



Special Issue

Feasibility and reliability of the Functional Movement Screen battery in adults with intellectual disability

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Abstract

Background The feasibility and reliability of the Functional Movement Screen (FMS) battery for predicting injury risk have been widely studied in athletic, military, public service and healthy populations. However, scant research has been carried out in people with disabilities. This study aimed at identifying the feasibility and reliability of the FMS battery when administered to adults with intellectual disability (ID).

Methods Adults from a residential and day care centre over 18 years of age, diagnosed with ID and able to follow simple instructions, were included in the study. All participants with behavioural or health problems that prevented the completion of the FMS battery were excluded. All exercises were video recorded to assure proper scoring. Three assessors (one trained and two novices) scored each of the FMS subtests performed separately from the videos. Feasibility was based on completion rates. Reliability of the composite test scores was

analysed using intraclass correlation coefficients (ICCs).

Results A total of 30 people with ID (mean age: 35.5 ± 7.12 years; 33.3% women) completed all assessments. The battery showed to be feasible, although difficulties when performing two of the subtests were observed among those with moderate and severe ID. Mean total scores from the three assessors ranged from 7.83 to 8.90. An inverse trend was observed indicating that the higher the ID level, the lower the total FMS score. Test–retest reliability was good for the trained assessor (ICC = 0.89) and mostly moderate for both novice assessors (ICC range: 0.60 to 0.76). Moderate to good inter-rater reliability was observed (ICC range: 0.65 to 0.80).

Conclusion The FMS battery is a reliable tool that can be performed by people with ID, albeit with certain difficulties, especially in those with moderate to severe impairment. The battery does not seem to be useful for identifying people with ID at risk of suffering a sport injury. Adequately powered, well-designed studies are required to determine if the FMS battery is appropriate for identifying changes in functional performance in this population.

Keywords adults, assessment methods, exercise, injury risk, safety

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Introduction

Adults with intellectual disability (ID) have significantly higher rates of mortality and morbidity than their non-disabled peers (Emerson *et al.* 2016). With proper healthcare and the promotion of a healthy lifestyle, many of the health problems experienced by this population can be prevented (Oppewal *et al.* 2020). In this regard, promoting physical exercise is an effective strategy to improve health outcomes among adults with ID (Oppewal *et al.* 2020). Nevertheless, such action seems difficult to put into practice, given that those with ID generally exhibit low exercise participation rates. To rectify this situation, facilitators and barriers to exercise should be first identified (Suárez-Iglesias *et al.* 2021).

Safety and health concern/injuries have been previously identified as barriers to exercise participation among people with ID (Bossink *et al.* 2017). For instance, unintentional injuries, especially falls, are highly prevalent in this population (Sherrard *et al.* 2004), while sport/play related injuries are also present (White *et al.* 2018). One of the main strategies that should be implemented for ensuring safe sport practice is the development of preventive measures aimed at reducing injury risk. In this regard, it has been suggested that a careful evaluation and a proper classification would help to ensure safe sports participation by athletes with physical and also intellectual disabilities (Patel and Greydanus 2010). One fine example of said preventive strategies is the assessment of functional movement tasks, because it provides information that helps to identify individuals with a high risk of future sport injury (Krumrei *et al.* 2014).

Thus, as a way of reducing the probability of sustained physical activity and sports-related injuries, it seems important to screen the functional status before encouraging adults with ID to exercise. For this purpose, functional movement screening tools, such as the Functional Movement Screen (FMS) battery, could be useful resources (Cook *et al.* 2006).

The FMS battery consists of a series of movement tasks aimed at assessing functional movement deficiencies and postural stability that may place individuals with low or moderate general motor quality at increased sport-related injury risk (Kraus *et al.* 2014). The utility and reliability of the FMS for predicting injury risk have been widely studied in

athletic, military, public service and populations without disabilities (Bonazza *et al.* 2017). However, to our knowledge, no previous research has been carried out in people with disabilities. Under these circumstances, this study aimed at identifying the feasibility and the test–retest and inter-rater reliability of the FMS when administered to adults with ID.

