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Neuromuscular fatigue during high-intensity intermittent exercise in individuals with intellectual disability

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A B S T R A C T

This study examined neuromuscular fatigue after high-intensity intermittent exercise in 10 men with mild intellectual disability (ID) in comparison with 10 controls. Both groups performed three maximal voluntary contractions (MVC) of knee extension with 5 min in-between. The highest level achieved was selected as reference MVC. The fatiguing exercise consists of five sets with a maximal number of flexion-extension cycles at 80% of the one maximal repetition (1RM) for the right leg at 90° with 90 s rest interval between sets. The MVC was tested again after the last set. Peak force and electromyography (EMG) signals were measured during the MVC tests. Root Mean Square (RMS) and Median Frequency (MF) were calculated. Neuromuscular efficiency (NME) was calculated as the ratio of peak force to the RMS. Before exercise, individuals with ID had a lower MVC ($p < 0.05$) and a lower RMS ($p < 0.05$). No significant difference between groups in MF and NME. After exercise, MVC decreases significantly in both groups ($p < 0.001$). Individuals with ID have greater force decline ($p < 0.001$ vs. $p < 0.01$). RMS decreased significantly ($p < 0.001$) whereas the NME increased significantly ($p < 0.05$) in individuals with ID, but both remained unchanged in controls. The MF decreased significantly in both groups ($p < 0.001$). In conclusion, individuals with ID presented a lower peak force than individuals without ID. After a high-intensity intermittent exercise, individuals with ID demonstrated a greater force decline caused by neural activation failure. When rehabilitation and sport train ID individuals, they should consider this nervous system weakness.

1. Introduction

The American Psychiatric Association (APA, 2000) affirmed that motor disorders are one of the complications resulting from intellectual disability (ID). It has been documented that individuals with ID show problems in motor skills (Kioumourtzoglou, Batsiou, Theodorakis, & Mauromatis, 1994), and a weakness of physical condition (Carmeli, Imam, & Merrick, 2012). Compared to individuals without ID, they have poor motor coordination (Henderson, Morris, & Ray, 1981), slower reaction time (Amemiya, 1982), lower postural stability (Blomqvist, Olsson, Wallin, Wester, & Rehn, 2013; Carmeli, Barchad, Lenger, & Coleman, 2002),

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and lower muscle strength (Angelopoulou, Tsimaras, Christoulas, Kokaridas, & Mandroukas, 1999; Blomqvist et al., 2013; Carmeli, Ayalon, Barchad, Sheklow, & Reznick, 2002; Horvat, Croce, Pitetti, & Fernhall, 1999).

These motor disorders suggest that individuals with ID may have difficulty when practicing physical exercise. However, athletes with ID make many records in paralympic games, and show that ID does not prevent them from practicing physical activities and competitive sports. In fact, several studies reported the positive effect of physical activities to improve general health in individuals with ID (Cuesta-Vargas, Paz-Lourido, & Rodriguez, 2011; Wu et al., 2010). For individuals with ID, physical activities must be under a medical control and with many precautions to avoid accidents as a result of their low physical fitness level (Winter, Bastiaanse, Hilgenkamp, Evenhuis, & Echteld, 2012; Winter, Magilsen, van Alfen, Penning, & Evenhuis, 2009).

In fact, the most important precaution to take is to consider their fatigue profile and their ability to tolerate high-intensity exercise. While several studies examined neuromuscular fatigue in individuals without ID (Enoka & Duchateau, 2008; Gandevia, 2001), information on the fatigue profile in individuals with ID is lacking. Compared to individuals without ID, Auxter (1966) reported that individuals with ID have a lower ability to resist against fatigue in maximal isometric contractions (the peak force produced by a muscle as it contracts while pulling against an immovable object). Recently, Zafeiridis et al. (2010) studied the fatigue profile in individuals with ID after a high-intensity intermittent exercise. Relying solely on mechanical parameters (strength), these authors found that individuals with ID generate lower quadriceps strength than individuals without ID, but they can maintain it for a longer time.

In order to explore the causes and the origins of neuromuscular fatigue, De Luca (1993) affirmed that it becomes more efficient to use the electromyography technique (EMG). The EMG is defined as experimental technique concerned with the development, recording, and analysis of myoelectric signals (Basmajian & DeLuca, 1985).

Numerous studies analyzed EMG signals following a high-intensity intermittent exercise to investigate neuromuscular fatigue in individuals with typical development. Some of these studies found a decrease in both frequency and timing related parameters after high-intensity exercise and suggested a nerve activation responsibility of strength decline (Decorte, Lafaix, Millet, Wuyam, & Verge, 2012; Mendez-Villanueva, Hamer, & Bishop, 2008; Taylor, Todd, & Gandevia, 2006). Others noticed that only frequency parameters decrease after such exercise (Bishop, 2012; Hautier et al., 2000; Lattier, Millet, Martin, & Martin, 2004). To our knowledge, no data concerning the neuromuscular fatigue effect following a high-intensity intermittent exercise on the EMG signal in individuals with ID are available.

Therefore, the aim of this study was to examine the neuromuscular fatigue manifestations in muscle strength and EMG signals in males with ID following a high-intensity exercise versus individuals without ID.

2. Methods

2.1. Participants

The sample population consisted of 20 sedentary men who met the same criteria in terms of cultural background, socio-economic status and ethnicity. Ten men with ID (age = 16.70 ± 1.76 years; height = 1.58 ± 0.02 m; weight = 66.10 ± 3.54 kg; BMI = 26.50 ± 1.69 kg/m^2) participated in the study. All participants with ID suffer from a slight ID with an intelligence quotient of 60 ± 2.78 determined by the WAIS–IV test (Wechsler, 2008). Participants with ID have been recruited randomly from the Educational Center Raid Elbjawi (Tunisian Union of Aide to Mental Insufficiency). The sample did not include neither individuals with Down Syndrome, nor with multiple disabilities. The informed consent for the individuals with ID was provided by their parents or legal guardians.

Control group consists of 10 men without ID matched in age, height, weight, and BMI: (age = 16.8 ± 1.75 years; height = 1.59 ± 0.02 m; weight = 65.80 ± 3.19 kg; BMI = 25.86 ± 1.09 kg/m^2). The participants without ID provided written consent.

The participants' morphological characteristics showed no statistical differences in terms of age, weight, height and BMI between the two groups. The study excluded individuals with metabolic diseases, as well as musculoskeletal, cardio and respiratory system diseases in order to avoid potential influence of health factors on tests results.

2.2. Study design

One day prior to the experiment, a familiarization session was realized with the leg extension machine and the testing procedure and to have their physical characteristics (height and weight) measured. The one maximal repetition (1RM) of the quadriceps muscle was calculated from the right leg according to the 10RM method and the repetitions-1RM relationship (Baechle, Earle, & Wathen, 2000) on a ''leg extension'' machine. Total range of motion during the contractions was set for all contractions from 0° (full extension) to 90° of flexion. The next day, all participants performed three maximal voluntary contraction (MVC) separated with 5 min recovery. After a high-intensity intermittent exercise, the MVC was tested again. Peak force and EMG signals were recorded during all MVC and then analyzed.

2.3. Testing procedures and instrumentation

2.3.1. Experimental setting

The experiment began with a warm-up phase, which consisted of submaximal cycling for 5 min at 60 rpm/min. Next, the participant performed three MVC separated by 5 min of rest to estimate the maximum voluntary force level. The MVC was tested again immediately after the last set of the fatiguing exercise.