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Validity of the Movement Assessment Battery for Children test – 2nd edition in older adolescents

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Background: The Movement Assessment Battery for Children test – 2nd edition (MABC-2) is one of the most commonly used tools to assess motor coordination in children. The question for clinical and psychological practice is whether the age band 3 (AB3) could be suitable also for 17–19-year-old adolescents. **Objective:** To examine the validity of the MABC-2 – AB3 test for 17–19-year-old adolescents. **Methods:** One hundred twenty participants (60 boys and 60 girls) were assessed using the AB3 of the MABC-2 test. The validity of the AB3 for 17–19-year-old adolescents was assessed using two procedures: (1) analysis of the age factor for performance in AB3 tasks (Kruskal-Wallis test), (2) the confirmatory factor analysis using the IBM SPSS AMOS 22.0 version performed on the test scores to verify the three-factor structure of the MABC-2 test. **Results:** Age was an important factor only in the unimanual task performed with the dominant and non-dominant hand, and in the bimanual task. The data of the 17–19-year-old participants did not fit to the original three-factor model of the MABC-2 test but fit to the modified model with two latent factors – manual dexterity and aiming & catching ($\chi^2(25) = 28.224$, $p = .298$, relative $\chi^2 = 1.129$, root-mean-square-error of approximation = .033, goodness of fit index = 0.966, adjusted goodness of fit index = 0.920, and Tucker-Lewis index = 0.977). **Conclusions:** The AB3 version of the MABC-2 test indicated unsatisfactory validity for the assessment of motor competency in 17–19-year-old adolescents. The aiming and catching tasks, together with unimanual and bimanual coordination tasks seem to be applicable in psychological, educational and clinical practice for motor testing of older adolescents. However, the creation of new norms for older adolescents should be taken into consideration.

Keywords: MABC-2 test, developmental coordination disorder, factor analysis, adolescents

Introduction

Compared to children with developmental coordination disorder (DCD), considerably less attention is paid to adolescents with persisting motor impairment (Hands, Licari, & Piek, 2015). DCD is a heterogeneous syndrome (American Psychiatric Association, 2013), and is purported to be related to a deficit in sensory perception and integration (Cox, Harris, Auld, & Johnston, 2015; Wilson, Ruddock, Smits-Engelsman, Polatajko, & Blank, 2013) in motor planning or programming (Wilson et al., 2017) and/or on-line motor control (Ruddock at al., 2016). These functional deficits are reflected in impaired fine and gross motor skills, balance, delayed reactions, impaired execution of more complex movement tasks, and others (see Wilson et al., 2013, 2017 for reviews). DCD can persist until adolescence and young adulthood in 32–87% of individuals with a history of DCD in childhood (Kirby, Edwards, & Sugden, 2011; Psotta & Kraus, 2014).

One of the reasons why impairment of motor coordination in older adolescence and young adulthood remains under-researched may arise from the limited availability of valid instruments for the motor assessment of this age group (Smits-Engelsman, Jover, Green, Ferguson, & Wilson, 2017). Indeed, there is evidence of some methodological issues in the current tests for motor coordination used in older adolescents and young adults, such as the Bruininks-Oseretsky Test of Motor Proficiency – 2nd edition (BOTMP-2; Bruininks & Bruininks, 2005), McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1997) and Zurich Neuromotor Assessment (ZNA; Largo, Fischer, & Caflisch, 2002). The first issue is insufficient verification of the validity of motor tests

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for older subjects. Specifically, verification of the validity of the BOTMP-2 and the MAND test was restricted to a clinical sample under 15 years (Bruininks & Bruininks, 2005) and young adults with mental retardation respectively (McCarron, 1997). No information is even provided about the validity and reliability of the ZNA test in older age groups.

A second problem of these motor tests may be the ceiling effect, as they were designed for younger subjects they use tasks which are relatively simple in order to cater to the skills of younger children. These tasks are too simple to be challenging enough for older subjects, and may lead to the inability of those tests to discriminate motor competency among them. The ceiling effect has been reported for the performance of older subjects in gross motor coordination and balance tasks of the MAND test, such as rod slide, one-foot stand, finger-nose-finger and heel walk task (Hands et al., 2015), and it is possible to observe same problem also in the fine motor precision task, fine motor integration task and bilateral coordination tasks of the BOTMP-2 test.

