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Balance stability in Intellectual Disability: Introductory evidence for the Balance Evaluation Systems Test (BESTest)

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Abstract

Introduction: Balance or postural control is the ability to maintain the center of gravity of the body within the base of support. Falling is one of the most common problems influencing both physical health and quality of life of people with Intellectual Disability (ID). The purpose of this research was to evaluate balance scores and Fear of Falling (FoF) in ID. Methods: A cross-sectional study was performed, including 54 ID subjects. Subjects were aged between 16 and 30 years. The experimental group included 34 ID subjects while the control group included 20 individuals with Down Syndrome (DS). Balance scores and FoF were assessed using the Balance Evaluation Systems Test (BESTest) and Falls

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Efficacy Scale – International (FES-I) questionnaire. Unpaired 't' test was used to compare ID and DS groups.
Results: According to the findings of this research referring to the total Balance Evaluation Systems Test and section Balance Evaluation Systems Test scores, FoF was found to be statistically and significantly different in DS compared to ID. Balance Evaluation Systems Test scores significantly correlated with FES-I scores.
Conclusion: It appears that due to the lowest section scores related to mechanical constraints, sensory orientation and stability in gait, measures to improve these sections are highly needed in Intellectual Disability.

Keywords: Intellectual Disability; Balance Evaluation Systems Test; Fear of falling.

1. Introduction

Intellectual Disability (ID) is characterized by significant deficits in both intellectual functioning and adaptive behavior that originates before the age of 18 years (Saeid, Hassan, & Noureddin, 2014). Intellectual Disability, with a prevalence of 1-3%, is one of the most common causes to seek a referral for genetic counseling and is one of the greatest challenges in healthcare services in the world. Among people with ID, those identified as having profound, severe, moderate and mild level account for 2%, 4%, 10% and 85%, respectively (Maulik, Mascarenhas, Mathers, Dua, & Saxena, 2011).

People with ID frequently present with health-related problems, including visual disorders, epilepsy, hypertension, obesity and hypothyroidism (Jansen, Krol, Groothoff, & Post, 2004). Motor difficulties are also common and include delayed motor development, decreased muscle strength, joint hypermobility, physical disorders and balance and postural deficits (Jansen *et al.*, 2004; Vuijk, Hartman, Scherder, & Visscher, 2010; Giagazoglou, Kokaridas, Sidiropoulou, Patsiaouras, Karra, & Neofotistou, 2013; Kashi, Sheikh, Dadkhah, Hemayattalab, & Arabameri, 2015).

Further motor related issues in individuals with ID include: falls and low levels of physical fitness and activity (Willgoss, Yohannes, & Mitchell, 2010; Blomqvist, Olsson, Wallin, Wester, & Rehn, 2013) leading to associated increased health risks and increasing limitations in mobility and balance (Rimmer & Braddock, 2002; Blomqvist *et al.*, 2013).

Balance or postural control is the ability to maintain the center of gravity of the body within the base of support (Bahiraei, Daneshmandi, & Sedaghati, 2017). Postural stability depends on a combination of motor and sensory systems, including musculoskeletal, visual, vestibular, somatosensory systems and cognitive subsystem (Kachouri, Borji, Baccouch, Laatar, Rebai, & Sahli, 2016; Dewar, Claus, Tucker, Ware, & Johnston, 2017). Deficits in postural stability may occur from impairments in any or all of these subsystems (Blomqvist *et al.*, 2013; Abdul Latheef, Thangadurai, & Mohamed, 2017; Dewar *et al.*, 2017). Thus, to fully evaluate posture and balance control, a range of tests are needed (Blomqvist *et al.*, 2013).

Deficits in postural stability have been shown in persons with ID and Down Syndrome (DS) (Shumway-Cook & Woollacott, 1985; Vuillerme, Marin, & Debû, 2001; Rigoldi, Galli, Mainardi, Crivellini, & Albertini, 2011; Blomqvist *et al.*, 2013; Dewar *et al.*, 2017); however, only some subcomponents of postural stability were assessed and no study has comprehensively assessed all system in these population groups.

In 2009, Horak and colleagues developed a comprehensive balance assessment tool, called the Balance Evaluation Systems Test (BESTest), based on systems theory (Horak, Wrisley, & Frank, 2009). It was expected to be beneficial to identify individual's affected balance subsystem(s) and, therefore, to design tailored balance retraining programs. The reliability and validity of BESTest in adults with or without balance deficits and people with ID have been assessed. This unique evaluation tool is appropriate for any age and severity of ambulatory patients with Parkinson's Disease, Intellectual Disability, Cerebellar Ataxia, Vestibular Disorders, Neuropathy, Head Injury, Multiple Sclerosis, Stroke, Cerebral Palsy, Cognitive Deficits and other balance disorders. The BESTest is a sensitive, quantitative balance assessment that will improve third party reimbursement by identifying subtle deficits and changes with therapy (Horak, 2006; Horak *et al.*, 2009).

Fear of Falling (FoF) is the lack of self-confidence that everyday activities can be done without falling. Studies have reported that fear of falling is a psychological experience, resulting in reduced quality of life and mobility, which in turn results in decreasing balance and mobility and social isolation (Foran, McCarron, & McCallion, 2013). Although FoF is an important health concern for people with ID given its described association with limitations in daily activities, little is known about postural stability in ID people with FoF.

FoF was assessed using the Falls Efficacy Scale-International (FES-I).

