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Reduced metaboreflex control of blood pressure during exercise in individuals with intellectual disability: A possible contributor to exercise intolerance

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ABSTRACT

The aim was to investigate the hemodynamic responses to isometric handgrip exercise (HG) and examine the role of the muscle metaboreflex in the exercise pressor response in individuals with intellectual disability (IID) and non-disabled control subjects. Eleven males with mild-moderate intellectual disabilities and eleven non-disabled males performed a testing protocol involving 3-min periods of baseline, HG exercise (at 30% MVC), circulatory occlusion, and recovery. The same protocol was repeated without occlusion. At baseline, no differences were detected between groups in beat-to-beat mean arterial pressure (MAP), heart rate (HR), stroke volume, and peripheral resistance. IID were able to sustain an exercise MAP response at comparable levels to the control group exerting similar peripheral resistance; however, IID exhibited a blunted chronotropic response to HG and a diminished exercise vagal withdrawal compared to controls. During occlusion, IID exhibited a lower pressor response than their control peers, associated with a lower increase in peripheral resistance during this task. In conclusion, although intellectual disabilities can be the consequence of many different genes, IID share common deficits in the chronotropic response to exercise and a blunted metaboreflex-induced pressor response

1. Introduction

Intellectual disability is a disorder characterized by impaired cognitive and adaptive skills, caused by multiple gene overexpression, single-gene mutations, different non-syndromic genes, as well as environmental factors (Chiurazzi & Oostra, 2000). In individuals with intellectual disabilities (IID), there is a failure of growth and maturation in brain areas during the developmental years. Post-mortem neuropathological studies in IID have shown detectable alterations in the cerebral cortex structure and in the hippocampus and a reduction in number of neurons (Dierssen & Ramakers, 2006); however, in some mild forms of intellectual disabilities, little if any changes in brain macroanatomy are observed. In spite of many differences in the manifestation of intellectual disabilities, there is a consistent feature across the multiple conditions: dendritic abnormalities (Dierssen & Ramakers, 2006; Fodale, Mafrica, Caminiti, & Grasso, 2006), and neurotransmitter system dysfunction with abnormal neuronal connectivity, resulting in deficient information processing (Kaufmann & Moser, 2000).

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Persons with intellectual disability experience similar health problems to the general population (Kerr, 1997), however, the frequency of occurrence of several chronic diseases, such as coronary artery disease, hypertension, and diabetes, is higher. In addition, IID have higher body mass index and obesity levels compared with non-disabled individuals (Pitetti & Campbell, 1991). Longitudinal research has indicated an increasing trend of these health risks over the years (Graham & Reid, 2000). Therefore, the need to increase physical fitness and promote an active lifestyle in IID has been emphasized. However, IID exhibit differences in physiological parameters during exercise compared with the general population, such as low levels of muscle strength and power (Fernhall & Pitetti, 2000), low peak oxygen consumption (Fernhall et al., 1996), as well as 8–12% lower than expected maximal heart rate and diminished work capacity (Fernhall et al., 1996). The lower maximal heart rates in IID were evident even when criteria for maximal effort were achieved, suggesting a dysfunction in the neural control of heart rate during exercise. Fernhall and Otterstetter (2003) reported that in adults with Down syndrome without congenital heart defects, the blood pressure (BP) and heart rate (HR) responses to a variety of adrenergic perturbations, were blunted. On the basis of these hemodynamic alterations and chronotropic incompetence, the authors speculated that persons with Down syndrome have reduced sympathetic activation in parallel with reduced vagal withdrawal (Fernhall et al., 2005; Iellamo et al., 2005). Although the evaluation of the sympathetic/parasympathetic system and baroreceptors function, at rest and during exercise, can provide answers to the increased risk of developing heart disease in IID, only a few studies have directly assessed the autonomic system function at rest and during sympathetic stimulation in Down syndrome and even fewer studies in non-syndromic IID (Fernhall & Otterstetter, 2003; Iellamo et al., 2005).

Isometric handgrip exercise (HG) is often used as a physiological excitatory stimulus for assessing the prompt responses of the autonomic nervous system. During HG, the neural control of circulation depends on the interaction between the receptors of the brain's motor cortex (central command) and the peripheral afferents (baroreceptors, mechanoreceptors and metaboreceptors). This system regulates cardiac output, peripheral resistance, and ventilation, in an attempt to remove the muscle byproducts of metabolism. The majority of studies in IID to date, that investigated the neural sympathetic modulation during sympatho-stimulatory tasks have used procedures involving central command and mechanoreflex activation (Fernhall & Otterstetter, 2003; Iellamo et al., 2005). The metaboreflex contribution to the blunted hemodynamic responses in IID, when central command is not involved has not been evaluated.

Understanding the factors that contribute to the low physical fitness levels in IID can assist in designing better fitness programs and promote an active lifestyle, increase work capacity, and therefore, decrease health risks, as well as the need for premature institutionalization. Therefore, the aims of the study were (i) to evaluate the hemodynamic function during isometric handgrip exercise and recovery and (ii) to assess the contribution of the metaboreflex to the exercise pressure response, in IID and non-disabled control individuals (ND-control). Our hypothesis was that IID would demonstrate a lower chronotropic response during HG and a lower pressor response during the metaboreflex activation compared to the ND-control group.

2. Materials and methods

2.1. Participants

Eleven healthy adult males with mild to moderate intellectual disabilities (chronological age 26.4 ± 0.5 years, IQ score on the Weschler Intelligence Scale, 55 ± 5) and eleven healthy age-matched non-disabled males (aged 25.1 ± 0.5 years) volunteered for the study. IID were recruited from the local community (local support groups), in collaboration with the local technical school for IID. They all lived at home or group settings and they were not institutionalized. Volunteers with known major diseases, such as cardiovascular, respiratory, metabolic, or renal disease as well as participants who were under medication were excluded from the study. None of the IID had severe mental retardation, Down syndrome or fragile X syndrome. IID participated in regional track and field events (non-competitive, Level 1).

The study was conducted in conformity with the Declaration of Helsinki and was approved by the institutional review board committee. Detailed information on the study benefits, risks, and procedures were provided to the adult ND-control participants and the parents or the direct caregivers and legal guardians of the IID. All adult participants and legal guardians signed the written informed consent form and completed a medical questionnaire. The participants were asked to follow their normal daily diet, to have sufficient rest the night before the study, to abstain from intense exercise activity for at least 24 h before the study, and not to consume any food, water or tobacco products at least three hours before the test. In addition, participants were asked to abstain from any coffee consumption the day of the testing.

2.2. Testing procedures and instrumentation

After participants' familiarization with equipment and procedures, their height and body mass were measured using an accurate stadiometer and a weighing scale (SECA, Hamburg, Germany). BMI was calculated in kg/m^2. Then, maximal voluntary contraction (MVC) was recorded using a Jamar hydraulic dynamometer (5030J, Sammons Preston, Chicago, IL). Each participant performed three maximal isometric handgrip (HG) trials with the dominant hand, with the elbow flexed at a 90° angle. Participants received "standardized" instructions as described by Mathiowetz, Rennells, and Donahoe (1985). The highest reading was considered as the maximal handgrip strength (maximal voluntary contraction, MVC) and was included in the data analysis (Mathiowetz et al., 1985). The trials were intercepted by 120-s intervals.