK) and CK-MB activity were determined in 21 trained runners participating in a marathon race (42.2 km). Enzyme activities immediately after the race increased two to three times compared with activities before the race. The greatest increases were found in the slowest runners, suggesting greater skeletal muscular trauma in the least trained or fit. As these are likely to include the older athletes who are also more likely to suffer acute myocardial injury during strenuous exercise, our findings assume special import in the interpretation of increased CK and CK-MB serum activities of older athletes.

**Key words.** Creatine kinase; exercise; myocardial injury; creatine kinase-MB; older athletes; skeletal muscle; runners.

Increased serum creatine kinase (CK) and CK-MB are important and sensitive tools for the diagnosis of acute myocardial injury<sup>1,2</sup>. Increases of serum CK and other enzymes in healthy long distance runners are also the subject of many reports<sup>3-8</sup>. For the latter, most authors suggest non-cardiac sources<sup>3-5,7</sup>. Moderate exercise is associated with small or inconsistent increases<sup>8,9</sup>. Stansbie et al.<sup>8</sup> describe a correlation of the total CK and the order in which marathon runners completed the race, the greater increases occurring in the slower runners. The present communication reports CK and CK-MB increases in marathon runners to more than twice the upper limits of a normal non-exercising control population. In addition, a direct correlation of the clocked running times and the magnitude of the enzyme increases for both the CK and CK-MB was found. The possibility of greater skeletal muscle trauma in the slower, less trained or less fit runners is proposed.

**Materials and methods.** 21 healthy long distance runners, 20 men and one woman who were regularly training but achieved different levels of fitness participated in a 42.2 km race and volunteered for the study. Informed consents were obtained. The ages ranged from 18 to 58 years with a mean of 37, the weights from 48 to 94 kg, mean 71, and the heights from 159 to 194 cm, mean 179. 21 runners completed the race. The remaining athlete completed at least one half. All runners were training regularly. Their estimated weekly average totaled  $93.5 \pm 45.2$  km (mean  $\pm$  SD) or  $8.0 \pm 4.1$  h.

Blood from the antecubital vein was obtained on the evening before the race and 0-1 h after the individual participant finished. Serum was separated within 2 h, stored refrigerated at 4°C for less than 24 h before analysis. Total CK and CK-MB activity were determined with a CK isoenzyme kit procedure supplied by Worthington Diagnostic Systems Inc. Freehold,

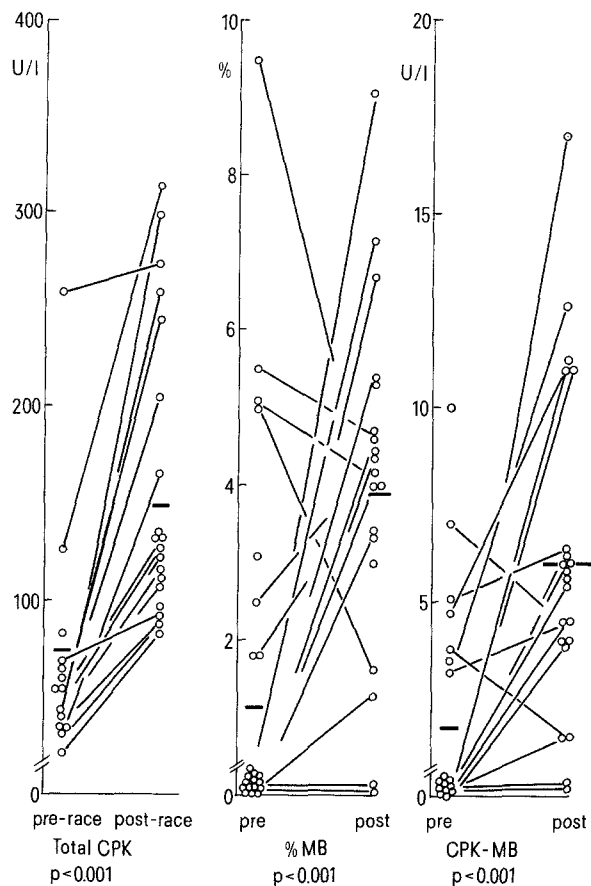


Figure 1. Serum CK, %MB, and CK-MB increases before and immediately after 42.2 km race in 21 runners. Horizontal bars indicate means.

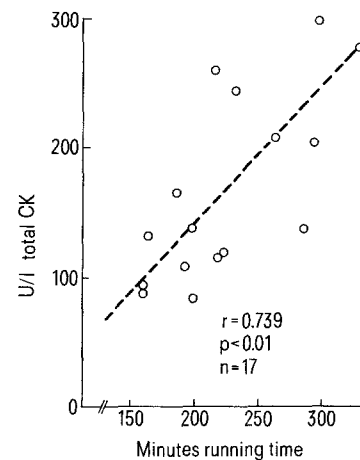


Figure 2. Correlation of post-race serum total CK activity and running time.

