

Physical Exercise Frequency Seem not to Influence Postural Balance but Trunk Muscle Endurance in Young Persons with Intellectual Disability

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Abstract

Background: The influence of various physical exercise frequencies on postural balance and muscle performance among young persons with intellectual disability (ID) is not well understood.

Method: Cross-sectional data from 26 elite athletes were compared with 37 students at a sports school and to 57 students at a special school, all diagnosed with mild to moderate ID and with different exercise frequencies. Data were also compared with a group of 149 age-matched participants without ID.

Results: There were no significant differences in postural balance between young ID groups regardless of physical exercise frequency, all of them had however impaired postural balance compared to the non-ID group. The group with high exercise performed better than the other ID groups in the trunk muscle endurance test.

Conclusions: It appears as if physical exercise frequency don't improve postural balance but endurance in the trunk muscles for young persons with ID.

Keywords: mental retardation; young; teenager; postural control, strength

1. Introduction

A number of studies have repeatedly shown that people with intellectual disability (ID) have inferior postural balance compared to their peers without ID (Blomqvist, Olsson, Wallin, Wester, Rehn, 2013; Enkelaar, Smulders, vanSchrojensteinLantman-de Valk, Geurts, Weerdesteyn, 2012; Vuijk, Hartman, Scherder, Visscher, 2010). Problems with postural balance for them start at a young age and then remain present during the entire lifespan (Enkelaar et al., 2012). Falls and injuries are then major problems among elderly people both with and without ID and can lead to injuries, institutionalization and impaired quality of life (Brady & Lamb, 2008; Finlayson, Morrison, Jackson, Mantry, Cooper, 2010; Sherrard, Tonge, Ozanne-Smith, 2001; Willgoss, Yohannes, Mitchell, 2010). It has been reported that muscle strength in the legs is important for postural balance in elderly individuals (Lee & Park, 2013) but the association for individuals with ID is controversial (Blomqvist, Wester, Persson, Sundkvist, Sundelin, Rehn, 2014; Carmeli, Zinger-Vaknin, Morad, Merrick, 2005). Postural balance and muscle strength are bodily functions that can be improved by physical activity (Axelsen, Danielsson, Norberg, Sjöberg, 2009; Mikolajczyk E & Jankowicz-Szymanska A, 2015), and it is interesting to speculate about preventive and rehabilitative effects from physical exercise.

The American College of Sports Medicine defined the dose or level of physical exercise as being a product of the intensity, duration and frequency. These components are all necessary for the physiological adaptation from training (ACSM, 2014).

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From a general health perspective, it is a necessity that people are regularly physically active, meaning using enough body movements to consume calories in order to avoid related diseases such as overweight, obesity, cardiovascular diseases and diabetes (Henriksson & Sundberg, 2014; WHO, 2010).

Studies of individuals with ID aged 12-70 showed that they were not engaging in enough physical activity to meet national guidelines (Alexander & Anthony, 2011; Temple & Walkley, 2003). Recent studies have also reported that young people with ID are less physically active and participate less in sports than adolescents without ID (Blomdahl & Elofsson, 2011; Hinckson and Curtis, 2013). Carmeli et al. (2005) showed a positive association between physical training, postural balance, muscle performance and wellbeing in a group of 22 adults aged 54-66 with ID. Blomqvist et al. (2014) reported no significant associations in young people with ID with regard to physical activity, aerobic capacity and postural balance.

Granacher et al. (2013) recently reported on the importance of the trunk muscle performance for postural balance. Van der Burg et al. (2005) found high activity in the trunk muscles when subjects stumbled when walking in order to stabilize the trunk over the base of support. Further, Kibler et al. (2006) showed that 12 weeks of trunk muscle training results in enhanced trunk strength, spinal mobility and golf performance.