All the above-mentioned motor tests involve identical test tasks across a large age range of individuals, i.e. from childhood to adolescence, and their motor coordination is set based on age-normalized test scores. The manifestation and signs of impaired motor coordination in adolescents may be somewhat different than in children, due to changes in their experience and repertoire of movement activities performed during their daily life and leisure time, such as driving a car, shaving, writing under time pressure and extreme sports (Kirby et al., 2011). More importantly, with increasing age motor abilities become more specific and differentiated, given by the neuromotor maturation (Psotta & Abdollahipour, 2017; Schulz, Henderson, Sugden, & Barnett, 2011). An insufficient age specificity of motor tasks may cause an impairment in specificity and validity of the tests, and as a consequence worsened clinical judgments of motor proficiency.

One of the tests which seems to better take into account the development of fundamental motor skills is the Movement Assessment Battery for Children – 2nd edition (MABC-2; Henderson, Sugden, & Barnett, 2007), as it involves three different age bands of test tasks, specifically for children aged 3–6, 7–10, and 11–16 years. Assessment of motor coordination in this test is based on performance of manual dexterity, aiming, catching and balance. At present, this test is one of the most frequently used tools for motor impairment identification in children in psychological and clinical practice. In addition, the frequent use of the test in research has been demonstrated by using this test in 73% and 77% of all studies focused on DCD in children (Smits-Engelsman, Schoemaker, Delabastita, Hoskens, & Geuze, 2015; Wilson et al., 2017).

The oldest age version of the MABC-2 test, age band 3 (AB3) determined for 11–16-year-old subjects was confirmed to have a three-factor structure with latent factors such as manual dexterity, aiming & catching and balance (Psotta & Abdollahipour, 2017; Schulz et al., 2011), excellent inter-rater reliability (.92–1.00) and acceptable to excellent test-retest reliability (.62–.92; Henderson et al., 2007). Based on the above-mentioned diagnostic qualities of the MABC-2 test, its AB3 age version may be considered useful for older adolescents above the age of 16 years. Indeed, the previous studies showed the AB3 version to be able to identify motor impairment in subjects aged over 16 years (Du, Wilmut, & Barnett, 2015; Hollund et al., 2018). These results suggest the possible sensitivity of the AB3 version for older adolescents. However, it might be that only more severe motor difficulties can be revealed in older individuals with this test (Sugden & Chambers, 2005).

The possible validity of the AB3 of the MABC-2 test for older adolescents is supported by the fact that some sensorimotor functions, such as eye-hand visuomotor coordination and kinaesthetic-motor coordination of the upper limbs, continue to mature during adolescence (Kagerer & Clark, 2015). The function of the corpus callosum matures up to adolescence (Gooijers & Swinnen, 2014), and as a consequence, control of bimanual tasks may be better tuned. Additionally, there is evidence of improvement in temporal and spatial aspects of bimanual coordination during adolescence (de Boer, Peper, & Beek, 2012). Both temporal and spatial coordination of the upper limbs, together with visual object tracking and predictive abilities, which also improve in adolescence (Ego, Yüksel, Orban de Xivry, & Lefèvre, 2015; Wolf et al., 2018), are the main underlying mechanisms required in interceptive tasks such as catching and hitting.

There is also evidence of improvement in balance control in older adolescence (Viel, Vaugoyeau, & Assaiante, 2009), which is affected by the still ongoing development efficiency of the vestibular functions (Ionescu, Morlet, Froehlich, & Ferber-Viart, 2006) and sensory organization for balance control (Ferber-Viart, Ionescu, Morlet, Froehlich, & Dubreuil, 2007).

