



ELSEVIER

Contents lists available at ScienceDirect

Research in Developmental Disabilities



Improvements in manual dexterity relate to improvements in cognitive planning after assisted cycling therapy (ACT) in adolescents with down syndrome



Simon D. Holzapfel^{*}, Shannon D.R. Ringenbach, Genna M. Mulvey, Amber M. Sandoval-Menendez, Megan R. Cook, Rachel O. Ganger, Kristen Bennett

Arizona State University, School of Nutrition and Health Promotion, 425N. 5th Street, Phoenix, AZ 85004, United States

ARTICLE INFO

Article history:

Received 28 March 2015
 Received in revised form 19 June 2015
 Accepted 4 August 2015
 Available online 26 August 2015

Keywords:

Intellectual disability
 Aerobic exercise
 Executive function
 Motor control
 Neuroplasticity

ABSTRACT

We have previously reported beneficial effects of acute (i.e., single session) Assisted Cycling Therapy (ACT) on manual dexterity and cognitive planning ability in adolescents with Down syndrome (DS). In the present study, we report the chronic effects of eight weeks of ACT, voluntary cycling (VC), and no cycling (NC), on the same measures in adolescents with DS. Participants completed 8 weeks of ACT, VC, or NC. Those in the ACT and VC groups completed 30 min sessions three times per week on a stationary bicycle. During ACT, the mechanical motor of the bicycle augmented the cadence to a rate which was on average 79% faster than the voluntary cadence. During VC, the participants pedaled at a self-selected rate. Unimanual dexterity scores as measured with the Purdue Pegboard test (PPT) improved significantly more for the ACT and VC groups compared to the NC group. ACT lead to greater improvements than VC and NC in the assembly sub-test, which is a task that requires more advanced temporal and spatial processing. The ACT group improved significantly more than the VC group and non-significantly more than the NC group in cognitive planning ability as measured by the Tower of London test (ToL). There were also significant correlations between the assembly subtest of the PPT and all measures of the ToL. These correlations were stronger during post-testing than pre-testing. Pre-post changes in the combined PPT score and ToL number of correct moves correlated positively in the ACT group. These results support the efficacy of the salutary effects of ACT on global fine motor function and executive function in DS. Additionally, the performance on complex bimanual dexterity tasks appears to be related to the capacity of cognitive planning ability. This research has important implications for persons with movement deficits that affect activities of daily living.

© 2015 Elsevier Ltd. All rights reserved.

^{*} Corresponding author. Tel.: +1 423 329 3038.

E-mail addresses: shannon.ringenbach@asu.edu, simon.holzapfel@asu.edu (S.D. Holzapfel), shannon.ringenbach@asu.edu (Shannon D.R. Ringenbach), genna.mulvey@asu.edu (G.M. Mulvey), amsando3@asu.edu (A.M. Sandoval-Menendez), megan.r.cook@asu.edu (M.R. Cook), rganger@asu.edu (R.O. Ganger), kristen.bennett@asu.edu (K. Bennett).

1. Introduction

To maximize independence and quality of life it is important for persons with Down syndrome (DS) to maintain function in terms of Activities of Daily Living (ADL). Over 50% of school-aged individuals with DS require support or supervision in some of the more complex self-care activities such as bathing, dressing, and grooming (Leonard, Msall, Bower, Tremont, & Leonard, 2002). Older adults with DS, on average, exhibit a lower functional status than age-matched persons with non-specific intellectual disabilities (Carmeli, Kessel, Bar-Chad, & Merrick, 2004). Activities with deficits specifically related to motor control of the hand include tooth brushing and tying shoe laces. Only 11.6% and 0% of children with DS aged five years are able to brush their teeth and tie their shoes, respectively (Dolva, Coster, & Lilja, 2004).

The effects of gross motor lower extremity exercise on lower extremity function in DS are well documented (e.g. Carmeli, Kessel, Coleman, & Ayalon, 2002; Shields, Taylor, & Dodd, 2008). There has also been attention in other populations regarding the effects of lower extremity exercise on upper extremity motor function (Shields et al., 2008). For instance, Ridgel, Vitek, and Alberts (2009) successfully improved the bimanual dexterity of Parkinson's disease (PD) patients with an eight-week assisted cycling intervention where tandem cycling was used to augmented the cadence to a rate which was 43% faster than the self-selected rate. An eight-week gross motor training intervention also improved the manual dexterity of children with developmental coordination disorder (Hung & Pang, 2010). However, the chronic effects of lower extremity exercise on upper extremity motor function in people with DS are unknown.

In addition to motor control deficits, persons with DS also face a number of formidable barriers to exercise participation. For instance, low cardiorespiratory fitness, poor motor control, low exercise motivation, and social barriers are common (Barr & Shields, 2011; Fernhall, Tymeson, Millar, & Burkett, 1989; Heller, Hsieh, & Rimmer, 2004). The Assisted Cycling Therapy (ACT) used by Ridgel et al. (2009) could potentially overcome these barriers.