A result of FoF is an enhanced risk of falling (da Costa, Pepersack, Godin, Bantuelle, Petit, & Levêque, 2012). Further, in individuals with ID, it has been indicated that balance deficits are independently associated with falls (Finlayson, Morrison, Jackson, Mantry, & Cooper, 2010). Falling is one of the most common reasons for physical injury and impaired quality of life in people with ID (Willgoss *et al.*, 2010). Falling may result in institutionalization, increases in the number of injuries, care costs, further fear of falling and decreased physical activity (Rubenstein & Josephson, 2006; Willgoss *et al.*, 2010). The frequency of falls and fractures are high in people with ID (Hale, Bray, & Littmann, 2007; Willgoss *et al.*, 2010). Some of the risk factors for falls in ID include increasing age, visual impairment, depression and anxiety, balance and gait disorders (Hsieh, Heller, & Miller, 2001).

Given the limited research to date regarding comprehensive balance assessment and knowledge of FOF in people with ID, the purpose of this study was to assess balance and FOF using the BESTest and the FES-I in individuals with ID.

2. Subjects and Methods

2.1. Participants

This was a descriptive cross-sectional study. The study groups included 54 boys with mild to moderate ID, aged 16-30 years. All participants were recruited randomly from schools attended by scholars with Intellectual Disability and the Down Syndrome Association of Gilan in Rasht, Iran. The Intelligence Quotient (IQ) of participants was determined using the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Wechsler, 2008). All participants had an IQ within mild-to-moderate ID (50-70). Sample size computation using G*Power 3.1.9.2 software was informed by previous studies that were carried out with similar outcome measure comparisons. Therefore, assuming a .05 type 1 error with statistical power of .8, effect size $f^2 = .7$, a sample size of approximately 54 participants was required as a study population. Fifty-four participants were assigned to two groups: ID-group (mean age = 20.2 ± 3.8 years) and DS-group (mean age = 18.5 ± 2.7 years). ID-group consisted of 34 boys and DS-group consisted of 20 boys aged 16-30 years old.

Participants with mild to moderate ID were chosen since this population represents the majority of school-aged children with ID in Iran school settings who are educable.

Inclusion criteria for both groups included: age range between 16-30 years, mild to moderate Intellectual Disability (IQ = 50-70), ability to follow verbal instructions. Additional inclusion criteria for participants with DS and ID were based on prior diagnosis and assessment by medical records and medical center that had classified subjects' level of mild-to-moderate ID. All individuals with ID and DS had normal vision and good hearing, were able to walk and go upstairs independently, were not taking any medications and were able to communicate well and understand the simple instructions needed to maintain balance.

Exclusion criteria included: presence of musculoskeletal disorders limiting mobility or orthopedic limitations, subject's dissatisfaction, lack of collaboration from families or legal representatives, vestibular or neuromuscular disease, drug therapies related to a psychiatric diagnosis.

All participants and their families/guardian received written and oral information about the study and signed informed consent before participation. The research was approved by the Institutional Review Board of Guilan University, Iran (IR.GUMS.REC.1397.021).

2.2. Procedures

Assessment were performed either at schools or at the Down Syndrome Association of Gilan in Rasht. All of the participants had been diagnosed with mild ID by a specialized doctor and their parent and/or guardian confirmed the diagnosis. All of the individuals appeared to be healthy, as stated by their medical history or referred by parents and/or guardians.

An interview was conducted on each participant concerning exclusion criteria followed by screening for any loss of sensory function. Age, height and weight were also measured. Vision test was carried out using an eye chart.

Balance and several underlying systems involved in balance control were assessed using the BESTest, a valid, reliable, low cost instrument widely used in clinical practice.

The FoF was assessed using the FES-I, which was selected because it has the highest reliability index among the available tests used to assess FoF among subjects with ID. The BESTest was performed before the FES-I and in an alternating order to avoid any systematic bias.

Three different test leaders alternated during the test period, two were experts in sport sciences and one was an adapted physical education student. All test leaders were trained and educated by one of the experts in sport science who was also a test leader. The training and education included a practical performance and discussion about the tests.

2.3. Instruments

2.2.1. BESTest

The BESTest consists of 27 items in 6 sections, with some items evaluated on both sides of the body, for a total of 36; it is based on a theoretical understanding of balance control systems (Tab. 1). Each item is scored from 0 to 3, with a higher score indicating better balance (Horak *et al.*, 2009). The maximum score for the full BESTest is 108. Higher scores show a better balance performance.

Table 1 - *Description of Sections and Items of the Balance Evaluation Systems Test (BESTest)*

Section	Description	Items (Number)
Biomechanical constraints	Items in this section evaluate constraints on standing balance, including posture, the range of motion and strength	Quality of base of support, postural alignment, ankle strength and range of motion, hip strength, ability to sit on the floor and stand up (1-5)
Stability limits/ verticality	Items in this section evaluate how far the body can move over its base of support and the internal perception of gravitational vertical	Lateral lean in sitting position, verticality and forward and lateral reach (6-8)
Anticipatory postural adjustments	Items in this section evaluate active movement of the center of mass in anticipation of positional changes	Sit-to-stand transfer, rising to toes, single-leg stance, stair tap and standing arm raise (9-13)
Postural responses	Items in this section evaluate in-place and compensatory stepping responses to external perturbations	In-place resistance to perturbation and forward, backward and lateral responses to "push and release" (14-18)
Sensory orientation	Items in this section evaluate increases in postural sway under different sensory conditions	Standing on flat ground and foam with eyes open or closed and standing on the ramp with eyes closed (19 and 20)
Stability in gait	Items in this section evaluate stability while walking under conditions in which balance is challenged	Usual gait speed, change in speed, walking with head turns, quick turning and stopping, stepping over an obstacle, Timed "Up & Go" Test (TUG), TUG with cognitive dual tasks (21-27)

The equipment needed for the BESTest consists of a 10-degree incline gradient, a 60*60 cm box of almost 10-cm, medium-density foam and the BESTest training DVD. All used items comply with BESTest written standards. The height of the stair and obstacle were 17 and 25 cm respectively. A 2.5 kg Dumbbell was used for the standing arm raise item in the anticipatory postural adjustments section (Horak *et al.*, 2009; Potter & Brandfass, 2015). Instructions, Special rankings and Stopwatch and ruler values were used to improve reliability. The BESTest has been determined to have great interrater reliability, great test-retest reliability. Results explained that the reliability of Total Scores was excellent for the Full-

BESTest for all conditions (all intraclass correlation coefficients – *ICC*s > .82) (Potter & Brandfass, 2015; Dewar *et al.*, 2017). The BESTest data of the 2 times had been averaged after being calculated from each trial and analyzed.

