Gait & Posture 96 (2022) 295–300

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Reliability and validity of the Turkish version of Fullerton Advanced Balance Scale in cerebral palsy

Sinem Erturan [a,*,1], Pelin Atalan [a], Yasin Ali Çimen [b], Derya Gökmen [c], Özlem Akkoyun Sert [d], Kamil Yılmaz [d], Bülent Elbasan [a]

[a] Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Gazi University, Ankara, Turkey
[b] Department of Physiology, Faculty of Medicine, Bezmialem Vakif University, Fatih, Istanbul, Turkey
[c] Department of Biostatistics, Faculty of Medicine, Ankara University, Sıhhiye, Ankara, Turkey
[d] Division of Physiotherapy and Rehabilitation, KTO Karatay University, School of Health Sciences, Konya, Turkey

A R T I C L E I N F O

Keywords:
Cerebral palsy
Validity
Balance
Diplegia
Hemiplegia

A B S T R A C T

Background: The Fullerton Advanced Balance Scale (FAB) is a multi-item balance assessment test designed to measure balance in relatively higher functioning individuals. The aim of this study was to examine the reliability and validity of the Turkish version of the FAB (FAB-T) in children with cerebral palsy (CP).
Research question: Is the Turkish version of the Fullerton Advance Balance Scale valid and reliable in determining balance problems in children with cerebral palsy and determining the underlying cause of this condition?
Methods: Forty-six children with CP participated in this study. Rasch analysis was used to investigate item adherence. Internal consistency of the FAB-T was established using Cronbach's alpha coefficient. Test-retest reliability was also evaluated. In addition, to assess concurrent validity, FAB-T scores were compared with the Pediatric Balance Scale (PBS) using the Spearman correlation coefficient.
Results: The FAB-T showed satisfactory internal consistency (Cronbach's alpha value=0.94) and excellent test-retest reliability (ICC=0.99). The FAB and the PBS exhibited concurrent positive validity ($r = 0.913$; $p < 0.001$). All items of the FAB-T were found to fit the Rasch Model (Chi-square 16.01(df=20), $p = 0.716$).
Significance: The FAB-T is a reliable and valid tool that can be used to measure balance skills and to identify the source of the problem in children with CP.

1. Introduction

Cerebral palsy (CP) is a persistent but non-progressive disease that develops due to a lesion in the fetal or newborn brain. In children with CP, motor disorders are often accompanied by impaired cognitive functions, sensory systems, sensory integration, communication and perception problems [1]. These issues seen in CP may cause serious outcomes on postural control, which is needed in daily life activities because postural control is achieved through the complex integration of multiple body systems, including the vestibular, visual, auditory, proprioceptive, and higher-level premotor systems [2,3].

Postural control is defined as a complex skill provided by the interaction of both static reflexes and dynamic sensorimotor processes. Postural balance and postural orientation are two basic components of postural control. Postural balance includes stabilization of the center of mass relative to the base of support, by improving sensorimotor coordination against both internal and external instability disorders. Postural orientation, on the other hand, provides active smoothness of body biomechanics according to internal references such as somatosensory, vestibular, visual systems, and external references such as gravity and support surface [4–6]. Biomechanical limitations, movement and sensory strategies, spatial orientation, dynamic control and cognitive processing resources must be provided in order to provide a good postural orientation and balance [5].

Postural control disorders may develop in CP as a result of somatosensory and somatomotor pathologies or damage to any underlying system. Children with CP have poorer postural control than children with typical development because of co-contraction in antagonist muscles, prolonged activation times, weak adaptive responses, proximal to distal muscle recruitment pattern, and difficulties in resolving

* Correspondence to: Emek Neighborhood Biskek Street 6th Street (former 81st Street) No:2, 06490 Çankaya, Ankara, Turkey.
E-mail address: snm.ertrn@gmail.com (S. Erturan).
[1] ORCID İD: 0000-0002-3135-5248.

https://doi.org/10.1016/j.gaitpost.2022.06.007
Received 27 February 2022; Received in revised form 28 April 2022; Accepted 14 June 2022
Available online 16 June 2022

intersensory conflict [7,8].