We have previously reported beneficial effects of acute (i.e., single session) ACT on manual dexterity in adolescents with DS (Ringenbach, Albert, Chen, & Alberts, 2014; Chen, Ringenbach, & Albert, 2014a). These benefits may be explained by acute arousal in the motor cortex. Acute arousal is associated with the temporary upregulation of dopamine and norepinephrine which can improve motor and executive function (Brown, Marsden, Quinn, & Wyke, 1984; Hillman, Snook, & Jerome, 2003; Kubesch et al., 2003; McMorris & Hale, 2015). The proposed biochemical pathways through which chronic (e.g. eight weeks) lower extremity exercise can lead to improvements in global motor function, which includes upper extremity motor function, includes the upregulation of brain-derived neurotrophic factor (BDNF), glial-derived neurotrophic factor (GDNF), insulin-like growth factor-3 (IGF₃), vascular endothelial-derived growth factor (VDGF), and dopamine, or sparing of the latter (Alberts, Linder, Penko, Lowe, & Phillips, 2011; Cotman, Berchtold, & Christie, 2007; Piepmeier & Etnier, 2015; Tillerson, Caudle, Reveron, & Miller, 2003). The upregulation of these growth factors can be initiated by the stimulation of Golgi tendon organs and muscle spindle fibers through the repeated shortening and lengthening of muscles and connective tissue. The associated sensory (afferent) neurons conduct signals through the spinal cord to the brain stem, motor cortex, striatum, and cerebellum (Alberts et al., 2011; Barker, 1948). Increased motor cortical activation occurs during voluntary and passive movements and, along with the stimulation of the cardiovascular system, has been associated with the upregulation of the aforementioned growth factors and neurotransmitters (Alberts et al., 2011; Barker, 1948; Cotman et al., 2007; Lotze, Braun, Birbaumer, Anders, & Cohen, 2003; Perez, Lungholt, Nyborg, & Nielsen, 2004; Piepmeier & Etnier, 2015; Proske & Morgan, 2001; Tillerson et al., 2003). Improvements in motor control are associated with neuroplasticity in the motor cortex and cerebellum precipitated through these growth factor cascades (Alberts et al., 2011), however, these growth factor cascades initiated through cycling may also lead to neuroplasticity in the prefrontal cortex and improved executive function (Ringenbach et al., 2014). Previous results suggest that ACT stimulates neuroplasticity in cortical regions associated with motor and executive function more effectively than voluntary cycling (VC) at self-selected cadences (Chen et al., 2014a; Ridgel et al., 2009; Ringenbach et al., 2014), however, it is important to point out that there is voluntary movement output during ACT which means that movement during ACT is not entirely passive. This is evidenced by the power output of patients with PD (47 ± 16 W) in the ACT conditions (Ridgel et al., 2009). The possibility of increased neuroplasticity in the central nervous system as a result of ACT is an important finding because persons with DS have deficits in executive function, including cognitive planning ability as well as other domains, and these deficits worsen with increasing age (Lanfranchi, Jerman, Dal Pont, Alberti, & Vianello, 2010). Additionally, the risk for dementia and Alzheimer's disease is greatly increased in individuals with DS and neuropathological signs of Alzheimer's disease can occur as young as eight years of age (Hyman, 1991; Leverenz & Raskind, 1998; Schupf et al., 1998; Wisniewski, Wisniewski, & Wen, 1985; Zigman & Lott, 2007). It is therefore important to counteract declines in motor and cognitive function early on through appropriate interventions.

The positive association between motor development and cognitive development is also well known (Piek, Dawson, Smith, & Gasson, 2008) and the cerebellum hypothesis may explain this connection (Diamond, 2000; Ridler et al., 2006). Cerebellar and prefrontal cortex development accelerates between the ages of five and 10 years which coincides with a major developmental span of both motor and executive function (Diamond, 2000; Westendorp, Hartman, Houwen, Smith, & Visscher, 2011). Additionally, the cerebellum and prefrontal cortex are activated during planning, sequencing, and monitoring which are all involved in motor performance and executive function tasks (Schall et al., 2003; Wagner, Koch, Reichenbach, Sauer, & Schlösser, 2006; Westendorp et al., 2011). Specifically, Chen, Ringenbach, Albert, and Semken (2014b) reported strong correlations of measures of manual dexterity (Purdue Pegboard test = PPT) to cognitive planning ability (Tower of London = ToL) and verbal working memory in adolescents with DS. Cognitive planning ability and the execution of goal-directed plans is a subdomain of executive function and it depends on activation of the prefrontal cortex and cerebellum

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات