Growth hormone and lactate responses induced by maximal isometric voluntary contractions and whole-body vibrations in healthy subjects

A. Sartorio1, F. Agosti1, A. De Col1, N. Marazzi1, F. Rastelli2, S. Chiavaroli2, C.L. Laforluna3, S.G. Cella4, and A.E. Rigamonti4

1Istituto Auxologico Italiano, Laboratorio Sperimentale di Ricerche Auro-endocrinologiche, IRCCS, Milan; 2Facoltà di Scienze motorie, Università degli Studi dell’Aquila, L’Aquila; 3Istituto di Bioimmagini e Fisiologia Molecolare, Consiglio Nazionale delle Ricerche, Segrate; 4Dipartimento di Farmacologia Medica, Università degli Studi di Milano, Milan, Italy

ABSTRACT. Background: In contrast with maximal voluntary resistance exercise, which is allegedly considered a potent GH stimulus in young subjects, evaluation of GH response to whole-body vibrations (WBV) has yielded conflicting results. Methods: The acute effects of WBV alone (test A), maximal voluntary isometric contractions (MVC) (test B), and combination of WBV and MVC (test C) on serum GH and blood lactate (LA) levels were studied in 9 healthy adult males. Muscle soreness was assessed 24 and 48 h after exercise by a visual analogue scale. Results: GH responses were significantly higher after tests B and C than after test A (GH peaks: 18.8±9.5 ng/ml or 20.8±13.7 ng/ml, respectively, vs 4.3±3.5 ng/ml; p<0.05), with no difference between tests B and C. LA concentrations significantly increased after tests A, B, and C, being significantly higher after tests B and C than after test A (LA peaks: 2.0±0.5 mmol/l or 6.7±2.3 mmol/l, respectively, vs 7.6±0.9 mmol/l; p<0.05). Peak LA values were significantly correlated to GH peaks in the 3 tests (r=0.48; p<0.05). Muscle soreness was significantly higher 24-48 h after tests B and C than after test A, no significant differences being present between tests B and C. Conclusions: WBV stimulates GH secretion and LA production, with no additive effect when combined with repeated isometric voluntary contractions. Optimization of protocols based on WBV seems important to maximize the positive effects of this intervention on the somatotropic function. (J. Endocrinol. Invest. 34: 216-221, 2011)

INTRODUCTION

Exercise is the most potent physiologic stimulus to GH release (1). GH levels start to increase 10-20 min after the onset of exercise, peak either at the end or shortly after exercise and remain elevated for up to 2 h following exercise (2).

The magnitude of the GH response to exercise is influenced by age (3-5), gender (6-8), body composition (9, 10), physical fitness (11, 12), and the intensity (13-16), nature (17-19), and duration (20-22) of exercise.

The physiologic mechanisms through which GH secretion increases during exercise are not completely known, but changes in body temperature (23), blood lactate (LA) levels (14), and pH (24) have all been postulated. Supporting the role of LA is the observation that the GH response to exercise is greatly increased during anaerobic exercise (14). Against an effect of LA are the observations that infusion of sodium L-LA does not increase GH secretion (11), although this experimental model differs significantly from an exercise-induced metabolic acidosis. Furthermore, there is a linear rise in GH secretion with increased exercise intensity, which may be observed before the LA threshold is reached (16). However, LA production occurs very early in exercise, although it does not increase substantially in blood until the attainment of LA threshold (1). Therefore, an effect on GH secretion by LA cannot be completely ruled out.

In recent years, vibrating platforms have become increasingly available and used at sports and rehabilitation institutes. Whole-body vibration (WBV), i.e. standing in different static positions or exercising on a vibrating platform, is being commercially promoted as an attractive efficient and sufficient complement, or even alternative, to resistance training to enhance muscle strength and athletic performance. Anyway, according to the most recent literature, WBV appears to provide no or only minor additional effects on muscle physiology as compared with those of the same exercises without WBV (25, 26). On the contrary, WBV has been demonstrated to be a beneficial intervention for maintaining or improving bone mass among people with low bone mineral density and osteoporosis (27, 28).

Hormonal evaluation of healthy young and old subjects after acute sessions of WBV has yielded conflicting results. Particularly, Bosco et al. (29) have shown an increase in circulating GH levels, a finding which has not been confirmed by other authors (30, 31). Up to date, only one study has shown an increase in GH-releasing effect of WBV when combined with maximal voluntary contractions (32). Although the neuroendocrine mechanisms through which GH secretion is stimulated by maximal contractions are not fully known, there is evidence that adrenergic, cholinergic, and opioid pathways are in-
volved (1). The possibility that WBV and maximal voluntary contractions share the same neuroendocrine mechanisms has not been so far investigated. Therefore, aim of the present study was to compare the effects of maximal voluntary leg press exercise at equivalent force output and/or repeated vibration bouts on serum GH concentrations, blood LA, and muscle soreness.

