Acute response of biochemical bone turnover markers and the associated ground reaction forces to high-impact exercise in postmenopausal women

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ABSTRACT: The aim of the study was to examine the acute response of biochemical bone turnover markers (BTM) to high-impact jumping exercise, and to quantify the ground reaction forces (GRF) achieved during each jumping exercise, in postmenopausal women. In a randomized controlled cross-over study over three days, 29 postmenopausal women (age (mean±SD): 60.0±5.6 years) were randomly assigned to 6x10 repetitions of three different jumps: countermovement jump (CMJ), drop jump (DJ), diagonal drop jump (DDJ). A fourth day without jumping served as a control (CON). Blood samples were collected before (PRE), after (POST), and 2 hours after (2Hr) exercise. Bone turnover was evaluated by bone formation markers (procollagen type-1 amino-terminal propeptide (P1NP) and osteocalcin (OC)) and the bone resorption marker C-terminal telopeptide of type-1 collagen (CTX). Peak anteroposterior (Fx), mediolateral (Fy), and vertical (Fz) GRF were measured using a force platform. From PRE to POST, P1NP increased ($p<0.01$) by 7.7±1.8%, 9.4±1.3%, and 10.6±1.6% for CMJ, DJ, and DDJ, which were higher ($p<0.01$) than CON. OC increased ($p<0.05$) by 5.5±1.8% for DJ, which was higher ($p<0.05$) than CON. CTX was not significantly changed at POST. There were no significant differences in BTM Δ-values between the jumps at any time point. For the CMJ, the combined three-axis peak GRF was positively associated with the PRE to POST Δ-change in P1NP ($r=0.71$, $p<0.05$). The acute, jumping-induced increase in P1NP and OC without any rise in CTX may indicate increased bone formation. Moreover, the study shows a dose-response relationship between GRF and the acute P1NP response after countermovement jumps.

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INTRODUCTION

Osteoporosis is a chronic bone disease of increasing public health concern. The disease is characterized by low bone strength due to reduced bone mass and impairment of bone micro-architecture, putting the patient at increased risk of bone fractures [1]. It is estimated to affect 200 million women worldwide, triggering more than 8.9 million fractures annually [2].

Thus, depending on the women's life stage, osteogenic exercise has different effects and aims [3]. For adolescents, the exercise is aimed at increasing peak bone mass, for premenopausal women it is aimed at increasing bone mineral density (BMD), and for postmenopausal women it is aimed at reducing the age-related bone loss [3,4]. In postmenopausal women, a combination of resistance and high-impact or odd-impact training is found to be effective in improving bone health [3,5].

The osteogenic effect of training is mostly estimated by dual-energy x-ray absorptiometry (DXA) [6]. Additionally, the International Osteoporosis Foundation (IOF) has recommended the use of biochemical bone turnover markers (BTM) as markers of fracture risk assessment and evaluation of treatment effectiveness in clinical settings [7], and the assessment of BTM [8] is a promising method to evaluate an osteogenic response in bone turnover acutely or after only a few weeks of training.

A number of studies have been conducted examining the acute effects of exercise on BTM in adults [8–21], but the results have