Response of bone metabolism related hormones to a single session of strenuous exercise in active elderly subjects

L Maïmoun, D Simar, D Malatesta, C Caillaud, E Peruchon, I Couret, M Rossi, D Mariano-Goulart

Objective: To evaluate the effect of strenuous exercise on bone metabolism and related hormones in elderly subjects.

Methods: Twenty one active elderly subjects (11 men and 10 women; mean age 73.3 years) showing a mean theoretical VO2max of 151.4% participated. Concentrations of plasma ionised calcium (iCa), serum intact parathyroid hormone (iPTH), 25-hydroxyvitamin D (25(OH)D), and 1.25-dihydroxy-vitamin D3 (1.25(OH)2D3), as well as the bone biochemical markers type I collagen C-telopeptide for bone resorption and osteocalcin and bone alkaline phosphatase for bone formation, were analysed before and after a maximal incremental exercise test.

Results: At basal level, iPTH was positively correlated with age (r = 0.56, p < 0.01) and negatively correlated with 25(OH)D (r = -0.50; p = 0.01) and 1.25(OH)2D3 (r = -0.47; p < 0.05). Moreover, 25(OH)D and 1.25(OH)2D3 levels were negatively correlated with age (r = -0.50, p < 0.01 and r = -0.53, p < 0.01, respectively). After exercise, iCa and 25(OH)D decreased (p < 0.001 and p = 0.01, respectively) while iPTH increased (p < 0.001). The levels of 1.25(OH)2D3, bone biochemical markers, haematocrit, and haemoglobin were unchanged. The variations in iCa and 25(OH)D were not related to age and/or sex. The iPTH variation was directly related to basal iPTH levels (p < 0.01) and indirectly related to age.

Conclusions: In active elderly subjects, strenuous exercise disturbed calcium homeostasis and bone related hormones without immediate measurable effect on bone turnover. Although an increase in iPTH could have an anabolic action on bone tissue, our findings from our short term study did not allow us to conclude that such action occurred.

Osteoporosis, which is a major public health problem, can be defined as a diffuse skeletal disease with reduced bone mass and altered bone micro-architecture as its main structural features. Both abnormalities result in increased fragility of the skeleton, and hip fracture is the most serious complication with associated high rates of morbidity and mortality. Osteoporosis is a multifactorial process that depends on several environmental factors, such as dietary calcium deficiency and genetic influences. Improving nutritional habits, particularly dietary calcium intake, and increasing the level of physical activity have been suggested as practical strategies for the non-pharmacological prevention of osteoporosis. Physical exercise has different beneficial effects on the skeleton according to the period of life in which it is undertaken: it optimises peak bone mass in growing children and maintains bone mass or reduces the bone loss rate in the elderly. The beneficial effect of physical activity on bone mineral density (BMD) was particularly well demonstrated in power trained athletes engaged in high impact or strengthening exercises, but such an activity level is not conceivable in fragile elderly subjects. Furthermore, the search for a relationship between physical activity and bone density in osteoporotic patients has not always led to consistent findings. Although most authors have reported the beneficial effects of exercise on bone mass, others have not. These conflicting results may be related to selection differences (age, gender, subject’s initial BMD), the explored bone sites, duration and type (intensity, mechanical loading, and so on) of the exercise program. To optimise the effect of physical activity on bone health, a better understanding of the bone tissue responses to specific mechanical stimuli is therefore needed. More precise definition of the biomechanical specifications, as well as the intensity, duration, and frequency of the exercise to be prescribed, would most likely lead to more efficient prevention of bone loss.

By consensus, BMD is usually measured to estimate bone health and may be the primary indicator of the risk of osteoporotic fractures. However, although BMD measurements provide a static representation of bone mineral status, they cannot be used to evaluate the slight bone metabolic changes induced by a single episode of physical exercise. Biochemical markers, on the other hand, can be used to assess dynamic changes in bone turnover and appear to be sensitive enough to determine the bone response to a given exercise. Brahm et al demonstrated favourable systemic effects of physical exercise on bone metabolism using serum bone markers, while Wallace et al showed that endurance exercise transiently activates bone and collagen turnover. In elderly subjects, bone markers are used especially for monitoring treatment for osteoporosis. Few reports, however, are available concerning the effects of physical exercise on bone markers in a healthy aged population. Moreover, the immediate effect of exercise on calcium homeostasis and bone turnover has never been evaluated in this population, even though the data obtained from bone marker based...
investigating methods would provide useful information for
the design of therapeutic programs to improve bone health.

