Creatine Kinase and Creatine Kinase-MB Isoenzyme during and after Exercise Testing in Normal and Obese Young People*

Alberto Salvadori, M.D.; Paolo Fanari, M.D.; Stefano Ruga, M.D.; Amelia Brunani, M.D.; and Erminio Longhini, M.D.

We report creatine kinase (CK) and CK-MB values during a cycleergometric test up to maximal work capacity in 10 normal subjects aged 20 to 39 years (mean body mass index, 22 kg/m²) and 11 obese patients aged 17 to 42 years (mean body mass index, 41 kg/m²), all without any cardiorespiratory diseases. Total CK was significantly higher in obese patients. The CK-MB was not significantly different between the two groups, except at the first recovery when it was increased in obese patients and decreased in normal subjects. These results could be due to more important total stress of the total musculature, especially cardiac, and especially cardiac musculature in obese patients during a physical effort. Considering the mean values of total CK of our obese patients, it may be possible that they have myocardial damage at percentages of CK-MB less than those of lean subjects generally accepted at more than 4 percent. Moreover, in obese heart patients myocardial distress during exercise testing may be present despite heart rate at peak exercise beneath the theoretic maximal.

(Chest 1992; 102:1687-89)

Previous studies of obese subjects at rest have reported an increase in cardiac work, representing percentages of 40 to 190 percent, of more than ideal body weight.¹ Necropsy studies on the relationship between heart weight and body weight have demonstrated an increase in heart weight in obese subjects.²

Increments of total creatine kinase (CK) have been noted in the blood of patients with ischemic heart disease when subjected to exercise testing.³⁻⁵ Some reports mention a slight elevation in CK-MB isoenzyme after strenuous physical exercise in marathon runners.⁶⁻⁷

Both these increases probably represent a physiologic enzyme leakage from musculature which is paramount to the normal muscular activity and are proportional to the metabolic demands of the muscle.⁸

The increased body mass of the obese patients requires a greater metabolic energy exchange both at rest and especially during physical exercise.⁹ To evaluate muscular stress, we recorded CK and CK-MB values during an exercise test up to the maximal work capacity in a group of young obese patients compared with normal young subjects, all without any cardiorespiratory disease.

METHODS

We studied 11 obese subjects (5 males) and 10 normal subjects (5 males), whose anthropometric data are reported in Table 1. The body mass index (BMI-kg/m²) was taken as a measure of obesity.¹⁰

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<table>
<thead>
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<th>Table 1—Anthropometric Data*</th>
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<td>Normal subjects</td>
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<td>(range)</td>
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<tr>
<td>No.</td>
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<td>Weight (kg)</td>
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<td>Height (cm)</td>
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<td>BMI (kg/m²)</td>
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*Values are mean ± SEM; BMI = body mass index.
†By two tailed analysis of variance.

With body mass index less than 25 for normal subjects.

None of the subjects was receiving medical therapy. The investigation was approved by the Institutional Ethics Commission and consent was obtained from each volunteer.

The exercise testing was performed on a cycle ergometer (Gould) with incremental steps of 20 W every 4 min until exhaustion and followed by a 30-min recovery period (modified protocol of Sjögren).¹¹

First, we recorded heart rate by means of a Kontron 504 heart station and systolic and diastolic pressure at rest and at the end of each step of work. Then, anaerobic threshold was determined using the following three criteria: (a) drift point in the diagram, oxygen consumption vs minute ventilation; (b) the increase of end-tidal P_O₂ (PETO₂) and (c) the increase of ventilatory equivalent for O₂ without a concomitant reduction of end-tidal P_O₂.¹²⁻¹⁴

By means of a needle inserted into the antecubital vein connected to a saline solution, blood samples were collected to determine CK and CK-MB isoenzyme at total rest, at the maximal peak of activity and after 5 (first recovery) and 30 min (late recovery).

Total CK was determined by means of activated the CK N-acetylcysteine (NAC) method. The CK-MB was determined using a specific antibody which inhibits CK-M subunits; thereafter, the remaining CK-B activity, corresponding to 50 percent of total CK-MB activity, was determined by means of the activated CK NAC method (Boehringer-Ingelheim).

The data obtained at each step of the test were compared across groups and with the total rest value by analysis of variance. The Dunnett method was used to determine which of the obese group

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RESULTS

We were not able to differentiate the group of normal subjects \((136 \pm 10.6 \text{ W [SEM]})\) by means of the maximal peak of activity reached. Anaerobic threshold AT was significantly lower in the obese subjects \((78 \text{ vs } 110, \ p < 0.05)\).