This unique evaluation tool is appropriate for any age and severity of ambulatory patients with Parkinson’s Disease, Intellectual Disability, Cerebellar Ataxia, Vestibular Disorders, Neuropathy, Head Injury, Multiple Sclerosis, Stroke, Cerebral Palsy, Cognitive Deficits and other balance disorders (Horak, 2006; Horak *et al.*, 2009).

2.2.2. FES-I

The FES-I is used to assess the FoF in Intellectual Disability. The tool consists of 16 items, each one in form of Likert scale measuring the amount of fear and concern in 4 levels: 1 = not at all concerned, 2 = somewhat concerned, 3 = fairly concerned, 4 = very concerned. The total score of the questionnaire is 64. A score of 1-16 means a lack of fear, 17-32 means low fear, 32-48 equals to average fear and 48-64 means great fear. In the study of Yardley and collaborators, reliability was obtained using Cronbach's alpha of 96% and as well as test-retest reliability (*ICC* = .96) (Yardley, Beyer, Hauer, Kempen, Piot-Ziegler, & Todd, 2005).

3. Data Analysis

The SPSS V. 22 was used to analyze the data. In addition to obtaining descriptive statistics, Shapiro-Wilks tests were performed to determine the normality of the data. The Independent samples T-test was used to examine differences in all of the anthropometric, demographic, BESTest and FoF outcome variables between the ID and DS group. The Pearson correlation coefficients were calculated to investigate the relationship between BESTest and FES-I scores of the subjects with ID and DS. The significant level was considered at .05.

4. Results

Delayed motor development has been shown in ID, which causes this decreased muscle strength, physical disorders, falling and postural deficits as well as reduced balance and falling which are major problems found in people with Intellectual Disability.

The demographics of the ID group were as follows: *M* (*SD*) age = 20.2 (3.8) yrs; *M* (*SD*) Body Mass Index (BMI) = 23.2 (4.3) kg/m^2; *M* (*SD*) weight = 60.7 (12.6) kg; *M* (*SD*) height = 161.8 (9.9) cm. The DS group demographics were as follows: *M* (*SD*) age = 18.5 (2.7) yrs; *M* (*SD*) BMI = 27.8 (3.7) kg/m^2; *M* (*SD*) weight = 58.3 (6.1) kg; *M* (*SD*) height = 145.4 (8.4) cm. There was no statistically significant difference in average age and weight between two groups, but there was a statistically significant difference in BMI and height (DS were shorter and had greater BMI) (Tab. 2).

Table 2 - *Demographic characteristics of the studied population*

	Intellectual Disability (*n* = 34) *M* ± *SD*	Down Syndrome (*n* = 20) *M* ± *SD*	*F(t)*	Statistic (*P*-value)
Age (yrs)	20.2 ± 3.8	18.5 ± 2.7	2.69 (1.68)	.9
BMI (kg/m^2)	23.2 ± 4.3	27.5 ± 3.7	1.34 (-3.99)	.01*
Height	161.8 ± 9.9	145.4 ± 8.4	.98 (6.25)	.01*
Weight	60.7 ± 12.6	58.3 ± 6.1	10.77 (.80)	.4

*$p < .05$

The subjects with DS showed significantly fewer section scores relevant to mechanical constraints, sensory orientation and stability in gait than the subjects with ID. Whereas, stability limits/verticality, transitions/ anticipatory, reactive scores were not statistically significant in both groups (Tab. 3).

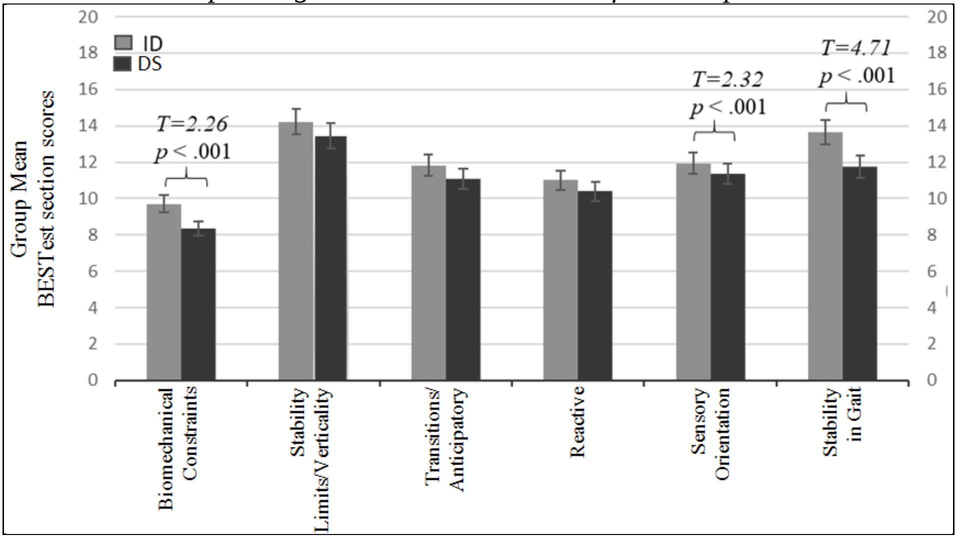
Table 3 - *Independent t-test comparing the section scores Balance Evaluation Systems Test between two groups*

