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GH responses to two consecutive bouts of whole body vibration, maximal voluntary contractions or vibration alternated with maximal voluntary contractions administered at 2-h intervals in healthy adults

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ABSTRACT

Background: Pharmacological or exercise stimuli repeated at a short interval (but not electrical muscle stimulation) are associated with a blunting of GH responsiveness.
Aim: To compare GH responses to repeated bout of three different GH-releasing stimuli.
Methods: The effects of two consecutive bouts (with a 2-h interval) of whole body vibrations (WBV), maximal voluntary contractions alone (MVC), or alternated with WBV (MVC–WBV) on blood GH and lactate (LA) were assessed in nine young males.
Results: Baseline levels of both GH and LA increased significantly after the first bout of all the tested stimuli, and were significantly lower after WBV than after MVC or MVC alternated with WBV, no difference being detected between these last. The administration of a second bout resulted in significantly lower GH increases than those elicited in the first bout in the three different tests; significantly lower LA responses were recorded after the second bout of MVC and MVC–WBV when compared with those obtained after the first bout, while no significant differences were observed after the two WBV bouts for LA. All responses after the second bout of MVC and MVC–WBV were significantly higher than those observed after WBV alone. GH concentrations were significantly correlated with LA after all stimuli, although LA concentrations after the second bout were associated with markedly lower GH levels.
Conclusions: A significant blunting of GH responsiveness ensues after a second bout of different GH-releasing stimuli, independent from the amount of GH released after the first bout. This is a pattern also observed for other pharmacological stimuli and exercise modalities, and suggests a common mechanism underlying different GH-releasing stimuli.

1. Introduction

The secretion of growth hormone (GH) is mainly under the influence of hypothalamic GH-releasing hormone (GHRH) and somatostatin, and GH regulates its own secretion via a negative auto-feedback mechanism, which operates at both at the pituitary and hypothalamic levels [1]. Increased GH concentrations evoke prompt hypothalamic somatostatin release, which in turn inhibits GHRH secretion, blocks pituitary GH exocytosis GH and sensitizes somatotrophs to the next GHRH stimulus [1]. In healthy adults, repeated GHRH stimuli administered at 2-h intervals are associated with blunting of GH responsiveness to the second stimulus [2–5], with restoration of GH responsiveness occurring when the time elapsed between the two pharmacological stimuli is longer [6].

Similar results have been reported with repeated bouts of high-intensity physical exercise, an attenuation of GH response being present when the exercise bouts are repeated within 1–2 h [6–8]. Reciprocal to the pattern recorded with repeated GHRH administration, normal GH responsiveness reappears progressively as the time interval between the two consecutive stimuli increases. When the interval between the two stimuli was 6 h, the GH response after the second exercise bout was comparable with that observed after the first bout [6]. By contrast, we have recently demonstrated that non-voluntary physical exercise (electrical stimulation of lower limb

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muscles) was able to maintain GH responsiveness also after a second bout repeated at a 2-h interval [9], probably due to the low GH response to the first bout (mean GH peak of 4.5 μg/l) in comparison to the greater response elicited by pharmacological and high-intensity voluntary exercise (>25 μg/l).

Among the different tools for strength training exercise, vibrating platforms have become increasingly popular and used in sport settings and rehabilitation institutes [10,11]. Whole body vibration (WBV), i.e., standing in different static positions or exercising on a vibrating platform, is being commercially promoted as an attractive and efficient complement or as an alternative to strength training for the enhancement of muscle function and athletic performance [12–18]. Recent evidence suggests that acute vibration exercise elicits a specific warm-up effect and that vibration improves muscle power, although the potential benefits over traditional forms of resistive exercise are yet to be completely understood [18]. Hormonal evaluation of healthy young and old subjects after acute sessions of WBV has yielded conflicting results. Particularly, Bosco et al. [19] have shown a sharp rise in circulating GH levels, a finding which could not be replicated by other authors [20,21]. We have recently detected a significant rise in plasma GH concentration after acute WBV in young male volunteers, although it was much less marked than that observed after isometric muscle contractions [22].

The aim of the present study was to compare changes in GH and lactate concentrations between three bouts of different GH-releasing stimuli: WBV, maximal voluntary contractions (MVC) and MVC alternated with WBV (MVC–WBV), administered at a 2-h interval in healthy adults. We have hypothesised that, due to the relatively small response of GH secretion to WBV [22], a second bout of the vibrating stimulus could not blunt the hormonal response, similar to what was observed after electrical muscle stimulation (9).

2. Materials and methods

2.1. Subjects

Nine healthy male adults, recruited among friends and colleagues (mean age ± S.D.: 23 ± 2 years, range: 21–26 years; weight: 68 ± 9 kg, range: 58–81 kg; body mass index (BMI): 22.2 ± 0.8 kg/m^2, range: 21.0–23.8 kg/m^2), volunteered to participate in this investigation after giving their written informed consent. The study protocol was approved by the Ethical Committee of the Italian Institute for Auxology. All the subjects were habitually active but were not involved in strength or endurance training on a regular basis, and none of them had any signs of musculoskeletal disorders.