Poor postural control causes impairments in walking ability, balance control, and functional skills [3,9]. This negatively affects daily living activities and quality of life of children with CP [10]. Accurate and early evaluation of the underlying problem of balance disorders (vestibular/tactile/visual sensory origin, postural control disorders, etc.) is highly important in terms of establishing an appropriate treatment protocol, examining the prognosis of patients, describing the symptoms in a detailed way, and increasing the effectiveness of treatment [11]. Therefore, a good assessment tool should measure the problem area, have high reliability-validity in the evaluated population, be easy to use, evaluate the relationship of individual characteristics with the environment and task performance, and be sensitive to changes [12,13]. There are many clinical and objective tests that evaluate balance in CP, namely, the Timed Up Go(TUG) test [14], the Timed Up Down Stairs (TUDS) test [15], the Functional Reach Test(FRT) [16], the Berg Balance Scale(BBS) [17], the Kids-Balance Evaluation Systems Test (Kids--BESTest) [18], the Clinical Test of Sensory Integration of Balance (CTSIB) [19], and the PBS [20,21]. While they are valid and reliable tests for assessing static and functional balance, each has several limitations [3,14–17,19]. While the TUG and TUDS tests measure dynamic balance, they do not measure static balance [14,15]. The FRT measures only the forward reaching control aspect of functional balance [16]. The Kids-BESTest and CTSIB have been used to distinguish the impact of the sensory systems and sensory integration dysfunction on postural control in children with CP but require more time and different equipment [19]. It has been reported that the BBS and PBS distinguish balance disorders in children with different levels of neurological involvement, but are insufficient in high-functioning, mildly-affected children [17]. Similarly, the PBS does not include items to assess impairment in the multi-sensory systems where visual, tactile, and vestibular sensory inputs are processed during function [3,4].

Recently, it has been suggested that there is a need for tools that target individuals at higher functional levels [22]. The Fullerton Advanced Balance Scale was developed for use in functionally independent active older adults [23]. The FAB scale, which was previously translated into Turkish as the FAB-T, has test-retest reliability (ICC=0.96) for active elderly with high-level functions, and its validity and reliability in Turkish were established [24]. It has not yet been determined whether the FAB-T, the Turkish version of the FAB, is a valid and reliable test to evaluate balance function in children with CP. The aim of this study was to investigate whether the FAB-T scale has validity and reliability in assessing balance function in children with CP.

2. Methods

2.1. Procedure

Before the study, permission was obtained from Rose, who developed the FAB, and Iyigun, who performed the Turkish validity and reliability study of the FAB-T [24]. Approval was obtained from the XXXXXXXX University Ethics Committee(91610558-604.01.02) for the validity and reliability study of the FAB-T in children with CP. Children and parents were informed about the study and their voluntary consent was obtained. The participants were informed about their Gross Motor Function Classification System(GMFCS) levels and the scales to be used in the study. Participants' GMFCS levels were evaluated by researchers who were physiotherapists. The participants' demographic information was obtained. To minimize measurement errors, assessments were made in centers where children were treated because they were familiar with the environment. The FAB-T was compared with the PBS, which was shown to be valid and reliable in children with CP, to determine its validity [20,21]. The first and second evaluations were made on the same day by two physiotherapists. For inter-rater reliability evaluation, while the child was performing the items in the measurement tools, the physiotherapists scored at the same time but independently(PT-1:First evaluation,PT-2: Second evaluation). In order to minimize the motor learning effect and developmental changes in retesting, 10–14 day intervals were suggested between test and retest [25]. Therefore, children who had their first and second assessments were reassessed 10 days later by the physiotherapist who made the initial assessment(PT-1:Third evaluation) to assess intra-rater reliability.

2.2. Participants

Forty-six children with CP referred to the Physiotherapy and Rehabilitation Department of the Faculty of Health Sciences of XXXX University were included in the study. The participants were aged between 6 and 16 years. The inclusion criteria were having the diagnosis of CP at GMFCS I or II [26,27], and having the cognitive ability to understand the tests and cooperate accordingly. Children with an orthopedic injury or a history of surgical intervention, and those who received Botulinum Toxin injection within 3 months before data collection, those with a diagnosis of vestibular disorder and a history of burns or injuries that would adversely affect sensory input were excluded from the study.

2.3. Instrument

2.3.1. Pediatric Balance Scale

The Pediatric Balance Scale was used in this study. The PBS consists of 14 items and each item is scored between 0 and 4 (Table 1). The total score ranges from 0 to 56, with a lower score indicating increased balance disorders. It is a reliable method for assessing balance in children with neurological disorders [4,28].