Improvements to postural balance have been observed after various training interventions for young people with ID (Jankowics-Szymanska, Mikolajczyk, Wojtanowski, 2011; Mikolajczyk and Jankowicz-Szymanska, 2015), but the levels of physical exercise were not investigated. One study found that combined aerobic, muscle performance and postural balance training programs had significant positive effects on aerobic, muscle performance and postural balance compared to a control group of adults with ID aged 20-60 (Oviedo, Guerra-Balic, Baynard, Javierre, 2014). Two studies (Barwick, Tillman, Stopka, Dipnarine, Delisle, SayedulHuq, 2012; Tamse, Tillman, Stopka, Weimer, Abrams, Issa, 2010) reported that young Special Olympic athletes (aged 19-24) benefit from both functional training and supervised strength training in terms of physical capacity, functional abilities and strength.

Only one study has investigated postural balance and muscle performance among very physically active individuals with ID (van de Vliet, Rintala, Fröjd, Verellen, van Houtte, Daly, Vanlandewijck, 2006). This study examined 313 athletes aged 17 to 49 competing in the International Sports Federation for Para-athletes with an Intellectual Disability's (INAS-FID) Global Games in 2004. The European test of physical fitness (EUROFIT) was used and their results were compared to the general population and a group of age-matched physical education students (assumed to have a high level of physical activity). The study could not compare results from their postural balance tests due to necessary alterations to the test for the ID group. The muscle strength tests, however, showed equal or lower results for the ID group compared to the general population and the student group.

Despite these studies, there is a lack of research on the importance of physical exercise frequency on postural balance and muscle performance among young individuals with ID, especially for high-performance athletes. The purpose of this study was to compare the influence of various physical exercise frequencies on postural balance and muscle performance in legs and trunk among three young groups with ID, including one elite group. The results were also compared to an age-matched group without ID. We hypothesized that a higher exercise frequency would be associated with better postural balance and muscle performance in legs and trunk.

1. Materials and methods

2.1 Participants

- Group 1 – High exercise with ID (HEID), including 26 participants from the European athletics indoor games for individuals with ID (elite athletes). They had a high physical activity level = Exercise frequency about 4-7 times a week.
- Group 2 – Medium exercise with ID (MEID), including 37 participants from an ID sports school. They had a medium to high physical activity level = Exercise frequency about 3-5 times a week.
- Group 3 – Low to normal exercise with ID (LNEID), including 56 participants from a special school for people with ID. They had a low to normal physical activity level = Exercise frequency about 0-2 times a week.
- Group 4 – Low to normal exercise without ID (LNE), including 150 participants without ID with a low to normal physical activity level = Exercise frequency about 0-2 times a week.

Each exercise session was assumed, from our many years of experience with the group, to last for about one hour, which is the regular time frame for training sessions. The demography of participants in each group is listed in Table 1. The inclusion criterion for the HEID, MEID and LNEID groups was that they must have been administratively defined as having a mild to moderate ID by means of tests (psychological and pedagogical) carried out by a registered psychologist. The exclusion criteria for all groups were loss of sensory function, abnormal stretch reflexes or reduced static strength in lower extremities, recent injury to lower extremities, impaired vision (visual acuity value >0.10), history of or on-going vestibular neuritis, illness during the last few days before the tests, a diagnosis of cerebral palsy, and use of walking aids. These criteria were all asked for or assessed by the test leaders of the study.

Outliers (with extreme values concerning weight, height and age more than two standard deviations from the mean) from all groups were excluded, resulting in the exclusion of four participants from the HEID group, one participant from the MEID group, six participants from the LNEID group and five participants from the LNE group.

There was a higher proportion of men in the HEID and MEID groups. Regarding age, statistically significant differences were found between all groups except between MEID and LNEID and between MEID and LNE. There was also a significant difference between HEID and MEID groups regarding weight. No other significant differences were found between the groups.

The HEID group was recruited at a European athletics indoor games event in Sweden in 2011. Coaches from all participating countries were approached on site and given written and verbal information about the project. They then suggested athletes who might be suitable for inclusion in the study. The athletes were given the same information as the coaches. The head coaches and the athletes had to sign an approval form for participation in the study. In total, 30 athletes aged between 14 and 41 (17 men and 9 women) volunteered to participate and were tested.

