*Acta Gymnica, vol. 46, no. 4*, 2016, 155–161
doi: 10.5507/ag.2016.017

# Gender differences in performance of the Movement Assessment Battery for Children – 2nd edition test in adolescents

**Ludvík Valtr*, Rudolf Psotta, and Reza Abdollahipour**

*Faculty of Physical Culture, Palacký University Olomouc, Olomouc, Czech Republic*



**Background:** The Movement Assessment Battery for Children – 2nd edition (MABC-2) is used for the assessment of motor proficiency and identification of motor impairments in 3–16 year old children. Although there are some gender differences in the motor development of children, in the MABC-2 test the same tasks and norms are used for both genders. **Objective:** The aim of the study was to determine gender differences in performance of motor tasks involved in the MABC-2 test in adolescents aged 15 to 16. **Methods:** Participants ($N = 121$, 50 boys and 71 girls, mean age $16.0 \pm 0.5$ years) randomly recruited from schools were assessed using the MABC-2 test. The Mann-Whitney $U$ test and effect size $r$ were used to analyse gender differences in performance outcome in the particular motor tasks of the MABC-2 test. **Results:** As compared to the boys, the girls achieved a significantly shorter time of completion of the unimanual coordination task executed with their preferred hand ($p < .001$, $r = .33$) and significantly fewer errors in the graphomotor task ($p = .001$, $r = .29$). On the other hand, the boys achieved significantly better results than the girls in the aiming and catching tasks ($p \leq .030$, $r = .20$–$.33$). Performance in the dynamic balance tasks was not significantly different between genders. The girls demonstrated a significantly longer duration of static balance in one-leg standing as compared to the boys ($p = .011$, $r = .23$). For the motor tasks some statistical differences were found, however the effect size of the gender on performance was small or medium. **Conclusions:** The findings of the study suggest that gender could be a significant factor of performance in the motor tasks associated with object control such as aiming and catching. Other domains, such as manual dexterity and balance, seem to be influenced by gender to a small extent.

*Keywords:* motor development, gender differences, performance, test

## Introduction

The development of motor skills plays an important role for children's involvement in daily life, social activities and being successful in academic achievement (Haapala, 2013). Assessment of motor skills and their development is required for many fields of human sciences such as physiotherapy, neurology and psychology. For such purposes, several test tools have been developed. The Movement Assessment Battery for Children test – 2nd edition (MABC-2) (Henderson, Sugden, & Barnett, 2007) is one of the widely used diagnostic tools for assessing motor performance in children and adolescents. The MABC-2 test or its older version the MABC (Henderson & Sugden, 1992) was used in 73% of studies in the last 5 years where motor performance deficits in Developmental coordination disorder were assessed (Smits-Engelsman, Schoemaker, Delabastita, Hoskens, & Geuze, 2015).

Evaluation of motor performance with MABC-2 is based on quantitative assessment and norms. Although the MABC-2 test has the same tasks and norms for both genders, other diagnostic tools such as the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks & Bruininks, 2005) or Zurich Neuromotor Assessment (Largo, Fischer, & Caflisch, 2002) have gender-specific norms. Indeed, differences in motor development have been identified between boys and girls (Davies & Rose, 2000; Gidley Larson et al., 2007; Vedul-Kjelsås, Stensdotter, & Sigmundsson, 2013). In other words, the concept of the MABC-2 test with the same tasks, administration and scoring could be disputed due to developmental and social differences between genders

* Address for correspondence: Ludvík Valtr, Department of Natural Sciences in Kinanthropology, Faculty of Physical Culture, Palacký University Olomouc, třída Míru 117, 771 11 Olomouc, Czech Republic. E-mail: ludvik.valtr@upol.cz

during their growth and maturation. Previous studies have reported gender differences in performance of the MABC and MABC-2 tasks in preschool children (Livesey, Coleman, & Piek, 2007; Sigmundsson & Rostoft, 2003), and elementary school children (Psotta & Hendl, 2012; Psotta, Hendl, Frömel, & Lehnert, 2012; Ruiz & Gutierrez, 2003; Vedul-Kjelsås et al., 2013). Only a few studies have pointed out gender differences in similar tasks to those which are involved in the MABC-2 test. For example, A. L. Barnett, Henderson, Scheib, and Schulz (2011) pointed out better graphomotor skills in 17–25 year old girl students in comparison to boy students. In addition, 14 and 15 year old adolescent girls have shown better performance than boys in balance tasks (Viel, Vaugoyeau, & Assaiante, 2009). In contrast, boys at the age of 16 outperformed girls in catching performance (L. M. Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Wicks, Telford, Cunningham, Semple, & Telford, 2015) and targeting tasks such as throwing balls at a target (Davies & Rose, 2000). However, no research regarding gender differences has been conducted with the MABC-2 test on 15 and 16 year old children.

