Measurement properties of the Body Awareness Scale Movement Quality (BAS MQ) in persons on the autism spectrum: A preliminary Rasch analysis

I. Bertilsson a,b,*, J. Melin c, C. Brogår bh, A. Opheim d,e, A.L. Gyllensten b, E. Björksell f, C. Sjödahl Hammarlund b

a Habilitation & Health, Region Västra Götaland, Lövångsvägen 3, 549 49, Skövde, Sweden
b Department of Health Sciences, Lund University, Box 117, 221 00, Lund, Sweden
c RISE Research Institutes of Sweden AB, Sven Hultins Plats 5, 412 58, Gothenburg, Sweden
d Habilitation & Health, Region Västra Götaland, Bergslagsgatan 2, 411 04, Gothenburg, Sweden
e Department of Rehabilitation Medicine, Institute for Neuroscience and Physiology, Sahlgrenska Academy, University of Gothenburg, Per Dabbagatan 14, 413 46, Gothenburg, Sweden
f Habilitation, Region Kronoberg, 351 88, Växjö, Sweden

A B S T R A C T

Background: Persons on the autism spectrum exhibit poorer body awareness than neurotypical persons. Since movement quality may be regarded as an expression of body awareness, assessment of movement quality is important. Sound assessments of measurement properties are essential if reliable decisions about body awareness interventions for persons on the autism spectrum are to be made, but there is insufficient research.

Objective: To assess measurement properties of the Body Awareness Scale Movement Quality (BAS MQ) in an autism and a neurotypical reference group.

Methods: Persons on the autism spectrum (n = 108) and neurotypical references (n = 32) were included. All were assessed with BAS MQ. Data were analyzed according to the Rasch model.

Results: BAS MQ was found to have acceptable unidimensionality, supported by the fit statistics. The hierarchical ordering showed that coordination ability was the most difficult, followed by stability and relating. Response category functioning worked as intended for 19 out of 23 items. There were few difficult items, which decreased targeting. Reliability measures were good. BAS MQ discriminated between the autism and the reference groups, with the autism group exhibiting poorer movement quality, reflecting clinical observations and previous research.

Conclusions: BAS MQ was found to have acceptable measurement properties, though suffering from problems with targeting item difficulty to person ability for persons on the autism spectrum. The BAS MQ may, along with experienced movement quality, contribute to clinically relevant information of persons on the autism spectrum, although we encourage refinements and further analyses to improve its measurement properties.

1. Background

Autism is a neurodevelopmental disorder with a prevalence of 1–2% in Sweden (Idring et al., 2015). Persons on the autism spectrum frequently have impaired sensorimotor functions (Whitty and Craig 2013), which may lead to problems with movement speed, balance, coordination (Kopp et al., 2010), postural stability (Yi Huey et al., 2017), and/or body image (Asada et al., 2018), which represents ‘the perceived form of our body, in terms of its size, shape, and distinctive characteristics’ (Longo et al., 2009). Difficulties understanding one’s emotions and inner state are also common (Rizzolatti and Fabbri-Destro 2010), as well as perceiving and interpreting other people’s intentions, non-verbal and verbal expressions (Rajendran and Mitchell 2007), even if understood intellectually (Cattaneo et al., 2007). All these difficulties could affect the persons’ communicative and social interaction abilities (American Psychiatric Association 2013), as well as movement quality (Bertilsson et al., 2020; Einspieler et al., 2014).

Movement quality is a complex construct. One theory describes the biomechanical, physiological, psycho-socio-cultural and existential dimensions of it (Gyllensten et al., 2018; Skjaerven et al., 2008, 2020), comprising several aspects (Abola et al., 2017), such as flexibility, balance, breathing, awareness, and flow of movements. Movement quality can be regarded as part of the expression of a person’s body awareness (Gyllensten et al., 2018). Body awareness has been described as being aware of one’s inner emotions and bodily signals, the ability to observe oneself from an outside perspective (Hedlund 2014), and the ability to use movements resourcefully in daily life (Bertilsson et al., 2018, 2020; Cesaroni and Garber 1991).

E-mail address: ingrid.bertilsson@vgregion.se (I. Bertilsson).

https://doi.org/10.1016/j.jbmt.2024.01.004
Received 20 January 2023; Received in revised form 21 August 2023; Accepted 8 January 2024
Available online 20 January 2024
1360-8592/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
on the autism spectrum, diagnosed according to DSM-IV (American Psychiatric Association 1994) or DSM 5 (American Psychiatric Association 2013). Classification according to DSM-IV were used. Therefore, diagnoses according to DSM 5 were converted to DSM-IV by experienced psychologists, based on the participants’ medical records. Further inclusion criteria were: being 15–30 years old, living in either of two regions in the southern part of Sweden, and receiving care from a habilitation unit. Exclusion criteria were: intellectual disability, needing more urgent care regarding psychological health and/or not being able to speak Swedish.

