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Improving physical fitness of individuals with intellectual and developmental disability through a Virtual Reality Intervention Program

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ABSTRACT

Individuals with intellectual and developmental disabilities (IDD) are in need of effective physical fitness training programs. The aim was to test the effectiveness of a Virtual Reality (VR)-based exercise program in improving the physical fitness of adults with IDD. A research group ($N = 30$; mean age = 52.3 ± 5.8 years; moderate IDD level) was matched for age, IDD level and functional abilities with a control group ($N = 30$, mean age = 54.3 ± 5.4 years). A 5–6 week fitness program consisting of two 30 min sessions per week included game-like exercises provided by the Sony PlayStation II EyeToy VR system. Changes in physical fitness were monitored by the Energy Expenditure Index (EEI), the modified 12 min walk/run and the Total Heart Beat Index (THBI). Significant ($p < 0.05$) improvements in physical fitness were demonstrated for the research group in comparison to the control group for the Modified Cooper test and the THBI but not for the EEI test. The EEI, Modified Cooper and THBI tests were found feasible to evaluate physical fitness levels and change of individuals with IDD under clinical conditions. VR technology intervention was suitable for adults with IDD and resulted in significant improvements in the physical fitness levels of the participants.

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1. Introduction

Positive effects of regular physical activity include an improvement in cardiovascular and respiratory muscle function, and a reduction in coronary artery disease risk factors (e.g., elevated systolic and diastolic blood pressures, abnormal serum lipid profiles) which lead to a decreased level of overall mortality and morbidity (Franklin, Whaley, & Howley, 2000). The benefits of exercise also appear to include decreased anxiety and depression, enhanced feelings of well-being, and improved performance during work, recreational and sports activities (Franklin et al., 2000). Regrettably, persons with intellectual and developmental disability (IDD) show a considerable lack of physical fitness as well as very low levels of cardiovascular endurance when compared to peers without IDD (King & Mace, 1990; Lotan, Isakov, Kessel, & Merrick, 2004; Pitetti & Boneh, 1995). A number of factors may account for the low levels of fitness found in persons with IDD including a passive lifestyle (Lotan et al., 2004; Pitetti & Boneh, 1995), and low motivation (Halle, Gabler-Halle, & Chung, 1999) as well as psychological and physiological factors (Fernhall & Tymeson, 1988). Of all the factors examined, an inactive life style appears to be most detrimental to physical fitness (Bickum, 1995).

Since poor fitness appears to be a risk factor for exacerbating the disabilities associated with IDD, considerable effort has been expended to enroll these individuals in a variety of training programs intended to improve their physical fitness (Halle et al., 1999; Lotan et al., 2004; Lotan, 2007). Due to the specific challenges presented by individuals with IDD, especially low motivation (Lotan, 2007) and less access to health care than the general population (Surgeon General, 2002), conventional training programs that provide only fitness routines or remedial-type instruction are not sufficiently motivating (Gignac, 2003). Thus, when seeking to activate individuals with IDD, a broader perspective should be applied, taking into account the person's social, emotional and cognitive development as well as his or her areas of interest (Temple, 2007). The implementation of fitness programs that incorporate motivational factors is therefore highly recommended (Lotan, 2007; Rogers-Wallgren, French, & Ben-Ezra, 1992).

In order to evaluate the effect of clinical fitness programs, pre- and post-intervention testing is necessary. A reduction in sub-maximal exercise responses such as heart rate, energy expenditure, and the ability to walk greater distances at a faster pace is consistent with improved aerobic conditioning and efficient use of energy during movement (Noonan & Dean, 2000). However, some of the fitness tests commonly used in research or sports settings are less suitable for on-site clinical applications. For example, there are several limitations to assessing maximal performance with a V_{O_2} max test (Noonan & Dean, 2000).[1] In addition, tests that require maximal effort often entail additional monitoring equipment (e.g., electrocardiograph machine) and trained staff who are not available in many clinical settings (American College of Sports Medicine, 1995). Thus, due to the motivational limitations of individuals with IDD as well as the complexities of some of the standard tests, alternate fitness tests may be preferable to measure the change in physical fitness in clinical settings.

The Energy Expenditure Index (EEI) is a clinical test developed to evaluate the influence of intervention programs on the efficiency of gait (Grant, Corbett, Amjad, Wilson, & Aitchison, 1995; Rose, Gamble, Burgos, Medeiros, & Haskell, 1990; Rose, Gamble, Lee & Haskell, 1991). The EEI, in units of beats/meters, is a ratio of the change in heart rate to walking velocity, and is calculated from the formula: EEI = (Walking Heart Rate − Resting Heart Rate)/Walking Velocity (Wiart & Darrah, 1999). EEI-based heart rate has been used to compare the economy of walking at various speeds by individuals with and without Cerebral Palsy (CP) and was found to be a useful clinical indicator of Oxygen Consumption Index at self-paced ambulation speeds in individuals with spastic diplegia CP (Norman, Bossman, Gardner, & Moen, 2004).

The Improved Cooper test, also known as the 12-Minute Walk Test (12-MWT), was first developed by Cooper (1968), and later revised by McGavin, Gupta, and McHardy (1976) to assess the distance covered in 12 min by individuals with chronic bronchitis. This test was later shown to be suitable to be administered to individuals with a variety of diagnoses to detect physiological change following an exercise program (Cockcroft, Saunders, & Berry, 1981; Noonan & Dean, 2000). It is a simple,

[1] Unless an individual is able to attain a V_{O_2} max without fatiguing first or being limited by musculoskeletal impairments or other problems such as maintaining high level of motivation the results of the test are invalid (Noonan & Dean, 2000).