PM R XXX (2018) 1-10

www.pmrjournal.org

Original Research

Exercise Prescription Using a Group-Normalized Rating of Perceived Exertion in Adolescents and Adults With Spina Bifida

Theresa M. Crytzer, PT, DPT, ATP, Mariam Keramati, DO, Steve Anthony, MS, Yu-Ting Cheng, MS, Robert J. Robertson, PhD, Brad E. Dicianno, MD, MS

Abstract

Background: People with spina bifida (SB) face personal and environmental barriers to exercise that contribute to physical inactivity, obesity, risk of cardiovascular disease, and poor aerobic fitness. The WHEEL rating of perceived exertion (RPE) Scale was validated in people with SB to monitor exercise intensity. However, the psycho-physiological link between RPE and ventilatory breakpoint (Vpt), the group-normalized perceptual response, has not been determined and would provide a starting point for aerobic exercise in this cohort.
Objectives: The primary objectives were to determine the group-normalized RPE equivalent to Vpt based on WHEEL and Borg Scale ratings and to develop regression model to predict Borg Scale (conditional metric) from WHEEL Scale (criterion metric). The secondary objective was to create table of interchangeable values between WHEEL and Borg Scale RPE for people with SB performing a load incremental stress test.
Design: Cross-sectional observational.
Setting: University laboratory.
Participants: Twenty-nine participants with SB.
Methods: Participants completed a load incremented arm ergometer exercise stress test. WHEEL and Borg Scale ratings recorded the last 15 seconds of each 1-minute test phase.
Outcome Measures: WHEEL and Borg Scale ratings, metabolic measures (eg, oxygen consumption, carbon dioxide production). Determined Vpt via plots of oxygen consumption and carbon dioxide production against time.
Results: Nineteen of 29 participants achieved Vpt (Group A). The mean $\pm$ standard deviation peak oxygen consumption at Vpt for Group A was 61.76 ± 16.26. The WHEEL and Borg Scale RPE at Vpt were 5.74 ± 2.58 (range 0-10) and 13.95 ± 3.50 (range 6-19), respectively. A significant linear regression model was developed (Borg Scale rating $= 1.22 \times$ WHEEL Scale rating $+ 7.14$) and used to create a WHEEL-to-Borg Scale RPE conversion table.
Conclusion: A significant linear regression model and table of interchangeable values was developed for participants with SB. The group-normalized RPE (WHEEL, 5.74; Borg, 13.95) can be used to prescribe and self-regulate arm ergometer exercise intensity approximating the Vpt.
Level of Evidence: II

Introduction

Spina bifida (SB) is a neural tube defect that affects 1500 babies born annually in the United States and Puerto Rico. Myelomeningocele is the most severe and prevalent form of SB (81%, N = 4664) [1,2]. Myelomeningocele leads to motor and sensory loss at or below the anatomic level of the spinal lesion and is typically permanently disabling. Neurogenic bowel and bladder dysfunction and other neurologic symptoms often occur in the presence of tethered cord, hydrocephalus, and Chiari II malformation [3,4]. Morbidity and mortality in the SB population are often due to preventable comorbidities, especially for older individuals [4,5]. For example, in adults older than 65 years with SB or other congenital spinal anomalies, greater than 20% of hospital admissions were due to cardiac and pulmonary complications [5]. Obesity [6], metabolic syndrome [7], cardiovascular disease (CVD) risk [8], hypertension [9], and lymphedema [10] also occur at greater-than-average

https://doi.org/10.1016/j.pmrj.2018.01.004

rates in this population. Most of these secondary conditions are treatable or preventable with a healthy lifestyle that includes exercise [11,12]. However, there is a scarcity of evidence-based exercise prescription information for individuals with SB.

Peak oxygen consumption ($VO_{2\ peak}$) is commonly used as a laboratory measure of cardiopulmonary (ie, aerobic) fitness in individuals with and without disabilities across the age spectrum. Based on cardiopulmonary exercise testing, people with SB had 30%-40% lower aerobic fitness levels compared with either controls without disabilities [13] or compared with normative values [14]. Many adults with SB use a wheelchair full time for mobility. Only a small number of studies have used an arm ergometer to test the cardiopulmonary fitness of full-time adolescent and adult wheelchair users. Sherman et al [15] found that children with myelomeningocele who used a combination of wheelchair, braces, and crutches had significantly lower $VO_{2\ peak}$ (mean $\pm$ standard deviation [SD] $= 13.8 \pm 4.8$ mL/kg/min) than an age-matched group of children without myelomeningocele (21.3 ± 7.5 mL/kg/min). In adolescents and young adults with myelomeningocele from the Netherlands, aerobic fitness (oxygen consumption [VO_2]) was lowest in wheelchair users (19.2 ± 6.8 mL/kg/min) compared with household ambulators (22.3 ± 6.6 mL/kg/min) or community ambulators (29.0 ± 7.7 mL/kg/min) [14]. Thus, within the SB population, full-time wheelchair users have lower functional aerobic power than those who are ambulatory, indicating that they could benefit from participation in physical activity that improves aerobic fitness [16]. Q5