Subjects were asked not to perform any strenuous exercise for at least 48 h prior to the experiment. None of them reported ingestion of drugs or nutritional supplements known to interfere with GH and/or cortisol secretion. The subjects were admitted to the laboratory 1 h before the start of the tests, after an overnight fast (10–14 h); all tests started between 8 and 8.30 AM.

2.1.1. Testing

All the subjects admitted to the study performed two consecutive and identical bouts of exercise (separated by 2 h) under the following conditions: WBV, MVC, and MVC alternated with WBV (MVC–WBV). The three different protocols were randomly performed in separate days with an interval of at least two days in between.

After a standardized warm-up (5 min on a cycloergometer; power: 50 W, cadence: 60 rpm), the different protocols were completed as follows. In WBV, subjects initially seated in a semi-recumbent position on a horizontal leg press machine (Technogym, Gambettola, Italy) for 30 s, with the trunk–thigh and thigh–shank angles at 80°, without making any efforts. Then a 30-s WBV bout was delivered while the subject stood on a vibrating platform (Nevisys H1©, RME, Ferrara, Italy) with the knees at 110°. The vibration platform produced vertical sinusoidal vibrations at a frequency of 35 Hz. At a peak-to-peak amplitude of vibration of 5 mm the acceleration of the platform was 2.85 g, as assessed with the standing subject by means of a magnetic monoaxial accelerometer (Vibration Meter, Lutron VB-8200).

These two rest–WBV cycles were repeated 15 times, for a total duration of 15 min. In MVC, subjects were initially placed on the leg press machine in the same supine position as in the WBV protocol, and performed three 5-s MVC, separated by 5-s resting periods in between. Then, 30 s of rest was respected in the same static position as WBV, with the knees at 110° but without WBV. These two MVC–rest cycles were repeated 15 times, for a total duration of 15 min. In MVC–WBV, subjects initially performed the three 5-s MVC like in the MVC condition, and then received the 30-s WBV bout, as in the WBV condition. These two MVC–WBV cycles were repeated 15 times, for a total duration of 15 min. The temporal pattern of the different protocols is summarised in Fig. 1.

The force generated during isometric efforts in tests MVC and MVC–WBV was measured by a strain gauge (Globus, Codognè, Italy) properly mounted on the leg press machine with chains attached to the frame of the machine and the sliding axis of the leg press seat. The signal from the strain gauge was sampled at 100 Hz and stored on a computer for later analysis with a commercially available software (TCS-SUITE 400, Globus, Codognè, Italy). The average isometric force developed during MVC and MVC–WBV was comparable, both for the first bout (MVC: 196 ± 42 kg; MVC–WBV: 186 ± 46 kg, $p = 0.164$), and for the second one (MVC: 180 ± 44 kg; MVC–WBV: 172 ± 43 kg, $p = 0.503$).

2.1.2. Blood sampling and measurements

Blood samples for glucose and GH measurements (5 ml at each time point) were collected before the start (baseline) and immediately after each 15-min exercise bout at 0, 10, 20 and 30 min post-exercise. While the baseline blood sample was obtained by syringe venipuncture, the remaining ones were drawn through an indwelling cannula inserted into an ante-cubital vein kept patent via a continuous infusion of isotonic saline. This approach was used both for the first and the second bouts of exercise. Between the end of the last blood sampling, ensuing the first bout and the baseline sampling of the second bout, the subjects were asked to stay relaxed in a semi-recumbent position. All blood samples were allowed to clot, centrifuged for 5 min, and immediately stored at −20 °C for the next analysis. Blood glucose levels were determined by an oxidase enzymatic method (Roche Diagnostics GmbH, Mannheim, Germany) and GH concentrations by a commercially available immunometric kit (Immulite 2000, DPC, Los Angeles, CA, USA).

In addition to peak GH values, integrated GH concentration [net incremental area under the curve (nAUC)] over 45 min, including all time points, was calculated by using the trapezoidal method [23]. All samples were run in the same assay to minimize inter-assay variability. Intra- and inter-assay coefficients of variation were 2.5% and 6%, respectively.

Before the standardized warm-up, a small blood sample (5 μl) was obtained from the earlobe for the determination of basal lactate concentration. The next blood samples were obtained immediately after the end of exercise and at 2-min intervals until the detection of the peak value. Blood lactate was measured by a portable analyzer (Lactate Pro, Akray, Japan). Intra- and inter-assay coefficients of variation were 3% and 7%, respectively.

2.1.3. Muscle soreness

Muscle soreness was assessed 24 and 48 h after exercise using an 11-point visual analogue scale (VAS), starting from “no pain” (level 0) up to “extremely painful” (level 10). Subjects were asked to mark their pain level on the VAS under supervision of the examiner, and the marked point provided a numeric measure of soreness.