2.4. Fullerton Advanced Balance Scale

The Fullerton Advanced Balance Scale includes the evaluation of static (items in which the center of mass is held on a fixed support base) and dynamic balance (items in which the support base changes with the movement) control, sensory inputs and their integration, and feed-forward and reactive postural control [29]. The Fullerton Advanced Balance Scale is a performance-based scale developed to identify subtle changes in balance and to comprehensively assess the underlying cause of balance disorders, enabling clinicians to create a more efficient treatment program [23]. The test consists of 10 items and each item is scored between 0 and 4 (Table 1). A higher score indicates better balance, and a score below 25 indicates a higher risk of falling in older adults [22,24].

Table 1
Items of the PBS and FAB.

PBS	FAB
1 Sitting to standing	1 Standing with feet together and eyes closed
2 Standing to sitting	2 Reaching forward to an object
3 Transfers	3 Turn in full circle
4 Standing unsupported	4 Step up and over
5 Sitting unsupported	5 Tandem walk
6 Standing with eyes closed	6 Stand on one leg
7 Standing with feet together	7 Stand on foam, eyes closed
8 Standing with one foot in front	8 Two-footed jump
9 Standing on one foot	9 Walk with head turns
10 Turning 360 degrees	10 Reactive postural control
11 Turning to look behind	
12 Retrieving object from floor	
13 Placing alternate foot on stool	
14 Reaching forward with outstretched arm	

PBS: Pediatric Balance Scale; FAB: Fullerton Advanced Balance scale.

2.5. Statistical analysis

2.5.1. Internal construct validity

The internal construct validity of the FAB was examined by fit of the data to the Partial Credit Model, which is one of the Rasch models for polytomous items [30]. The Rasch analysis includes the following sequential steps: [31].

1. Rescoring of the FAB items that demonstrated 'disordered thresholds':

   Firstly, items showing 'disordered thresholds' were identified from the threshold map. Disordered thresholds were corrected by collapsing the adjacent response categories for the problematic items.
2. Deletion of the misfitting items.
3. Re-analysis of the overall model and individual item fit.

   After all items showed orderly thresholds, individual items were deleted one at a time and the overall fit was reexamined after each item deletion. The fit was determined by a number of fit statistics. At the scale level, summary fit statistics included item- and person-residuals which, with perfect fit, would have a mean of zero, and a standard deviation of 1. A chi-square interaction fit statistic should be non-significant, to show lack of deviation from model expectations. At the individual item level, fit residuals should be between + 2.5; and the Chi square statistics should be non-significant (>0.05 Bonferroni adjusted).
4. Examination for differential item functioning (DIF) for diagnosis

   DIF, examined for diagnosis (hemiplegic/diplegic CP), should show non-significant differences between groups (Bonferroni adjusted).
5. Test for unidimensionality

   To test unidimensionality, the sample is divided into class intervals. For each item, the degree of similarity between the observed responses in each class interval and the expected responses predicted by the model is computed through a standardized residual and a χ^2 fit statistic.
6. Examination of local dependency.

This assumption was tested by inspection of residual correlation matrix. If a pair of items had a residual correlation of 0.30 or more, one of the items that showed a higher accumulated residual correlation with the remaining items was eliminated.

2.5.2. External construct validity

The external construct validity of the FAB was assessed by testing for expected associations of Rasch transformed FAB scores with PBS through the process of convergent construct validity. The degree of associations with these outcome measures was analyzed by Spearman's correlation coefficient.

The reliability of the FAB was examined by both internal consistency and test-retest reliability. An estimate of the internal consistency reliability of the FAB was tested by the Person Separation Index(PSI) [32]. This is equivalent to Cronbach's alpha but has the linear transformation from the Rasch model [33]. For test-retest reliability of FAB, DIF was carried out to verify the invariance of item difficulty hierarchy across the first and second assessment at 10-day intervals. Data were analyzed using the Rasch-Model Computer program RUMM2020 [34].

3. Results

Forty-six children were included in the study. The demographic characteristics of the participants are presented in Table 2.