The sample size was estimated to reach an item-reliability of 0.8 in the Rasch analysis, using Spearman Brown prophecy formula (Remmers et al., 1927; Spearman 1910). The estimate showed that at least 80 participants were necessary. The potential participants were randomly generated from the patient records of each region, 20 at a time. In order to inform and prepare the selected persons, a letter was sent out which included a description of the research project, and also information when they would be contacted by one of two physiotherapists (IB or EB). If the person agreed to participate in the study, a meeting was scheduled. Each participant was assessed with BAS MQ at a habilitation clinic, performed by one of the two physiotherapists, both certified in BAS MQ. To improve inter-rater reliability, calibrations between assessors were made prior to the study. In total, 108 participants on the autism spectrum were included (Table 1). The distribution between sexes represented the clinical picture (Lundin Remnelius 2023).

The reference group with neurotypical participants (n = 32) consisted of university students or individuals from convenience sampling that were recruited and assessed by the first author (IB) (Table 1), in order to compare some of the measurement properties between groups. The inclusion criteria were being 15–30 years old and neurotypical, and the exclusion criteria were having an intellectual disability, a medical condition or not being able to speak Swedish. The assessments took place either on the university premises or in the participant’s home.

Informed consent was obtained from all participants. The study complies with the Declaration of Helsinki and its later amendments. It was approved by the Regional Ethical Review Board of Gothenburg, Sweden, registration number 651-17.

2. Material and methods

2.1. Participants and procedure

BAS MQ data in this cross-sectional study were sampled from persons

Table 1

Demographic data of the participants, diagnosed from criteria in DSM-IV.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Autism group (n = 108)</th>
<th>Reference group (n = 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD) (range)</td>
<td>22.7 (4.0) (15–30)</td>
<td>23.8 (3.6) (15.5–30)</td>
</tr>
<tr>
<td>Gender, female/male, n (%)</td>
<td>67 (62 %)/41 (38 %)</td>
<td>23 (72 %)/9 (28 %)</td>
</tr>
<tr>
<td>Autism sub-diagnosis, n</td>
<td>Pervasive developmental disorder/atypical autism, n = 12</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>Asperger syndrome, n = 57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Autism in childhood, n = 39</td>
<td></td>
</tr>
</tbody>
</table>
complex though unified construct (Gyllensten et al., 2018; Skjaerven et al., 2008, 2020), the choice was to evaluate the BAS MQ according to the unidimensional Rasch model at this preliminary stage.

2.3. Analysis

All data were compiled in SPSS® 27.0 (IBM 2020) and imported to Winsteps® 6.8 for Rasch analysis (Linacre 2020b). There were no missing data. A partial credit model was used to allow for different threshold distribution (Linacre 2000), since the 5-graded ordinal scale of BAS MQ’s response categories was judged to be clinically different between items.

The following measurement properties were studied:

1. **Targeting** describes how the set of items represents the ability of the persons. For persons with high abilities, there must be difficult items in a rating scale, while for persons with low abilities, there must be easy items, in order to obtain reliable measures for the whole span of abilities (Bond and Fox 2015). If the average person measure is less than one standard error (SE) of measurement from the mean of the item hierarchy at zero logits, then the scale is on target (>2 SE = poor, <1 SE = good, <0.5 SE = very good, and <0.25 SE = excellent) (Fisher 2007).

2. **Response category functioning** means that the order of the ordinal responses monotonically increases with the underlying construct, in this study movement quality. A disordered threshold occurs when there is a higher probability of response to a different category than expected (Linacre 2002a).

3. **Unidimensionality** assesses how well the items measure one single construct. It is studied by a principal component analysis of item fit residuals (PCAR). Unexplained variance of residuals ought to be <10% in order to indicate unidimensionality (<3% = excellent, 3–5% = very good, 5–10% = good, 10–15% = fair and >15% = poor) (Fisher 2007). Based on the loadings in the PCAR, items are assigned into three ‘clusters’, in which the dimensionality can be further evaluated qualitatively, i.e., if the content of the items is noticeably different between clusters. Also, the dimensionality is evaluated quantitatively based on the correlations between person measures in each cluster, using disattenuated Pearson correlation to adjust for measurement error (Linacre 2020a; Spearman 1910). A disattenuated correlation of 0.2 is considered very weak, 0.2–0.4 = weak, 0.4–0.7 = moderate, 0.7–0.9 = strong, and 0.9–1.0 = very strong correlation (Boone and Staver 2020), stronger correlation indicates unidimensionality.