Based on the above-mentioned suggestions concerning the possible validity of the AB3 version of the MABC-2 test in older adolescents, the aim of the current study was to examine whether the tasks involved in AB3 may be valid for assessing motor coordination in 17–19-year-old adolescents. This examination was based on two assumptions. First, if the AB3 tasks cover sensorimotor functions which are still maturing during older adolescence and are associated with manual dexterity, aiming, catching and balance, the performance of these tasks should change (improve) during this age period. In the current study, the examination of this assumption has been based on an assessment of the age effect on performance in the test tasks. Secondly, if the original construction of the MABC-2 test is to be maintained regardless of age, the test should demonstrate a three-factor structure with latent factors as manual dexterity (MD), aiming & catching (AC), and balance (Bal) also in older adolescents. Therefore, the purpose of the study is also to verify the structural validity of the AB3 version.

Methods

Participants

Participants of three age groups (17:0–17:11 years:months, 18:0–18:11 years:months, 19:0–19:11 years:months), n = 40 (20 boys, 20 girls) in each age group (total N =120), participated in the study. Average height of the participants was 173.6 ± 10.7 cm and average weight was 68.8 ± 15.1 kg. The participants were students from six secondary schools. The informed consent was obtained from the students or their parents via the schools' principals. In order to secure a representative sample of the Czech population of 17–19 years olds, a stratified sampling plan was used to ensure that the representative proportions of the subjects for each year (17, 18, 19) from each type of secondary education group (30 students from grammar school, 59 students from technical school and 31 students from vocational school) and sex (male, female) would be included in the sample of participants. Pedagogical and psychological anamneses of the students were obtained from school psychologists. Based on the obtained anamneses, only participants who were physically and psychologically healthy and without general medical conditions were included in the study.

Procedure

The participants were tested with the age band 3 (AB3) of the MABC-2 Test (Table 1). The administration of the test was carried out according to the Examiner's Manual of the MABC-2 Test (Henderson et al., 2007). Scoring of data was performed according to the norms for the population of 16-year-old Czech subjects (Psotta, 2014) and raw scores were used for statistical analyses. All the participants were tested individually in their schools by a team of five graduate examiners, who were holders of the official user's certification after having participated in a user's training program by an authorized psychodiagnostic company. The study was approved by the Ethics Committee of Faculty of Physical Culture, Palacký University Olomouc (No. 44/2014).

Statistical analyses

Analysis of the age effect on motor test performance

The test results for 16-year-old adolescents (n = 52, 21 boys and 31 girls) obtained during the first stage of the MABC-2 test verification in the normative samples of Czech children (Psotta, 2014), as well as the test results for 17–19 years olds, were subjected to analysis.

The Shapiro-Wilk test showed an abnormal distribution of test scores in each motor task for each age group, with the exception of scores from the MD 2 task and the AC 2 task in 16 and 18 years olds respectively. The effect of age (four levels: 16, 17, 18, and 19 years) on performance of each motor task was analyzed by a Kruskal-Wallis test and a post-hoc Kruskal-Wallis pairwise

Table 1
The test tasks of the MABC-2 test – age band 3

Code of test tasks	Name of the test task	Motor component
MD 1p	Turning pegs – preferred hand	Manual dexterity
MD 1n	Turning pegs – non-preferred hand	Manual dexterity
MD 2	Triangle with nuts and bolts	Manual dexterity
MD 3	Drawing trial 3	Manual dexterity
AC 1b	Catching – better hand	Aiming & Catching
AC 1o	Catching – other hand	Aiming & Catching
AC 2	Throwing at a wall target	Aiming & Catching
Bal 1	Two-board balance	Balance
Bal 2	Walking toe-to-heel-backwards	Balance
Bal 3b	Zig-zag hopping – better leg	Balance
Bal 3o	Zig-zag hopping – other leg	Balance

comparison for two independent samples. A level of $\alpha = .05$ was set for all tests. The size of the effect (η^2) was calculated according Cohen's formula and was interpreted as .02 = small, .13 = medium and .26 = large effect (Cohen, 2008). Data analyses were performed with IBM SPSS (Version 24; IBM, Armonk, NY, USA).

Confirmatory factor analysis (CFA)

CFA using the IBM SPSS AMOS 22.0 version (Arbuckle, 2013) was performed on the raw item scores to verify whether the presumed structural model of the AB3 version is valid for 17–19-year-old adolescents. According to this hypothesized model, the eleven test items (Table 1) should be manifestations of three interrelated latent factors – MD, AC and Bal – making the test a three-specific factor structure. Thus, in the CFA performance in the test, tasks (items) were dependent on observable variables, while the latent motor factors presented independent variables.