One of the possible explanations for gender differences in the different coordinative types of motor skills might be due to social issues (Meyers-Levy & Loken, 2015). For example, gender differences in favour of boys were reported in parental motor stimulation during child-rearing (Lytton & Romney, 1991). Also, it has been suggested that participation in physical activities influences children's motor competence (L. M. Barnett et al., 2010; Green et al., 2011). The type and time of physical activities during leisure time has differed between boys and girls, when boys spend more time on sport activities (Kauderer & Randler, 2013; Mota, Santos, & Ribeiro, 2008; Vašíčková & Kalman, 2013). Higher involvement of boys in ball games can enhance their performance in aiming and catching skills (Badrić, Prskalo, & Matijević, 2015; Harrell et al., 2003). Girls tend to participate more in dancing activities (Badrić et al., 2015) and as a result they perform balance tasks better than boys. At the age of 15 and 16 children have been exposed to social and environmental factors longer than younger children and thus motor skills performance can be affected more.

From a neural perspective, the different maturation of neural pathways and neural systems that underlie motor development between genders has been reported (De Bellis et al., 2001; Gidley Larson et al., 2007). Since males in comparison to females use distinct pathways that connect different brain areas, they may have a more efficient system for coordinated actions, where the cerebellum and cortex participate in bridging between perceptual experiences in the back of the brain (e.g. visual), and action, in the front of the brain (Ingalhalikar et al., 2014). Females, on the other hand, show stronger bilateral cortical activation (Lissek et al., 2007) and greater connectivity between the two hemispheres (Ingalhalikar et al., 2014), which may give them an advantage in multitasking assignments and bimanual coordination tasks.

Additionally, gender difference in interceptive visuomotor coordination associated with execution of catching or hitting a ball may be due to differing patterns of prism adaptation between males and females (Moreno-Briseño, Díaz, Campos-Romo, & Fernandez-Ruiz, 2010). Results from Moreno-Briseño et al. (2010) suggest a different contribution of strategic calibration and spatial alignment between genders may enhance males' performance in aiming tasks. It is also assumed that boys may lag behind girls in developing postural control (Nolan, Grigorenko, & Thorstensson, 2005). Furthermore, generally different body height between the genders could also be partially responsible for gender variance in balance. In the age period which is the focus of our study children have almost finished puberty during which the growth spurt is completed There is a consensus in the literature that increased body height worsens balance (Alonso et al., 2012; Hue et al., 2007).

Therefore, the purpose of the study was to examine whether performance in the different coordinative types of motor tasks involved in the MABC-2 – age band 3 (AB3) test may be affected by gender. We hypothesized that due to partially different motor skills development affected by some divergence in the neural mechanisms of motor coordination underlying the fine and gross motor skills and posture control, and differences in socially determined behaviour between genders, the MABC-2 test should provide different performance in the test tasks in adolescent boys and girls. As consequence, we predicted that some parts of the MABC-2 test might not be appropriate for both genders since the tests are based on unified tasks and scoring system.

## Methods

### Participants

One hundred and twenty-one adolescents (age = 16.0 ± 0.5 years) including 50 males (age = 16.1 ± 0.5 years) and 71 females (age = 15.9 ± 0.5 years) participated in the study. The participants were randomly recruited from five randomly selected Czech high schools. Informed consent was obtained from the parents via the schools' principals. Pedagogical and psychological anamneses of students were obtained from the school psychologists.

Participants who were physically and psychologically healthy and without general medical conditions or other neurological dysfunctions were included in the study. The study was approved by the Ethics Committee of the Faculty of Physical Culture, Palacký University Olomouc.

**Motor coordination assessment**

The MABC-2 test involves three age versions including age band 1 (AB1) for 3–6 year old children, age band 2 (AB2) for 7–10 year old children, and age band 3 (AB3) for 11–16 year old children (Henderson et al., 2007). Each age version of the test consists of eight motor tasks (test items) divided into three motor components: manual dexterity (MD; fine motor coordination) including unimanual, bimanual and graphomotor tasks, aiming and catching (AC), and balance (Bal) including static and dynamic balance tasks. Each participant performed the MABC-2 – AB3 test (Henderson et al., 2007). This test included the following tasks: Turning pegs (MD 1) executed with the preferred and non-preferred hand, Triangle with nuts and bolts (MD 2) and Drawing trail (MD 3) for assessment of the MD component, Catching with one hand (AC 1) including catching with the hand with best score and the other hand respectively, and Throwing a ball at a wall target (AC 2) for assessment of the AC component and Two-board balance (Bal 1), Walking toe-to-heel backwards (Bal 2) and Zig-zag hopping (Bal 3) including hopping on the leg with the best score and the other leg to assess the Bal component. Raw scores were used for statistical analyses.