4. **Fit statistics of items** indicates how the items fit the Rasch model. Mean square (MNSQ) statistics show the size of the randomness (Linacre 2002b). MNSQ values between 0.5 and 1.5 are regarded as fitting the model, while values < 0.5 indicate overfit (more predictable than expected), 1.5–2.0 as neither productive or degrading to the test, and >2.0 as underfit (more random than expected) (Linacre 2002b). Standardized fit statistics (ZSTD) test whether data fit the model, and values within −1.9 to 1.9 SD have reasonable predictability (Linacre 2002b). Both infit and outfit are estimated for MNSQ and ZSTD. Infit of items focuses on the central performance of an item and outfit statistics pick up outliers, as either being too predictable (negative values) or too unpredictable (positive values) (Wright and Linacre 2021).

5. **Local dependency** is measured by correlation of item residuals, i.e., how much of their variance is shared. It means that a response to one item is associated to the response of another, a low correlation indicates no local dependency (Baghaei 2008). This study applied a relative cut-off, influenced by the number of items and the sample size (Christensen et al., 2017). It was calculated to be 0.16.

6. **Hierarchical ordering of items** shows which item is more easy or difficult. The difficulty of an item is the average of the difficulties of the thresholds for the item in the specific sample (Linacre 2007). Based on clinical experience, items addressing the aspect coordination/breathing were expected to be the most difficult for persons on the autism spectrum, followed by stability items and easiest being relating/awareness items.

7. **Person separation reliability (PSR) and person separation index (PSI)**, as well as item separation reliability (ISR) and item separation index (ISI) indicate the internal consistency and how many subgroups of persons and items that can be separated. PSR and ISR values of the internal consistency are interpreted as α = 0.67 = poor, 0.67–0.80 = fair, 0.81–0.90 = good, 0.91–0.94 = very good, and >0.94 = excellent. The PSI and ISI show the ability to differentiate between persons or items, respectively (0–2 = poor, 2–3 = fair, 3–4 = good, 4–5 = very good, and >5 = excellent) (Fisher 2007).

8. **Differential item functioning (DIF)** implies that responses from different groups of persons influence item measures (Hagquist and
Andrén 2017). In this study, DIF was analyzed between sexes within the autism group, and between the autism and reference groups. Generally, together with a significant t-test, a size difference of >0.5 logits is considered a DIF, but depends on the sizes of the groups. Therefore, in this sample, a size difference of >1.0 logits was used (Linacre 2013), for both comparison between sexes and between the autism and reference groups.

9. **Discrimination** investigates whether groups can be separated from each other, assessed with ANOVA. As such, it is related to the reliability measure of separation index. In this study, it was investigated between the autism and the reference groups, and between different diagnoses of autism. The clinical experience was that persons on the autism spectrum have poorer movement quality than the reference group, and that persons with higher degrees of autistic symptoms have poorer movement quality than those with lower degrees of autistic symptoms (Kaur et al., 2018).

3. **Results**

The results present measurement properties in the autism group, except for the properties of reliability, DIF, and discrimination, where the reference group was included.

1. **Targeting:** The average person ability measure was −0.68 and 2SE 0.60, indicating a poor targeting. Person ability measures ranged from −3.91 logit (2SE 0.50) to 1.08 logit (2SE 1.04) and item thresholds ranged from −1.46 logit (2SE 0.28) to 0.94 logit (2SE 0.28), i.e., were negatively skewed (Fig. 1). Thirteen people had a better movement quality than could be assessed with the difficulty in the BAS MQ items, within logits from −3.91 to −1.75 (Fig. 1). Between logits −1.75 to 0.0, eight items targeted more able persons’ abilities. Fifteen items, within logits 0.0 to 1.0, targeted less able people.

2. **Response category functioning:** In eleven out of 23 items, the response categories 3 and 4, that reflect severe problems, were not used (Fig. 2). For item ‘19 Relation to mirror’, category 3 had a lower threshold measure than both categories 1 and 2. For items ‘4 Flexibility in the balance line’, ‘5 Weight transfer’ and ‘20 Eye contact’ disordered thresholds were present with one category step. This indicates that the response categories of these items did not work as intended, and refinement of the response scales may be needed.