Material and methods

Participants

Eligible participants were invited and subsequently screened by a researcher who was undertaking an internship in a residential and day care centre for people with ID. The inclusion criteria were (1) to be over 18 years of age; (2) to be diagnosed with ID according to the criteria set by the *American Association on Intellectual and Developmental Disabilities* (Schalock *et al.* 2010); severity of ID were classified as follows: mild (IQ score of 50–55 to approximately 70), moderate (IQ score of 30–35 to 50–55) and severe (IQ score of 20–25 to 35–40) (American Psychiatric Association 2013); (3) to be able to follow simple instructions. All participants with limited mobility (i.e. wheelchair dependence), disturbing behaviours or health problems (i.e. morbid obesity and joint pain) that prevented the completion of the FMS battery were excluded from the study. The participants, their relatives, caregivers and the management of the centre were informed about the objectives of the research. Potential participants were asked by their legal representatives and by their caregivers as to their willingness to participate in the research as well as to give their written consent. Participants or their legal guardians (as appropriate) of all the people with ID who took part in the study provided written informed consent. All procedures were in accordance with the ethical standards of the Ethics Committee of the Faculty of Education and Sport Sciences of the University of Vigo and the Declaration of Helsinki (World Medical Association 2013).

Data collection

Sociodemographic characteristics

Information regarding age, sex and the severity of their disability were directly retrieved from the records of the residential and day care centre.

Anthropometric measurements

Body weight (kg) and height (cm) were measured barefoot and with light clothing using a standard stadiometer (SECA 217; Hamburg, Germany) and a balance-beam scale (SECA 899; Hamburg, Germany), respectively. Body mass index (BMI) was then calculated as weight (kg)/height(m)² and expressed as kg/m².

Functional Movement Screen battery

The FMS battery is composed of seven subtests: 'deep squat', 'hurdle step', 'in-line lunge', 'active straight-leg raise', 'shoulder mobility', 'trunk stability push-up' and 'rotary stability'. Each subtest is evaluated using a 0–3 ordinal scale: 0 = *pain during the movement*; 1 = *participant is unable to execute the correct movement*; 2 = *participant executes the movement with compensations*; and 3 = *participant executes correct movement without pain or compensations*. The FMS total score ranges from 0 to 21. Any pain identified during the movement results in a score of 0. The participant only receives a 3 if the movement meets all the criteria outlined in the manual. A score ≤14 indicates a significantly higher risk of future injuries (Bonazza *et al.* 2017).

Procedures

Each participant attended two testing sessions (sessions number 1 and 2) separated by 14 days, in which the seven subtests were performed. During the first session, each subtest was individually explained and then performed by an assessor trained in using the FMS. Right after this, the participant was allowed to perform a familiarisation attempt, which was not scored. Immediately after this first attempt, a second one was carried out, and the obtained score was considered as a valid attempt (test). The whole sequence was repeated during the second session (retest). The same assessor, who had experience working with people with ID, was in charge of all testing sessions and offered guidance to the participants while performing the subtests.

All exercises performed in both sessions were video recorded to assure a later adequate scoring (Mitchell *et al.* 2016). For this purpose, two iPads were positioned in the sagittal and frontal planes on tripods

in the same location and height for all tests (Shultz *et al.* 2013).

Three assessors, the trained assessor and two novice evaluators (both specialists in exercise and physical activity who knew the FMS but had never administered it), viewed the videos from session 1 and session 2 several times and scored each of the performed subtests separately.

Statistical analysis

We represent data as means ± standard deviation (SD), after assessing normal distribution with the Kolmogorov–Smirnov test, and qualitative variables as *n* (%). We compared serial variables with ANOVA test, with Bonferroni correction for post-hoc multiple comparisons. Feasibility was based on completion rate for each subtest. Each subtest was considered feasible or fairly feasible when completion rates were 75% or 50–75%, respectively. A subtest was considered not feasible when completion rates were <50% (Wouters *et al.* 2017).

Reliability of the composite test scores was analysed using intraclass correlation coefficients (ICCs) calculating the 95% confidence intervals (CIs). ICC values of 0.75 and above represent good reliability, those between 0.50 and 0.74 represent moderate reliability and those below 0.50 indicated poor reliability (Portney and Watkins 2009). Absolute reliability was also assessed through the estimation of the standard error of measurement (SEM) and the minimum detectable change (MDC), using the formula (de Vet *et al.* 2006):

$$\text{SEM} = \text{SD} \sqrt{(1 - \text{ICC})}$$

$$\text{MDC} = 1.96 \text{SD} \sqrt{2}$$

We calculated the limits of agreement as the average difference ±1.96 SD, with the Bland and Altman method (Bland and Altman 2016). A two-tailed *P* value of less than 0.05 indicated statistical significance.

All analyses were performed using the SPSS software (IBM Corp., Armonk, N.Y., USA).