The data for the other groups had been collected earlier and analysed in another study (Blomqvist et al., 2013). A convenience sample was carried out when these groups were recruited at two upper secondary schools in central Sweden: one school for adolescents with ID, offering sports classes and normal education classes, and one school for adolescents without ID. The principals of the schools gave their permission to visit all the classes and provide verbal and written information about the study to all pupils, both with and without ID. The pupils were then asked to volunteer. The guardians of the pupils with ID under the age of 18 received a letter with information about the study and a request to return a signed approval form allowing their son/daughter to participate in the study. If the form was not returned, the pupil was not allowed to participate in the study. Some subjects from the sports school group were recruited from another secondary school in northern Sweden. They were given the same written and verbal information and volunteered to participate by signing up to a list. In total, 102 participants with ID and 157 participants without ID were tested. Of the tested subjects, four subjects did not meet the inclusion criteria for the study and were excluded (two with and two without ID). For some subjects, a few internal dropouts appeared during the test procedure due to inadequate performance.

Table 1. Overview of groups of participants with and without intellectual disability (ID) with regard to age, sex, weight and height. Median and minimum/maximum values for each group.

	Age Median (min-max)	Sex Men/Women (%)	(number)	Weight (kg) Median (min-max)	Height (m) Median (min-max)
HEID: High Exercise with ID (n=26)	22.5 (14-32)	17/9 (65/35)		63.6 (46.1-78.1)	1.69 (1.49-1.87)
MEID: Medium Exercise with ID (n=37)	18 (16-20)	23/14 (62/38)		66.1 (53.6-95.4)	1.73 (1.56-1.89)
LNEID: Low to Normal Exercise with ID (n=56)	18 (16-21)	33/23 (58/42)		63.5 (45.5-92.8)	1.72 (1.52-1.90)
LNE: Low to Normal Exercise without ID (n=150)	17 (16-20)	65/85 (43/57)		65.2 (45-97.9)	1.72 (1.53-1.93)

1.2. Testing procedure

Two experienced physiotherapists tested the HEID group. The instructions were given in English in those cases where the athletes could understand English. Otherwise, an interpreter helped with the instructions. The participants had the opportunity to ask questions. Instructions were also given by showing how the task should be done. The tests took place over the course of four days. Six different test leaders – two experienced physiotherapists and four physiotherapy students – tested the MEID, LNEID and LNE groups. All test leaders were educated and trained by one of the experienced physiotherapists. The instructions were the same as for the HEID group, but in Swedish.

In total, data were collected from five different postural balance tests and three different muscle performance tests. The muscle tests were performed after the balance tests. In this study, data from one test (force platform test) which was shown to be sensitive for both groups and all three muscle performance tests were used and analysed. The length of the test procedure for each participant was between 45 and 60 minutes.

2.3 Postural balance tests

Postural balance was measured during static conditions by using a force platform test (FPT). A lower sway velocity (mm/s) was considered to indicate better postural balance (Salavati, Hadian, Mazaheri, Negahban, Ebrahimi, Talebian, HomayounJafari, Sanjari, Mansour, Parnianpour, 2009). The participants were tested both sighted and blindfolded (using taped ski-goggles), standing on the force platform with arms hanging by their sides for a maximum of 30s. The measure of total sway was stopped if the subject lost postural balance. The subjects were asked to stand in three different positions:

- (1) Feet together – FT
- (2) One foot in front of the other (semi-standing) – SS
- (3) One leg stance (left leg) – OLS

The positions were also tested blindfolded (BF). The tasks FT and SS were added to the testing procedure after 26 subjects from groups 2, 3 and 4 had been tested. The reason was that the OLS position could conceivably be too difficult for the ID groups and therefore it would have been difficult to compare their results with the results from the non-ID group. The participants were instructed to stand as still and relaxed as possible. A signal was given from the test leader when to start and stop the test. Positions 1 and 2 were tested first sighted, then blindfolded, two times each. Position 3 was tested first by measuring the left leg three times, then the right leg three times, both sighted and blindfolded. Participants were not permitted to hook their free leg against the supporting leg or to move the supporting leg from its original position. The data from the best trial of the tests were used. No significant differences were found between the legs and therefore only data from one leg were used (left) in this study. The reliability of measuring mean velocity by using a force platform was considered high to very high in a study by Salavati et al. (2009). The FPT position was also tested for reliability for the ID group, and the ICC (intraclass correlation) was found to be good (Blomqvist, Wester, Sundelin, Rehn, 2012)

