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Original Article

Reliability and validity of the basic motor ability test in preschool children.

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Abstract:
The Basic Motor Ability Test (BMAT) is a motor ability battery specifically designed for children between 4 and 12 years of age but its psychometric properties have not been thoroughly examined. The purpose of this study was to analyze the feasibility, reliability and validity of the BMAT when administered to preschool children. Spanish healthy children (N = 75) from three different kindergarten schools were assessed on two occasions separated by four weeks. Five BMAT subtests showed high test-retest correlations (0.75-0.86) whereas the rest revealed a weak to moderate reliability (0.48-0.64). BMAT internal consistency was found to be weak (Cronbach's Alpha = 0.49). All the subtests correlated with age. The BMAT is a feasible motor assessment tool that can be performed by preschoolers, albeit with some modifications. The lack of reliability reported in several subtests is an important concern that should be confirmed by future studies with larger samples.
Key Words*:* - Psychometric properties, field-based battery, motor skills, child motor development, human performance

Introduction

The assessment of motor ability in young children has become increasingly important in recent years, since it has been suggested that it could be linked to cognitive, language, social and emotional difficulties (Piek, Hands, & Licari, 2012). Moreover, there is evidence that poor motor ability may impact on physical fitness (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008), an important marker for health and disease during childhood (Ortega et al., 2014). Therefore, there is a need for accurately measuring motor ability during the preschool years.

Motor ability in preschoolers is often assessed by means of norm-referenced field-based batteries that should meet some criteria such as easy and fast administration, low cost, appropriate psychometric properties and simplicity in the calculation of a final score (Cools, De Martelaer, Samaey, &Andries., 2009). In this respect, the Basic Motor Ability Test (BMAT) (Arnheim & Sinclair, 1975) is a motor ability battery specifically designed for children between 4 and 12 years of age. Although BMAT accomplishes most of the requirements mentioned earlier, there are three important issues that need to be considered regarding its use. First, two of its nine subtests, Bead Stringing and Tapping, require specific instruments to be implemented. Although they can be adapted by using other non-specific materials, it is unknown how this would affect their reliability. Secondly, as the normative values for the BMAT were established 40 years ago, its current validity is unclear since preschoolers' motor development might have changed during this period (Runhaar et al., 2010). Furthermore, there might be differences related to the sociodemographic characteristics of the population studied (Kambas et al., 2012). Lastly, while the overall psychometric properties of the BMAT have been reported (Arnheim & Sinclair, 1975), its reliability and validity for different age groups remain unestablished. This is of special relevance because preschoolers may have difficulties in understanding the test protocol or may lack in motivation and this could affect the psychometric properties of the BMAT (Ayán, Cancela, Romero, & Alonso, 2015).

Given these issues, the present study aims to identify the feasibility, reliability and validity of the BMAT when administered to preschool children.

Material & methods

Participants

The participants were Spanish healthy children from three different kindergarten schools. Children enrolled in the second level (4 and 5 years old) of the first period of the Spanish Education Curriculum were considered eligible for the study. Only children without any pathology were assessed. Before commencing the

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study, formal permission from the principals of the schools involved was sought and granted. Written informed consent was obtained from the parents/guardians of all children and assent was obtained from the minors previously to their participation in the study. The regional ethics committee reviewed and approved the protocol of the study.

Measures

Anthropometry. Body weight was measured to the nearest 0.1 kg using a digital scale (Tefal PP1200VO) and height was measured to the nearest millimetre with a field stadiometer (Seca 220). Weight and height were measured in light clothing without shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m2).

Basic motor ability test (BMAT). This battery is composed of the following nine subtests:

Bead stringing (BS). This subtest consisted in threading beads (1 cm in diameter) onto a cord (45 cm long with a plastic end of 2 cm in diameter) as rapidly as possible during 30 s. Given that the Stanford-Binet test beads recommended by the standard protocol of the BMAT weren't available, screws with identical dimensions were used.

Target throwing (TT). In this subtest, children were required to throw 15 squared bags of seeds (10-12.5 cm wide) towards three targets (placed on a wall at a height of 1.2 m), from a distance of 2 m. The targets consist of three rectangles with heights of 12, 27 and 45 cm. Each target is given a different score according to its size so that 1, 2 and 3 points are awarded to the large, medium and small rectangles, respectively. Once the 15 bags have been thrown, the final score was summed up for each participant.

Tapping (T). This subtest consisted in hitting alternatively two circles located on an electronic board (45 cm long), during 20 seconds. Given that the specific electronic board wasn´t available and following the BMAT guidelines, a 45 cm long board was built of cardboard and the two circles were drawn on the corners. The examiner was responsible for keeping track of hits.

Hamstring stretch (HS). In this subtest, the children were required to sit on the floor with both legs outstretched and heels 15 cm apart from each other. A 3 m ruler or stick should have been placed in the middle of both legs with the 30 cm mark aligned with the heels, but as there was none available, a measurement tape was fixed to the ground at the corresponding position. Without bending their knees, children should try to reach forward as far as possible with their fingertips. The distance reached was recorded in centimeters.