Results

Out of the 33 participants that agreed to take part in the study, two of them decided not to perform the FMS later due to lack of motivation, and one participant did not attend the retest session. The characteristics of the 30 people with ID (mean age: 35.5 ± 7.12 years; 33.3% women) that completed all the assessments are depicted in Table 1. All the participants were able to understand and to follow the assessors' guidelines for executing the FMS, and most of them completed the battery without reporting muscular pain. The battery showed to be feasible, with completion rates of 100% for the 'active straight-leg raise' and 'shoulder mobility', 93.4% for the 'deep squat', 83.4% for the 'hurdle step', 'in-line lunge' and 'trunk stability push-up' and 66.6% for the 'rotary stability'. Difficulties were observed specially, when performing the 'in-line lunge' subtest due to poor balance level and the 'rotary stability' subtest, in which the participants lacked adequate motor control. These difficulties were especially evident among those with moderate and severe ID.

The score awarded by the three assessors for each of the subtests and for the total FMS are shown in Table 2. Mean total scores ranged from 7.83 to 8.90.

An inverse trend ($P < 0.05$) was observed indicating that the higher the ID level, the lower the total FMS score (Table 3).

Figure 1 shows the scores obtained in the seven subtests as well as the total FMS score awarded to each participant by the trained assessor. Out of a total 210 subtests performed, only in three occasions (1.43%) a 3-point score was awarded (in subtests two and five). Less than 10% of the sample received a 2-point score in a subtest.

Table 1 Descriptive characteristics of the participants included in the study

Variable	Mean	SD	Range
Age (years)	35.57	7.12	21–48
Height (m)	1.62	0.13	1.37–1.81
Weight (kg)	75.55	18.12	50.7–142
Body Mass Index (kg/m^2)	29.12	6.93	20.05–48.56
Down Syndrome (n; %)	8	26.67	

SD, standard deviation.

Test–retest reliability was good for the trained assessor (ICC = 0.887) and mostly moderate for both novice assessors, with ICC values of 0.602 to 0.759. SEM and MDC depicted lower values for the trained assessor in comparison with the novel ones (Table 4).

Inter-rater reliability comparing every novice assessor with the trained assessor was good for assessor A (ICC 0.801, 95% CI 0.616–0.901) and moderate for assessor B (ICC 0.708, 95% CI 0.427–0.864).

Discussion

In this study, we found that it was possible to administer the FMS to a group of adults with ID. The FMS also showed to be a reliable tool. However, although the participants understood the subtests and were able to execute them, it was observed that balance and motor competence problems substantially hampered participant's performance mainly in two subtests (the 'in-line lunge' and the 'rotary stability'). In addition, hypotonia and joint laxity could have affected the range of motion of the joints (Cioni *et al.* 2001), impeding a proper execution. As a result, the FMS total scores were very low, suggesting that this tool, despite being feasible, is not suitable for identifying people with ID at risk of suffering a sport injury.

When the FMS was administered by a trained assessor, good test–retest reliability was observed, which is in accordance with the findings of the review by Bonazza *et al.* (2017), who reported an ICC summary of 0.869.

Lower reliability values were found when the novice assessors rated the performance of the participants in the FMS. Nevertheless, both evaluators showed a moderate to good intra-rater test–retest and inter-rater reliability in the FMS composite score, with similar values to the ones obtained by other novice assessors who have administered the FMS in people without disabilities in real time (ICC = 0.76; 95% CI: 0.63, 0.85; and ICC = 0.74; 95% CI: 0.60, 0.83) (Teyhen *et al.* 2012). Traditionally, the FMS battery is assessed in real time. However, in our study, the assessors measured all movements with the benefit of being able to replay a videotape, a fact that could have helped to achieve good reliability values. It remains to be determined whether the degree of reliability would be the same if the FMS battery had

Table 2 Results obtained in the Functional Movement Screen (FMS) battery

FMS items	Trained assessor				Novice assessor A				Novice assessor B			
	Test		Retest		Test		Retest		Test		Retest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FMS subtests												
1: Deep squat	1.00	0.37	1.03	0.42	1.37	0.49	1.28	0.59	1.33	0.48	1.17	0.54
2: Hurdle step	1.57	0.77	1.55	0.78	1.20	0.71	1.03	0.63	1.17	0.70	0.97	0.50
3: Inline lunge	1.23	0.73	1.28	0.70	1.00	0.53	1.00	0.46	0.97	0.49	1.00	0.38
4: Shoulder mobility	1.10	0.31	1.07	0.26	1.10	0.31	1.07	0.26	1.10	0.31	1.07	0.26
5: Leg raise	2.07	0.25	2.21	0.41	1.53	0.57	1.55	0.69	1.40	0.56	1.45	0.69
6: Push up	0.90	0.40	0.97	0.50	1.07	0.25	1.24	0.44	1.07	0.25	1.21	0.41
7: Rotary stability	0.67	0.61	0.79	0.68	0.83	0.46	1.00	0.60	0.80	0.41	1.00	0.53
Total score	8.53	2.22	8.90	2.41	8.10	1.67	8.17	2.04	7.83	1.44	7.86	1.79

FMS, Functional Movement Screen; SD, standard deviation.