Starting with 10 items, seven items displayed disordered thresholds, necessitating collapsing of categories. Following this, all items were found to fit the model (given a Bonferroni adjustment fit level of 0.005) (Table 3). The overall mean item fit residual was 0(SD 1.791) and the mean person fit residual was 1.839(SD 2.779). Item trait interaction was non-significant, supporting the invariance of the items(Chi-square 16.01 (df=20),p = 0.716). When DIF was tested for diagnosis none of the items showed DIF. Both the Cronbach's alpha and PSI were high(0.94), indicating the ability of the scale to differentiate more than 5 groups of patients. When the test-retest was examined via DIF by time, none of the items showed DIF. In addition, the FAB-T showed excellent test-retest reliability(ICC=0.99).

All 10 items define a unidimensional scale of balance since there were no significant differences between observed and expected scores in terms of p values. When the assumption of local independence was examined, there was no pair of items which had a residual correlation of 0.30 or more. Overall, the resulting 10-item bank was not particularly well targeted. With a mean person score of 1.839, children in this study displayed a higher average level of balance than the average level of the item bank (Fig. 1).

Table 2
Demographic and Clinical Data of the Participants.

Age (years) (Mean ± SD)	10.54 ± 3.59	
Sex	**n**	**%**
Female	20	43.5
Male	26	56.5
Type of Cerebral Palsy	**n**	**%**
Hemiplegic	17	37.0
Diplegic	29	63.0
GMFCS Level	**n**	**%**
Level I	30	65.2
Level II	16	34.8
Mean ± SD (n = 46)		
FAB-T	28.45 ± 9.79	
PBS	49.41 ± 11.99	

GMFCS: Gross motor function classification system; FAB-T: Turkish version of the Fullerton Advance Balance Scale; PBS: Pediatric Balance Scale; SD: Standard deviation.

Table 3
Fit of FAB to Rasch model.

Items	Location	Standard Error	Individual Item Fit Residual	Chi-Square Test Statistics	p
1. Stand with feet together and eyes closed	-1.682	0.425	-0.756	1.095	0.578
2. Reach forward to retrieve an object held at shoulder height with outstretched arm	-2.785	0.342	0.295	0.996	0.608
3. Turn in a circle in both directions	-1.952	0.446	-0.286	0.971	0.615
4. Step up and over a 6-inch bench	-0.503	0.427	-0.536	0.307	0.858
5. Tandem walk	1.683	0.239	-0.158	1.663	0.435
6. Stand on one leg	2.933	0.284	0.044	0.381	0.826
7. Stand on foam with eyes closed	-0.462	0.577	-1.190	2.017	0.365
8. Two-footed jump	0.887	0.336	-0.079	3.614	0.164
9. Walk with head turns	0.816	0.222	0.578	0.831	0.660
10. Reactive postural control	1.065	0.343	0.066	4.130	0.127

FAB: Fullerton Advance Balance Scale.

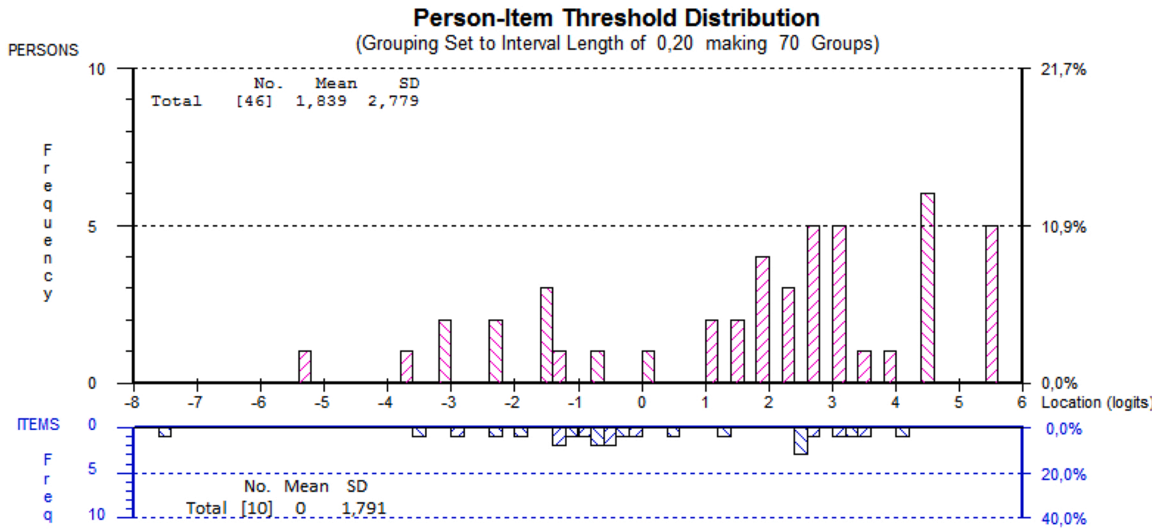

Fig. 1. Targeting of FAB to children's balance.