3. **Unidimensionality:** When studying residual variance in the PCAR, an unexplained variance of 7% was found, indicating a good unidimensionality. The unidimensionality was evaluated qualitatively: in clusters 2 and 3, items from all three aspects in BAS MQ were represented. In cluster 1 there were predominantly stability items but no coordination/breathing items. In cluster 2 all aspects were evenly distributed and cluster 3 consisted mainly of items regarding coordination/breathing and relating/awareness (Table 3). The unidimensionality was also investigated quantitatively, with the disattenuated Pearson correlation of person measures between clusters 1 and 3 being 0.56, indicating a moderate correlation, while between clusters 1 and 2 it was 0.76, and between clusters 2 and 3 it was 0.77, indicating strong correlations.

4. **Fit statistics:** Most items fitted the model well (Table 3). Two items showed misfit: ‘19 Relation to mirror’ had an outfit MNSQ of 1.78 and an outfit ZSTD of 3.44. Item ‘22 Meeting’ had an outfit MNSQ value of 1.30 and an outfit ZSTD 2.02 (fit statistics for both the autism and the reference groups in Table 4, online resource).

5. **Local dependencies,** based on the relative cut off of 0.16, were present for 17 out of 253 (7%) item residual correlations (Table 5, online resource). The highest correlations were observed between ‘1 Stability in balance line’ and ‘6 Balance on one leg’ (0.42) and ‘2 Step up on stool’ (0.31). Items showing dependencies could mostly be related to the same original subscale. The exception was item ‘4 Flexibility in balance line’ that had residual correlations above the relative cut off with items ‘11 Centering of movements’ (0.30), ‘23 Conscious awareness’ (0.20) and ‘10 Orientation through movement center’ (0.18), respectively.

6. **Hierarchical ordering of items** is presented in Table 3. Items involving coordination/breathing were most difficult, with measures from −1.46 to 0.13 logits, with item ‘15 Muscle tension’ as most difficult and ‘17 Isolated movements’ as the easiest item. Stability items measured from −0.93 to 0.82 logits, item ‘1 Stability in balance line’ being the most difficult and ‘2 Step up on stool’ the easiest. Relating/awareness items measured from 0.40 to 0.94 logits, item ‘21 Handshake’ being the most difficult and ‘22 Meeting’ the easiest (Fig. 2). The results indicate coherence with clinical experience.

7. **Reliability:** In the autism group, the PSR was good (0.85), enabling a fair PSI (2.41). The ISR was excellent (0.95) with a very good ISI (4.57). All reliability measures increased slightly when the reference group was included: the PSR was good (0.85), enabling a fair PSI (2.41). The ISR was excellent (0.95) with a very good ISI (4.57), and the ISR and PSI were excellent (0.96 and 5.07, respectively).

8. **DIF:** Adjusted to the sample size (size difference >1.0 logits), no item showed significant DIF between sexes within the autism group. One item, ‘6 Balance on one leg’, showed significant difference between the autism and the reference groups (DIF 1.28 logits, p = 0.002).

9. **Discrimination:** There was a significant difference of person measures between the autism and the reference groups (F 282, p < 0.001). The BAS MQ average scoring patterns in the autism and reference groups were similar, but generally with worse movement quality in the autism group (Fig. 3). Within the autism group, there was no significant difference between the three different diagnoses (Fig. 4). The results indicated discriminative ability of BAS MQ between the autism and the reference groups.

![Fig. 1. Distribution of person ability (upper panel) and item difficulty (lower panel) measures of the autism group. Measures are presented in logits, the more negative value the better movement quality and the more difficult items, respectively.](image-url)
Fig. 2. Response category functioning of the BAS MQ in the autism group. The items showing disordered category functioning are framed. The items are presented in hierarchical ordering, with the easiest at the top and the most difficult at the bottom.

Table 3
Fit statistics, following hierarchical ordering of item measure in the autism group, from the easiest to the most difficult.