Table 3 Comparative analysis by degree of intellectual disability

	Mild (n = 11)		Moderate (n = 10)		Severe (n = 9)		Total sample (n = 30)		P value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age (years)	30.64	6.70	36.90	6.15	40.11	5.11	35.57	7.12	0.005*
Height (m)	1.71	0.08	1.58	0.16	1.54	0.09	1.62	0.13	0.005**
Weight (kg)	84.48	24.15	75.10	10.99	65.14	9.68	75.55	18.12	0.054
Body mass index (kg/m ²)	28.80	8.13	30.74	6.64	27.71	6.03	29.12	6.93	0.639
FMS total score									
Trained assessor (test)	9.36	1.75	8.90	1.91	7.11	2.57	8.53	2.22	0.059
Trained assessor (retest)	9.91	1.76	9.30	2.11	7.00	2.67	8.90	2.41	0.021*
Novice assessor A (test)	8.73	1.56	8.20	1.62	7.22	1.64	8.10	1.67	0.129
Novice assessor A (retest)	8.73	1.74	8.70	1.89	6.75	2.12	8.17	2.04	0.062
Novice assessor B (test)	8.36	1.36	7.80	1.23	7.22	1.64	7.83	1.44	0.216
Novice assessor B (retest)	8.45	1.57	8.30	1.42	6.50	1.93	7.86	1.79	0.033*
Test–retest mean, trained assessor	9.64	1.64	9.10	1.94	7.00	2.66	8.72	2.27	0.030*
Test–retest mean, novice assessor A	8.73	1.56	8.45	1.57	6.81	1.67	8.10	1.74	0.038*
Test–retest mean, novice assessor B	8.41	1.22	8.05	1.12	6.69	1.56	7.81	1.44	0.023*

FMS, Functional Movement Screen; SD: Standard deviation.

* $P < 0.05$ for the post-hoc comparison of mild vs. severe.

** $P < 0.05$ for the post-hoc comparison of mild vs. severe and mild vs. moderate.

been scored in real time. Our results indicate that the trained assessor performed a more solid interpretation of the result, suggesting that the level of experience of the rater scoring the FMS should be considered, as previously indicated by other authors (Gulgin and Hoogenboom 2014).

The main finding of our research was that the FMS battery, despite being a feasible and reliable instrument, does not seem to be a useful tool to discriminate between adults with ID at risk of suffering a sport-related injury, given that none of the participants reached the established cut-off point of

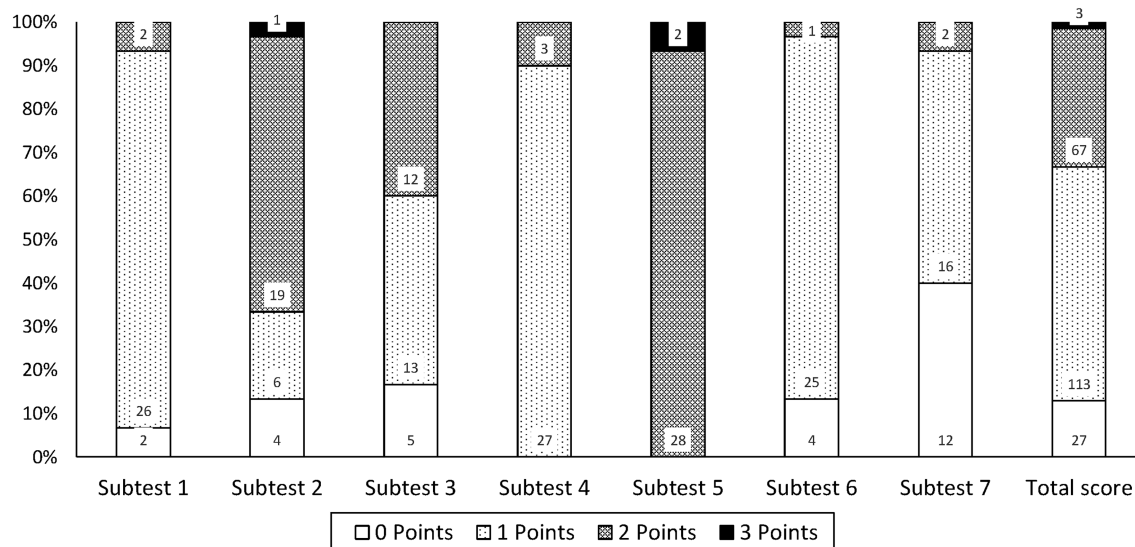


Figure 1. Functional Movement Screen battery scores by subtest and total score assessed by the trained examiner in the first assessment.