	Intellectual Disability (*n* = 34) *M* ± *SD*	Down Syndrome (*n* = 20) *M* ± *SD*	*F(t)*	Statistic (*P*-value)
BC	9.71 ± 1.87	8.35 ± 1.7	.47 (2.26)	.01*
SLV	14.23 ± 1.78	13.45 ± 2.01	1.04 (1.49)	.14
TA	11.82 ± 1.9	11.1 ± 1.7	.49 (1.41)	.16
R	11 ± 1.72	10.40 ± 1.9	.27 (1.18)	.24
SO	11.94 ± .81	11.35 ± 1.04	3.22 (2.32)	.02*
SG	13.65 ± 1.4	11.75 ± 1.33	.73 (4.71)	.001*

*$p < .05$

Note: BC: Biomechanical Constraints; SLV: Stability Limits/Verticality; TA: Transitions/Anticipatory; R: Reactive; SO: Sensory Orientation; SG: Stability in Gait.

Figure 1 - *Group means BESTest section. Blue columns indicate data for the ID group; red columns data for the DS group. Significant differences between groups are highlighted by brackets with the corresponding t-statistic and P-value of the comparison*



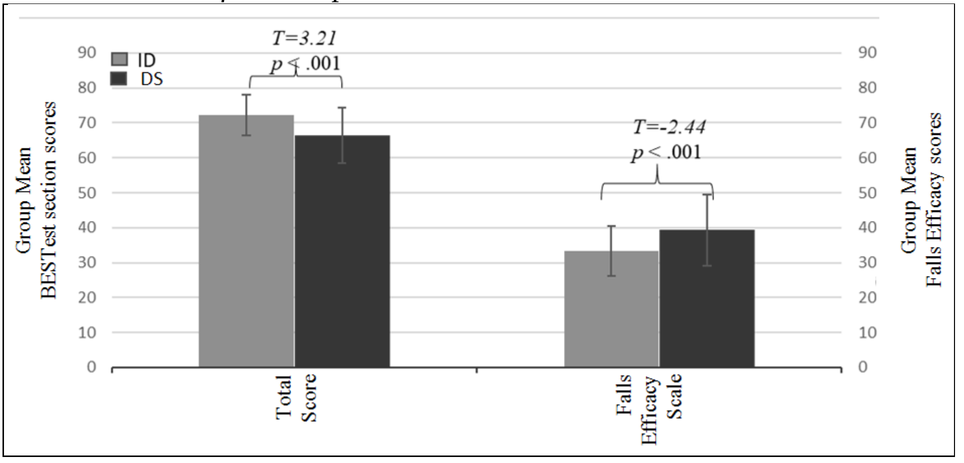
Also, subjects with DS showed significantly less total BESTest and FES-I scores than the subjects with ID (Tab. 4, Fig. 2).

Table 4 - *Independent t test comparing the total Balance Evaluation Systems Test (BESTest) and Falls Efficacy Scale – International (FES-I) scores between two groups*

	Intellectual Disability (n = 34) $M \pm SD$	Down Syndrome (n = 20) $M \pm SD$	$F(t)$	P-Value
TS	72.23 ± 5.94	66.4 ± 7.22	.48 (3.21)	.002*
FES-I	33.26 ± 7.95	39.35 ± 10.2	2.41 (-2.44)	.018*

*$p < .05$
Note: PTS: Percent Total Score, FES-I: Falls Efficacy Scale – International.

Figure 2 - *Group means BESTest total scores and Falls Efficacy Scale. Blue columns indicate data for the ID group and red columns data for the DS group. Significant differences between groups are highlighted by brackets with the corresponding t-statistic and P-value of the comparison*



There is a significant negative relationship between the FES-I and the total BESTest scores; the subjects with ID (P = .01, r = -.86), DS (P = .01, -r = .83) and both groups (P = .01, r = -.87) (Tab. 5); [R^2 = .749 both ID and DS, R^2 = .747 ID and R^2 = .717 in DS] (Fig. 3, 4, 5).

The results showed that decrease in BESTest scores correspond to increase in FES-I scores, leading to an increased risk of falling. These results are shown in both groups ID and DS. Therefore, decreasing BESTest scores causes the fall of ID and DS.

Table5 - *The correlation of total Balance Evaluation – Systems Test and fear of falling an individual with ID and DS*

		FES-I Pearson correlation coefficient	*P*-value
	Intellectual Disability (*n* = 34)	-.865	.001*
PTS	Down Syndrome (*n* = 20)	-.834	.001*
	Total (*N* = 54)	-.866	.001*

*$p < .05$
Note: PTS: Percent Total Score, FES-I: Falls Efficacy Scale – International

Figure 3 - *Negative correlation between FES-I and PTS scores in both of person DS and ID*

