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# Postural muscle responses and adaptations to backward platform perturbations in young people with and without intellectual disability

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ABSTRACT

This study examines postural muscle responses to backward perturbations in young people (16–20 years) with and without intellectual disability (ID). The study included 56 young people with ID and 43 age-matched without ID volunteers. The subjects stood on a platform that was moved backwards in a surface translation. Lower and upper leg muscles and lower back spine muscles were recorded with surface electromyography (EMG). Muscle onset latency, time to peak amplitude (EMG), adaptation of muscle responses to repeated perturbations (using integrated EMG (IEMG) for epochs), and synergies and strategies were assessed. The result showed no differences between the two groups in muscle onset latency, synergies, and strategies. Young people with ID reduced their time to peak amplitude in investigated muscles, a response that was different from the group without ID. Also, young people with ID tended to adapt their IEMG less compared to the controls. These findings suggest that young people with ID have limited ability to use somatosensory information and adapt their postural muscle responses to repeated external perturbations.



## 1. Introduction

Young and old individuals with intellectual disability (ID) have reduced postural balance compared to age-matched individuals without ID [1–4] and they fall more often than their peers [5]. Researchers have found that people with ID have limited ability to anticipate postural adjustments when they move from the sitting to standing position and when they stand on one leg [6]. In addition, these researchers have found that ID-limited people exhibit general stability problems (Forward Reach Test) [4,7] and gait stability issues (Timed Up and Go Test) [7,8], but the reason for these problems is unclear. One reason for the reduced postural balance could be that individuals with ID have slower postural muscle responses compared to individuals without ID.

The postural balance system uses principally four different motor control strategies after external perturbations have been attended: ankle, hip, mixed of ankle/hip or step strategies [9,10]. Ankle strategy restore the CoM primarily around the ankle joints, hip strategy restore the CoM primarily by motions at the hip joints and step strategy restore the CoM by taking a step to reposition the base of support [11]. If the platform on which the subject is standing moves backwards, the subject's body sways forward. If the duration and velocity of the backwards translation is not too difficult, the subject uses an ankle strategy to control the movement in the ankle and knee joint. The muscle synergy for an ankle strategy begins in the gastrocnemius muscles and then proceeds to the hamstrings and then to the paraspinal muscles [12,13]. For more challenging perturbations, the other strategies are used.

After a perturbation, the first muscle response is a stretch reflex (latency 40–50 ms), followed by automatic postural responses (latency 70–150 ms), and then voluntary reaction responses (180–250 ms) [14]. Delays in the activation could occur from slowed sensory or motor conduction or decreased central processing and can lead to reduced balance control [15].

Studies have shown that persons with decreased central processing – such as in traumatic brain injury [16], Huntington's disease [17], ageing [15], and in children with Down's syndrome [18] – have delayed muscle onset latencies, but no studies have examined muscle onsets for young people with ID. To this end, this study investigates muscle onset latencies from external perturbations. This study included young people with ID and age-matched peers without ID. The use of aged-matched peers presented several questions: Do young people with ID have delayed muscle onset latencies? Are their times to peak amplitude (EMG) slower? Do they exhibit different muscle synergies and strategies? Do young people with ID have a slower adaptation of their postural muscle responses?

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## 2. Method

### 2.1. Subjects and recruitment

The participants – 56 young people with ID (females 54%) and 43 young people without ID (females 44%) – were recruited from two high schools in Sweden (Table 1). These volunteer participants were randomly picked from a pool of 500 young people who volunteered for an earlier study. All participants were given verbal and written information about the study and informed consent was obtained from the guardians of all young people with ID younger than 18 years old. All participants in the ID group had been defined as having mild to moderate ID (IQ 70–35) as determined by intellectual functioning test (IQ Test) and an adaptive behaviour test and none of the participant had Down's syndrome or Prader–Willi syndrome. Exclusion criteria for both groups was impaired vision (visual acuity value >0.10), history of or on-going vestibular neuritis, diagnosis of cerebral palsy, sensory deficits in lower extremities (loss of sensibility, affected stretch reflexes, or reduced strength in lower extremities), and use of walking aids.

### 2.2. Test procedure

Height and weight were measured and ages were noted for all subjects. Vision was tested using an eye chart and neurological deficits in lower extremities were assessed using clinical screening. Next, EMG surface electrodes were placed on the lateral head of gastrocnemius, the biceps femoris, and erector spinae (lumbar region L4) according to The European Recommendation for Surface Electromyography (SENIAM). Six postural perturbations were performed consecutively on a platform with 30 s of rest between trials. No practice trial was used. The first perturbation was used to calculate the muscle onset latencies and comparison between first and last perturbation was used to explore any adaptation of the postural response.