<table>
<thead>
<tr>
<th>Item</th>
<th>Item measure</th>
<th>2SE</th>
<th>Original subscale</th>
<th>Cluster</th>
<th>Infit MNSQ</th>
<th>Infit ZSTD</th>
<th>Outfit MNSQ</th>
<th>Outfit ZSTD</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 Meeting</td>
<td>0.94</td>
<td>0.28</td>
<td>RA</td>
<td>2</td>
<td>1.21</td>
<td>1.68</td>
<td>1.30</td>
<td>2.02</td>
</tr>
<tr>
<td>2 Step up on stool</td>
<td>0.82</td>
<td>0.24</td>
<td>SF</td>
<td>1</td>
<td>1.03</td>
<td>0.22</td>
<td>0.97</td>
<td>−0.11</td>
</tr>
<tr>
<td>8 Lie down, lie, stand up</td>
<td>0.72</td>
<td>0.28</td>
<td>SF</td>
<td>2</td>
<td>0.86</td>
<td>−0.84</td>
<td>0.85</td>
<td>−0.94</td>
</tr>
<tr>
<td>20 Eye contact</td>
<td>0.66</td>
<td>0.24</td>
<td>RA</td>
<td>2</td>
<td>1.10</td>
<td>0.73</td>
<td>1.07</td>
<td>0.49</td>
</tr>
<tr>
<td>6 Balance on one leg</td>
<td>0.62</td>
<td>0.26</td>
<td>SF</td>
<td>1</td>
<td>0.90</td>
<td>−0.58</td>
<td>0.86</td>
<td>−0.89</td>
</tr>
<tr>
<td>18 Psychomotor activity</td>
<td>0.49</td>
<td>0.32</td>
<td>RA</td>
<td>3</td>
<td>0.79</td>
<td>−1.76</td>
<td>0.78</td>
<td>−1.79</td>
</tr>
<tr>
<td>23 Conscious awareness</td>
<td>0.46</td>
<td>0.32</td>
<td>RA</td>
<td>3</td>
<td>1.12</td>
<td>0.95</td>
<td>1.10</td>
<td>0.67</td>
</tr>
<tr>
<td>3 Stomp</td>
<td>0.45</td>
<td>0.24</td>
<td>SF</td>
<td>2</td>
<td>1.25</td>
<td>1.81</td>
<td>1.25</td>
<td>1.77</td>
</tr>
<tr>
<td>19 Relation to mirror</td>
<td>0.42</td>
<td>0.24</td>
<td>RA</td>
<td>1</td>
<td>1.42</td>
<td>2.15</td>
<td>1.78</td>
<td>3.44</td>
</tr>
<tr>
<td>21 Handshake</td>
<td>0.40</td>
<td>0.22</td>
<td>RA</td>
<td>2</td>
<td>1.24</td>
<td>1.69</td>
<td>1.36</td>
<td>1.93</td>
</tr>
<tr>
<td>5 Weight transfer</td>
<td>0.35</td>
<td>0.19</td>
<td>SF</td>
<td>1</td>
<td>0.86</td>
<td>−0.79</td>
<td>0.87</td>
<td>−0.71</td>
</tr>
<tr>
<td>7 Sit down, sit, stand up</td>
<td>0.26</td>
<td>0.32</td>
<td>SF</td>
<td>1</td>
<td>1.01</td>
<td>0.09</td>
<td>1.02</td>
<td>0.17</td>
</tr>
<tr>
<td>9 Jump</td>
<td>0.15</td>
<td>0.26</td>
<td>SF</td>
<td>1</td>
<td>1.11</td>
<td>0.67</td>
<td>1.09</td>
<td>0.55</td>
</tr>
<tr>
<td>17 Isolated movements</td>
<td>0.13</td>
<td>0.34</td>
<td>CB</td>
<td>2</td>
<td>0.90</td>
<td>−0.65</td>
<td>0.92</td>
<td>−0.55</td>
</tr>
<tr>
<td>14 Rotate around balance line</td>
<td>−0.09</td>
<td>0.26</td>
<td>CB</td>
<td>3</td>
<td>0.90</td>
<td>−0.77</td>
<td>0.93</td>
<td>−0.56</td>
</tr>
<tr>
<td>11 Centering of movements</td>
<td>−0.39</td>
<td>0.28</td>
<td>CB</td>
<td>2</td>
<td>0.90</td>
<td>−0.83</td>
<td>0.90</td>
<td>−0.81</td>
</tr>
<tr>
<td>12 Free breath</td>
<td>−0.68</td>
<td>0.28</td>
<td>CB</td>
<td>3</td>
<td>0.94</td>
<td>−0.49</td>
<td>0.95</td>
<td>−0.37</td>
</tr>
<tr>
<td>16 Accompanying movements</td>
<td>−0.70</td>
<td>0.26</td>
<td>CB</td>
<td>2</td>
<td>0.92</td>
<td>−0.62</td>
<td>0.93</td>
<td>−0.55</td>
</tr>
<tr>
<td>13 Integration of breath</td>
<td>−0.73</td>
<td>0.22</td>
<td>CB</td>
<td>3</td>
<td>0.93</td>
<td>−0.52</td>
<td>0.91</td>
<td>−0.67</td>
</tr>
<tr>
<td>4 Flexibility in balance line</td>
<td>−0.85</td>
<td>0.30</td>
<td>SF</td>
<td>3</td>
<td>0.94</td>
<td>−0.40</td>
<td>0.95</td>
<td>−0.31</td>
</tr>
<tr>
<td>1 Stability in balance line</td>
<td>−0.93</td>
<td>0.30</td>
<td>SF</td>
<td>1</td>
<td>0.94</td>
<td>−0.41</td>
<td>0.94</td>
<td>−0.42</td>
</tr>
<tr>
<td>10 Orientation through movement center</td>
<td>−1.03</td>
<td>0.26</td>
<td>CB</td>
<td>3</td>
<td>1.03</td>
<td>0.25</td>
<td>1.04</td>
<td>0.32</td>
</tr>
<tr>
<td>15 Muscle tension</td>
<td>−1.46</td>
<td>0.28</td>
<td>CB</td>
<td>3</td>
<td>0.82</td>
<td>−1.40</td>
<td>0.80</td>
<td>−1.60</td>
</tr>
</tbody>
</table>