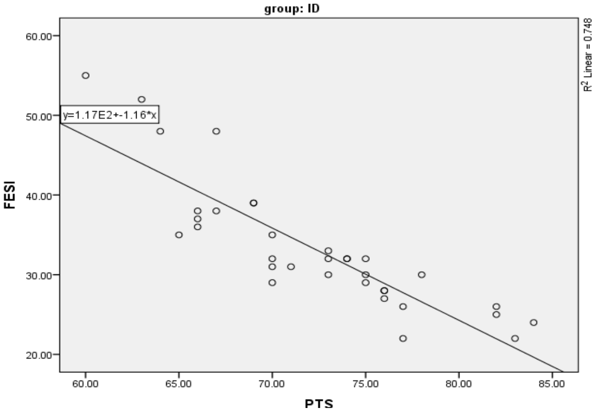


Figure 4 - *Negative correlation between FES-I and PTS scores in person with DS*

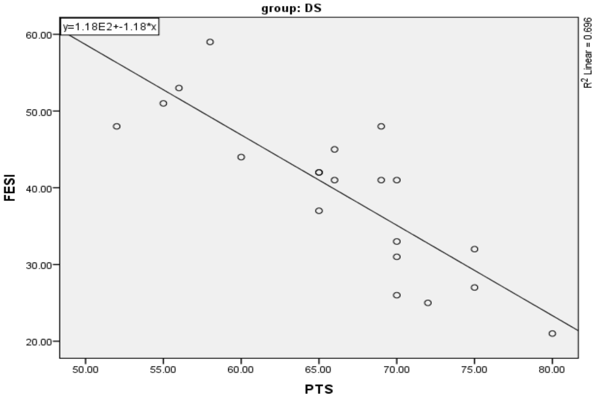
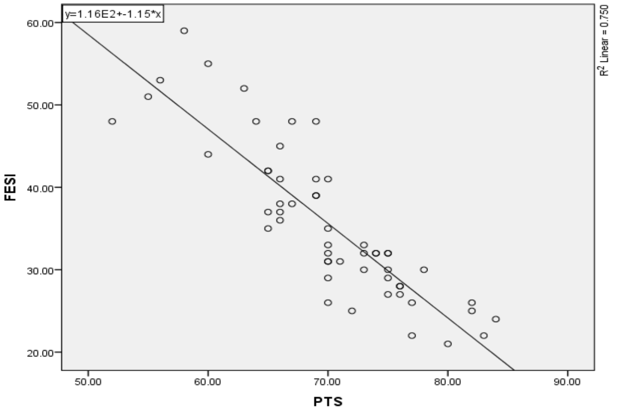


Figure 5 - *Negative correlation between FES-I and PTS scores in both of group DS and ID*



5. Discussion

The purpose of our study was to evaluate BESTest score and FoF in boys with ID. The principal result of our study demonstrated that BESTest and FES-I scores were significantly different between subjects with DS and ID.

As regards the tools available to assess clinical balance, it can be stated that these cannot help the therapist in the diagnosis of the underlying causes of the balance impairment, but the BESTest test can identify sub-systems balance and can be targeted for the treatment process. In this study, total BESTest scores and section scores relevant to mechanical constraints, sensory orientation and stability in gait were lower in the DS group than in ID group. However, reactive scores obtained in the sections concerning stability limits/verticality, transitions/anticipatory were not significantly different between DS and ID groups (Pitetti, Miller, & Loovis, 2017). The subjects with DS showed significantly lower FES-I scores than the ID subjects. Furthermore, a significant negative relationship between the FES-I scores with the total BESTest scores has been found. Considering findings that objective measures of mechanical constraints, sensory orientation and stability in gait as significant predictors of future falls for people with ID, it may be useful to maintain a balanced evaluation within these grounds using the BESTest.

The individual with DS showed ligament laxity, resulting from the connective tissue disorder characterizing the condition (Galli, Rigoldi, Brunner, Virji-Babul, & Giorgio, 2008). One of the most important factors affecting DS subjects is hypotonia. Hypotonia is the first sign of musculoskeletal problems in DS. Hypotonia is a cause of muscular performance weakness and motor development delays (Kashi *et al.*, 2015).

The compound of these difficulties prevents dynamic joint stabilization and describes the enhanced prevalence of musculoskeletal deformities. DS needs to compensate for their muscle and ligament dysfunction to deal with daily activities and keep functioning.

Since mechanical constraints include the base of the item of support and Center of Mass (CoM) alignment, segmental postural alignment, disruption in any of these cases can lead to decrease BESTest section scores. Weakness and muscular constraint is one of these, therefore ankle or hip weakness limit the capacity of subjects with DS to use the ankle and hip strategy or compensatory steps to recover balance after, for instance, tripping (Silva-Batista, Corcos, Kanegusuku, Piemonte, Gobbi, de Lima-Pardini *et al.*, 2018). The reduction in hip and ankle muscle strength is one of the factors that reduce the ability of DS individuals to restore balance with ankle and hip strategies, followed by an increase in muscles and joints to achieve a rebalance (Kashi *et al.*, 2015). Therefore, this may be one of the reasons for the decrease of the BESTest section scores in mechanical constraints, postural malalignment and hypotonia or muscle weakness in people with DS. Lin and colleagues (2010) observed that there was 14.5% and 8.5% cases had spinal and limb deformities based on physician's observation and X-ray test (Lin, Lin, Lin, Lai, Leu, Yen *et al.*, 2010; Jacobs & Kasser, 2012). Based on the results of Biomechanical Constraints, one of the reasons for reducing the balance of these individuals is spinal and limb abnormalities. These individuals have a high prevalence of flat foot, forward head and scoliosis abnormalities.

Hence musculoskeletal deformities evaluation and muscle performance are very important in balance assessment.

It is possible that no significant difference stability limits/verticality, Transitions/Anticipatory and reactive sections scores we observed in the ID and DS groups could be the outcome of a trunk-stiffening strategy. Carmeli and colleagues (2008) indicated that adults with ID the decreased sway rate resulted in a trunk-stiffening strategy (Carmeli, Bar-Yossef, Ariav, Levy, & Liebermann, 2008) which is in line with the result of the present research. The results of trunk stiffness lead to reduced Center of Pressure (CoP) (Carmeli *et al.*, 2008). One possible cause for decreasing CoP could be actively stiffening up because of a fear of falling. Another possible cause to stiffen up could be that the limits of stability are lower physical activity and inactivity in ID individuals.