In this model, each test item had one fixed number representing the latent factor load. Asymptotically distribution-free estimates of the non-standardized and standardized partial regression weights were made using the covariance matrix. The model fit was evaluated with the following criteria for a good fitting model, according to the recommendation from Hooper, Coughlan, and Mullen (2008): the Chi-Square χ^2 test ($p > .05$), relative χ^2(CMIN/*df*) (< 3.0), root-mean-square-error of approximation RMSEA (< .07), goodness of fit index (GFI > 0.95), adjusted goodness of fit index (AGFI > 0.95), and Tucker-Lewis index (TLI > 0.95).

If the models differed significantly from the data, they would be modified (Hooper et al., 2008). The main discrepancies between the real and the fitted covariance structure were found using modification indices (MI), with MI > 4.0 as a significant discrepancy. The statistical significance of all the parameters was verified according to a Wald test ($p = .05$).

Factor loadings were classified according to the criteria for clinical significance of standardized factor loading (Tabachnick & Fidell, 2007) as follows: < .32 as very poor, .32–.44 poor, .45–.54 fair, .55–.62 good, .63–.70 very good, and > .70 excellent clinical significance. The same authors recommend these criteria for items with a different frequency distribution, as is the case in this study.

Results

Age effect on motor performance

If raw scores were converted according to the norms for 16 years olds, seven and nine 17–19-year-old participants out of a total number of 120 achieved a total test score of TTS ≤ 5th and TTS ≤ 15th percentile, which indicates significant motor difficulties and a risk of movement difficulty (Henderson et al., 2007; Psotta, 2014). A non-parametric analysis of variance showed a significant effect of age on the motor performance of two manual dexterity tasks – MD 1 performed with both the preferred and non-preferred hand ($\chi^2(3) = 18.787$, $p < .001$, $\eta^2 = .136$; $\chi^2(3) = 25.199$, $p < .001$, $\eta^2 = .191$), and MD 2 ($\chi^2(3) = 10.302$, $p = .016$, $\eta^2 = .063$), while scores in the aiming & catching tasks and balance tasks were not significantly affected by age (Table 2). A post-hoc analysis showed that 17-, 18-, and 19-year-old participants completed the unimanual task MD 1 with both the preferred and non-preferred hand in a significantly shorter time, $\chi^2(1) = 10.556$, $p = .001$, $\eta^2 = .106$; $\chi^2(1) = 4.541$, $p = .033$, $\eta^2 = .033$; $\chi^2(1) = 14.461$, $p < .001$, $\eta^2 = .15$ respectively, and $\chi^2(1) = 12.445$, $p < .001$, $\eta^2 = .127$; $\chi^2(1) = 12.240$, $p < .001$, $\eta^2 = .125$; $\chi^2(1) = 20.007$, $p < .001$, $\eta^2 = .211$ respectively, as compared to 16-year-old adolescents (Figure 1). In addition, in comparison with 18 years olds, the 19 years olds required a shorter time to complete the MD 1 task with the preferred hand, $\chi^2(1) = 3.923$, $p = .048$, $\eta^2 = .037$ (Figure 1).

Nineteen-year-old adolescents executed the MD 2 bimanual task in a significantly shorter time compared to the 16-, 17-, and 18-year-old adolescents, $\chi^2(1) = 6.904$, $p = .009$, $\eta^2 = .066$; $\chi^2(1) = 6.974$, $p = .008$, $\eta^2 = .077$ and $\chi^2(1) = 6.543$, $p = .011$, $\eta^2 = .071$ respectively (Figure 1). Other pairwise comparisons of performance in both MD 1 and MD 2 between the age groups were not significant.

The effect of age was not significant for the performance of the graphomotor task (MD 3), or for all the aiming & catching and balance tasks (Table 2).