Total CK was significantly higher in the obese patients at rest, at peak of activity, and during first and late recovery. During exercise, there was no significant increase in CK in either obese patients or normal subjects, but the CK of the first recovery in the obese patients, unlike that in normal subjects, was slightly higher compared with CK at peak of activity (Fig 1).

The CK-MB was not significantly different in obese patients and normal subjects at rest or at the peak of activity and there was no significant increase during the exercise in either group.

Nevertheless, at the first recovery there was an increase of the value in obese patients compared with that at the peak of activity, while there was a decrease in normal subjects, with a significant difference between these mean values (Fig 2), which persisted at the late recovery.

The heart rate was significantly higher in obese subjects both at rest and when pedaling at zero resistance; the subsequent increase during exercise was more pronounced in normal subjects who reached a significantly higher value at peak activity when compared with obese patients (Fig 3).

Systolic and diastolic blood pressures increased during exercise both in normal and obese patients, with no significant difference between the two groups (at rest: normal subjects \(-116 \pm 1.9/77 \pm 2.4\); obese patients \(-120 \pm 2.3/84 \pm 2.9\); at peak activity: normal subjects \(-153 \pm 4.7/90 \pm 2.7\), obese patients \(-155 \pm 3.7/95 \pm 1.8\)).

DISCUSSION

The obese subjects show increased total CK values at rest and during activity and subsequent recovery when compared with control subjects.

This aspect probably is due to their higher body mass which is likely characterized by the increase in muscle mass as well as in fat,\(^2\) and skeletal muscle is the most important source of the increase in its enzymatic activity.\(^3\)

No significant difference was noticed at rest in CK-MB isoenzyme levels between obese and normal subjects; the slightly increased value in obese patients could be due to their probable higher heart weight.\(^2\)

At the end of training no significant increase in CK-MB was measured and this is conceivable since none of the subjects had myocardial illness. Nevertheless, at first recovery the obese patients showed a further increase, while normal subjects showed a slight decrease.

From the literature, we know about the very good correlation between myocardial \(O_2\) consumption and the product of cardiac frequency with systolic arterial pressure.\(^4\) By means of this correlation, we can state that at rest the hearts of obese patients consume more \(O_2\) than those of control subjects; during exercise, both groups experience an increase in oxygen consumption at the top of training; and myocardial \(O_2\) consumption in obese subjects is less than that of normal subjects.

We must remember that cardiac stroke volume increases to over resting values at low levels of work, but there is no further increase once cardiac frequency has risen to 120 beats per minute.\(^5\) At the top of training both our groups were in this condition.

Obese subjects generally exercise less and are probably less fit than normal subjects, which means that their cardiac maximal oxygen consumption may be reduced.

The behavior of CK-MB in our obese subjects at

\[ \text{Results Table} \]

\begin{tabular}{|c|c|c|c|}
\hline
 & Normal & Obese & SEM & SEM \\
\hline
Rest & 62.9 & 70.1 & 69.5 & 60.8 \\
Peak & 9.01 & 9.44 & 9.33 & 9.15 \\
Min 5 & 132.8 & 109.5 & 126.5 & 111.6 \\
Min 30 & 18.05 & 19.03 & 21.59 & 17.73 \\
\hline
\end{tabular}

\[ \text{Figure 1. Mean CK at rest, at the top of exercise and during recovery for obese patients compared with normal subjects.} \]

\[ \text{Figure 2. Mean CK-MB; the representation is the same as Figure 1.} \]
first recovery could be due to myocardial distress with leakage of the enzyme from the cardiac musculature, which is similar to what already has been described in normal subjects subjected to massive physical stress without previous training.\textsuperscript{30}

In the clinical setting, the amount of CK-MB isoenzyme in blood is expressed as a percentage of total CK and it is generally accepted that myocardial necrosis is more than 4 percent with a temporary elevation of total CK.\textsuperscript{31}

Just considering the mean values of total CK of our obese patients, it may be possible that they have myocardial damage at percentages of CK-MB lower than those of lean subjects.

Attainment of a given heart rate is generally used in exercise testing for detecting myocardial ischemia.\textsuperscript{19}

Considering our data, in obese heart patients, myocardial distress or damage may be present at a heart rate beneath the theoretic maximal rate so that further physical stress could be more useless than dangerous.

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\textbf{FIGURE 3.} Mean HR during ergometric test for obese patients compared with normal subjects.

Only the values for SEM graphically representable are plotted. * = p<0.05; ** = p<0.01; two-tailed analysis of variance and Dunnett method.

At the bottom of the figure the mean values of HR, the corresponding SEM and the number of subjects who have reached each work rate.

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Mean HR during ergometric test for obese patients compared with normal subjects.