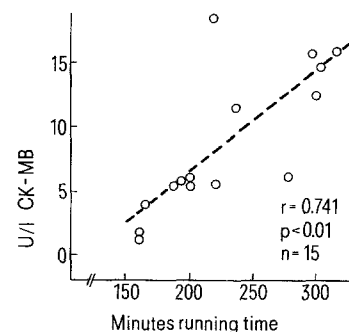


Figure 3. Correlation of post-race serum CK-MB activity and running time.

NJ, according to the manufacturer's instructions updated in March 1979. The technique combines resin column chromatographic separation with colorimetric quantitation. Enzyme activities were assessed at 30°C. Locally established ranges for a normal control population not participating in strenuous sports were 0–83 U/l total CK and less than 4% CK-MB. The paired Student's t-test was applied to the pre- and post-race data.

**Results.** Serum total CK, percent MB, and CK-MB activities before and immediately after the race are summarized in figure 1. The mean pre-race activities were close to the upper limits of normal. In three runners, the total CK, and in additional three, the CK-MB were greater than normal. These athletes trained in the two days before the race. The mean enzyme activities of the other runners fell into the middle of the normal range or were below detectability.

Post-race total CK and percent MB activities doubled, while CK-MB activities more than tripled. The total CK increased in all runners. However, the percent MB declined in four athletes, in two of which the CK-MB also declined.

The correlation of the clocked running time of 17 or 15 athletes who completed the race and for whom times were recorded are given in figures 2 and 3. Increases were greater in the slower runners.

**Discussion.** Serum CK and CK-MB as well as other enzyme tests are important and sensitive tools for the diagnosis of acute myocardial infarcts and other myocardial injuries<sup>1,2</sup>. Increased CK and CK-MB are also found in healthy persons after long distance running<sup>3–8</sup>, thus complicating the interpretation of enzyme changes in athletes with chest pain or other cardiac symptoms. In asymptomatic runners, the source of the circulating CK and CK-MB likely is not the myocardium, but rather injured skeletal muscle, according to numer-

ous reports<sup>3–5,7</sup>. Most studies of exercise-related enzyme changes are performed in long distance runners<sup>3–8</sup>, consistently documenting significant increases. Moderate exercise, however, is associated with inconsistent or smaller increases<sup>8,9</sup>, presumably because of minor muscular injury. Symansky et al.<sup>9</sup> report absence of enzyme changes in competitive swimmers. Forces of 130–215 kg reportedly are exerted during down strokes during running, while forces of 2–9 kg are recorded during swimming<sup>9</sup>, suggesting less trauma in swimmers. These findings argue for a correlation of the severity of trauma and the magnitude of enzyme increases.

Stansbie et al.<sup>8</sup> describe a direct correlation of serum total CK and the order in which marathon runners complete their races. The present study demonstrates a significant correlation of clocked running time and both CK and CK-MB increases. The greatest increases are found in the slower runners, suggesting that longer running times are associated with greater trauma to skeletal muscle leading to enzyme leakage into the circulation. The slower runners are very likely also the less trained or less fit, older athletes.

Little is known about the time course of enzyme increases and subsequent normalization<sup>5</sup>. Therefore, alternatively, the greater increase in the slower runners may, because of different timing of sample collection in reference to the midpoint of the race, reflect the peak of enzyme leakage rather than greater trauma.

In view of the findings of ours, of Stansbie et al.<sup>8</sup>, and others<sup>5</sup>, increased serum CK and CK-MB activities in athletes suspected of having suffered recent myocardial injury should be interpreted after exclusion of recent exercise related skeletal muscle trauma, especially in the slower, less fit, and older athletes.

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## Free amino acid pattern in stressed leaves of two contrasting resistant and susceptible cultivars of chick pea (*Cicer arietinum*)

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**Summary.** Drought resistant cv. C-214 of *Cicer arietinum* L. showed higher accumulation of  $\alpha$  alanine, threonine, glutamine,  $\beta$ -alanine, arginine,  $\gamma$  amino butyric acid, valine, leucine, phenylalanine than the susceptible cv. G130 under water stress.

**Key words.** *Cicer arietinum*; free amino acids, drought resistance; water stress.

Higher proline accumulation has been proposed as an index of drought resistance in barley<sup>1</sup>, but its usefulness could not be confirmed in chick pea, rice or barley<sup>2–4</sup>. Exogenous proline,

leucine, asparagine, arginine, alanine, phenylalanine,  $\gamma$  amino butyric acid, glutamine and threonine protect membranes of *Vinca* against acid and alkali<sup>5</sup>. Here, the amino acid spectra in