Long jump (LJ). In this subtest, the children had to perform 3 standing long jumps on a level and non-slip floor surface. A take-off line was marked with tape on the floor. At the start of the jump the feet must be behind the take-off line. There must be no movement of the feet prior to take-off and the children must retain balance after landing. Jump distance was measured as the distance from the take-off line to the nearest body part upon landing (this is typically the point of heel contact). The best of the three trials was recorded.

Face down to standing (FD). This subtest began with the child lying upside down on a mat (1.2 x 1.8 m). At the examiner's signal "Ready? Go!" the child had to stand up and go back to the initial position as many times as possible during 25 s. The number of times the child was able to complete this whole action was registered.

Static balance (SB). In this subtest the children were asked to stand on one foot as long as possible on a 2.5 cm wide wooden platform (SB1). Children were instructed to close their eyes, to place their hands at the waist and to hook the lifted foot behind the knee of the supporting leg. The test finished when the participant sat the lifted foot on the floor, opened the eyes or removed the hands from the waist. A 10 s trial repetition was allowed before the test was recorded. According to the BMAT guidelines, this subtest was repeated on a 5 cm wide wooden platform (SB2).

Push-ups (PU). In this subtest, children had to do as many arm push-ups as they could, setting both feet on the floor and placing both hands on a bench so the body was in inclined position.

Agility run (AR). This subtest consisted in running in a zig-zag pattern between four cones spread 1.5 m apart in a straight line. The starting point was at the right side of the first cone. Children had to perform as many zig-zag runs as they could in 20 seconds. The number of runs achieved represented the final score.

Procedure

All subtests were carried out in groups of 20 children on a four-week schedule. In the first week, BMI was determined and the BMAT protocol was carefully explained to the children to avoid learning effects during the experiment. In the second week, the participants performed the BMAT (test). During the third week no assessments were done. Finally, BMAT was carried out again in the fourth week (retest). Three senior students who were majoring in early childhood education administered the tests and a kindergarten teacher supervised the assessments. They were all specialized in Physical Education.

Statistical Analysis

Data were analyzed in several stages. First, assumptions of normality and homoscedasticity were checked for each dependent variable using a one-sample Kolmogorov-Smirnov test and Levene's test, respectively. Secondly, descriptive statistics were calculated and a comparison of means was carried out using an independent samples Student's t-test to examine the differences between sexes. Thirdly, reliability was assessed for each BMAT subtest by calculating the test-retest correlation. Pearson's and Spearman's correlations were used for normal and non-normally distributed variables, respectively. Fourthly, internal consistency was assessed using

Cronbach's alpha. Lastly, construct validity was established by correlating BMAT subtests scores with age since it was expected that preschoolers' motor skills improve with maturation. SPSS 15.0 for Windows was used for statistical analysis (SPSS Inc., Chicago, IL, USA) and statistical significance was established at $p<0.05$.

Results

A total of 75 children (mean age 5.51 ± 0.29 years) volunteered to participate and completed the study. Participant characteristics are summarized in Table 1 along with their performance in the different BMAT subtests. Significant intersexual differences were observed only for flexibility, both in the test and the retest ($p<0.05$), with girls presenting higher values of HS than boys.

The battery showed to be feasible as children found no difficulties in understanding the tasks that were to be executed. Regarding task execution, children found difficult to perform the SB and the PU subtests since it took some time to achieve their correct realization pattern.

Concerning the reliability of the BMAT, five subtests (BS, T, HS, LJ and PU) showed high test-retest correlations (0.75-0.86), whereas the rest of the subtests revealed a weak to moderate reliability (0.48-0.64) (Table 2).

In relation to the internal consistency of the battery, the Cronbach's Alpha coefficient was 0.49, thus suggesting a weak correlation among the different subtests that the BMAT comprises.

Finally, regarding construct validity, all the subtests directly correlated with age, except HS, which was inversely correlated, as expected (Table3). The TT was the only subtest that showed a significant statistical association with age.

Dicussion

Reliability and validity are necessary features of a good instrument for the assessment of motor ability. So this study tried to identify if the BMAT proved to be valid and reliable when administered to preschoolers. The obtained results may be used to assist any physical education teacher or health professional in establishing children´s level of motor development or in ascertaining the effects of interventions on children's motor ability.

The BMAT proved to be feasible except for the balance subtest, which showed a high level of difficulty reflected by the short time that the children were able to hold the required body posture, regardless of platform width. It also needs to be pointed out how difficult it was for the children to correctly execute the PU subtest, a common issue in previous studies (Ayán, Cancela, Senra, & Quireza, 2014). The feasibility of the BMAT when administered in preschool settings was ratified by the fact that the adjustments made to the materials used in the BS and the TT subtests did not affect its execution.

The present study also allowed us to compare the current sample mean scores with normative data from the original manual of the BMAT published 40 years ago. Both boys and girls were on the 50th percentile in BS, TT, LJ and FD subtests and both surpassed the 90th percentile in T and AR. In HS and PU the children scored close to the 25th percentile but none of the participants reached this percentile in SB. Given that the original manual of the BMAT did not provide detailed information about the sample employed to establish the normative curves, the differences observed in some subtests are acceptable. Only the scores in SB can be considered an unusually low level of performance. The reason that would explain this extremely low balance scores is the difficulty of the subtest because standing on one foot with eyes closed on a narrow platform can be excessively demanding for preschoolers.