2.4 Muscle performance tests in legs and trunk

2.4.1. Counter movement jump

Counter movement jump (CMJ) assesses maximum jump height, which is considered to measure leg muscle strength, power and coordination. The participants were instructed to stand on a box with their hands on their waists, and their feet shoulder width apart, and then make a counter movement jump by first bending their knees to about 90 degrees and then jumping as high as possible. The height of the jump was measured in centimetres using Muscle Lab System, with a string attached to a belt around the participant's waist. The participants had three trials with a short pause between each jump. The result from the best of the three jumps was used in the study. The participants were first asked to stand with their feet raised on their toes before jumping so the actual jump height could be measured. One study has shown that CMJ and leg muscle strength have a high correlation (Wisløff, Castagna, Helgerud, Jones, Hoff, 2004). Another study found CMJ to be one of the most reliable and valid field tests for estimating the explosive power of the lower limbs in physically active men (Markovic G, Dizdar, Jukic, Cardinale, 2004).

2.4.2. Sit-ups for 30 seconds

To measure abdominal muscle endurance, the participants were asked to perform as many sit-ups as possible during 30 seconds. The instruction was to touch the thigh with the elbows. The sit-ups were performed lying supine on the floor with knees flexed at 90 degrees and with the test leader supporting the feet and knees. The hands were held at the side of the head holding a rope which was placed behind the participant's head. The elbows should point forward. The sit-up was approved if performed by rolling up the trunk high enough for the elbows to touch the knees and then rolling back down until the scapula touched the ground. The head did not have to touch the ground (van de Vliet et al., 2006)

2.4.3. Biering-Sørensen trunk extensor endurance test

To measure the endurance of the extensor muscles of the trunk, the Biering-Sørensen trunk extensor endurance test (BSEET) was used. This test was performed with the participants lying prone on a bench with belts strapped over their ankles, knee creases and buttocks to hold the lower body in place. The torso, above the top line of the iliac crest, was held unsupported beyond the bench. The participants were allowed to rest their torso on a chair before the test started. The test leader then asked the participants to cross their arms by the chest and then try to hold their torso in a horizontal position for as long as possible. If the torso was lowered, the test leader requested that the correct position should be resumed. A stopwatch was used to measure the time in seconds for which the test subject could hold their torso in a satisfactorily position. The validity of measuring back muscle fatigue with BSEET has been found to be good (Coorevits, Danneels, Cambier, Ramon, Vanderstraeten, 2008). Studies have also indicated that BSEET is reliable and has good discriminative validity when it comes to distinguishing subjects with or without low back pain, and can predict future occurrence of this condition (Demoulin, Vanderthommen, Duysens, Crielaard, 2006; Latimer, Maher, Refshauge, Colaco, 1999).

2.5 Ethics

Participation in this study was voluntary and the participants had right to stop the testing procedure at any time. All participants received verbal and written information about the tests before consent was obtained. The scorecards were assigned a code so the participants' results would be anonymous, and then locked in. The results were treated as group values and no individual data were assessed that could identify individual participants. The study was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). Ethical approval for the study was obtained from the Regional Ethics Review Board in Umeå, Sweden (No. 09-076M).

2.6 Statistics

Extreme values/outliers concerning age, weight and height in all four groups, determined via the statistical software using box-plots, was identified and then excluded. A check for normality was first applied using the Shapiro-Wilk normality test. The chi-square test was applied to compare the groups regarding sex distribution. All data except from one test (CMJ) were not normally distributed. Kruskal-Wallis was used to compare group values for non-normal distributions followed by Mann-Whitney U tests. One-way ANOVA was used when data were normally distributed, followed by Bonferroni post-hoc tests. The initial alpha value was set to 0.05 but corrected according to Bonferroni due to many comparisons. The alpha value was therefore divided by the number of comparisons (α/n). For differences in age, sex, weight and height between the groups this was $0.05/24 = 0.002$, and for differences of postural balance and strength this was $0.05/54 = 0.001$. The PASW Statistics 18 for Windows package was used for the statistical analysis.