The aim of our study was to determine to what extent a
single session of brisk walking exercise affected bone
metabolism related hormones in active elderly subjects.
Normal walking is generally not considered to be a high
impact loading activity, but it is the only physical exercise
commonly practiced by the elderly. Moreover, we examined
whether the response was sex or age dependent, and whether
it was likely to provide early indications of the effects of
physical exercise (if any) on the bone biochemical markers.

**METHODS**

**Subjects**

Twenty one physically active elderly subjects, 11 men and 10
women (mean age 73.3 years, range 60–88) who were free of
any limiting orthopaedic conditions, underwent medical
screening that included a medical history, a physical
examination, and an electrocardiogram. The non-inclusion
criteria were medical treatment known to affect bone
metabolism, osteoporotic hip or vertebral fractures, cardio-
vascular disease, diabetes mellitus, smoking, and excessive
alcohol intake. Ethical approval was obtained from the local
ethics committee and informed consent was given by the
subjects. The subjects were asked to complete a series of ques-
tionnaires concerning their medical history and physical
activity level. This last was assessed with a questionnaire
specifically adapted for the elderly, with different scores to
quantify household, sports, and other physically active leisure
time activities, together resulting in a total activity score. The
questionnaire provided a method for classifying elderly
subjects into categories of high, medium, and low physical
activity, with cut off points of 16.5 and 9.4. Answers to
routine queries about known metabolic disorders, current
medication, diet, possible vitamin and mineral supplementa-
tion, and smoking/alcohol consumption were also collected.

**Experimental protocol**

The experiments were carried out in two sessions separated
by at least 4 days and never more than 7 days. During the
first session, the subjects’ preferred walking speed was
determined. The second session was devoted to a maximal
incremental exercise test.

**Preferred walking speed determination**

The subjects began treadmill walking at the lowest familiar-
isation speed (0.67 m s⁻¹), which was then slowly increased
until each subject subjectively identified his or her preferred
walking speed. This speed was maintained for 1 min and was
then modified slightly. The subject was again asked to
evaluate the speed and adjustments were made according to
the subject’s directives. This procedure was repeated starting
with the highest familiarisation speed (1.56 m s⁻¹) and
gradually reducing to the preferred speed. The final preferred
walking speed was considered to be the mean of the two
speeds selected by the subject during both the increasing and
decreasing speed trials. During this session and the
exercise test, the subjects were secured continuously by a
cross-belt fixed to the handrails in such a way that arm swing
was not impeded.

**Maximal incremental exercise test**

The subjects arrived at the laboratory at 8.00 a.m. after a 12 h
overnight fast. At 8.30 a.m., resting blood sample was
drawn for analysis of biochemical parameters. The subjects
then performed a maximal incremental exercise test at the
individually determined preferred walking speed as pre-
viously described. After a 3 min standing rest period, they
were asked to walk for 5 min at 0% grade for warm up. The
grade was then increased by 1–2% each minute until
exhaustion, resulting in a test duration of between 8 and 12 min. During the test, oxygen consumption (Vo₂), CO₂
output (VCO₂), and ventilation (VE) were analysed by breath
by breath using an on line system (LE 200 CE, Jaeger,
Hoechberg, Germany) and averaged every 20 s. Cardiac
activity was continuously monitored using a 12 lead
electrocardiogram (Oxycon Pro, Jaeger). Theoretical Vo₂
maximum (Vo₂max) values were obtained using reference
equations specifically developed in older adults aged 55–
86 years during a treadmill maximal exercise test, according
to age and sex. Different equations were thus specifically
developed for men (Vo₂max (ml kg⁻¹ min⁻¹) = 44.23–
0.31 × age) and women (Vo₂max (ml kg⁻¹ min⁻¹) = 36.63–
0.25 × age). Vo₂max was considered to be attained if
the subject reported a feeling of fatigue and if one of the
following criteria was reached: (a) a plateau in oxygen
uptake concurrent with continuing increase in exercise
intensity or (b) respiratory exchange ratio (RER) greater
than 1.0 and heart rate (HR) within 5 beats per minute
(bpm) of the theoretical age specific maximal HR =
(−0.84 × age)+217.31 for men and HR = (−0.91 × age)+221.7
for women.²⁶