The difficulty of the task involved in the SB subtest could have also affected its reliability, given that similar balance tests have demonstrated to be easier for preschoolers and have shown acceptable reliability when executed on the floor (Crock, Horvat, & McCarthy, 2001; Fjortof, 2010; Larkin & Revie, 1994; Mc Carron, 1997), or on a platform (Bös, Bappert, Tittlbach, & Wall, 2004; Klein, Koch, Dordel, Strüder, & Graf, 2012), with eyes open. In this line, the low reliability observed in some other subtests of the BMAT (AR, TT and FD) could be attributed to their protocol characteristics. For example, the agility subtest comprises several changes in direction in a 6 m distance and it has been noted that including many changes in direction and a long distance are questionable aspects of an agility test (Sayers, 2015). In fact, all of the agility tests that have proved to be reliable for children less than six years of age propose a shorter distance (4m) and fewer changes in direction (Ortega et al., 2014). Analogously, the TT subtest asked the children to throw toward a concentric rectangular target, while it has been observed that there is a higher reliability in tests with circular targets (Malina, 1968). Moreover, the reliability on this kind of tests strongly depends on the target size and on the throwing distance (Zahradník, Vaverka, & Gajda, 2008). In addition, the BMAT protocol does not consider the participant physical capacities and anthropometric characteristics, as the dimensions and distances established for the TT subtest does not change with age. It could be expected that the TT subtest would be more reliable if this requirement were fulfilled and target dimensions were bigger for the younger children, as in other motor development assessment batteries (Bruininks, 2005; Zimmer & Volkamer, 1987). Finally, concerning the FD subtest reliability, the BMAT guidelines state that the face down to standing task demands speed and agility from the participants, but after analyzing their execution it became clear that strength and resistance are also necessary capacities in order to perform the subtest correctly. As a consequence of the great effort required to complete the FD, motivation was a crucial factor and, to this regard, it has been suggested that when a test is applied to young children, its

reliability can be affected if the task is perceived to be exhausting or when it is not known how to meet its physical or conditional demands (Ayán et al., 2014).

On the other hand, The BAMT comprises two subtests (LJ and BS) that showed a good reliability. The LJ is a reliable test commonly used to assess lower body muscular strength in young children (Ortega et al., 2014). Similarly, despite the adjustments made in this study, the BS also resulted to be reliable, as previously observed (Crock et al, 2001). In this line, the T subtest showed an acceptable reliability after the modifications implemented in this research. With respect to this finding, it is worth mentioning that Fjortof (2010) suggested that the protocol of the Tapping test included in the EUROFIT battery, which is similar to the T subtest in the BMAT, should be modified due to the its poor reliability when applied to young children. In addition, it is important to point out the high reliability observed for both PU and HS subtests, two of the very few field-based tests that evaluate upper limb strength and flexibility without the need of special equipment, since to the authors' knowledge it has not been previously reported in preschoolers.

The BMAT battery has been regarded as a valid tool by its creators and given the positive correlations found in the present study between subtests scores and participants' age, the BMAT demonstrated to have acceptable criterion validity. In this regard, it is important to highlight that the correlation was only significant for the flexibility subtest and this could be due to the fact that this physical capacity worsens rapidly with age. The narrow age range of the sample (60-72 months) could explain the absence of other statistically significant associations. Indeed, a greater number of statistically significant associations would be expected simply by covering a broader age range.

The BMAT showed a weak internal consistency because each subtest measures different physical capacities (e.g. strength, agility, balance, etc.). In contrast, a high level of internal consistency (Cronbach's alpha = 0.89) has been reported in a previous study (Kavianpour, Raki, & Malekpour, 2014), but its sample consisted of only three preschoolers who were diagnosed with developmental coordination disorder.

Several studies have reviewed the psychometric properties of various batteries assessing motor ability (Cools et al., 2009; Slater, Hillier, & Civetta, 2010; Piek et al., 2012; Wiart & Darrah, 2001), but none of them have thoroughly analyzed the BMAT. The results provided here represent an initial attempt to remedy this lack of information. However, the small sample size and the fact that no data regarding the criterion validity of the battery have been incorporated are two important limitations that must be considered when interpreting them.

Conclusions

This investigation shows that the BMAT can, with certain modifications, be applied to 4-6 year old children, but its effectiveness in evaluating young children's motor development is in doubt. Professionals who are willing to apply the BMAT should take into account that some items, especially the balance subtest, can be difficult to perform by preschoolers, while others, such as the flexibility or the tapping subtests, seemed to be very reliable and easier to carry out. Consequently, the most appropriate option for physical education and psychomotor activity professionals would be to apply this later BMAT subtests and to use other alternatives to evaluate those mobility components in which the BMAT showed a weak reliability.

Conflicts of interest - The authors report no conflicts of interest.

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