



Individuals with intellectual disability have lower voluntary muscle activation level



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ABSTRACT

The aim of this study was to explore the voluntary activation level during maximal voluntary contraction (MVC) in individuals with intellectual disability (ID) versus individuals without ID using the twitch interpolation technique. Ten individuals with mild ID (ID group) and 10 sedentary men without ID (control group) participated in this study. The evaluation of neuromuscular function consisted in three brief MVCs (3 s) of the knee extension superimposed with electrical nerve stimulation (NES) to measure voluntary activation. Muscle activity levels were also measured with surface EMG. The root mean square (RMS) was extracted from the EMG signal. The RMS/Mmax ratio and the neuromuscular efficiency (NME) were calculated. Our results reported that individuals with ID present lower muscle strength ($p < 0.001$), lower voluntary activation level ($p < 0.001$), lower RMS values of vastus lateralis ($p < 0.05$), vastus medialis ($p < 0.05$), and rectus femoris ($p < 0.001$) muscles. In addition, our results showed lower RMS/Mmax values in the ID group than in the control group for the VM (0.05 ± 0.01 mV vs. 0.04 ± 0.01 mV; $p < 0.05$) and the RF (0.06 ± 0.02 mV vs. 0.05 ± 0.02 mV; $p < 0.05$) muscles. However, no significant difference was reported for the VL muscle (0.05 ± 0.02 mV vs. 0.05 ± 0.02 mV; $p = 0.463$). Moreover, Individuals with ID present smaller potentiated twitch ($p < 0.001$). However, no significant difference was reported in the NME ratio. These results suggest that the lower muscle strength known in individuals with ID is related to a central nervous system failure to activate motor units and to some abnormal intrinsic muscle properties. It seems that the inactive lifestyle adopted by individuals with ID is one of the most important factors of their lower voluntary activation levels. Therefore, physical activities should be introduced in life style of individuals with ID to improve their neuromuscular function.

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1. Introduction

Individuals with intellectual disabilities (ID) present several abnormalities in their nervous system structure (Gabrielli et al., 1998) localized in the white matter tracts that are responsible for the processing of sensory and motor

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information (Yu et al., 2008). Several studies have mentioned that individuals with ID present several abnormalities in motor nervous control and neuromuscular coordination (Chia, Lee, & Teo-Koh, 2002). In addition, individuals with ID present lower muscle strength compared to individuals without ID (Angelopoulou, Tsimaras, Christoulas, Kokaridas, & Mandroukas, 1999; Blomqvist, Olsson, Wallin, Wester, & Rehn, 2013; Borji, Sahli, Zarrouk, Zghal, & Rebai, 2013; Carmeli, Ayalon, Barchad, Sheklow, & Reznick, 2002; Horvat, Croce, Pitetti, & Fernhall, 1999). Moreover, in a previous study, we demonstrated that individuals with ID present lower root mean square (RMS) value in comparison with individuals without ID (Borji et al., 2013). Nevertheless, the reason for this force deficiency has not been identified yet.

In individuals without ID, it has been demonstrated that muscle force level depends on several factors such as muscular fiber typology (Fitts & Widrick, 1996), training status (Fitts & Widrick, 1996), sex difference (Miller, MacDougall, Tarnopolsky, & Sale, 1993), and age difference (Lindle et al., 1997). Muscle force level depends also on neural mechanisms such as the voluntary activation level of motor units (Gandevia, 2001, 1992). Voluntary activation describes the level of neural drive of muscle during voluntary contractions (Gandevia, Allen, & McKenzie, 1995). One of the methods to evaluate the activation of motor units by the central nervous system is the superimposed twitch technique (Gandevia, 2001; Millet et al., 2012). The presence of a superimposed twitch produced by motor nerve stimulation during a MVC indicates that the whole motor units are not totally recruited by the central nervous system (Merton, 1954). If voluntary activation is incomplete, failure to drive the muscle should occur at or above the site of stimulation of the motor axons (Merton, 1954).

Using this technique, many studies have attempted to investigate the relationship between the reduced voluntary force production and the voluntary activation levels in general population (Belanger & McComas, 1981; Bigland-Ritchie, Donovan, & Roussos, 1981), athletic population (Huber, Suter, & Herzog, 1998), and clinical populations (Hurley, Jones, & Newham, 1994; Rutherford, Jones, & Newham, 1986). Studies investigating this relationship in elderly persons and individuals with cerebral palsy found that the lower muscle force noted in both populations had been related to the activation deficit (AD) from central nervous system (Stackhouse et al., 2001; Stackhouse, Binder-Macleod, & Lee, 2005; Yue, Ranganathan, Siemionow, Liu, & Sahgal, 1999). Nevertheless, to our knowledge no data is available about the voluntary activation in individuals with ID.

Thus, the aims of this study were to compare the force production and the level of voluntary activation between individuals with ID and individuals without ID as well as to investigate the implication of the central nervous system deficiency in the force production in individuals with ID.

2. Methods

2.1. Participants

The sample population consisted of 20 sedentary men who met the same criteria in terms of socioeconomic status and ethnicity. Ten men with ID (age = 24.9 ± 4.9 years; height = 1.7 ± 0.1 m; weight = 77.9 ± 8.3 kg; BMI = 25.7 ± 2.5 kg/m²) participated in the study as an experimental group. The control group consisted of 10 sedentary and healthy (no cardiovascular, metabolic, immunologic, or neuromuscular disorders) men without ID matched for age, height, and weight: (age = 25.2 ± 2.7 years; height = 1.7 ± 0.1 m; weight = 75.3 ± 9.2 kg; BMI = 23.9 ± 1.7 kg/m²).

All participants with ID suffered from a mild ID with an intelligence quotient (IQ) between 50 and 55 and 70 (The American Psychiatric Association, 2000) determined by the WAIS-IV test (Wechsler, 2008) elaborated by the educational center psychologist (IQ = 62 ± 3.5). Participants with ID have been recruited randomly from the Tunisian Union of Aid to Mental Insufficiency (TUAMI). The sample excluded individuals with down syndrome, and with multiple disabilities. The participant's morphological characteristics showed no statistical differences in terms of age, weight, height and BMI between the two groups. The participants were fully informed of the procedure and the risks involved and gave their written consent. The informed consent for the individuals with ID was provided by their parents or legal guardians.

2.2. Study design

Three days after a familiarization session with the experimental procedures, participants engaged in the experimental session. The experimental session was preceded by a warm-up consisting of several submaximal contractions (12–15) of knee extension muscles at a freely chosen intensity. The evaluation of neuromuscular function consisted in three brief (3 s) maximal voluntary contractions (MVCs) of the knee extension superimposed with nerve electrical stimulation (NES) to measure voluntary activation. Muscle activity levels were also measured with surface electromyography (EMG). To exclude the confounding effect of fatigue induced by repeated muscular contractions, the three MVCs were separated by a 2-min recovery period. The comparison of data obtained during the first and the third MVC did not reveal any significant difference, suggesting that the experimental procedures did not induce any fatigue.

2.3. Testing procedures and instrumentation

2.3.1. Force measurement

The participants performed three MVCs with strong encouragement by the investigator. During testing, the participants were seated on an isometric dynamometer (Good Strength, Metitur, Finland) equipped with a cuff attached to a strain gauge. This cuff was adjusted ≈ 2 cm above the lateral malleolus using a Velcro strap. The participants stabilized themselves by

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