Furthermore, the BESTest evaluates sensory orientation based on visually observable imbalance or an incapacity to keep the feet in place over 30 s, which may be as sensitive as the instrumented measures of CoP displacement (Jacobs & Kasser, 2012) previously found to differentiate between ID and DS. Moreover, changes in sway patterns were evident in people with ID and significant differences between ID and DS in sensory orientation was found. One possible reason for decreased section sensory orientation scores could be a major disorder in coordinating cooperation of the organ of sight, the inner ear, proprioception and the central nervous system in DS group compared to ID group (Dellavia, Pallavera, Orlando, & Sforza, 2009; Vuijk *et al.*, 2010; Jankowicz-Szymanska, Mikolajczyk, & Wojtanowski, 2012).

The results of a research by Cabeza-Ruiz and collaborators (2011) showed that in the absence of visual information, the energy control group was raised in low repeats, but DS patients decreased it, which was more than closed eyes, which may be due to cognitive abnormalities in system function vestibular problems associated with DS, or problems with the use of information (Cabeza-Ruiz, García-Massó, Centeno-Prada, Beas-Jiménez, Colado, & González, 2011). Postural control assessment in young people with DS in different conditions of proprioception and vision showed that there might be qualitative differences in the integrity of sensory information in postural control, but the two groups also used similar strategies for postural control (Vuillerme *et al.*, 2001). Studies by Paus (2010) and Baudry and colleagues (2007) reported that individuals with lower sensory orientation (sensory integration dysfunction and Proprioception) are less likely to detecting weaker postural sway, thus failing to produce appropriate muscle responses to control postural sway and a weaker equilibrium show (Baudry, Klass, Pasquet, & Duchateau, 2007; Paus, 2010). Blomqvist and colleagues (2013) found that adolescent with ID (16-20 years) do have more visual dominance of postural balance (Blomqvist *et al.*, 2013). Dellavia and colleagues (2009) indicated that athletic with ID had a higher mean body sway than their peer without ID (Dellavia *et al.*, 2009) which is in line with the result of the present research.

Instability in gait, such as the gait level surface, change in gait speed, walk with head turns-horizontal, walk with pivot turns, step over obstacles, timed get up & go, timed get up & go with dual-task was demonstrated in subjects with DS and ID.

About stability in gait, poor dynamic balance during gait seems to be due to impaired coordination between spinal locomotor and brain-stem postural sensorimotor programs (Takakusaki, 2017). In this study, it was observed that ID population present with gait impairment. Also, since DS is characterized by muscle weakness and hypotonia, the number of muscle fibers or less percentage of fasting fibers, their joint stability decreases by increasing the range of motion. In person with DS, joint stiffness throughout gait modifies according to the level: at hip level, DS improved stiffness states; at ankle level, a significant decrease (Cimolin, Galli, Grugni, Vismara, Precilios, Albertini *et al.*, 2011). This different approach may consider our results: the lower balance scores in DS may be related to their dysfunction as correlated to ID (Cimolin *et al.*, 2011). Smith and colleagues (2007) described the experience of young people with DS to modify their movement model with practice, even if there were typical characteristics of DS, i.e. wider stride width or shorter stride length, that are typically expected of DS gait pattern, due to compensatory plans of balance protection (Smith, Kubo, Black, Holt, & Ulrich, 2007).

Gait difficulties have been recognized as risk factors for falls. Recent studies have demonstrated that particularly ambulatory individuals with ID are more at risk of falling. This is consistent with the observation that, in the general population, falls happen most commonly during walking. A recent review indicated the importance of movement problems concerning fall in the individual with ID. Nevertheless, no prior study has straight investigated (Enkelaar, Smulders, van Schrojenstein Lantman-de Valk, Geurts, & Weerdesteyn, 2012).

Foran and collaborators (2013) found that people with ID who self-reported were consistent in their responses to the degree of FoF they experienced and their activity restriction due to FoF (Foran *et al.*, 2013).

Risk factors for falls in people with ID include older age, epilepsy and visual deficits. Some of the risk factors for falls in ID are similar to that of the general population, which include increasing age, visual impairment and recency of falls (Chiba, Shimada, Yoshida, Keino, Hasegawa, Ikari *et al.*, 2009).

In brief, people with ID show balance impairments across various contexts of postural stability and, although further research is needed to prove these findings, this study confirms the use of the BESTest as a clinical diagnostic of balance impairment in subjects with ID (Jacobs & Kasser, 2012). For treatment targets, it is important to know the reliability of the six postural stability areas evaluated by the Full-BESTest. From the clinical point of view, quantitative characterization of postural balance in ID and DS is important to improve and differentiate the rehabilitative options. Goals in the DS populations are to improve biomechanical constraints, sensory orientation, stability in gait. Also, both ID and DS patients need particular balance practice training as part of a comprehensive rehabilitation program, and especially DS should be encouraged to strengthening the muscles of the lower limbs, sensory orientation and gait with the dual task to counteract instability. Full-BESTest is reliable tools to measure postural balance for young people with mild to moderate ID. The Full-BESTest has slightly better reproducibility and a broader range of items, which suggests it could be the most useful version for treatment planning.

There are some restrictions that must be addressed. First, this study includes only boys with mild to moderate ID, so nothing is known about postural stability in adolescents and adults with the severe and profound ID. Second, one possible limitation could be the lack of social and cognitive effects, as these could act as determinant of the functional performance of boys with ID. Third, no control group has been included in this study, therefore the results obtained could be compared with age-matched, non-ID samples.