**Sample collection**

Blood samples (20 ml) were collected in sterile chilled tubes,
at rest and just after the maximal incremental exercise test.
The samples were allowed to clot at room temperature and
were then centrifuged at 2500 rpm for 10 min at 4°C. Serum
samples were stored at −80°C until analysis.

**Biochemical assays**

All samples were run in duplicate and, to reduce inter-assay
variation, all the serum samples were analysed in a single
session.

**Calcium homeostasis**

Isonised serum calcium (iCa) was measured by an ion-
selective electrode (BGE, Electrolytes Instrumentation
Laboratory, Lexington, MA). Intact parathyroid hormone
(1–84) (iPTH) was measured by an immunoradiometric assay
(IRMA) (N-lact PTH SP, DiaSorin, Stillwater, MN). The intra-
and inter-assay coefficients of variation (CVs) were 3.6% and
3.4%, respectively. The sensitivity of the test was 0.7 pg ml⁻¹
with no cross-reaction with human PTH fragments. The
reference range for iPTH in our laboratory was 10–
55 pg ml⁻¹. The level of 25-hydroxyvitamin D (25(OH)D)
was measured by radioimmunoassay (RIA) (25-hydroxyvit-
imin D RIA kit, Nichols Institute Diagnostics, Paris, France).
The intra- and inter-assay CVs were 5% and 8.1%, respecti-
vately. Assay sensitivity was 1.12 ng ml⁻¹. Serum 1,25-
dihydroxy-vitamin D3 (1,25(OH)₂D₃) was measured by RIA
(1,25-dihydroxyvitamin D RIA kit, Nichols Institute
Diagnostics). The sensitivity of the assay was 2.1 pg ml⁻¹.
The intra- and inter-assay CVs were 5% and 10.8%, respec-
tively. The reference range for 1,25(OH)₂D₃ in our
laboratory was 20–66 pg ml⁻¹.

**Bone biochemical markers**

**Markers of bone formation**

Serum osteocalcin (OC) was measured by IRMA assay (Elsa-
OST-NAT, CIS Biointernational, Gif/Yvette, France). The intra-
and inter-assay CVs were below 5% and the sensitivity
was 0.3 ng ml⁻¹. The reference range for serum OC in our
laboratory was 5–20 ng ml⁻¹. Serum bone alkaline phospha-
tase (B-ALP) was measured by IRMA assay (Tandem-R
Ostase, Hybri Tec, San Diego, CA). The sensitivity of the assay
was 0.2 ng ml⁻¹, and the intra- and inter-assay CVs were less
Institute, Cary, NC) was used for statistical analysis. A level of $p < 0.05$ was considered significant. SAS software, version 8.2 (SAS Institute, Cary, NC) was used for the statistical analysis. 

RESULTS

Marker of bone resorption

Serum type I-C telopeptide breakdown products (CTX) were measured by ELISA (CrossLaps ELISA, Osteometer, Rodovre, Denmark). The intra- and inter-assay CVs were less than 5.7% and 9.4%, respectively, and the detection limit was 0.5 μg L$^{-1}$. The reference range for CTX was $<5500$ pmol L$^{-1}$ (manufacturer’s specification).

Other parameters

Haematocrit (Hct) and haemoglobin (Hb) were determined by routine laboratory tests at rest and during exercise to ensure that measurements of metabolite and hormone concentrations were not influenced by changes in plasma volume.

Statistical analysis

All data are expressed as means (SD). The Gaussian distribution of variables was assessed by the Shapiro-Wilk statistical test. The differences between baseline pre-exercise and post-exercise data were assessed with Student’s paired $t$ test. When the $t$ test was significant, the effect of independent variables such as sex and age was assessed by ANCOVA. When the ANCOVA test revealed that the independent variable significantly contributed to the outcome, Pearson correlation was performed to examine the degree of association between the variables. A level of $p < 0.05$ was considered significant. SAS software, version 8.2 (SAS Institute, Cary, NC) was used for statistical analysis.