MATERIALS AND METHODS

Study design

The study was approved by the Ethics Committee of the Italian Institute for Auxology and was conducted in accordance with the principles expressed in the Declaration of Helsinki. To compare the effects of repeated isometric contractions, repeated vibration bouts, and the combination of both (see below for detail) on GH and LA, a group of healthy voluntary subjects, recruited among friends and colleagues, was admitted to the study.

Subjects

Written informed consent was obtained from 9 healthy men [mean±SD; age: 23.8±1.9 yr, height: 172.4±10.1 cm, body mass: 65.4±9.4 kg; fat free mass (FFM): 90.1±5.3%] following detailed explanation of experimental procedures and associated risks. All subjects were habitually active and involved in training on a regular comparable basis, and none of them had any signs of musculoskeletal disorders. The subjects were asked not to perform any strenuous exercise for at least 48 h before and during the experimental period, and not to take any medication or nutritional supplements. No significant differences were present in the alimentary habits among the study groups.

Testing

All the subjects admitted to the study performed 3 different exercises [test A: repeated WBV bouts; test B: repeated maximal voluntary isometric contractions (MVC); test C: repeated MVC combined with repeated WBV bouts], in separate days, in random order and with an interval in-between of at least 2 days. After a common standardized warm-up protocol (5 min on a cycloergometer, Lode Excalibur Sport, Lode, The Netherlands, at 50 W, 60 rpm), different tests took place as follows.

In test A, subjects initially seated in semi-recumbent position on a horizontal leg press machine (Technogym, Gambettola, Italy) for a period of 30 sec, with the trunk-thigh and thigh-shank angles at 80°, without making any efforts. Then a 30-sec WBV was immediately delivered while subject stooded on a vibrating platform (Nevisys H1, RME, Ferrara, Italy, 35 Hz, amplitude: 4 mm) with the knee angle of 110°. These 2 periods were repeated with the same characteristics, without resting in-between for a total of 15 series.

In test B, subjects were initially placed on leg press machine in the same supine position of test A and performed three 5-sec MVC, separated by 5-sec resting periods in-between. Then followed a 30-sec permanence in the same static position of test A, with the knee angle of 110° but without WBV. These 2 periods were repeated with the same characteristics, without resting in-between for a total of 15 series.

In test C, subjects initially performed the three 5-second MVC like in test B, then received the 30-sec WBV, like in test A. These 2 periods were repeated with the same characteristics, without resting in-between for a total of 15 series. The 3 protocols are graphically summarised in Figure 1.

The force generated during MVC (in tests B and C) 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 recorded at 100 Hz and saved on a computer for subsequent analysis with commercially available software (TCS-SUITE 400, Globus, Codognè, Italy). FFM was assessed by bioelectric impedance analysis (Human-IM scan, DS Medigroup, Milan, Italy), performed in early morning after an overnight fast.

Blood sampling and measurements

Blood samples for GH determinations (5 ml for each time point) were collected immediately before the 5-min standardized warm-up (i.e. baseline) and immediately after the end of the total series of exercises at 0, 10, 20, and 30 min. While the baseline blood sample was obtained by syringe venipuncture, the remaining blood samples were drawn through an indwelling cannula inserted into an antecubital vein kept patent with a continuous infusion of isotonic saline. All blood samples were allowed to clot, centrifuged for 5 min to obtain serum, and immediately stored at –20°C for the next analysis. GH concentrations were determined by a commercially available immunometric kit (Immutopik 2000, DPC, Los Angeles, CA, USA). Intra- and inter-assay coefficients of variation for this assay were 2.5% and 6%, respectively. All of the samples were run in the same analysis to minimize inter-assay variability. The sensitivity of the method was 0.01 ng/ml.

Muscle soreness

Muscle soreness was assessed 24 and 48 h after exercise using a 11-points visual analogue scale (VAS), starting with “no pain” among friends and colleagues, was admitted to the study.

![Fig. 1 - Schemes of protocols used in the study: vibrations only (test A), isometric contractions only (test B), and combination of isometric contractions and vibrations (test C). WBV: whole-body vibrations; MVC: maximal voluntary isometric contractions. See the text for further details.](image-url)