SF: stability in function, CB: coordination/breathing, RA: relating/awareness.

a In the original subscale column, SF is positioned to the left, CB in the middle and RA to the right.
b In the Cluster column, cluster 1 is positioned to the left, 2 in the middle and 3 to the right.
c Misfit results are bold italicized.
4. Discussion

To the best of our knowledge, this is the first study that has evaluated measurement properties of BAS MQ in persons on the autism spectrum. The main finding was that BAS MQ overall had acceptable measurement properties, though suffering from problems with targeting item difficulty to person ability for the most abled persons in the autism group. The analysis supported unidimensionality and showed good fit statistics. The hierarchical ordering showed that items addressing the aspect coordination/breathing were the most difficult for persons on the autism spectrum, followed by stability items and easiest being aspects of relating/awareness items. Despite few difficult items, which influenced the targeting of BAS MQ, the scale could discriminate between movement quality in persons on the autism spectrum and a reference group. The analysis showed minor problems with disordered response category functioning and local dependency. However, since the sample consisted of persons with high-functioning autism, the sample was partly off-target. Therefore, the results should be interpreted as preliminary.

Since the fit statistics, unidimensionality, hierarchical ordering and local dependency are closely related and address validity aspects of BAS MQ, these are discussed together, as well as response category function and DIF. Discussion on reliability aspects includes; targeting, person and item reliability, separation indices and discrimination between groups. Thereafter, there are some items discussed that was further investigated on how they fitted the model.

4.1. Validity of BAS MQ

Unidimensionality was supported by an unexplained variance of only 7% in the PCAR, the fit statistics and moderate to strong disattenuated correlation between clusters. To ensure unidimensionality, it is desirable that each cluster include different aspects of movement quality (Linacre 2018), which was supported in the analysis as stability in function and relating/awareness were included in all three clusters.
and coordination/breathing in two clusters (Table 3). Together, these findings suggest that BAS MQ can be used to measure a higher ordered construct of movement quality. However, the unidimensionality may be further strengthened with some refinements of BAS MQ, as discussed below.

In the clinic, centered coordination (coordination/breathing aspect) and flexibility (stability aspect) are often difficult for persons on the autism spectrum. Both aspects were included in the same cluster in the Rasch analysis and exhibited local dependency, which may threaten unidimensionality (Baghai 2008). One reason for these findings may be that balance between centered coordination and flexibility is essential for the flow of movements (Gyllensten et al., 2016), and that these items bind together two different aspects in one construct - movement quality.

Movement quality is a generic ability which differs between persons. It includes both easy and more difficult tasks in a hierarchical ordering depending on the sample, while still belonging to a unidimensional construct. Regarding the hierarchical ordering (Table 3), persons on the autism spectrum had most difficulties with aspects of coordination/breathing. The most difficult item within this aspect was ‘15 Muscle tension’, followed by ‘13 Integration of breath’ and ‘11 Centering of movements’, with ‘17 Isolated movements’ being most easy. These findings may be explained as follows: persons on the autism spectrum have described how everyday life comprises mental efforts to move as intended, which may be influenced by both mental and bodily tensions as well as lack of stability (Bertilsson et al., 2018; Cesaroni and Garber 1991). To coordinate movements, isolated movements and balanced muscle tension between agonist and antagonist muscles are needed (Antohe et al., 2020; Zehr and Sale 1994). However, if the muscle tension is predominantly triggered by a mental effort to control movements, it may still be possible to perform isolated movements, but at the expense of vitality. Also, both mental and muscular tensions may explain difficulties with breathing (Brage 2013).

Second in the item hierarchical ordering of difficulty, were items that involved stability in function, also observed in the clinic. Bodily stability and flexibility are essential in postural control, to daily functioning, and to the function of other movement qualities (Droppo 2004; Gyllensten et al., 2018). Items ‘1 Stability in balance line’ and ‘4 Flexibility in balance line’ were the most difficult items of the stability aspect in this study. Having autism also implies a difficulty with mental flexibility (Frisch and Happé 1994) and a need to use conscious thoughts to move (Bertilsson et al., 2018; Eigsti 2013). This may be reflected as bodily inflexibility and instability (Gyllensten et al., 2018) and may also explain the DIF between groups regarding ‘6 Balance on one leg’.