Table 4 Results of the test–retest reliability analysis

Assessor	Test		Retest		Test–retest average		Test–retest difference		ICC (95% CI)	Bland–Altman limits of agreement		MDC	SEM
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Lower	Upper		
Trained assessor	8.53	2.22	8.90	2.41	8.72	2.27	0.34	1.08	0.887 (0.772, 0.946)	-1.77	2.45	2.16	0.78
Novice assessor A	8.10	1.67	8.17	2.04	8.10	1.74	0.14	1.30	0.759 (0.548, 0.879)	-2.41	2.69	2.52	0.91
Novice assessor B	7.83	1.44	7.86	1.79	7.81	1.44	0.10	1.45	0.602 (0.305, 0.792)	-2.74	2.94	2.82	1.02

CI, confidence interval; ICC, intraclass correlation coefficient; MDC, minimum detectable change; SD, standard deviation; SEM, standard error of measurement.

≤14. In this regard, it should be acknowledged that the validity of the FMS to predict injury risk based on this cut-off point has been previously called into question (Moran *et al.* 2017; Warren *et al.* 2018). Given that the FMS total score ranges from 0 to 21, and roughly 95% of our participants scored between 5 and 12 points. Thus, the battery has no discriminating capacity. Taken together, our results indicate that using the FMS for identifying people with ID at risk of suffering a sport injury might not be an accurate preventive strategy.

Despite the lower scores obtained by the participants in our sample, it is plausible to think that the FMS could be administered to detect functional

limitations among people with ID, as has been the case with active adults (Mitchell *et al.* 2016). Moreover, the battery could be useful for determining the results of interventions aimed at improving motor skills, due to the established relationship between motor competence and the FMS scores (Silva *et al.* 2019). However, validity studies are needed to confirm the suitability of the FMS for these purposes.

In addition to relative reliability, absolute reliability was also assessed through the estimation of the SEM and MDC. These statistics are unaffected by the range of measurements and can provide an indication of the variability in repeated tests for specific populations (Atkinson and Nevill 1998). Generally,

SEM, MDC, and Bland–Altman limits of agreement values were low, indicating that the FMS battery is reliable. We registered higher SEM and MDC values than those reported in people with low back pain (SEM = 0.33 and MDC = 0.90) when analysing the test–retest reliability data provided by the trained assessor (Alkhatami *et al.* 2021). However, when comparing the data provided by the novice assessors, SEM and MDC values were similar to the ones registered by other inexperienced examiners (SEM = 0.98 and MDC = 2.07) (Teyhen *et al.* 2012).

Finally, it is worth mentioning that both the reliability and the difficulty of performing the subtests were affected by the level of ID of the sample. The FMS composite score showed lower values when performed by those with moderate and severe disability, who also found greater difficulties for performing the subtests. These data are in agreement with previous findings suggesting that the higher the ID, the lower the postural control, which in turn affects motor performance (Martinez-Aldao *et al.* 2019).

Researchers and health professional working with people with ID may find the results of this investigation of interest, when trying to screen and train motor performance in adults with ID. Nevertheless, there are several limitations that should be acknowledged for a proper interpretation of the reported data. First, the sample size resulting from stratifying the participants according to the severity of the ID was small, which makes it difficult to generalise the results. Second, it was not possible to score the FMS in real time. We had to use a video-recorded method, because the trained assessor had to guide the participants through the FMS performance and control the risk of falls at the same time. Finally, we merely focused on the feasibility and reproducibility of the seven subtests. Further studies should analyse additional aspects of validity of the FMS battery when administered in this population.

Conclusion

The FMS battery is a feasible and reliable tool that can be performed by people with ID, albeit with certain difficulties, especially in those with moderate to severe impairment. The battery does not seem to be a useful tool for identifying people with ID at risk of suffering a sport injury. Adequately powered,

well-designed studies are required to determine if the FMS is appropriate for identifying changes in functional performance in this population.

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Conflict of interest

None of the authors have any financial, personal or potential conflicts of interest.

Data availability statement

All data used in this study are available upon request to the corresponding author.

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