Results of the CFA

It was not possible to estimate the initial strict three-specific factor model. The cause of the problem consists in that both test items of the task Hopping on mats (Bal 3b and Bal 3o) were almost constants, with most sample participants achieving close to the maximum score (five jumps). Therefore, the tasks Bal 3b and Bal 3o were excluded in order to achieve the modified fitting model of the test. The modified model met the criteria of a good fit, the $\chi^2(25) = 28.224$, $p = .298$, CMIN/*df* = 1.129, RMSEA = .033, GFI = 0.966, AGFI = 0.920, and TLI = 0.977 only when cross-loading of the Drawing trail task (MD 3) on the balance latent factor was added. This factor loading would be difficult to justify theoretically. In addition, this factor loading was marginally significant ($p = .0506$). Therefore, to find a better fitting model of the test, all balance tasks had to be excluded. The reason was

Table 2

Descriptive characteristics of the performance in the test tasks of the MABC-2 test – age band 3 in 16-, 17-, 18-, and 19-year-old adolescents

	M	*SD*	*Mdn*	IQR	*p*
MD 1p (s)					
16 years	18.3	3.4	18	4	< .001
17 years	16.4	2.2	16	3	
18 years	17.0	2.4	16	3	
19 years	16.0	2.7	16	3.8	
MD 1n (s)					
16 years	21.4	3.8	22	5.8	< .001
17 years	18.8	3.8	19	4	
18 years	19.0	3.7	19	5	
19 years	18.1	3.2	18	5	
MD 2 (s)					
16 years	34.1	10.5	30	14.5	.016
17 years	33.2	9.8	32	7	
18 years	34.3	10.4	32.5	14.8	
19 years	29.2	8.7	26.5	9	
MD 3 (errors)					
16 years	0.2	0.4	0	0	.175
17 years	0.1	0.2	0	0	
18 years	0	0	0	0	
19 years	0.2	0.8	0	0	
AC 1b (catches)					
16 years	8.9	2.0	10	1.8	.694
17 years	8.8	2.2	10	1	
18 years	9.3	1.1	10	1	
19 years	8.9	1.9	10	1	
AC 1o (catches)					
16 years	7.9	2.2	9	3	.941
17 years	7.6	2.6	8.5	4	
18 years	7.8	2.6	9	4	
19 years	7.8	2.5	9	3.8	
AC 2 (hits)					
16 years	6.6	1.9	6.5	2.8	.092
17 years	6.9	1.8	7	2	
18 years	7.1	2.1	7.5	3	
19 years	7.3	2.0	8	3	
Bal 1 (s)					
16 years	23.3	9.2	30	17	.165
17 years	22.2	9.5	29.5	15	
18 years	22.0	10.4	30	19.8	
19 years	26.0	7.5	30	5.8	
Bal 2 (steps)					
16 years	14.0	3.0	15	0	.073
17 years	14.9	0.7	15	0	
18 years	14.1	2.1	15	0	
19 years	13.7	4.2	15	1.8	
Bal 3b (hops)					
16 years	5.0	0.2	5	0	.511
17 years	5.0	0	5	0	
18 years	5.0	0	5	0	
19 years	5.0	0	5	0	
Bal 3o (hops)					
16 years	4.9	0.3	5	0	.318
17 years	4.9	0.3	5	0	
18 years	5.0	0	5	0	
19 years	5.0	0.2	5	0	

Note. *Mdn* = median; IQR = interquartile range; MD 1 – Bal 3 = the test tasks (see Table 1).

