ORIGINAL ARTICLE

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, or the 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 measures 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


Abbreviations: 1.25(OH)2D3, 1.25-dihydroxy-vitamin D3; 25(OH)D, 25-hydroxyvitamin D; B-ALP, bone alkaline phosphatase; BMD, bone mineral density; BMI, body mass index; bpm, beats per minute; CTX, type I collagen C-telopeptide; CV, coefficient of variation; Hb, haemoglobin; Hct, haematocrit; HR, heart rate; iCa, ionised calcium; iPTH, intact parathyroid hormone; IRA, immunoradiometric assay; OC, osteocalcin; RER, respiratory exchange ratio; RIA, radioimmunoassay; VO2max, VO2, oxygen consumption
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, cardiovascular 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 questionnaires 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 supplementation, 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, according to age and sex. Different equations were thus specifically developed for men (VO₂max th (ml kg⁻¹ min⁻¹) = 44.23−0.31×age) and women (VO₂max th (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.

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

Ionised 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-hydroxyvitamin D RIA kit, Nichols Institute Diagnostics, Paris, France). The intra- and inter-assay CVs were 5% and 8.1%, respectively. Assay sensitivity was <1.2 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%, respectively. 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 phosphatase (B-ALP) was measured by IRMA assay (Tandem-R Ostase, Hybritec, San Diego, CA). The sensitivity of the assay was 0.2 ng ml⁻¹, and the intra- and inter-assay CVs were less...
RESULTS

The anthropometric data and the parameters of physical fitness of the participants are shown in Table 1. VO\textsubscript{2max} represented 150% of the predicted value, highlighting the high physical fitness of our population. According to the physical activity questionnaire previously established, all subjects were classified in the medium or high physical activity categories.

Table 1 Characteristics of the study participants

<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\textsuperscript{-2})</td>
<td>23.6 (2.9)</td>
<td>18.7–31.1</td>
</tr>
<tr>
<td>VO\textsubscript{2max} (l min\textsuperscript{-1})</td>
<td>2.06 (0.77)</td>
<td>1.16–3.49</td>
</tr>
<tr>
<td>VO\textsubscript{2max} (ml min\textsuperscript{-1} kg\textsuperscript{-1})</td>
<td>30.5 (7.1)</td>
<td>18.3–45.1</td>
</tr>
<tr>
<td>VO\textsubscript{2max} th (ml min\textsuperscript{-1} kg\textsuperscript{-1})</td>
<td>20.1 (3.5)</td>
<td>14.6–25.6</td>
</tr>
<tr>
<td>% VO\textsubscript{2max} th (ml min\textsuperscript{-1} kg\textsuperscript{-1})</td>
<td>151.4 (12.5)</td>
<td>125–195</td>
</tr>
<tr>
<td>Exercise duration (min)</td>
<td>8–13</td>
<td></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; VO\textsubscript{2max}, maximal O\textsubscript{2} uptake. VO\textsubscript{2max} th, theoretical maximal O\textsubscript{2} uptake.

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\textsuperscript{-1}. The reference range for CTX was <5500 pmol l\textsuperscript{-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.

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 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)\textsubscript{2}D\textsubscript{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).

Table 2 Parameters of calcium homeostasis before and after exercise

<table>
<thead>
<tr>
<th>Biochemical parameters</th>
<th>Pre-exercise</th>
<th>Post-exercise</th>
<th>%Δ</th>
<th>p value</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium homeostasis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iCa (mmol l\textsuperscript{-1})</td>
<td>1.185 (0.027)</td>
<td>1.150 (0.034)</td>
<td>−3</td>
<td>&lt;0.001</td>
<td>1.10–1.25</td>
</tr>
<tr>
<td>25(OH)D (pg ml\textsuperscript{-1})</td>
<td>23.4 (11.2)</td>
<td>21 (9.3)</td>
<td>−10.3</td>
<td>0.013</td>
<td>16–28</td>
</tr>
<tr>
<td>1.25(OH)\textsubscript{2}D\textsubscript{3} (pg ml\textsuperscript{-1})</td>
<td>46 (12.5)</td>
<td>46.1 (12.9)</td>
<td>0.2</td>
<td>0.900</td>
<td>20–66</td>
</tr>
<tr>
<td>iPTH (pg ml\textsuperscript{-1})</td>
<td>28.9 (9.7)</td>
<td>36.2 (11.8)</td>
<td>−25</td>
<td>&lt;0.001</td>
<td>10–55</td>
</tr>
<tr>
<td>Other parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hct (%)</td>
<td>43.1 (3.7)</td>
<td>43.4 (3.6)</td>
<td>0.7</td>
<td>0.850</td>
<td>39–54</td>
</tr>
<tr>
<td>Hb (g dl\textsuperscript{-1})</td>
<td>14 (1.2)</td>
<td>14 (1.1)</td>
<td>0</td>
<td>0.958</td>
<td>13–18</td>
</tr>
</tbody>
</table>

