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Short-term effect of whole-body vibration training on balance, flexibility and lower limb explosive strength in elite rhythmic gymnasts

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The purpose of this study was to examine whether whole-body vibration (WBV) training results in short-term performance improvements in flexibility, strength and balance tests in comparison to an equivalent exercise program performed without vibration. Eleven elite rhythmic gymnasts completed a WBV trial, and a control, resistance training trial without vibration (NWBV). The vibration trial consisted of eccentric and concentric squatting exercises on a vibration platform that was turned on, whereas the NWBV involved the same training protocol with the platform turned off. Balance was assessed using the Rhythmic Weight Shift (RWS) based on the EquiTest Dynamic Posturography system; flexibility was measured using the sit & reach test, and lower limb explosive strength was evaluated using standard exercises (squat jump, counter movement jump, single leg squat). All measurements were performed before (pre) immediately after the training program (post 1), and 15 minutes after the end of the program (post 15). Data were analyzed using repeated measures ANOVA was used with condition (WBV-NWBV) as the primary factor and time (pre, post 1, post 15) as the nested within subjects factor, followed by post-hoc pairwise comparison with Bonferroni corrections. Results confirmed the hypothesis of the superiority of WBV

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training, especially in the post 15 measurement, in all flexibility and strength measures, as well as in a number of balance tests.

1. Introduction

Rhythmic gymnastics is a sport that combines elements of gymnastics, dance, and apparatus manipulation that require a great sense of balance. The integration of visual, vestibular and somatosensory components is used to maintain postural balance (Massion, 1994; Matheson, Darlington, & Smith, 1999). Postural control represents a complex interplay between the sensory systems, with the visual system to be the primary sensory information to maintain postural balance (Gaerlan, 2010; Gill et al, 2001). As one ages, the sensory systems used for balance decline (Cook & Woollacott, 2000; Ricci, Goncalves, Coimbra, & Coimbra, 2009). Although, optimal control of postural sway is achieved during late adolescence and maintained until about the age of 60 years (Liaw, Chen, Pei, Leong, & Lau, 2008), younger adults use distinct patterns of response and strategies to maintain their balance (Ricci et al., 2009), which are not the same as in other age groups (Choy, Brauer, & Nitz, 2003). The degree to which individuals rely on those information sources depends on task difficulty, cognitive load (Vuillerme & Nafati, 2007) and motor skill (Bressel, Yonker, & Kras, 2007; Schmit, Regis, & Riley, 2005). The suppression of one type of sensory information can be used to estimate the importance of that information to postural control and indicate how the central nervous system adapts and reorganizes information provided by the remaining sensory information (Teasdale, Stelmach, & Breunig, 1991).

A number of studies focused on the effects of whole-body vibration on postural control in Parkinson's disease. For example Haas, Turbanski, Kaiser, and Schmidtbleicher (2004) found that patients showed spontaneous improvements in balance depending on their postural disturbance and the test procedure. This is important in view of the findings by Buchman, Wilson, Luergans, & Bennett (2009) that vibratory thresholds are associated with mobility, supporting the link between peripheral sensory nerve function and mobility in the elderly. Finally in a meta-analysis conducted by Lau et al. (2011) it was concluded that whole body vibration is beneficial for enhancing leg muscle strength among older adults.

According to Kioumourtzoglou et al expert gymnasts can control their balance better than inexperienced athletes or novices and they relied mainly on visual cues to perform accurate complex movements (Danion, Boyadjian, & Marin, 2000; Kioumourtzoglou, Derri, Mertzanidou, & Tzetzis, 1997). Furthermore, the lateral sway of the center of pressure was smaller in dancers than in untrained subjects during unilateral leg movements performed while standing (Mouchnino, Aurenty, Massion, & Pedotti, 1992). Whole-body vibration (WBV) training requires standing on a vibration platform that generates to side to side alternating vertical sinusoidal mechanical vibration, and has been reported to be an effective method to enhance athletic performance (Cardinale & Wakeling, 2005; Rittweger, Beller, & Felsenberg, 2000) and improve muscle strength during a short time period (Cardinale & Bosco, 2003). However, Torvinen, Kannus, Sievanen, et al. (2003) reported that WBV training had no effect on the dynamic or static balance of the young subjects after either a 4-month or an 8-month treatment (Torvinen et al., 2002b). Despite the benefits on muscle strength, the efficacy of WBV on balance ability is still uncertain, and may be dependent on age (Ferber-Viart, Ionescu, Morlet, Froehlich, & Dubreuil, 2006) and physical conditions (Schuhfried, Mittermaier, Jovanovic, Pieber, & Paternostro-Sluga, 2005; van Nes, Geurts, Hendricks, & Duysens, 2004). Previous studies have suggested that WBV induces several neural and muscular changes, such as stimulation of human spindle endings (Burke, Hagbarth, Lofstedt, & Wallin, 1976a,b), and changes in biogenic amines (Ariizumi & Okada, 1985), which might lead to the improvement of contractile properties and muscle strength, and hence the balancing ability. It is therefore believed that the positive effects of WBV on the muscle performance (Bautmans, Van Hees, Lemper, & Mets, 2005; Schuhfried et al., 2005; van Nes et al., 2004) should help to improve balance (Okada, Hirakawa, Takada, & Kinoshita, 2001; Rudd, 1989). Further,