The test was administered by six examiners who were certificated and experienced users of this method. Environmental conditions, administration and scoring of the test were completed according to the MABC-2 Examiner's manual (Henderson et al., 2007). The MD tasks were carried out in a classroom and the AC and Bal tasks in a school gym. All the participants were tested individually.

**Data analysis**

The Shapiro-Wilk test was used to analyse data distribution. Since distribution of the data was not normal, the Mann-Whitney *U* test was used for the statistical analysis of differences between the genders. The level of significance was set at $\alpha = .05$ for the statistical tests. According to Fritz, Morris, and Richler (2012), *r* was calculated as an effect size for the Mann-Whitney *U* test using the formula $r = z/\sqrt{N}$. The coefficient was then interpreted with suggested thresholds of .1, .3, and .5 for small, medium and large magnitudes, respectively. All the analyses were carried out using the statistical software IBM SPSS Statistics (Version 21; IBM, Armonk, NY, USA).

## Results

Tables 1, 2 and 3 show the descriptive characteristics of performance in the manual dexterity, aiming and

Table 1
*Descriptive characteristics of performance in the manual dexterity tasks*

| | *M* | *SD* | *Mdn* | IQR | *p* (S-W) | α | β | *p* (M-W) | *r* |
|---|---|---|---|---|---|---|---|---|---|
| MD 1 – preferred hand (s) | | | | | | | | | |
| Boys | 19.5 | 3.5 | 19 | 4 | **< .001** | 1.60 | 4.19 | **< .001** | .33 |
| Girls | 17.4 | 2.4 | 17 | 2 | **.005** | 0.72 | 0.71 | | |
| MD 1 – non-preferred hand (s) | | | | | | | | | |
| Boys | 22.0 | 4.2 | 22 | 5 | **.002** | 1.40 | 1.31 | .188 | .12 |
| Girls | 20.7 | 3.7 | 21 | 6 | **.028** | 0.40 | 0.26 | | |
| MD 2 (s) | | | | | | | | | |
| Boys | 35.2 | 9.9 | 33 | 13 | **.002** | 1.11 | 1.63 | .307 | .09 |
| Girls | 32.8 | 7.0 | 31 | 11 | **.005** | 0.78 | 0.97 | | |
| MD 3 (errors) | | | | | | | | | |
| Boys | 0.3 | 0.7 | 0 | 1 | **< .001** | 2.19 | 5.13 | **.001** | .29 |
| Girls | 0.1 | 0.2 | 0 | 0 | **< .001** | 3.93 | 13.85 | | |

*Note.* *M* = mean; *SD* = standard deviation; *Mdn* = median; IQR = interquartile range; *p* (S-W) = *p* value of Shapiro-Wilk test; α = coefficient of skewness; β = coefficient of kurtosis; *p* (M-W) = *p* value of Mann-Whitney *U* test; *r* = effect size. *P* values smaller than .05 are in boldface.

Table 2
*Descriptive characteristics of performance in the aiming and catching tasks*

| | *M* | *SD* | *Mdn* | IQR | *p* (S-W) | α | β | *p* (M-W) | *r* |
|---|---|---|---|---|---|---|---|---|---|
| AC 1 – best hand (catches) | | | | | | | | | |
| Boys | 9.4 | 1.3 | 10 | 1 | **< .001** | −2.36 | 5.40 | **.003** | .27 |
| Girls | 8.5 | 2.0 | 9 | 2 | **< .001** | −1.85 | 3.37 | | |
| AC 1 – other hand (catches) | | | | | | | | | |
| Boys | 8.5 | 1.8 | 9 | 2 | **< .001** | −1.32 | 1.10 | **< .001** | .33 |
| Girls | 7.1 | 2.4 | 8 | 3 | **< .001** | −0.86 | 0.04 | | |
| AC 2 (hits) | | | | | | | | | |
| Boys | 6.8 | 1.8 | 7 | 2 | **.016** | −0.30 | −0.31 | **.030** | .20 |
| Girls | 6.0 | 1.9 | 6 | 6 | .106 | −0.17 | 0.02 | | |

*Note.* *M* = mean; *SD* = standard deviation; *Mdn* = median; IQR = interquartile range; *p* (S-W) = *p* value of Shapiro-Wilk test; α = coefficient of skewness; β = coefficient of kurtosis; *p* (M-W) = *p* value of Mann-Whitney *U* test; *r* = effect size. *P* values smaller than .05 are in boldface.