3.1. *External construct validity*

When the correlations of the FAB Rasch transformed score with the PBS were examined, there was a positive correlation with the PBS ($r = 0.913$; $p < 0.001$).

4. Discussion

The current study aimed to determine whether the FAB-T is a valid and reliable scale for evaluating balance functions in children with CP, and the FAB-T was found to be a unidimensional, valid, and reliable scale for children with CP. It was shown that the FAB-T is feasible for use with children with hemiplegic or diplegic CP and it has a positive and significant correlation with the PBS scale, which is frequently used in pediatric population for balance assessment.

Sim et al. used factor analysis for the Korean version of the FAB, which is a different statistical method than the one used in the current study, and found it valid and reliable in children with CP [29]. On the other hand, Kim et al. used Rasch analysis for the validity of the Korean version of the FAB, similar to the statistical analysis of the current study, and found the scale valid [35]. Rasch analysis helps individuals to be evaluated accurately by transforming the answers obtained with the ordinal scale into a range variable. In addition, the psychometric properties of the scale can be evaluated with Rasch analysis [30,31,33]. Therefore, Rasch analysis was used in our study to determine the validity and reliability of the FAB-T in children with CP.

Starting with 10 items, seven items displayed disordered thresholds, necessitating collapsing of categories. Before the evaluation of the item fit, where polytomous items are involved, response categories should be examined for correct ordering. This involves the examination of the threshold pattern, the threshold being the transition point between adjacent categories. For an item with an appropriate ordering of thresholds, each response option would demonstrate the highest probability of endorsement at a specific range of the scale, with successive thresholds found at increasing levels of the construct being measured. One of the most common sources of item misfit concerns is respondents' inconsistent use of these response options. This results in what is known as disordered thresholds and usually, although not always, collapsing of categories where disordered thresholds occur improves overall fit to the model. These disordered thresholds mean that the categories can be reduced in number. In scale scoring, children with lower skills were expected to score as low as 0 or 1 in item scoring, while children with higher skills were expected to get higher scores. In the Korean version study of the FAB, the results were found in parallel with our study and it was reported that the questionnaire should be converted into a 4-category scale by combining the 3rd and 4th categories [35].

Misfitting indicates that an item on the questionnaire is poorly defined or measures something different from what was intended. In such a case, inconsistent items are revised to improve clarity. Kim et al. evaluated the Korean version and did not report incompatibility in the diplegic CP group, but they reported that they showed inconsistency in items 2 and 1 in the hemiplegic CP group, and they suggested revisions for these items [35]. However, in our study, all items were found to be suitable for the model. This difference is thought to be due to the cultural, pathological, or sub-clinical constraint differences of the children with CP who participated in both studies. This shows that the FAB-T is a suitable scale for assessing balance in children with hemiplegic and diplegic CP, none of the items required revision, and all items fit the model.

The Cronbach α coefficient of the scale allows for internal consistency assessment, and the higher Cronbach α value reveals that the variables are homogeneous and the original scale materials are reliable [36]. A high PSI value indicates the scale's ability to distinguish between different abilities of patient groups. In this study, both the Cronbach α and PSI coefficients were found to be 0.94. This shows that the FAB-T scale has high internal consistency in children with CP and the FAB-T can distinguish between the different balance abilities of children with CP.

Item difficulties expressed as logit in Rasch analysis are used to investigate the item hierarchy of the scale, and higher logit values indicate that those particular items are more difficult to perform [37]. In this scale, the most difficult item was item 6 with a logit value of 2.933 in both children with hemiplegic or diplegic CP. The reason for this can be explained by the fact that the children participating in the study had lower extremity problems and balance disorders are more easily noticed when the support base is narrowed. The easiest item was item 2 with a logit value of −2.785 in both hemiplegic and diplegic children with CP. This may be due to the fact that the participants had fewer trunk and upper extremity problems. In their study with children with CP, Kim et al [35]. and Jeon et al [38]. have found that item 9 was the most difficult, while item 1 was the easiest. However Sim et al. did not mention the hardest and easiest items in their study [29]. In studies conducted with different patient groups, the most difficult and easiest items may differ. Because children with CP may present with very different clinical outcomes.