Data are expressed as means (SD). 1.25(OH)\textsubscript{2}D\textsubscript{3}, 1,25-dihydroxy-vitamin D\textsubscript{3}; 25(OH)D, 25-hydroxyvitamin D; Hb, haemoglobin; Hct, haematocrit; iCa, ionised calcium; iPTH, intact parathyroid hormone; %Δ, 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, probably 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 x-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 PTH secretion. Brent et al. found a strong relationship between extracellular iCa concentration and PTH secretion. This relationship was represented by an inverse sigmoidal curve, suggesting that a slight modification in iCa concentration induces large reciprocal changes in serum PTH. The net changes in these parameters cannot be attributed to haemoconcentration, since no variation in Hct or Hb was observed. It is more probable that the metabolic acidosis induced by strenuous exercise was the main factor inducing the calcium metabolism disturbance. Ashisawa et al. reported an increase in urinary calcium excretion after a single bout of resistance exercise through a decrease in renal calcium reabsorption. These alterations were not accompanied by an increase in osteoclast activity. The imbalance between urinary Ca excretion and Ca release from bone may induce a net decrease in serum iCa level. In addition, Lopez et al. demonstrated that acidosis may also have a direct effect on the increase in PTH secretion independently of calcium level.

The findings reported in the literature concerning the effect of physical activity on PTH and iCa values are conflicting and the degree of variation might reflect differences in the intensity and duration of the exercise. Our results were, nevertheless, in agreement with those of Bouassida et al. who found a decrease in iCa levels and a rise in PTH levels in young subjects during continuous exercise at 70 and 80% of Vo2max. These findings were also observed by Nishiyama et al. in athletic and non-athletic young men after short and moderately intense exercise. In contrast, Kristoffersson et al. found increased iCa levels after short term maximal work, without significant changes in the serum PTH levels. PTH has been shown to act directly on osteoblasts, whereas its action on osteoclasts is mediated by local factors. Animal experiments have demonstrated that intermittent administration of PTH increased bone mass and improved trabecular bone microarchitecture, whereas continuous administration by infusion at the same mean rate leads to a net loss of bone mass and altered bone structure. In accordance with these experimental results, a therapeutic protocol with daily injections of PTH produced the largest gain in trabecular bone mass and reduced the risk of fracture in osteoporotic patients. Although our results seem to lend support to these findings, the small iPTH variation and the short duration of our study make it difficult to interpret the increase in iPTH during physical exercise as a potential factor to improve bone health. The physiological and clinical significance of the iPTH variation related to strenuous exercise thus remains to be determined.

### Table 3  Biochemical markers of bone turnover before and after exercise

<table>
<thead>
<tr>
<th>Biochemical parameters</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></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTX (pmol l⁻¹)</td>
<td>5998 (3045)</td>
<td>5959 (2866)</td>
<td>0.945</td>
<td>&lt;5500</td>
</tr>
<tr>
<td>Bone formation markers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC (ng ml⁻¹)</td>
<td>12.7 (5.5)</td>
<td>12.5 (5.3)</td>
<td>0.627</td>
<td>5-20</td>
</tr>
<tr>
<td>B-ALP (ng ml⁻¹)</td>
<td>13.1 (4.8)</td>
<td>13.2 (4.7)</td>
<td>0.605</td>
<td>4-16</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 4  Pearson correlation coefficient of the relationships between age, BMI, and basal biochemical parameter levels

<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>0.175</td>
<td>0.263</td>
<td>-0.341</td>
<td>-0.427*</td>
<td>-0.410*</td>
<td>-0.364</td>
</tr>
<tr>
<td>iCa</td>
<td>0.017</td>
<td>0.142</td>
<td>0.154</td>
<td>0.236</td>
<td>-0.341</td>
<td>-0.427*</td>
<td>-0.410*</td>
<td>-0.364</td>
</tr>
</tbody>
</table>
| 25(OH)D   | 0.464     | 0.281     | 0.585** | 0.506**    | -0.506**| -0.410*| -0.364 | -0.584
| 1,25(OH)2D| -0.468    | -0.154    | 0.136   | 0.148      | 0.075**| 0.821**| 0.750**|

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.
Figure 1  Relationship between age and basal iPTH levels. iPTH, intact parathyroid hormone.

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,34 or serum B-ALP and serum OC, which are considered to reflect newly synthesised bone.35 36 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.37 38 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,39 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.40 41 Therefore, the relatively short duration of exercise (range 8–13 min), as well as the short time of post-exercise investigation,40 41 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.42 This was confirmed by Wallace et al40 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/and release of bone markers, must be carried out.

CONCLUSION
In active elderly subjects, calcium homeostasis and bone metabolism related factors 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 endocrine modifications. Finally, no measurable effect on bone turnover could be demonstrated immediately after strenuous physical exercise.

ACKNOWLEDGEMENTS
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Competing interests: none declared

REFERENCES

What is already known about 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.


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