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

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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 cardio respiratory 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. J Necropsy studies on the relationship between heart weight and body weight have demonstrated an increase in heart weight in obese subjects. Increments of total creatine kinase (CK) have been noted in the blood of patients with ischemic heart disease when subjected to exercise testing. Reports mention a slight elevation in CK-MB isoenzyme after strenuous physical exercise in marathon runners. 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.

The increased body mass of the obese patients requires a greater metabolic energy exchange both at rest and especially during physical exercise. 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.*

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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 Sjøstrand). 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 PO₂ (PETO₂) and (c) the increase of ventilatory equivalent for O₂ without a concomitant reduction of end-tidal PCO₂. 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 acetylkysteine (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

### Table 1 — Anthropometric Data*

<table>
<thead>
<tr>
<th></th>
<th>Normal Subjects (range)</th>
<th>Obese Patients (range)</th>
<th>p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>10</td>
<td>11</td>
<td>NS</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>5/5</td>
<td>5/6</td>
<td>NS</td>
</tr>
<tr>
<td>Age (years)</td>
<td>28.9 ± 1.9 (20-39)</td>
<td>26.5 ± 2.4 (17-42)</td>
<td>NS</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.8 ± 3.6 (49-85)</td>
<td>113.6 ± 4.9 (91-130)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.0 ± 3.8 (154-194)</td>
<td>167.3 ± 2.6 (150-177)</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.8 ± 0.6 (19-26)</td>
<td>40.7 ± 3.9 (36-46)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Values are mean ± SEM; BMI = body mass index.
†By two tailed analyses of variance.

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values differed from those obtained in the control subjects at a
given step of exercise.\(^{10}\)

**RESULTS**

We were not able to differentiate the group of
normal subjects \((136\pm10.6\) W [SEM]) by means of
the maximal peak of activity reached. Anaerobic
threshold AT was significantly lower in the obese
subjects \((78\) 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 be-
tween 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 \(-116\pm1.9/77\pm2.4,\) obese
patients \(-120\pm2.3/84\pm2.9\); at peak activity: normal
subjects \(-153\pm4.7/90\pm2.7,\) obese patients—
\(155\pm3.7/95\pm1.8).\)

**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,\(^{16}\) and skeletal muscle
is the most important source of the increase in its
enzymatic activity.\(^{17}\)

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 de-
crease.

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.\(^{18}\) 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 con-
sumption 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.\(^{19}\) 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

![Figure 1](http://journal.publications.chestnet.org/)

**Figure 1.** Mean CK at rest, at the top of exercise and during
recovery for obese patients compared with normal subjects.
\(***p<0.05;\) two-tailed analysis of variance and Dunnett method.
At the bottom of the figure the mean values of CK and the
respective SEM are given.

![Figure 2](http://journal.publications.chestnet.org/)

**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{20}

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{21}

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.

REFERENCES
1 Alexander JK. Obesity and cardiac performance. Am J Cardiol 1964; 14:960-5
2 Smith HL. Relation of the weight of the heart to the weight of the body and of the weight of the heart to age. Am Heart J 1928; 4:79
7 Klein MS, Weiss AN, Roberts R, Coleman R. Technetium-99m stannous pyrophosphate scintigrams in normal subjects, patients with exercise induced ischemia and patients with calcified valves. Am J Cardiol 1977; 39:360-7
12 Reinhard U, Muller PH, Schmulling RM. Determination of anaerobic threshold by ventilation equivalent in normal individuals. Respiratation 1979; 38:36-42
17 Chahine RA, Eber LM, Kattus AA. Interpretation of the serum enzyme changes following cardiac catheterization and coronary angiography. Am Heart J 1974; 87:170-4
19 Jones NL. Clinical exercise testing. 3rd ed. Philadelphia: WB Saunders, 1988; 44