The study also provides good construct validity, none of the items included DIF in children with hemiplegic or diplegic CP. DIF analysis plays complementary roles in verifying the fairness of the test. This means that all questions in the scale can be administered indiscriminately to all children with CP, both hemiplegic and diplegic children at GMFCS levels I or II. In parallel with this study, Kim reported that the most difficult and easiest items were the same in the hemiplegic and diplegic groups, and item difficulties were similar in these groups [35].

All 10 items defined a unidimensional scale of balance since there were no significant differences between observed and expected scores in terms of p values. When the assumption of local independence was examined, there was no pair of items which had a residual correlation of 0.30 or more.

The results of this study showed that in order to accurately assess balance, item difficulty should be considered according to the disability level in CP. In Rasch analysis, harder items have higher positive values and easier items have higher negative values [39]. In the present study, item 5-6-8-9-10 had positive values. These items evaluate the effects of postural control and vestibular sense on balance in children with CP, and high positive values are associated with lack of postural control and vestibular and lower extremity involvement in children with CP. Items 1, 2, 3, 4, and 7 had negative values. These are items that evaluate the effect of visual and tactile sense on balance in the FAB-T scale. This is associated with the fact that the children included in the study were GMFCS I-II and children with CP who had high-level functions, and they were able to perform this easily. Similarly, Kim et al. found that items 5, 6, and 9 had positive values [35]. In addition, in another study in which balance scales were compared using Rasch analysis, similar results were obtained and it was reported that the items of the FAB were more distinctive than those of the PBS [38].

When the PBS and FAB-T total scores were compared in the study, it was found that the individual total score of the PBS was higher than that of the FAB-T. This result shows similarity with previous studies [29,38]. This means that it is relatively easier to reach the criteria for item scores in PBS scoring compared to FAB-T scoring, and it proves that the FAB-T distinguishes postural control deficits better than the PBS.

When the correlations of the FAB Rasch-transformed score with that of the PBS were examined, there was a positive correlation($r = 0.913$; $p < 0.001$). The FAB-T scale, which shows a positive correlation with the PBS scale, shows similarity with previous studies in which the FAB scale was used in CP and compared with the PBS [29]. This result shows that the FAB-T is a scale that is feasible for the assessment of postural control in children with CP.

The feature that makes our study superior to other studies is that Rasch analysis, which is an important analysis method, was used in the structuring and validity of assessment tools [29,30,33]. With Rasch analysis, it was determined that all items in the FAB-T scale were suitable for the model and could be used in children with hemiplegic and diplegic CP. In addition, the validity and reliability of the FAB-T in children with CP will allow its use in larger populations. Considering the items in the FAB-T, it is a scale that evaluates postural control and vestibular/visual/tactile senses in addition to balance assessment in children with CP.

4.1. Study limitation

Among the limitations of the study are the small number of children participating in the study, the fact that psychometric features such as age, cognition, fear of falling, which affect the balance function of the children, were not taken into account, and that most of the participants had diplegic CP at GMFCS I. Further investigation may focus on these parameters.

5. Conclusion

The use of the FAB-T in children with CP is thought to be useful for a better understanding of the underlying mechanism of balance problems. In children with CP experiencing balance disorders, it is important to determine the cause of the balance disorder, to develop an appropriate intervention program, and to increase the efficiency in the intervention. The FAB-T is a scale that evaluates postural control disorders and their causes in detail in children with CP.

Presentation

Reprints of the work are not available.

Statements and declarations

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University XXX (91610558-604.01.02-).

Disclosure statement

The authors declare that this study has received no financial support. The authors declare no conflict of interest.

Suppliers

There is no supplier involved in the study.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Acknowledgements

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Yasin Ali Çimen], [Derya Gökmen], [Özlem Akkoyun Sert] and [Kamil Yılmaz]. The first draft of the manuscript was written by [Sinem Erturan], [Pelin Atalan] and [Bülent Elbasan] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.gaitpost.2022.06.007.