Relating/awareness aspects of movement quality were the least difficult in the hierarchical ordering. This was evident, despite the difficulties with social interaction that is common in autism (Candini et al., 2018). Items ‘20 Eye contact’ and ‘22 Meeting way is something that is especially trained’ were easier items in the relating aspect, whereas ‘21 Relation to mirror’ are especially scored, which may explain why this item was more difficult in the relating/awareness aspect.

Although all response categories were not used for all items of BAS MQ, the response category functioning was good in most of them with the intended use (Fig. 2). There was only one minor DIF in one of the items between the autism and the reference group. These findings suggest that the items in general fitted well to the model, supporting the validity of the BAS MQ. Item ‘19 Relation to mirror’ showed misfit (Table 3), which could be explained by disordered thresholds (Fig. 2). This disorder may be explained by the everyday functioning when having autism. The scale steps of this item are to be understood as the ability to relate to oneself and to the test leader, whilst standing in front of a mirror, from 0 = free/unrestrained to 4 = do not perform. The clinical experience of persons on the autism spectrum is that their nuances are not as fine-tuned as for neurotypical people, possibly because of difficulties with theory of mind, i.e., difficulty to experience one’s own mind as separated from other’s (Rajendran and Mitchell 2007), central coherence, i.e., to fully understand a context out of details (Baron-Cohen et al., 2009), and processing of sensorimotor information (Trevisan et al., 2017). Hence, when experiencing discomfort, instead of being slightly reluctant, a larger step is often immediately present, moving directly from category 1 to category 4.

4.2. Reliability of BAS MQ

There was a large mistargeting between item difficulty and person ability measures for the most able persons, exhibiting an inverted ceiling effect. This may be expected since the most able persons, all have healthy and vital movement qualities which cannot be differentiated in BAS MQ.

In the reference group, the movement quality was overall good, as for some in the autism group. This study included persons with high-functioning autism, hence several were more able in daily functioning. Still, the need to protect oneself from sensory impressions and social interaction may explain why most in the autism group had an affected movement quality (Bertilsson et al., 2018, 2020).

Although the distribution of person ability was slightly skewed (Fig. 1), it represented a normal distribution from more to less able persons, and with most persons in the middle of the scale. In some of the items, the higher scoring categories were not used. The consequence was that the most able persons were measured with less precision due to lack of targeting items. The clinical implication of this is that there will be less precision to discriminate between, or to evaluate any change for the more able persons. Also, there were proportionally more items with less difficulty, that were targeted by fewer less able participants. This implicates higher measurement uncertainties due to fewer participants, with the clinical implication being that the least difficult items do not give precise information about the autism group.

Reliability measures for persons and items were high, but PSI and ISI were lower in the autism group than in the reference group. This may be explained by persons on the autism spectrum showing less nuances and fluency in movement quality, in concordance with the rigid adaptive ability often seen (Zukerman et al., 2021). In the clinic, this rigidity may be seen in more extensive negative effects on movement quality than for neurotypicals (Kaur et al., 2018), and therefore more of them are given the same higher scores on the BAS MQ scale, separating fewer groups. The participants often exhibited difficulties with flexibility and centered coordination, which are both influenced by rigidity.

The study was not primarily designed to evaluate the discriminative ability between groups. However, the present results indicate that BAS MQ may discriminate between persons on the autism spectrum and neurotypical individuals. This is in line with clinical observations and previous research in other patient groups and neurotypical individuals (Bertilsson et al., 2020; Sundén et al., 2014).

4.3. Recommendations to advance possibilities to measure movement quality with BAS MQ

With the aim of investigating the measurement properties of BASMQ, the existing BAS MQ was used. Thus, no modification of composition of items or response categories were made. At this initial stage, it could be a risk taking a too hardline driven statistical approach (Morel and Cano 2017), since experiential perspectives (Gyllensten and Mattsson 2015), sample variability (Crosby et al., 2003) of person ability, and end-user involvement (Joss et al., 2016) need further consideration. Item misfit and disordered thresholds were minor issues in this study, which may have been impacted by item removal or collapsing response categories. Though the unidimensionality could benefit from further variation of which item aspects that were included in each cluster, targeting was the
major problem to reliably measure movement quality with BAS MQ in persons on the full autism spectrum. To compensate for these issues, there are potential improvements that may be evaluated in existing items:

Items ‘4 Flexibility in balance line’ and ‘10 Orientation through movement center’ loaded to the same cluster (Table 3), and were often scored higher than other items. Item 4 also exhibited disordered category functioning. Both items are observed in two different positions/movements in BAS MQ (Table 2), in which different movement qualities may be observed in each. The higher score should then be given (Gyllensten and Mattsson 2015). Possibly, by splitting both these items in the scale and scoring the different positions/movements separately, it could diversify item construction to highlight more nuances. This could improve the response category functioning, targeting to the scale (Eddy et al., 2021), as well as qualitative content of items in the three clusters.