References

Abdul Latheef, K., Thangadurai, C., & Mohamed, S. S. (2017). Evaluation of age and gender-related balance scores in normal adults using Mini Balance Evaluation Systems Test. *International Journal* of *Physiotherapy, 4* (3), 196-200.

Bahiraei, S., Daneshmandi, H., & Sedaghati, P. (2017). The effect of a selective combined training program on motor performance, balance and muscle strength in boys with Down Syndrome (DS). *Journal of Paramedical Sciences, 6* (4), 40-45.

Baudry, S., Klass, M., Pasquet, B., & Duchateau, J. (2007). Age-related fatigability of the ankle dorsiflexor muscles during concentric and eccentric contractions. *European journal of applied physiology, 100* (5), 515-525.

Blomqvist, S., Olsson, J., Wallin, L., Wester, A., & Rehn, B. (2013). Adolescents with intellectual disability have reduced postural balance and muscle performance in trunk and lower limbs compared to peers without intellectual disability. *Research in Developmental Disability, 34* (1), 198-206. doi: https://doi.org/10.1016/j.ridd.2012.07.008.

Cabeza-Ruiz, R., García-Massó, X., Centeno-Prada, R., Beas-Jiménez, J., Colado, J., & González, L.-M. (2011). Time and frequency analysis of the static balance in young adults with Down syndrome. *Gait & Posture, 33* (1), 23-28. doi: https://doi.org/10.1016/j.gaitpost.2010.09.014.

Carmeli, E., Bar-Yossef, T., Ariav, C., Levy, R., & Liebermann, D. G. (2008). Perceptual-motor coordination in persons with mild intellectual disability. *Disability and rehabilitation, 30* (5), 323-329.

Chiba, Y., Shimada, A., Yoshida, F., Keino, H., Hasegawa, M., Ikari, H., Miyake, S., & Hosokawa, M. (2009). Risk of fall for individuals with intellectual disability. *American Journal on Intellectual and Developmental Disabilities, 114* (4), 225-236.

Cimolin, V., Galli, M., Grugni, G., Vismara, L., Precilios, H., Albertini, G., Rigoldi, C., & Capodaglio, P. (2011). Postural strategies in Prader-Willi and Down syndrome patients. *Research in Developmental Disability, 32* (2), 669-673. doi: https://doi.org/10.1016/j.ridd.2010.11.017.

da Costa, E. M., Pepersack, T., Godin, I., Bantuelle, M., Petit, B., & Levêque, A. (2012). Fear of falling and associated activity restriction in older people. results of a cross-sectional study conducted in a Belgian town. *Archives of public health, 70* (1): 1.

Dellavia, C., Pallavera, A., Orlando, F., & Sforza, C. (2009). Postural stability of athletes in Special Olympics. *Perceptual and Motor Skills, 108* (2), 608-622. doi: https://doi.org/10.2466/pms.108.2.608-622.

Dewar, R., Claus, A., Tucker, K., Ware, R., & Johnston, L. (2017). Reproducibility of the Balance Evaluation Systems Test (BESTest) and the Mini-BESTest in school-aged children. *Gait & Posture, 55*, 68-74.

Enkelaar, L., Smulders, E., van Schrojenstein Lantman-de Valk, H., Geurts, A. C., & Weerdesteyn, V. (2012). A review of balance and gait capacities in relation to falls in persons with intellectual disability. *Research in developmental disabilities, 33* (1), 291-306.

Finlayson, J., Morrison, J., Jackson, A., Mantry, D., & Cooper, S. A. (2010). Injuries, falls and accidents among adults with intellectual disabilities. Prospective cohort study. *Journal of Intellectual Disability Research, 54* (11), 966-980.

Foran, S., McCarron, M., & McCallion, P. (2013). Expanding assessment of fear of falling among older adults with an intellectual disability: A pilot study to assess the value of proxy responses. *ISRN Geriatrics, 2013*. doi: http://dx.doi.org/10.1155/2013/493042.

Galli, M., Rigoldi, C., Brunner, R., Virji-Babul, N., & Giorgio, A. (2008). Joint stiffness and gait pattern evaluation in children with Down syndrome. *Gait & Posture, 28* (3), 502-506.

Giagazoglou, P., Kokaridas, D., Sidiropoulou, M., Patsiaouras, A., Karra, C., & Neofotistou, K. (2013). Effects of a trampoline exercise intervention on motor performance and balance ability of children with intellectual disabilities. *Research in developmental disabilities, 34* (9), 2701-2707.

Hale, L., Bray, A., & Littmann, A. (2007). Assessing the balance capabilities of people with profound intellectual disabilities who have experienced a fall. *Journal of Intellectual Disability Research*, *51* (4), 260-268. doi: https://doi.org/10.1111/j.1365-2788.2006.00873.x.

Horak, F. B. (2006). Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? *Age Ageing, 35* (suppl_2), ii7-ii11. doi: https://doi.org/10.2522/ptj.20080071.

Horak, F. B., Wrisley, D. M., & Frank, J. (2009). The balance evaluation systems test (BESTest) to differentiate balance deficits. *Physical Therapy, 89* (5), 484-498. doi: https://doi.org/10.2522/ptj.20080071.

Hsieh, K., Heller, T., & Miller, A. B. (2001). Risk factors for injuries and falls among adults with developmental disabilities. *Journal of Intellectual Disability Research, 45* (1), 76-82. doi: https://doi.org/10.1111/j.1365-2788.2001.00277.x.

Jacobs, J. V., & Kasser, S. L. (2012). Balance impairment in people with multiple sclerosis: preliminary evidence for the Balance Evaluation Systems Test. *Gait & Posture, 36* (3), 414-418. doi: https://doi.org/10.1016/j.gaitpost.2012.03.026.