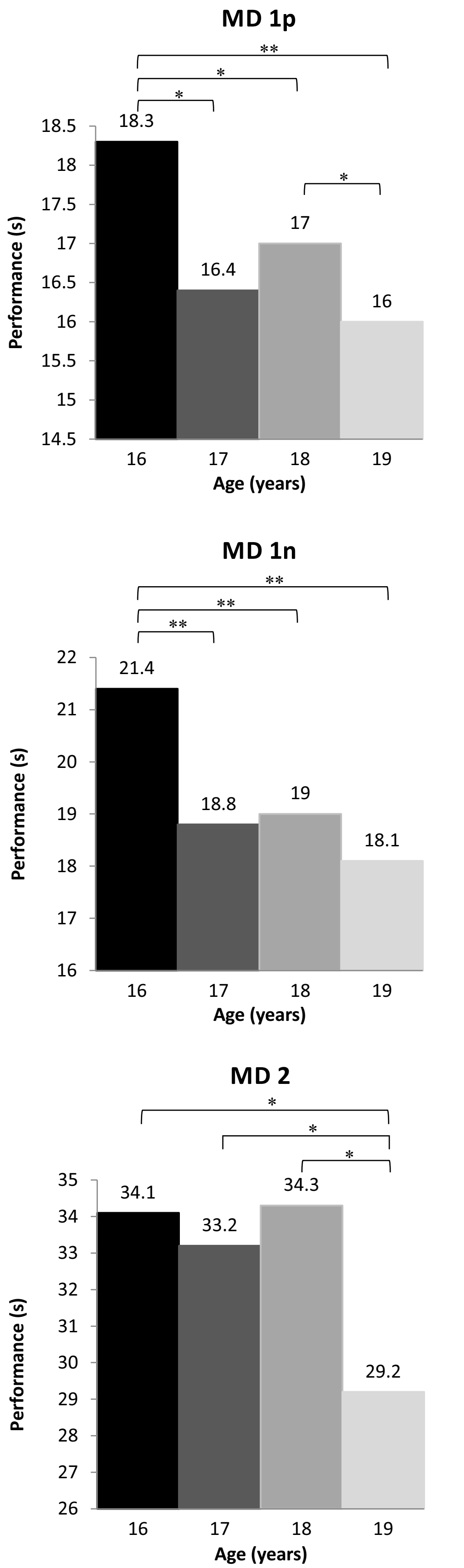

Figure 1. Post-hoc comparison of Turning pegs – preferred hand (MD 1p), Turning pegs – non-preferred hand (MD 1n), and Triangle with nuts and bolts (MD 2) tasks. $^{*}p < .05$, $^{**}p < .001$.

that after rejecting the factor loading of the MD 3 on the balance latent factor, both Bal 1 and Bal 2 became insignificant. The cause of insignificant Bal 1 and Bal 2 was strong disruption of the Gaussian normal distribution of both the variables, as they were close to being constants.

The final well-fitting model of the AB3, $\chi^2(9)$ = 14.035, p = .121, CMIN/df = 1.559, RMSEA = .069, GFI = 0.966, AGFI = 0.920, and TLI = 0.954 is presented in Figure 2. This model includes two latent factors, MD and AC, which are interrelated significantly but poorly. All factor loadings of the test items on the MD or AC latent factor were statistically significant (p < .05; Figure 2). More specifically, the test tasks MD 1p, and AC 1b and AC 1o showed excellent significance of their factor loading on the MD factor and AC factor respectively, while on the other hand the task AC 2 showed poor significance of factor loading on the AC factor. The correlation matrix of the manifested variables introduced in Table 3 suggests factorial overlapping between the motor tasks.

Discussion

If the raw scores were converted according to the norms of 16 years olds, then 5.8% of 17–19-year-old participants achieved a total test score of TTS ≤ 5th percentile, which is the cut-off score for significant motor difficulties (Henderson et al., 2007). The proportion of determined individuals with such difficulties generally corresponds to the expected 2–6% incidence of DCD in children (American Psychiatric Association, 2013). As a result, the current study implies that the AB3 version could also detect motor difficulties in older adolescents with good sensitivity.

The MD 1 task consists in repeated reaching for a peg, and after grasping and turning it in the fingers placing into a pegboard with one hand. Thus, unimanual visuomotor "eye-hand" coordination is demonstrated by the execution of this task. The better performance of the 17, 18, and 19 years olds compared to 16 years olds may be related to improvement in both reaching (Golenia, Schoemaker, Otten, Mouton, & Bongers, 2018) and grasping (Jover, Ayoun, Berton, & Carlier, 2014). According to the two-component model, reaching movement is under feedforward control, with additional use of feedback control to estimate the current position of the hand approaching a target to adjust the speed of the hand so that accurate grasping of the object is achieved (Hoff & Arbib, 1993; Rand, Shimansky, Hossain, & Stelmach, 2008). A longer time needed to execute reaching for an object or target is a sign of immature feedforward control, and thus of greater dependence on feedback control (Elliot, et al., 2010). Currently, the deficit in internal modeling of movements including feedforward control is considered to