RESULTS

The anthropometric data and the parameters of physical fitness of the participants are shown in Table 1. $V_{O2\text{max}}$ represented 150% of the predicted value, highlighting the high physical fitness of our population. According to the physical activity questionnaire previously established, $7\%$ and $9\%$, respectively. The reference range for serum B-ALP in our laboratory was $4–15$ ng ml$^{-1}$.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>73.3 (9.1)</td>
<td>60–88</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65.8 (13.2)</td>
<td>47–89</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.3 (9.2)</td>
<td>152–180</td>
</tr>
<tr>
<td>BMI (kg m$^{-2}$)</td>
<td>23.6 (2.9)</td>
<td>18.7–31.1</td>
</tr>
<tr>
<td>$V_{O2\text{max}}$ (l min$^{-1}$)</td>
<td>2.06 (0.77)</td>
<td>1.16–3.49</td>
</tr>
<tr>
<td>$V_{O2\text{max}}$ th (l min$^{-1} \cdot kg^{-1}$)</td>
<td>30.5 (7.1)</td>
<td>18.3–45.1</td>
</tr>
<tr>
<td>$V_{O2\text{max}}$ th (%)</td>
<td>20.1 (3.5)</td>
<td>14.6–25.6</td>
</tr>
<tr>
<td>%$V_{O2\text{max}}$ th (l min$^{-1} \cdot kg^{-1}$)</td>
<td>151.4 (12.5)</td>
<td>125–195</td>
</tr>
<tr>
<td>Exercise duration (min)</td>
<td>9.9 (1.4)</td>
<td>8–13</td>
</tr>
<tr>
<td>Maximal slope (%)</td>
<td>15 (5)</td>
<td>5–24</td>
</tr>
<tr>
<td>Physical activity score</td>
<td>20.1 (7.1)</td>
<td>11.9–38.6</td>
</tr>
</tbody>
</table>

Data are presented as means (SD). BMI, body mass index; $V_{O2\text{max}}$, maximal $O_2$ uptake. $V_{O2\text{max}}$ th, theoretical maximal $O_2$ uptake.

Exercise and bone metabolism in active elderly subjects

Response of biochemical parameters to exercise

The variations in the parameters of calcium homeostasis are shown in Table 2. The concentrations of $iCa$ and $25(OH)D$ were decreased significantly after exercise ($p < 0.001$ and $p = 0.01$, respectively) compared with pre-exercise measurement. The values of $1.25(OH)\text{D}_3$, Hct, and Hb were unchanged ($p > 0.05$). The concentrations of iPTH were significantly increased after exercise ($p < 0.001$).

The values of the post-exercise bone biochemical markers (CTX, OC, B-ALP) were unchanged compared with pre-exercise values (Table 3).

Basal levels of hormones and bone biochemical markers

All basal hormonal and bone biochemical markers were found to be within the normal ranges (Tables 2 and 3). After stratification for gender, there were no significant differences between males and females.

Relationships between age, anthropometric data, and biochemical parameters at baseline

Table 4 shows the different relationships between age, body mass index (BMI), and the various biochemical parameters at baseline. Age was positively correlated with iPTH ($r = 0.56$) (fig 1) and negatively correlated with $25(OH)D$ ($r = -0.51$) and $1.25(OH)\text{D}_3$ ($r = -0.53$). A negative relationship was found between iPTH and $25(OH)\text{D}$ ($r = -0.51$, $p = 0.001$). $1.25(OH)\text{D}_3$, BMI, and $25(OH)D$ were decreased significantly after exercise ($p < 0.001$, $r = -0.51$) and negatively correlated with $25(OH)D$ ($p < 0.05$, $r = -0.47$), and BMI ($p < 0.05$, $r = -0.43$). Correlations were also found between markers at baseline (OC $v$ B-ALP: $p < 0.001$, $r = 0.76$; OC $v$ CTX: $p < 0.01$, $r = 0.82$; B-ALP $v$ CTX: $p < 0.01$, $r = 0.75$). There were no correlations between markers of bone turnover and age, anthropometric data (weight, height, BMI), parameters of physical fitness ($V_{O2\text{max}}$ and $V_{O2\text{max}}$ th), or physical activity score.