Aerobic exercise conditioning can improve cardiopulmonary fitness and reduce the risk of secondary clinical conditions (ie, CVD, obesity, metabolic syndrome) [11,12]. Aerobic exercise requires the integration of the cardiac and pulmonary systems to respond to the oxygen requirements of the contracting muscles. The work of breathing during graded aerobic exercise testing is greater for those with restrictive lung disease compared with those with unimpaired lung function [17–19]. It was found in the parent study from which the present SB cohort was sampled that pulmonary restriction was present in 55% of those tested (n = 29) [20,21]. Furthermore, for those with cardiopulmonary limitation, maximal cardiac output may be limited, or changes in vascular resistance may be inadequate to support the oxygen demands of the exercising muscles [22].

Mobility limitations in people with SB can present personal and environmental barriers that contribute to physical inactivity [23,24], greater-than-expected rates of obesity [6], metabolic syndrome [7], and increased risk of CVD [14]. It has been demonstrated that an individualized aerobic exercise prescription that produces an overload training intensity can improve cardiopulmonary fitness and lead to weight loss and/or maintenance in individuals without neuromotor disabilities [25]. The optimal overload intensity to improve cardiopulmonary fitness typically occurs at an individual's anaerobic threshold. The anaerobic threshold can be determined by using the blood lactate inflection point and/or the ventilatory breakpoint (Vpt), both of which are calculated from responses to a graded maximal exercise test. The physiological reference point for determining the anaerobic threshold is an abrupt, nonlinear increase in blood lactate above resting level in the presence of systematically increasing exercise intensity [11,12]. However, measurement of blood lactate involves an invasive procedure and is costly. Although determining Vpt by using respiratory–metabolic responses to an exercise stress test is not invasive, the procedure is nevertheless costly and labor-intensive, requiring complex instrumentation.

In people without disabilities, rating of perceived exertion (RPE) scales, such as the Borg (6-20) RPE Scale and the OMNI RPE Scale, often are used to prescribe target exercise training intensities [26,27]. The OMNI Scale presents a series of pictorial images paired with verbal descriptors and numerical response categories that clinicians can use to establish exercise training zones that improve cardiopulmonary fitness in people without disabilities [27]. When employing such prescription procedures to identify cardiopulmonary training zones, RPE can be linked to a target intensity range that spans the Vpt (ie, anaerobic threshold). Aerobic exercise conditioning at intensities within this range can improve aerobic fitness and musculoskeletal health. The psycho-physiological link between RPE and the Vpt has been determined for selected groups of people who share common characteristics (eg, gender, age, fitness, and sport participation) [28]. This linkage is called a group-normalized perceptual response [25]. This group-normalized RPE–Vpt is first determined by using perceptual and physiological responses to a load-incremented exercise test [25]. Subsequently, subjects are instructed to self-regulate their exercise intensity (ie, cycle, wheelchair, walk/run, steps) until they produce a level of exertion equivalent to the group-normalized RPE–Vpt range [25]. Exercise conditioning is then performed at the perceptually regulated intensity, providing an overload training stimulus for that particular session. Robertson et al [27] and Goss et al [28] showed that exercising at a target RPE equivalent to Vpt provides the training stimulus needed to improve cardiopulmonary fitness in individuals without disabilities. An overall body RPE of 5-7 on the OMNI Scale and 12-14 on the Borg (6-20) Scale is congruent with the anaerobic threshold in most adults [25].

In a cohort of individuals with SB, both concurrent and construct validity have been confirmed by using responses from the WHEEL Scale [29]. The WHEEL Scale was designed for wheelchair users with SB and features color photos paired with verbal descriptors and numerical categories [29]. However, the group-normalized RPE equivalent to the Vpt for people with SB who are