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Neuromuscular differences between boys with and without intellectual disability during squat jump

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ABSTRACT

The purpose of this study was to identify the differences in vertical squat jump (SJ) between volunteers with and without intellectual disability (ID). Thirteen boys with ID (average intelligence quotient, estimated by Wisk III test: 55.6 ± 11.2) and 13 peers without disabilities performed maximal SJ on a force platform. Kinematic data were captured using a six-camera 3D motion analysis system and electromyographic (EMG) activity was recorded using surface electrodes. Unpaired T-test determined the statistical difference between the two groups. The obtained results indicated that the group with ID, jumped lower, developed lower vertical ground reaction forces, knee power output, knee angular velocity, and take-off velocity, and showed longer propulsion duration, decreased mean to maximum agonist EMG activity and higher antagonist/agonist activity ratio. The deficit in the SJ observed in individuals with ID was attributed to a deficit in the examined mechanical and neuromuscular parameters, and especially to the agonist and antagonist co-contraction.

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1. Introduction

Intellectual disability (ID) is one of the most prevailing reasons of disability in children. Its case and neurophysiological development are still poorly understood (Yu et al., 2008). Among the deficits on various functional domains such as cognition, language, audition and moral judgment, ID has also negative effects in gross and fine motor performance, in terms of motor reaction time (LeClair, Pollock, & Elliott, 1993) and balance (Vuijk, Hartman, Scherder, & Visscher, 2010) or when performing a visuo-manual rhythmic tracking task (Van Aken et al., 2010). A possible neurophysiological mechanism leading to such motor deficits in people with ID could be the damage in the integrity of the cortico-spinal tract and the changes in morphometry of the frontal and paretial cortex in people with lower intelligence quotient (Haier, Jung, Yeo, Head, & Alkire, 2004; Yu et al., 2008). It is important to note though, that the motor deficit of people with ID could be influenced and deteriorated by behavioral factors, such as sedentary life (Horvat & Franklin, 2001) which might have several consequences. Previous studies have shown that individuals with ID, exert less strength and power (Angelopoulou, Tsimaras, Christoulas, Kokaridas, & Mandroukas, 1999; Horvat, Pitetti, & Croce, 1997; Horvat, Croce, Pitetti, & Fernhall, 1999), and have poorer skill performance (Horvat, Croce, Zagrodnik, Brooks, & Carter, 2012; Skowronski, Horvat, Nocera, & Croce, 2009) compared to peers without ID.

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An earlier study highlighted the importance of physical fitness to promote health and well-being of persons with ID (Fernhall, Tymeson, & Webster, 1988). Recently, Hinckson, Dickinson, Water, and Sands (2013) showed that children with ID can benefit from training programs in order to manage their weight. This finding in conjunction with the fact that children with ID have an increased risk for obesity (Maiano, 2010) support the importance of exercise, especially for these children.

During the past decades team sports are becoming more popular for people with ID. Such activities consist a very useful medium to increase physical activity and develop or enhance various motor skills, which might have positive impact on the activities of daily living (Watkinson et al., 2001). Basketball is a popular team sport which incorporates various motor skills such as running, dribbling, shooting, ball passing/receiving and jumping. This implies that targeted training programs improving these skills have to be developed. In order to achieve this, it is important to understand the causes of possible motor deficits on individual motor tasks, by describing in detail their properties.

The investigation of jumping in people with ID is very limited, although it is a common task used in their training, competition and daily life. It has been previously reported that people with ID are inferior in standing long jump distance (Skowronski et al., 2009). Jump is a very complex task and depends on many factors, such as the coordination and energy flow through the joints of the lower extremities (Bobbert & van Ingen Schenau, 1988; Pandy & Zajac, 1991; Prilutsky & Zatsiorsky, 1994), as well as the morphology of the muscle tendon unit (Bobbert, 2001; Bosco, Tihanyi, Komi, Fekete, & Apor, 1982), the muscle activation patterns (Bobbert & van Soest, 2001; Bobbert & van Zandwijk, 1999), and the mechanical power output (Canavan & Vescovi, 2004; Kollias, Panoutsakopoulos, & Papaiakovou, 2004; Vanezis & Lees, 2005). Studies on jumping performance of persons with ID seem to be limited. However, taking into account that people with ID have similar adaptation responses after training programs (Carmeli, Zinger-Vaknin, Morad, & Merrick, 2005; Hemayattalab & Movahedi, 2010), it is essential to understand the reasons that cause any performance deficit in individuals with ID, by describing their neuromuscular properties during jumping and comparing them to peers with no ID.

Therefore, the purpose of this study was to examine the neuromuscular differences in vertical squat jump (SJ) between boys with and without ID. The results will provide evidence for the causes of the performance deficit in boys with ID and will help in the future to develop strategies in order to improve their performance by designing more targeted and specific training programs. Such training interventions are becoming more necessary if we consider the increasing number of people with ID who participate systematically in competitive sports that have jumping as a crucial task determining the athlete's performance.

2. Methods

2.1. Participants

Twenty-six boys (14–17 years old) participated voluntarily in the study. The participants with ID ($n = 13$, mean age: 15.3 ± 1.6 years, body mass: 56.3 ± 15.7 kg, body height: 164.2 ± 11.3 cm) had an intelligence quotient of 55.6 ± 11.2, as estimated by Wisk III test. The group without ID ($n = 13$) had mean age 15.4 ± 1.2 years, body mass 58.5 ± 12.5 kg, and body height 168.5 ± 11.5 cm.

A medical board consisted of a physician, a psychiatrist and a neurologist, verified that the participants were free of any neurological motor deficit or any injury history on the back or lower extremities. All participants agreed to participate in the study after being informed about the procedures. Before testing, they and their parents read and signed a written informed consent statement. The participants were asked to abstain from any exercise activity for 48 h before the examination. The experimental procedures were according to the ethic guidelines of the Aristotle University of Thessaloniki, Greece.

2.2. Experimental procedure

All participants were informed verbally about the procedure. Two weeks before the main protocol, they visited the laboratory for familiarization, including execution of SJ from a starting position of 90° knee flexion, as previously suggested (Bobbert, Casius, Sijpkens, & Jaspers, 2008). When they visited the laboratory, after orientation in space, the evaluation of anthropometric parameters was assessed. Afterwards they performed a general warm up (5 min pedaling with selected pace on a bicycle and warming up exercises) followed by a specific warm up, including submaximal vertical jumps with increasing intensity. Before the final assessment three maximal SJ were performed for further familiarization and three extra jumps were performed for the evaluation. The best jump in height was selected for further evaluation. To avoid any fatigue effect, the interval between SJ was set at 3 min.

2.3. Instruments and testing

Kinematic data were captured at 100 Hz using a six-camera 3D motion analysis system (VICON 612, Oxford Metrics Ltd., Oxford, Oxfordshire, UK). Vertical Ground Reaction Forces (vGRF) were recorded with a ground-mounted 40 cm × 60 cm force plate (Bertec Type 4060, Bertec Corporation, Columbus, OH, USA). The electromyogram (EMG) was recorded using a BTS Telemg device (Milano, Italy).

In the testing day after assessment of the physical characteristics the EMG electrodes were located on the dominant limb, as determined by the preference limb to kick a ball (Wikstrom, Tillman, Kline, & Borsa, 2006). The EMG electrodes were

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