Effects of age and sex on the variation in biochemical parameters during exercise

The variations ($\Delta$) in $iCa$ and $25(OH)D$ were not related to age or sex. A negative correlation ($r = -0.46$, $p = 0.015$) was found between iPTH and age. However, since we found that basal iPTH levels were also correlated with age ($r = 0.56$, $p < 0.01$) (Table 4), a stepwise linear regression analysis was performed to determine the contribution of possible independent variables (age and basal iPTH) to iPTH. In fact, only basal iPTH levels ($p < 0.01$) were independently related to iPTH.

DISCUSSION

To our knowledge, this investigation is the first to examine the effects of a single session of high intensity physical exercise on the parameters of calcium homeostasis and the

<table>
<thead>
<tr>
<th>Table 1 Characteristics of the study participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Age (year)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>BMI (kg m$^{-2}$)</td>
</tr>
<tr>
<td>$V_{O2\text{max}}$ (l min$^{-1}$)</td>
</tr>
<tr>
<td>$V_{O2\text{max}}$ th (l min$^{-1} \cdot kg^{-1}$)</td>
</tr>
<tr>
<td>$V_{O2\text{max}}$ th (%)</td>
</tr>
<tr>
<td>%$V_{O2\text{max}}$ th (l min$^{-1} \cdot kg^{-1}$)</td>
</tr>
<tr>
<td>Exercise duration (min)</td>
</tr>
<tr>
<td>Maximal slope (%)</td>
</tr>
<tr>
<td>Physical activity score</td>
</tr>
</tbody>
</table>

Data are presented as means (SD). BMI, body mass index; $V_{O2\text{max}}$, maximal $O_2$ uptake. $V_{O2\text{max}}$ th, theoretical maximal $O_2$ uptake.

| Table 2 Parameters of calcium homeostasis before and after exercise |
|-------------------------|---------|---------|---------|---------|---------|
| Biochemical parameters   | Pre-exercise | Post-exercise | % change | $p$ value | Normal range |
| Calcium homeostasis      |          |          |         |         |            |
| $iCa$ (mmol l$^{-1}$)    | 1.185 (0.027) | 1.150 (0.034) | -3 | $<0.001$ | 1.10–1.25 |
| $25(OH)D$ (pg ml$^{-1}$) | 23.4 (11.2) | 21 (9.3) | -10.3 | 0.013 | 16–28 |
| $1.25(OH)\text{D}_3$ (pg ml$^{-1}$) | 46 (12.5) | 46.1 (12.9) | 0.2 | 0.900 | 20–66 |
| iPTH (pg ml$^{-1}$)      | 28.9 (9.7) | 36.2 (11.8) | 25 | $<0.001$ | 10–55 |
| Other parameters         |          |          |         |         |            |
| Hct (%)                  | 43.1 (3.7) | 43.4 (3.6) | 0.7 | 0.850 | 39–54 |
| Hb (g dl$^{-1}$)         | 14 (1.2) | 14 (1.1) | 0 | 0.958 | 13–18 |

Data are expressed as means (SD). 1.25(OH)\text{D}_3, 1.25-dihydroxy-vitamin D$_3$; 25(OH)D, 25-hydroxyvitamin D; Hb, haemoglobin; Hct, haematocrit; $iCa$, ionised calcium; iPTH, intact parathyroid hormone; % change, per cent change from pre- to post-exercise.
bone biochemical markers in a large elderly population. The main findings were that in elderly physically active subjects: (a) strenuous exercise induced a decrease in iCa and 25(OH)D concentrations associated with a concomitant increase in iPTH concentration; (b) the variations in these parameters, with the exception of iPTH, were independent of sex and age; and (c) no modification concerning bone turnover, as evaluated by bone biochemical markers, was observed.

**Basal calcium homeostasis and bone remodelling**

At baseline, the major factor found to influence hormonal values was age. A relative consensus concerning the increase in serum iPTH with age in the general sedentary population has emerged from the literature, presumably related to vitamin D status. The similar finding in our study suggests that maintaining a high level of physical activity is not sufficient to compensate for the hormonal profile alteration related to age. Indeed, in our study, an inverse relationship was found between the basal 25(OH)D, 1,25(OH)2D3, and iPTH levels. The gradual reduction in 1,25(OH)2D3 production with advancing age seems to be multifactorial and due to a reduction in 1-α-hydroxylase synthesis associated with the reduced sensitivity of this enzyme to PTH, a reduced capacity of the skin to produce vitamin D, and lack of exposure to sunlight. In agreement with the majority of studies, we found no relationship between serum iCa and age. Moreover, no gender related difference in calcitropic hormonal status or bone turnover was found.

**Response of calcium homeostasis to strenuous exercise**

The study showed that a brief incremental exercise test induced a significant variation in the parameters of calcium homeostasis. The rise in serum iPTH level may directly reflect the decrease in serum iCa level, the main regulating factor of calcium homeostasis. The rise in serum iPTH level may directly reflect the decrease in serum iCa level, the main regulating factor of calcium homeostasis. The rise in serum iPTH level may directly reflect the decrease in serum iCa level, the main regulating factor of calcium homeostasis. The rise in serum iPTH level may directly reflect the decrease in serum iCa level, the main regulating factor of calcium homeostasis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-exercise</th>
<th>Post-exercise</th>
<th>p value</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone resorption marker</td>
<td>CTX (pmol l⁻¹)</td>
<td>5998 (3045)</td>
<td>5959 (2866)</td>
<td>0.945</td>
</tr>
<tr>
<td>Bone formation markers</td>
<td>OC (ng ml⁻¹)</td>
<td>12.7 (5.5)</td>
<td>12.5 (5.3)</td>
<td>0.627</td>
</tr>
<tr>
<td></td>
<td>B-ALP (ng ml⁻¹)</td>
<td>13.1 (4.8)</td>
<td>13.2 (4.7)</td>
<td>0.605</td>
</tr>
</tbody>
</table>

Data are expressed as means (SD). B-ALP, bone alkaline phosphatase; CTX, type I collagen C-telopeptide; OC, osteocalcin; %Δ, per cent change from pre- to post-exercise.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BMI</th>
<th>iCa</th>
<th>25(OH)D</th>
<th>1.25(OH)2D</th>
<th>iPTH</th>
<th>OC</th>
<th>B-ALP</th>
<th>CTX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>−0.378</td>
<td>−0.165</td>
<td>−0.504**</td>
<td>−0.533**</td>
<td>0.558**</td>
<td>0.036</td>
<td>0.055</td>
<td>0.196</td>
</tr>
<tr>
<td>BMI</td>
<td>0.037</td>
<td>0.075</td>
<td>0.154</td>
<td>0.263</td>
<td>−0.427*</td>
<td>−0.128</td>
<td>−0.073</td>
<td>−0.344</td>
</tr>
<tr>
<td>iCa</td>
<td>0.175</td>
<td>0.585**</td>
<td>−0.261</td>
<td>−0.341</td>
<td>−0.373</td>
<td>0.281</td>
<td>0.345</td>
<td></td>
</tr>
<tr>
<td>25(OH)D</td>
<td>0.486*</td>
<td>0.154</td>
<td>0.238</td>
<td>0.136</td>
<td>0.148</td>
<td>0.075</td>
<td>0.342</td>
<td></td>
</tr>
<tr>
<td>1.25(OH)2D</td>
<td>0.755***</td>
<td>0.821***</td>
<td>0.750**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B-ALP, bone alkaline phosphatase; BMI, body mass index; CTX, type I collagen C-telopeptide; iCa, ionised calcium; iPTH, intact parathyroid hormone; OC, osteocalcin.

*p<0.05; **p<0.01; ***p<0.001.
We were unable to determine precisely why the 25(OH)D level decreased during exercise. It is probable that the increase in iPTH stimulates the kidney production of 1,25(OH)2D3, the most biologically active metabolite of vitamin D from the precursor 25(OH)D. However, as no variation in 1,25(OH)2D3 was observed, this assumption remains purely speculative and we cannot rule out the possibility that the change in 25(OH)D levels resulted from a modification in metabolic clearance or degradation.

Response of bone markers to strenuous exercise

Bone biochemical markers provide a new way to examine the response of bone cells to exercise. Nevertheless, we could not show any significant changes in either serum CTX, which indicates resorption activity, or serum B-ALP and serum OC, which are considered to reflect newly synthesised bone. It is widely acknowledged that long term physical activity with high mechanical loading produces an increase in bone mass, especially at the load bearing bone sites. In our experiment, specific physical exercise did not induce any variation in bone biochemical markers, probably because the ground reaction forces generated by brisk walking, that is, approximately 1.1 times body weight, were insufficient to produce an immediate measurable bone response. Our results were, nevertheless, in accordance with the majority of studies that have investigated the immediate response of bone markers to short and intense or moderate exercise bouts. Therefore, the relatively short duration of exercise (range 8–13 min), as well as the short time of post-exercise investigation, could also explain why no significant bone marker response was observed. Moreover, it seems probable that the bone tissue of our elderly population had become less responsive to exercise. This was confirmed by Wallace et al who stated that age is probably a negative determinant of the bone marker response to exercise. However, given the complexity of the bone marker response to physical exercise, these results should be cautiously interpreted. Further investigations of the effects of some of the physical activity related factors, such as clearance or release of bone markers, must be carried out.

CONCLUSION

In active elderly subjects, calcium homeostasis and bone metabolism related hormones were noticeably modified after a single session of strenuous physical exercise. These modifications were mainly characterised by a decrease in iCa and an increase in iPTH levels. Although a transitional increase in iPTH level may have a potential anabolic effect on bone health, the specific iPTH variation observed after short duration exercise did not allow us to draw a definitive conclusion. Further investigations are required to elucidate the physiological and clinical significance of the observed iPTH modifications. Finally, no measurable effect on bone turnover could be demonstrated immediately after strenuous physical exercise.

What is already known on this topic

Although bone mineral density measurements provide a static representation of bone mineral status, they cannot be used to evaluate the slight bone metabolic changes induced by a single episode of physical exercise.

What this study adds

In active elderly subjects, calcium homeostasis and bone metabolism related hormones were noticeably modified after a single session of strenuous physical exercise.

ACKNOWLEDGEMENTS

We are indebted to Dr Dore (Service de Biochimie), Professor C. Sultan (Service d’Hormonologie du Développement et de la Reproduction), and the staff of the Laboratoire de Physiologie des Interactions UPRES EA 701, CHU Arnaud de Villeneuve, and the Service de Médecine Nucléaire, CHU Lapeyronie, for excellent technical assistance; and to Dr Regis Verdier and Dr Eric Barbotte for statistical analysis (Département d’Information Médicale).

Authors’ affiliations

D Simar, C Caillaud, Laboratoire Sport Performance Santé UPRES EA 2991, Faculté des Sciences du Sport, Montpellier, France
L Maimoun, D Malatesta, Laboratoire de Physiologie des Interactions UPRES EA 701, CHU Arnaud de Villeneuve, Montpellier, France
E Peruchon, INSERM, Montpellier, France
L Maimoun, I Courret, M Rossi, D Mariano-Goulart, Service de Médecine Nucléaire, CHU Lapeyronie, Montpellier, France

Competing interests: none declared

REFERENCES


---

**Call for papers**

11th European Forum on Quality Improvement in Health Care

26–28 April 2006, Prague, Czech Republic

Deadline 30 September 2005.

For further information and to submit online go to: www.quality.bmjpg.com

www.bjsportmed.com
Response of bone metabolism related hormones to a single session of strenuous exercise in active elderly subjects

L Maïmoun, D Simar, D Malatesta, C Caillaud, E Peruchon, I Couret, M Rossi and D Mariano-Goulart

doi: 10.1136/bjsm.2004.013151

Updated information and services can be found at:
http://bjsm.bmj.com/content/39/8/497

These include:

References
This article cites 40 articles, 8 of which you can access for free at:
http://bjsm.bmj.com/content/39/8/497#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections
Articles on similar topics can be found in the following collections
Musculoskeletal syndromes (431)

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/