Jankowicz-Szymanska, A., Mikolajczyk, E., & Wojtanowski, W. (2012). The effect of physical training on static balance in young people with intellectual disability. *Research in Developmental Disability, 33* (2), 675-681. doi: https://doi.org/10.1016/j.ridd.2013.05.034.

Jansen, D. E., Krol, B., Groothoff, J. W., & Post, D. (2004). People with intellectual disability and their health problems: a review of comparative studies. *Journal of Intellectual Disability Research, 48* (2), 93-102.

Kachouri, H., Borji, R., Baccouch, R., Laatar, R., Rebai, H., & Sahli, S. (2016). The effect of a combined strength and proprioceptive training on muscle strength and postural balance in boys with intellectual disability: An exploratory study. *Research in Developmental Disability, 53*, 367-376. doi: https://doi.org/10.1016/j.ridd.2016.03.003.

Kashi, A., Sheikh, M., Dadkhah, A., Hemayattalab, R., & Arabameri, E. (2015). The Effect of "Kashi Practices" on the Improvement of Psycho-Motor Skills in People with Down Syndrome. *Iranian Rehabilitation Journal, 13* (3), 13-21.

Lin, J.-D., Lin, P.-Y., Lin, L.-P., Lai, C.-I., Leu, Y.-R., Yen, C.-F., Hsu, S.-W., Chu, C.-M., Wu, C.-L., & Chu, C. M. (2010). Spinal and limb abnormalities in adolescents with intellectual disabilities. *Research in Developmental Disability, 31* (3), 686-691. doi: https://doi.org/10.1016/j.ridd.2010.01.008.

Maulik, P. K., Mascarenhas, M. N., Mathers, C. D., Dua, T., & Saxena, S. (2011). Prevalence of intellectual disability: a meta-analysis of population-based studies. *Research in developmental disabilities, 32* (2), 419-436.

Paus, T. (2010). Growth of white matter in the adolescent brain: myelin or axon? *Brain and cognition, 72* (1), 26-35.

Pitetti, K., Miller, R. A., & Loovis, M. (2017). Balance and coordination capacities of male children and adolescents with intellectual disability. *Adapted Physical Activity Quarterly, 34* (1), 1-18.

Potter, K., & Brandfass, K. (2015). The Mini-Balance Evaluation Systems Test (Mini-BESTest). *Journal of Physiotherapy, 61* (4): 225. doi: https://doi.org/10.1016/j.jphys.2015.04.002.

Rigoldi, C., Galli, M., Mainardi, L., Crivellini, M., & Albertini, G. (2011). Postural control in children, teenagers and adults with Down syndrome. *Research in Developmental Disability, 32* (1), 170-175. doi: https://doi.org/10.1016/j.ridd.2010.09.007.

Rimmer, J. H., & Braddock, D. (2002). Health promotion for people with physical, cognitive, and sensory disabilities: An emerging national priority. *American Journal of Health Promotion, 16* (4), 220-224. doi: https://doi.org/10.4278/0890-1171-16.4.220.

Rubenstein, L. Z., & Josephson, K. R. (2006). Falls and their prevention in elderly people: what does the evidence show? *Medical Clinics of North America, 90* (5), 807-824. doi: https://doi.org/10.1016/j.mcna.2006.05.013.

Saeid, B., Hassan, D., & Noureddin, K. (2014). The relationship between alignment of upper limb and postural control in adolescents with Down Syndrome. *Medicina Sportiva, 10* (2), 2322-2329.

Shumway-Cook, A., & Woollacott, M. H. (1985). Dynamics of postural control in the child with Down syndrome. *Physical Therapy*, *65* (9), 1315-1322.

Silva-Batista, C., Corcos, D. M., Kanegusuku, H., Piemonte, M. E. P., Gobbi, L. T. B., de Lima-Pardini, A. C., de Mello, M. T., Forjaz, C. L. M., & Ugrinowitsch, C. (2018). Balance and fear of falling in subjects with Parkinson's disease is improved after exercises with motor complexity. *Gait & Posture*, *61*, 90-97.

Smith, B. A., Kubo, M., Black, D. P., Holt, K. G., & Ulrich, B. D. (2007). Effect of practice on a novel task-walking on a treadmill: preadolescents with and without Down syndrome. *Physical Therapy*, *87* (6), 766-777.

Takakusaki, K. (2017). Functional neuroanatomy for posture and gait control. *Journal of movement disorders, 10* (1), 1-17.

Vuijk, P. J., Hartman, E., Scherder, E., & Visscher, C. (2010). Motor performance of children with mild intellectual disability and borderline intellectual functioning. *Journal of Intellectual Disability Research, 54* (11), 955-965. doi: https://doi.org/10.1111/j.1365-2788.2010.01318.x.

Vuillerme, N., Marin, L., & Debû, B. (2001). Assessment of static postural control in teenagers with Down syndrome. *Adapted Physical Activity Quarterly*, *18* (4), 417-433. doi: https://doi.org/10.1123/apaq.18.4.417.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale - Fourth edition.* San Antonio, TX: Pearson Assessment

Willgoss, T. G., Yohannes, A. M., & Mitchell, D. (2010). Review of risk factors and preventative strategies for fall-related injuries in people with intellectual disabilities. *Journal of Clinical Nursing, 19* (15-16), 2100-2109. doi: https://doi.org/10.1111/j.1365-2702.2009.03174.x.

Yardley, L., Beyer, N., Hauer, K., Kempen, G., Piot-Ziegler, C., & Todd, C. (2005). Development and initial validation of the Falls Efficacy Scale-International (FES-I). *Age and ageing, 34* (6), 614-619.