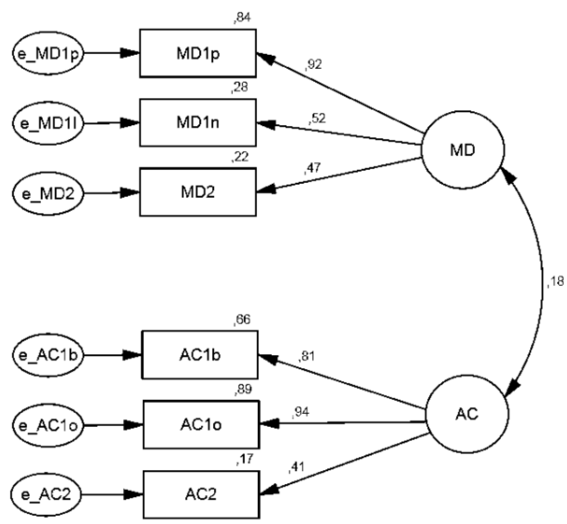

Figure 2. Three-specific factor model of the MABC-2 test – age band 3 for 17–19-year-old adolescents. $\chi^2(9)$ = 14.035, p = .121, CMIN/df = 1.559, RMSEA = .069, GFI = 0.966, AGFI = 0.920, and TLI = 0.954. MD1p – Bal3o = the test tasks (see Table 1); e_MD1p – e_Bal3o = error variables; latent factors: MD = manual dexterity, AC = aiming & catching, Bal = balance.

Table 3
Correlation matrix of the MABC-2 *test – age band 3*

	MD 1p	MD 1n	MD 2	AC 1b	AC 1o	AC 2
MD 1p	–	.481*	.426*	.111	.172	–.081
MD 1n		–	.247*	.068	.062	.113
MD 2			–	.073	.108	–.148
AC 1b				–	.769*	.296*
AC 1o					–	.399*
AC 2						–

Note. MD 1 – AC 2 = the test tasks (see Table 1). *p < .05.

be the core neuromotor problem in subjects with DCD (Wilson et al., 2013). Our results suggest that this task may capture improvement in feedforward control of reaching, grasping and fine manipulation movements of the hand.

The improvement in performance of the MD 2 task did not take place continuously across the age period of 16–19 years (Figure 1). This construction task demands repeated reaching and grasping of objects (strips, nuts and bolts) and fine movement manipulation of them. The significant correlations between performance in the MD 2 and MD 1 tasks (Table 3) suggest a partial overlapping of sensorimotor functions. However, the construction task is associated with asymmetrical bimanual coordination, which depends on the ability to inhibit undesirable congruent (mirror) movements of both limbs (Koerte et al., 2010).

Although visual-motor unimanual coordination is applied in the MD 3 graphomotor task as in the MD 1 task, performance in the MD 3 task was not affected by the age of the adolescents. The test score in this task is the number of errors. This scoring expresses the precision of hand movements but not the speed of drawing a trail. 95.8% of participants completed the task with no error. The low ability of this task to differentiate better visuomotor coordination of the arm/hand among children and adolescents was also reported in previous studies (Psotta & Abdollahipour, 2017; Psotta, Hendl, Kokštejn, Jahodová, & Elfmark, 2014). These findings indicate the problem of the ceiling effect.

The performance in tasks of throwing and catching was not affected by the age of the adolescents. Successful execution of an interceptive task, such as catching or striking, depends on the spatio-temporal anticipation of the trajectory of the flying object (Craig, Bastin, & Montagne, 2011). This kind of anticipation is fully developed at about the age of 11, and further improvement was not observed in later years (Kim, Nauhaus, Glazek, Young, & Lin, 2013). Performance in the Bal tasks was not affected by the age of the adolescents (Table 2). This finding might be partially caused by the ceiling effect, when 83.3%, 100%, and 96.7% of participants achieved the maximum possible score in the both dynamic balance tasks - Bal 2 (fifteen correct consecutive steps), Bal 3b and Bal 3o, respectively (five correct consecutive hops on one leg). Moreover, 93.8% of participants, who were identified as having moderate to significant motor difficulties based on their total test score, accomplished the BAL 3 task with the maximum possible score. These findings indicate the poor sensitivity of the balance tasks of the AB3 version in adolescents, which had already previously been questioned even for adolescents under 17 years of age (Psotta et al., 2014; Valtr, Psotta, & Abdollahipour, 2016).