2. Results

3.1 Postural balance tests

The performance of postural balance for the ID groups was worse than for the non-ID group in the OLS, SS and SS BF tests. The HEID and LNEID groups showed significantly higher sway velocity than the non-ID group in the OLS BF test. The HEID and MEID groups had higher sway velocity compared to the non-ID group in the FT test, but not when blindfolded. No other significant differences were noted for the postural balance tests (Figure 1).

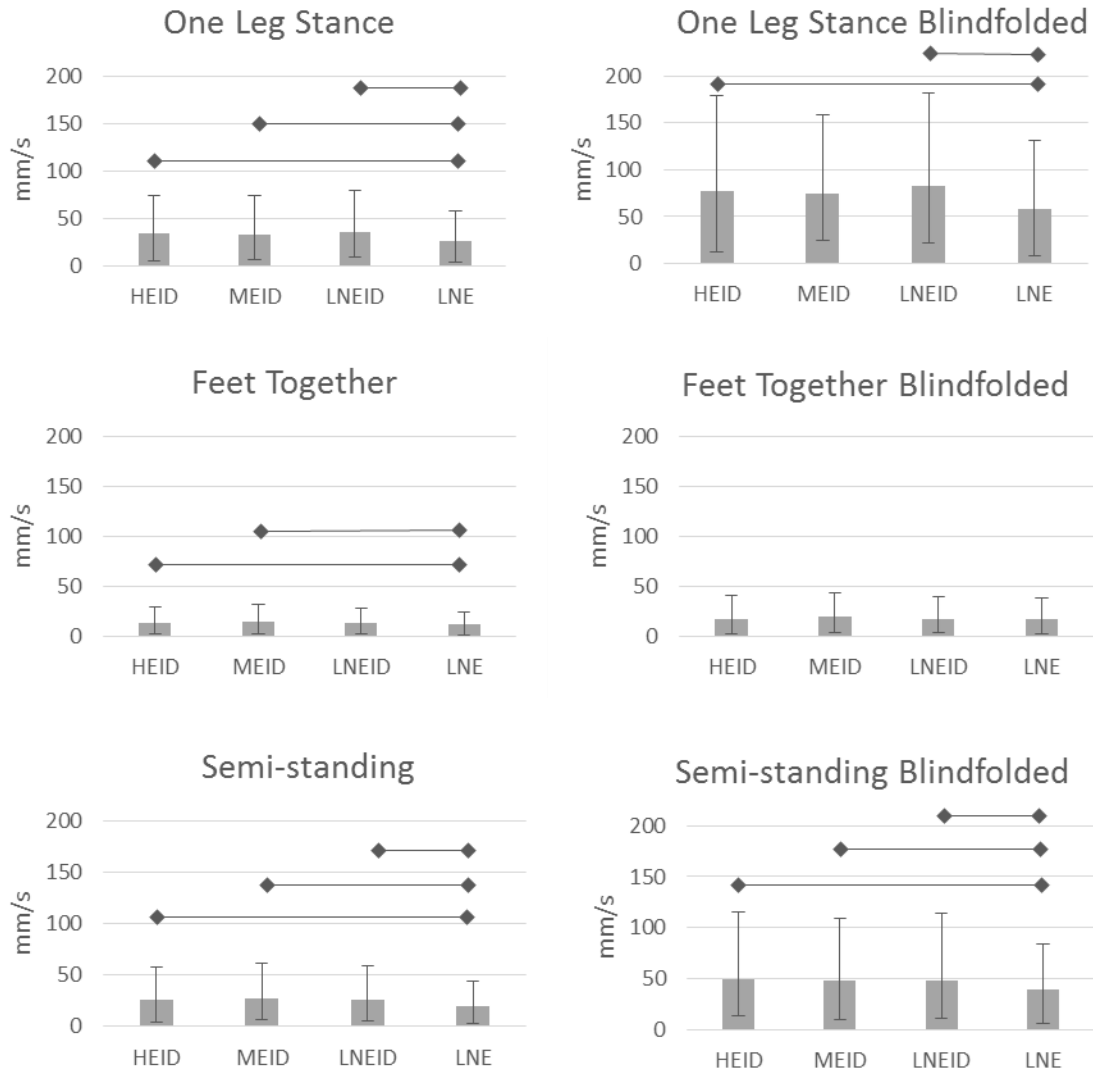
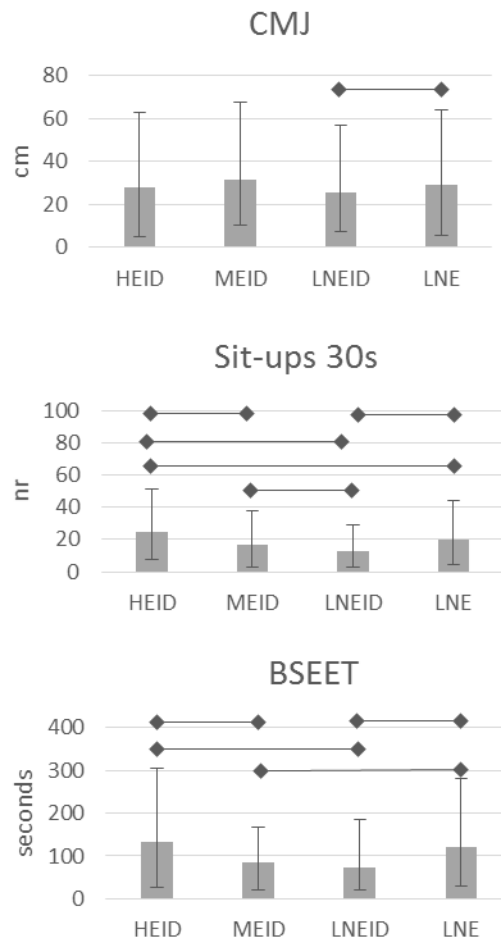


