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Heart rate recovery and variability following combined aerobic and resistance exercise training in adults with and without Down syndrome

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ABSTRACT

Persons with Down syndrome (DS) are at high risk for cardiovascular morbidity and mortality, and there is compelling evidence of autonomic dysfunction in these individuals. The main purpose of this study was to determine whether a combined aerobic and resistance exercise intervention produces similar results in cardiac autonomic function between adults with and without DS. Twenty-five participants (13 DS; 12 non-DS), aged 27–50 years, were included. Aerobic training was performed 3 days/week for 30 min at 65–85% of peak oxygen uptake (VO_{2peak}). Resistance training was prescribed for 2 days/week and consisted of two rotations in a circuit of 9 exercises at 12-repetition-maximum. There was a significant improvement in the VO_{2peak} and muscle strength of participants with and without DS after training. Heart rate recovery improved at 1 min post-exercise, but only in participants with DS. Both groups of participants exhibited a similar increase in normalized high frequency power and of decrease in normalized low frequency power after training. Therefore, 12 weeks of exercise training enhanced the heart rate recovery in adults with DS, but not in those without DS. Contrasting, the intervention elicited similar gains between groups for cardiovagal modulation.

1. Introduction

Persons with Down syndrome (DS) are at high risk for cardiovascular morbidity and mortality (Esbensen, Seltzer, & Greenberg, 2007), and have low levels of cardiovascular fitness (Fernhall et al., 1996). There is compelling evidence that these individuals may exhibit cardiac autonomic dysfunction manifested as a reduced heart rate response to acute sympatho-stimulatory tasks (Agiovlasitis et al., 2010; Figueroa et al., 2005; Iellamo et al., 2005). The attenuated chronotropic response in adults with DS is associated with less vagal withdrawal than in adults without DS during isometric handgrip (Figueroa et al., 2005); following active standing (Iellamo et al., 2005) and upright tilt (Agiovlasitis et al., 2010). Importantly, adults with DS also have reduced heart rate recovery after peak exercise and this is independent of their lower chronotropic response to peak exercise (Mendonca & Pereira, 2010). To date, the only study that examined the effects of an exercise intervention on the cardiac autonomic function of persons with DS observed improved sympathovagal balance and increased vagal modulation after training (Giagkoudaki, Dimitros, Kouidi, & Deligiannis, 2010). Unfortunately, since these authors did not measure the participants' peak oxygen uptake (VO_{2peak}) at pre- or post-training periods, these results are difficult to interpret. As importantly, it is not known whether systematic exercise training can improve the autonomic profile of persons with DS in similar magnitude as in those without DS.

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Vagal modulation of heart rate is influenced by several physiological factors such as aging (Tulppo, Mäkikallio, Seppänen, Laukkanen, & Huikuri, 1998), obesity (Christou, Jones, Pimentel, & Seals, 2004), aerobic training (Al-Ani, Munir, White, Townend, & Coote, 1996; Iwasaki, Zhang, Zuckerman, & Levine, 2003; Levy et al., 1998; Melanson & Freedson, 2001) and physical fitness (Tulppo et al., 1998). Longitudinally, increases in measures of heart rate variability (HRV) in healthy persons have been demonstrated following intense ($\geq$85% VO_{2peak}) or prolonged ($\sim$30 weeks) moderate intensity aerobic training (Al-Ani et al., 1996; De Meersman, 1992; Levy et al., 1998; Melanson & Freedson, 2001). The beneficial effects of exercise training on HRV indices have also been detected in patients with sympathovagal imbalance, such as those with coronary artery disease, heart failure, end-stage renal disease on dialysis and diabetes mellitus (Androne, Hryniewicz, Goldsmith, Arwady, & Katz, 2003; Deligiannis, Koudi, & Tourkantonis, 1999; Pagkalos et al., 2008; Tsai et al., 2006). Similarly, faster heart rate recovery has also been reported after 4 weeks of aerobic training in healthy adults and after 2 weeks of cycle-ergometry in cardiac patients (Legramante, Iellamo, Massaro, Sacco, & Galante, 2007; Sugawara, Murakami, Maeda, Kuno, & Matsuda, 2001). This is important because heart recovery after peak exercise has also been advanced as an index of vagal reactivation (Pierpont & Voth, 2004) and a prognostic marker of sudden death and all-cause mortality (Cole, Blackstone, Pashkow, Snader, & Lauer, 1999; Jouven et al., 2005; Molgaard, Sorensen, & Bjerregaard, 1991).

The primary purpose of this study was to determine whether 12 weeks of combined exercise training, using both aerobic and resistance exercise, results in similar responses in resting cardiac autonomic function and heart rate recovery after peak exercise in adults with and without DS.

2. Materials and methods

2.1. Participants

Thirteen individuals with DS (10 men and 3 women) and 12 individuals without DS (9 men and 3 women) matched for sex participated in this study. The two groups did not differ in age or body mass index (BMI); however, participants with DS had shorter height and lower body mass ($p < 0.05$; Table 1). All participants were healthy, as assessed by medical history, and had medical clearance from a personal physician to participate in the study. No participants with ambulatory, metabolic, endocrine, musculoskeletal, severe visual or auditory problems were included in this study. None of the participants from either group had any background in regular endurance or resistance training for at least 6 months. They all were normotensive, non-smokers, and were not taking any medications at the time of the study. Participants were familiarized with the testing and training equipment used in the study for approximately 2 weeks before data collection. Familiarization sessions were continued until the following criteria were met by each participant: (1) ability to walk comfortably on the treadmill without handrail support and (2) proper lifting technique (correct biomechanical motion) in 9 different resistance training exercises. The study was conducted according to the declaration of Helsinki and was approved by the Institutional Review Board. All participants and the legal guardians of those with DS provided written informed consent.

2.2. Experimental design

This study included 12 weeks of combined aerobic and resistance training. Heart rate recovery and HRV measurements were carried out prior (pre-training) and following (post-training) the training period in both groups of participants. Participants were evaluated over the course of two visits, on separate days, at both pre- and post-training periods. During the first visit, after a 12-h overnight fast, participants performed a treadmill graded exercise test to determine their heart rate recovery. During a second visit (48 h after the first visit), each participant rested while lying down in the supine position (with their face up) on a bed in a quiet, semi-dark environment for 10 min of R–R interval data collection under spontaneous breathing conditions. Participants were tested in the postprandial state ($\sim$12 h) and asked to refrain from caffeine and exercise for 24 h before testing. After the 12 weeks of training, all participants repeated the testing procedures under the same conditions and at the same time of day. This report describes the second part of a larger study designed to explore the physiological effects of a combined aerobic and resistance training regimen on adults with and without DS. Other outcomes (i.e., cardiorespiratory and metabolic data) have been presented in more detail elsewhere (Mendonca, Pereira, & Fernhall, 2011).

Table 1
Characteristics of participants with and without Down syndrome (DS) at pre-training conditions.

Variable	DS ($n = 13$)	Non-DS ($n = 12$)
Age (years)	36.5 ± 1.5	38.7 ± 2.4
Body mass (kg)	$68.6 \pm 2.6^{*}$	81.2 ± 4.9
Height (cm)	$152.9 \pm 2.2^{*}$	174.3 ± 1.8
Body mass index (kg/m^2)	29.3 ± 1.0	26.6 ± 1.3

Note. Values are expressed as mean $\pm$ standard error of the mean.
* Between-group differences at $p < 0.05$.