References

[1] M. Burak, E. Kavlak, Investigation of the relationship between quality of life, activity participation and environmental factors in adolescents with cerebral palsy, Neurorehabilitation 45 (4) (2019) 555–565.
[2] A. Shumway-Cook, S. Hutchinson, D. Kartin, R.P. Msme, M. Woollacott, Effect of balance training on recovery of stability in children with cerebral palsy, Dev. Med. Child Neurol. 45 (9) (2003) 591–602.
[3] M.R. Franjoine, J.S. Gunther, M.J. Taylor, Pediatric balance scale: a modified version of the berg balance scale for the school-age child with mild to moderate motor impairment, Pediatr. Phys. Ther. 15 (2) (2003) 114–128.
[4] M.R. Franjoine, N. Darr, S.L. Held, K. Kott, B.L. Young, The performance of children developing typically on the pediatric balance scale, Pediatr. Phys. Ther. 22 (4) (2010) 350–359.
[5] F.B. Horak, Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age Ageing 35 (suppl_2) (2006) ii7–ii11.
[6] E. Kavlak, A. Ünal, F. Tekin, F. Altuğ, Effectiveness of Bobath therapy on balance in cerebral palsy, Cukurova Med. J. 43 (4) (2018) 975–981.
[7] J. Pierret, S. Caudron, J. Paysant, C. Beyaert, Impaired postural control of axial segments in children with cerebral palsy, Gait Posture 86 (2021) 266–272.
[8] M.H. Woollacott, P. Burtner, J. Jensen, J. Jasiewicz, N. Roncesvalles, H. Sveistrup, Development of postural responses during standing in healthy children and children with spastic diplegia, Neurosci. Biobehav. Rev. 22 (4) (1998) 583–589.