Figure 1. Comparisons of static balance tests between groups with and without intellectual disability (ID). Medians and interquartile ranges are shown. HEID = high exercise with ID, MEID = medium exercise with ID, LNEID = low to normal exercise with ID, and LNE = low to normal exercise without ID. A line between groups indicates statistically significant differences.

3.2 Muscle performance tests

The participants from the LNEID group had a statistically lower jump height compared to the non-ID group. The HEID group was significantly better than the two other ID groups in the sit-ups 30s and BSEET tests. The HEID and LNEID groups achieved fewer sit-ups in 30 seconds compared to the non-ID group (LNE). Both the MEID and LNEID groups had significantly lower values in the BSEET test compared to the non-ID group. No other statistical significant differences were noted (Figure 2).

Figure 2. Comparisons of muscle performance tests between groups with and without intellectual disability (ID). Medians and interquartile ranges are shown. HEID = high exercise with ID, MEID = medium exercise with ID, LNEID = low to normal exercise with ID, and LNE = low to normal exercise without ID. CMJ = counter movement jump, BSEET = Biering-Sørensen trunk extensor endurance test. A line between groups indicates statistically significant differences.



Discussion

This is, to our knowledge, the first study that reports the influence of physical exercise frequency on postural balance and muscle performance among young individuals with ID and that included a group of high-performance athletes. There were no statistically significant differences between the ID groups for the postural balance parameters. This indicates that having a higher physical activity level for young people with ID does not automatically improve postural balance. All of the ID groups had however worse postural balance compared to the non-ID group in the majority of the tests. These results are similar to Vuijk et al. (2010), who found that 64% of the people with ID in their study had inferior postural balance compared to normative population values. In contrast, Kiers et al. (2013) showed however, that high-level athletes without ID had better postural balance than low-level athletes, but in our study, the balance tests did not differ between the ID groups. Our speculation is nevertheless that postural control may require more sophisticated use of the skeletal muscles in contrast to generating strength and endurance, and is therefore difficult to achieve for the ID groups with lower control of motor functions.