To improve the assessments, the wording (Clifton 2020) in the BAS MQ manual may be reconsidered. One item with disordered thresholds was ‘20 Eye contact’ (Fig. 2). It is common for persons on the autism spectrum to describe unpleasant feelings or experiences with eye contact (Trevisan et al., 2017). The training during upbringing to try to be more ‘normal’ may include having eye contact with other people. But this takes energy when they do it in everyday life (Mottron 2017; Schulze et al., 2013). In the movement quality, this may be noticed as a tension, but since the values 2–4 of item ‘20 Eye contact’ all include not meeting the test leader’s eye contact, with increasing degree of difficulty, these values were not scored in this study. The experiences of the individual may be assessed with the second and third parts of BAS MQ-E.

4.4. Limitations

This study included more than 80 participants, which was estimated as the least number of participants needed. There were few or no observations in some response categories, and it was therefore premature to any modelling adjustments such as collapsing response categories or item removal. Furthermore, more participants with a large variety of movement qualities, may have increased the possibility to discriminate between movement quality in persons belonging to the different diagnoses of autism. This study is a preliminary exploratory step (Linacre 2017) to evaluate measurement properties of BAS MQ in persons on the autism spectrum, and further studies are warranted.

People with intellectual disability were excluded, thus limiting the understanding of the measurement properties of BAS MQ in the full spectrum of autism. This choice was based on how body awareness treatment is used in the clinical setting, since a prerequisite for the person is the ability to verbalize bodily experiences. Furthermore, persons on the autism spectrum are a heterogeneous group, often with additional neuropsychiatric or psychiatric diagnoses, which may affect movement quality.

To summarize, there were overall few difficult items in BAS MQ, which limited targeting for the included population. If item difficulty targets the person ability, BAS MQ could possibly be used to assess changes of movement quality. For the most able persons in this study, there was poor targeting, and therefore interpretations of them need to be made carefully. On the other hand, since the most abled persons usually have less need of an intervention, it might not be a major clinical issue. The response category functioning in 19 out of 23 items was ordered, but warrants further investigations with more observations in each response category. The unidimensionality of BAS MQ to persons on the autism spectrum was acceptable, supported by the PCAR and fit statistics. The hierarchical ordering of items was in line with clinical expectations, going from coordination/breathing that included more difficult movement qualities, followed by stability in function and relating/awareness items. The overall PSR was good and the ISR excellent. BAS MQ discriminated between the autism and the reference groups, but not between different autism diagnoses. Some of the findings may be explained by imprecision of BAS MQ, but several of them could also be due to actual movement qualities exhibited in general in the autism group.

5. Conclusions

The BAS MQ was found to have acceptable measurement properties in people with autism, when evaluated by the unidimensional Rasch model. BAS MQ may be regarded a valid assessment scale for movement quality in persons on the autism spectrum, although there are possible improvements to be made to the scale to improve the targeting.

Clinical relevance

With future psychometric analysis, the BAS MQ for persons on the autism spectrum is able to:

• measure movement quality
• target individuals that might benefit from further treatment to improve their body awareness
• assess, describe, and separate different levels of movement quality
• discriminate between movement quality in them and neurotypical individuals

CRediT authorship contribution statement

I. Bertilsson: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. J. Melin: Formal analysis, Methodology, Validation, Visualization, Writing – review & editing, Conceptualization. C. Brogård: Methodology, Supervision, Validation, Writing – review & editing, Conceptualization. A. Opheim: Methodology, Supervision, Validation, Writing – review & editing, Conceptualization. A.L. Gyllensten: Conceptualization, Methodology, Validation, Writing – review & editing. E. Björkell: Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. C. Sjödahl Hammarlund: Conceptualization, Project administration, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

No conflict of interest is declared. The study is the third of four, intended as part of a doctoral dissertation.

Acknowledgements

We acknowledge all the participants. The study was supported by the Faculty of Medicine at Lund University, Sweden and funded by Habilitation & Health in Region Västra Götaland, Sweden; the Skaraborg Institute for Research and Development, Sweden; and the Renee Eander Fund, Sweden. The funding sources had no active involvement in the conduct of the research.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbmt.2024.01.004.

References