### 2.3. Experimental apparatus and procedures

The subjects stood on a platform (50 cm × 50 cm) that could move in a translational manner backwards causing the subject to sway forward. For this experiment, the platform (SUH-2012-SB) moved backward by 3.5 cm on a trigger signal with a peak velocity of 55 cm/s and peak acceleration of 200 cm/s$^2$. These settings were used to elicit an ankle or mixed strategy response. The subjects were instructed to stand barefoot with feet parallel in a relaxed position and with arms hanging relaxed by the side of the body.

For the EMG recordings on the right side, Ambu Neuroline 720 electrodes were used. The same testleader placed all electrodes on all participants, before electrodes were placed, all the subjects were shaved and the area shaved was scrubbed with Nuprep (Weaver and Company) and cleaned with DAX Alcogel 85% (Opus Health Care). The EMG signal from each muscle was recorded at 1 kHz with MuscleLab 10 (Ergotest Innovation as) and band-pass filtered (10–500 Hz), full-wave rectified, and saved.

The latency of each muscle was identified as the first burst that was >2 SDs above baseline, which was determined using the software programme Visual3D (C-Motion, Inc., USA) and then checked manually. The baseline mean was calculated between 50 ms and 250 ms before platform onset. The time from the first burst to onset of platform was calculated. The beginning of the platform displacement was determined as the moment when the platform acceleration reached 5% of its peak. The acceleration was recorded with an accelerometer, that was fixed to the platform by the test leader, with MuscleLab 10 (Ergotest Innovation a.s.). Both the EMG signal and the signals from the accelerometer are integrated in the Muscle Lab. The first and the sixth trials for each subject were used to explore muscle onset time and time to peak amplitude for each muscle. Time to peak amplitude was identified by counting the time from the start of displacement of the platform to the maximum EMG activation in each muscle. To determine whether young people with ID used an ankle or a mixed muscle strategy, the activation pattern for the subject was analysed. An ankle strategy was noted if the activation started with the gastrocnemius, then proceeded to the biceps femoris, and lastly reached the erector spinae with more than 10 ms between the activation for each muscle. A mixed strategy was noted if the muscles were activated in less than 10 ms between the activation for each muscle [10].

To evaluate adaptation, the first and the sixth trials for the three muscles were compared. The total amplitude of muscle responses was determined by integrating the area under the EMG response (IEMG) during three time epochs. The first epoch was between 0 ms and 69 ms (stretch reflex latencies), the second epoch between 70 ms and 150 ms (automatic postural responses), and the third epoch between 151 ms and 250 ms (voluntary reaction times) after the perturbation [14]. The total background level of IEMG activity between 181 ms and 250 ms (70 ms) before the displacement of the platform onset was subtracted from the two first epochs, and 151–250 ms (100 ms) total background level was subtracted from the third epoch. Then, the first trial mean IEMG area was compared with the sixth trial. No calibration for EMG on absolute scale was made and amplifier gain was fixed for the whole experiment for all subjects. These constraints were made so a meaningful comparison between first and the sixth trial was possible.

### 2.4. Statistical methods

An independent samples *t*-test was applied to calculate differences in means between the two groups for anthropometrics, onset latency, time to peak amplitude (EMG), and IEMG for the three muscles. To analyse whether differences in group structure could have an effect, a correlation analysis was made between sex, height, onset latency, time to peak amplitude (EMG), and IEMG for the three muscles. To evaluate whether the *p*-value altered because

**Table 1**
Descriptive characteristics of subjects with and without intellectual disability (ID), means, and standard deviations.

| | Subjects with ID ($n = 56$) | Subjects without ID ($n = 43$) | *p*-Value |
|---|---|---|---|
| Sex | Females = 30 | Females = 19 | |
| | Males = 26 | Males = 24 | |
| Age (years) | 18.3 (1.3) | 17.9 (0.9) | 0.087 |
| Height (cm) | 169.8 (9.2) | 176.3 (9.3) | 0.001* |
| Weight (kg) | 70.4 (18.8) | 70.3 (9.2) | 0.990 |
| BMI (kg × m$^{-2}$) | 24.3 (5.9) | 22.6 (2.7) | 0.062 |

* Independent *t*-test was used and significance level was set to a *p*-value of less than 5%.