[9] M.H. Woollacott, A. Shumway-Cook, Postural dysfunction during standing and walking in children with cerebral palsy: what are the underlying problems and what new therapies might improve balance? Neural Plast. (2005) 12.
[10] L.A. Prosser, S.C. Lee, A.F. VanSant, M.F. Barbe, R.T. Lauer, Trunk and hip muscle activation patterns are different during walking in young children with and without cerebral palsy, Phys. Ther. 90 (7) (2010) 986–997.
[11] C. Schlenstedt, S. Brombacher, G. Hartwigsen, B. Weisser, B. Möller, G. Deuschl, Comparison of the fullerton advanced balance scale, mini-BESTest, and berg balance scale to predict falls in Parkinson disease, Phys. Ther. 96 (4) (2016) 494–501.
[12] J. Vargus-Adams, Understanding function and other outcomes in cerebral palsy, Phys. Med. Rehabil. Clin. 20 (3) (2009) 567–575.
[13] R. Saether, J.L. Helbostad, I.I. Riphagen, T. Vik, Clinical tools to assess balance in children and adults with cerebral palsy: a systematic review, Dev. Med. Child Neurol. 55 (11) (2013) 988–999.
[14] E.N. Williams, S.G. Carroll, D.S. Reddihough, B.A. Phillips, M.P. Galea, Investigation of the timed 'up & go'test in children, Dev. Med. Child Neurol. 47 (8) (2005) 518–524.
[15] C.A. Zaino, V.G. Marchese, S.L. Westcott, Timed up and down stairs test: preliminary reliability and validity of a new measure of functional mobility, Pediatr. Phys. Ther. 16 (2) (2004) 90–98.
[16] R.A. Norris, E. Wilder, J. Norton, The functional reach test in 3-to 5-year-old children without disabilities, Pediatr. Phys. Ther. 20 (1) (2008) 47–52.
[17] G. Kembhavi, J. Darrah, J. Magill-Evans, J. Loomis, Using the berg balance scale to distinguish balance abilities in children with cerebral palsy, Pediatr. Phys. Ther. 14 (2) (2002) 92–99.
[18] R. Dewar, A.P. Claus, K. Tucker, R.S. Ware, L.M. Johnston, Reproducibility of the Kids-BESTest and the Kids-Mini-BESTest for children with cerebral palsy, Arch. Phys. Med. Rehabil. 100 (4) (2019) 695–702.
[19] R.M. Dewar, K. Tucker, A.P. Claus, W. van den Hoorn, R.S. Ware, L.M. Johnston, Evaluating validity of the Kids-Balance Evaluation Systems Test (Kids-BESTest) Clinical Test of Sensory Integration of Balance (CTSIB) criteria to categorise stance postural control of ambulant children with CP, Disabil. Rehabil. (2021) 1–8.
[20] J.-G. Her, J.-H. Woo, J. Ko, Reliability of the pediatric balance scale in the assessment of the children with cerebral palsy, J. Phys. Ther. Sci. 24 (4) (2012) 301–305.
[21] C.-l Chen, I.-h Shen, C.-y Chen, C.-y Wu, W.-Y. Liu, C.-y Chung, Validity, responsiveness, minimal detectable change, and minimal clinically important change of Pediatric Balance Scale in children with cerebral palsy, Res. Dev. Disabil. 34 (3) (2013) 916–922.
[22] P.J. Klein, R.C. Fiedler, D.J. Rose, Rasch analysis of the Fullerton Advanced Balance (FAB) scale, Physiother. Can. 63 (1) (2011) 115–125.
[23] D.J. Rose, N. Lucchese, L.D. Wiersma, Development of a multidimensional balance scale for use with functionally independent older adults, Arch. Phys. Med. Rehabil. 87 (11) (2006) 1478–1485.
[24] G. Iyigun, B. Kirmizigil, E. Angin, S. Oksuz, F. Can, L. Eker, D.J. Rose, The reliability and validity of the Turkish version of Fullerton Advanced Balance (FAB-T) scale, Arch. Gerontol. Geriatr. 78 (2018) 38–44.
[25] M. Ferdjallah, G.F. Harris, P. Smith, J.J. Wertsch, Analysis of postural control synergies during quiet standing in healthy children and children with cerebral palsy, Clin. Biomech. 17 (3) (2002) 203–210.
[26] R.J. Palisano, P. Rosenbaum, D. Bartlett, M.H. Livingston, Content validity of the expanded and revised Gross Motor Function Classification System, Dev. Med. Child Neurol. 50 (10) (2008) 744–750.
[27] P.L. Rosenbaum, S.D. Walter, S.E. Hanna, R.J. Palisano, D.J. Russell, P. Raina, E. Wood, D.J. Bartlett, B.E. Galuppi, Prognosis for gross motor function in cerebral palsy: creation of motor development curves, JAMA 288 (11) (2002) 1357–1363.
[28] A. Erden, E.A. Arslan, B. Dündar, M. Topbaş, U. Cavlak, Reliability and validity of Turkish version of pediatric balance scale, Acta Neurol. Belg. (2020) 1–7.
[29] Y.J. Sim, G.M. Kim, C.H. Yi, The reliability and validity of the Korean version of the Fullerton Advanced Balance Scale in children with cerebral palsy, Physiother. Theory Pract. 35 (11) (2019) 1087–1093.
[30] D. Andrich, Rasch Models for Measurement, 68, Sage, 1988.
[31] A.H. Elhan, D. Öztuna, Ş. Kutlay, A.A. Küçükdeveci, A. Tennant, An initial application of computerized adaptive testing (CAT) for measuring disability in patients with low back pain, BMC Musculoskelet. Disord. 9 (1) (2008) 1–15.
[32] L.J. Cronbach, Coefficient alpha and the internal structure of tests, Psychometrika 16 (3) (1951) 297–334.
[33] W. Fisher, Reliability statistics, Rasch Meas. Trans. 6 (3) (1992) 238.
[34] D. Andrich, B. Sheridan, G. Luo, RUMM2020 (Rasch Unidimensional Measurement Models), RUMM Laboratory Perth, Western Australia, 2003.
[35] G.-m Kim, Validation of the Fullerton Advanced Balance Scale in children with cerebral palsy, Int. J. Ther. Rehabil. 25 (9) (2018) 459–466.
[36] D.L. Streiner, G.R. Norman, J. Cairney, Health Measurement Scales: a Practical Guide to their Development and Use, Oxford University Press, USA, 2015.
[37] P.W. Duncan, R.K. Bode, S. Min Lai, S. Perera, Rasch analysis of a new stroke-specific outcome scale: the Stroke Impact Scale, Arch. Phys. Med Rehabil. 84 (7) (2003) 950–963.
[38] Y.-J. Jeon, G.-M. Kim, Comparison of the psychometric properties of two balance scales in children with cerebral palsy, J. Phys. Ther. Sci. 28 (12) (2016) 3432–3434.
[39] Bond TG, Fox CM, Lacey H. Applying the Rasch Model: Fundamental Measurement, in: Proceedings of the Second Paper Presented at: in the Social Sciences, 2007.