The HEID group performed better than the other ID groups in trunk muscle performance tests which suggests that high physical exercise frequency for young people with ID can lead to better muscle performance. Granacher et al. (2013), reported that trunk muscle performance is important for postural balance in seniors without ID. Previous studies by Tamse et al. (2010) and Barwick et al. (2012) have also shown that physical exercise in the form of functional training and supervised moderate intensity resistance exercise training twice a week can improve muscle performance in young individuals (aged 19-24) with ID. They examined the physical effects of different training regimes of Special Olympic athletes with a mild to moderate ID and measured muscle strength using squats, push-ups, static bar hang and static plank. A higher level of physical exercise did however not influence explosive leg strength using the CMJ test, and no significant difference was found between the groups.

Similar results has been found by van de Vliet et al.(2005) who reported that an elite athlete ID group had lower results than the general population in standing broad jump tests but scored better in upper body muscle endurance (measured by bent arm hang) and similar abdominal muscle endurance (using sit-ups for 30s). When compared to sportive peer university students, the elite athletes scored lower on most tests. For elderly people without ID, Lee and Park (2013) found that better leg strength was associated with improved postural balance, but in this study no difference in leg strength was found between the groups. Therefore, the reason why the subjects with ID had poorer results for postural balance may not be explained by their leg strength. The reason for this dissimilarity has to be studied further.

This is a cross-sectional study, with a retrospective view of the exercise frequency, and it is difficult to make assumptions about impacts in a longer time perspective. Another limitation of this study was that the selection of participants was not randomized and power was not calculated even though it was considered that the sample size was quite high and involved athletes, a rarely studied group. The data had already been gathered and groups decided on beforehand, so it was not possible to accomplish perfect matching and the required size of the groups. There was a difference between groups regarding sex and age, although they were fairly comparable. Nevertheless, together, this makes generalization of the results difficult.

In this study, no data were collected concerning the content or intensity of the physical exercise, only repetitiveness or regularity. However, it was assumed that the elite group would also have a higher level in these respects. Elite athletes might exercise differently compared to the other groups, for example with activities requiring more muscle endurance training of the trunk. As the muscle endurance in the trunk was lower for the ID groups, especially for low to normal and medium exercise groups, it should be included in training regimes for people with ID.

There were standardized instructions for the performance of the FPT tests which included arm movements such as scratching the nose or adjusting clothing not being allowed, as this could increase postural sway. These instructions might not have been perceived by all participants in the ID groups. No directly significant alterations of sway were noted though when performing movements, but they might have performed better if they had kept their arms completely still. Foot size might influence the results of the CMJ. To neutralize this, test leaders measured the feet when the subjects rose to their feet and measured the jump height. However, it is possible that not all the subjects succeeded in rising all the way which might result in gaining a few centimetres when performing the CMJ. During the Biering-Sørensen trunk extensor endurance testing, the test leaders were able to note a difference between the non-ID group and the ID group (but not the HEID group) in terms of motivation. They reported that subjects in the ID group had more difficulties motivating themselves, possibly because they did not fully understand the meaning of the testing and therefore might have showed lower performance in this test. Hale et al. (2009) experienced similar difficulties when attempting to measure postural balance capabilities in a group of individuals with profound ID.

People with ID have different degrees of difficulties with functions like memory, perceptual organization and ability to receive and process impressions (Andersson, Björklund, Emanuelson, Stålhammar, 2003). Test situations challenge these functions and it is therefore important to develop tests that are easy to perform and understand. The tests in our study were chosen because they are simple to do (stand still, jump as high as you can, do sit-ups and hold up back) and have been used earlier on people with ID (Markovic et al., 2004).

In this study, it is reported that frequent physical exercise does not seem to be associated with postural balance in young ages. However, future studies should continue to examine what type and level of exercise/physical activity is most effective for improving postural balance in young groups and follow them prospectively, observing the number of falls.

3. Conclusion

This study showed no differences in postural balance between young ID groups regardless of their physical exercise frequency. However, all of the ID groups had impaired postural balance compared to the non-ID group. It seems that muscle performance, especially endurance in the trunk, is to some extent affected by the exercise frequency for groups with ID.

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