The MABC-2 test results found in 17–19-year-old adolescents did not fit the expected three-factor structure of the AB3 version, and only two latent factors – MD and AC components – were included in the adjusted fitted model of the test (Figure 2). This result may reflect the above-discussed problem of sensitivity of the balance tasks. In CFA the manifest dependent variables (test raw scores in the particular tasks) were rather constants, with the consequence of the elimination of the balance tasks from the MABC-2 test structure.

The very low correlation between the latent factors of MD and AC indicates a high degree of factor specificity of both assessed components. High specificity of the components in the AB3 of the MABC-2 test was also found in previous studies (Psotta & Abdollahipour, 2017; Schulz et al., 2011). Such a finding may be explained with reference to processes of the internal differentiation and specification of motor abilities and/or sensorimotor functions, with neural maturation during childhood and adolescence (Gallahue, Ozmun, & Goodway, 2012).

The unimanual task of turning pegs with the preferred hand (MD 1p) demonstrated excellent clinical significance for the assessment of manual dexterity, while the same task executed with the non-preferred hand (MD 1n) and the bimanual task MD 2 demonstrated fair loading only on the factor of manual dexterity. These findings indicate that the MD 1p task alone could reflect the level of manual dexterity of older adolescents with sufficient validity. Also, both catching tasks showed excellent clinical significance for the assessment of the aiming and catching component compared to the throwing task, which showed rather only fair factor loading for the same component. This can be explained by the fact that even in the catching task participants are required to throw the ball in the right manner in order to be able to catch it successfully. Therefore, it again seems that the AC1 task performed with both hands alone could reflect the level of aiming and catching abilities in a satisfactory way.

Overall, the results of the current study bring several findings. It seems that balance tasks together with the graphomotor task from MABC-2 are not valid for assessing motor coordination in older adolescents, probably due to their low sensitivity. Therefore, the creation of new specific and ecologically valid tasks with a proper level of difficulty for subjects over 16 should be taken into consideration. Tasks which assess fine unimanual and bimanual coordination and gross motor coordination appear to be suitable for older adolescents. However, it seems that aiming and catching tasks do not cover the sensorimotor functions which are still maturing during older adolescence. In future research, age norms for unimanual and bimanual tasks for older adolescents should be determined based on testing in larger representative samples.

Strengths and limitations

To our knowledge, this is the first study that examined the validity of the MABC-2 test in older adolescents as MABC-2 test was not originally designed for subjects over 16 years. The current study could be considered as the first step towards validation of MABC-2 test in age range of 17–19 years who need psychological or clinical services. Although representativeness of the sample has been arranged in several aspects (see Methods), the socio-economic status of families and the education level of parents were not involved into a stratification strategy. Another possible limitation of the sample representativeness may be a different ratio between males and females in the group of 16 years olds obtained during the MABC-2 test verification in the normative samples of Czech children. It is possible that these characteristics might interfere with the level of motor competency and as consequence decrease generalizability of the study. Also, generalizability of results might be impaired with the model modifications which were used to find a well-fitting model of the MABC-2 test for the age-specific group of subjects. However, the previous studies that examined structural validity of the MABC-2 test with use of a confirmatory factor analysis (Schulz et al., 2011; Wagner, Kastner, Petermann, & Bös, 2011) showed that it is not possible to confirm a strict structural model of the test and model modifications are needed.

Conclusions

The AB3 version of the MABC-2 test did not prove to be sufficiently valid to assess the motor coordination of adolescents aged 17–19. Especially, the balance tasks do not seem to be valid enough to capture developmental changes in balance performance. Only the tasks of unimanual and bimanual coordination of the test seems to be valid for assessment of manual dexterity in 17–19-year-old subjects. Future research should focus on modification and development of the new test tasks which would be valid for assessment of motor functions in older adolescents and young adulthood.

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Conflict of interest

There were no conflicts of interest.

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