Table 3
*Descriptive characteristics of performance in the balance tasks*

| | *M* | *SD* | *Mdn* | IQR | *p* (S-W) | α | β | *p* (M-W) | *r* |
|---|---|---|---|---|---|---|---|---|---|
| Bal 1 (s) | | | | | | | | | |
| Boys | 21.6 | 9.7 | 30 | 20 | **< .001** | −0.42 | −1.69 | **.011** | .23 |
| Girls | 26.0 | 7.5 | 30 | 5 | **< .001** | −1.70 | 1.55 | | |
| Bal 2 (s) | | | | | | | | | |
| Boys | 13.7 | 3.0 | 15 | 0 | **< .001** | −2.36 | 4.74 | .387 | .08 |
| Girls | 14.2 | 2.4 | 15 | 0 | **< .001** | −2.94 | 7.55 | | |
| Bal 3 – best leg (hops) | | | | | | | | | |
| Boys | 5.0 | 0.0 | 5 | 0 | – | – | 0.00 | > .99 | .08 |
| Girls | 5.0 | 0.1 | 5 | 0 | **< .001** | −8.43 | 71.00 | | |
| Bal 3 – other leg (hops) | | | | | | | | | |
| Boys | 5.0 | 0.3 | 5 | 0 | **< .001** | −7.07 | 50.00 | .403 | .09 |
| Girls | 4.9 | 0.2 | 5 | 0 | **< .001** | −8.43 | 13.85 | | |

*Note.* *M* = mean; *SD* = standard deviation; *Mdn* = median; IQR = interquartile range; *p* (S-W) = *p* value of Shapiro-Wilk test; α = coefficient of skewness; β = coefficient of kurtosis; *p* (M-W) = *p* value of Mann-Whitney *U* test; *r* = effect size. *P* values smaller than .05 are in boldface.

catching, and balance tasks, respectively. The girls outperformed the boys with statistical significance in the MD 1 task executed with their preferred hand ($p < .001$, $r = .33$) and in the graphomotor MD 3 task ($p = .001$, $r = .29$). On the other hand, the boys achieved significantly better results than the girls in all the AC tasks: AC 1 – best hand, AC 1 – other hand and AC 2 (Table 2). As regards the balance tasks, the girls' performance was not significantly different from that of the boys in dynamic balance tasks but the girls had a significantly longer duration of balance standing than the boys in Bal 1 task ($p = .011$, $r = .23$).

## Discussion

The purpose of the study was to examine whether performance in the different coordinative types of motor tasks involved in the MABC-2 – AB3 test may be affected by gender.

The current study showed that girls outperformed boys in unimanual coordination tasks with the preferred hand such as turning pegs (MD 1 task) and drawing trail (MD 3 task) with a rather moderate effect size. Activities requiring fine motor coordination (e.g. sewing, knitting) are generally perceived as girls' activities.

Girls spend more time on activities requiring fine motor coordination such as housework activities, meal preparation, personal care, cleaning, cutting, nail polishing and applying make-up (Mota et al., 2008; Wight, Price, Bianchi, & Hunt, 2009). Females were reported as better than males at visual perception of near stimuli which are steady or slow-moving (Abramov, Gordon, Feldman, & Chavarga, 2012). Such an advantage may enhance performance in manual dexterity tasks associated with hand-eye coordination. Therefore, the superior performance of females rather than males in fine motor coordination tasks could be explained by some differences in visual perception and practice of manual skills between genders.

However, the possible advantage for girls mentioned above has not been confirmed for the unimanual non-preferred hand performance and bimanual coordination performance. Because the turning peg item score (MD 1 task) is calculated as a mean of scores from the preferred and non-preferred hands, the gender effect on performance in this task may not be substantial. Therefore, with regard to the effect size of gender on MD 3 task performance that approached to the lower limit of the medium effect size, it seems that the manual dexterity component calculated as a sum of the three manual dexterity tasks could be affected by gender rather to a small extent only.

It seems that the aiming and catching component could be influenced by gender to some extent. Statistical significance was found in all three aiming and catching tasks. Specifically, the aiming and catching component could be potentially affected by gender to some extent due to the small and moderate effect sizes in AC tasks. Boys tend to participate in ball games more than girls (Badrić, Prskalo, & Matijević, 2015; Harrell et al., 2003), therefore their performance seems to be better in aiming and interceptive tasks. Research studies in the Czech Republic (Kudláček & Frömel, 2012; Vašíčková & Kalman, 2013) and in other countries (Badrić et al., 2015; Křen, Kudláček, Wąsowicz, Groffik, & Frömel, 2012) have shown that football (soccer), handball, basketball, floorball and tennis are the most popular sport activities for male adolescents. Additionally, due to the large number of testosterone receptors in the cerebral cortex and their highest density in the occipital lobe where the centre for primary visual processing is located, gender differences in visual perception may arise (Abramov et al., 2012). Abramov et al. (2012) also reported that males perceive fast-moving stimuli with greater sensitivity. Such findings may partially explain why adolescent boys are more successful in catching tasks because success in interceptive tasks is dependent on visual information on a moving object.

The girls also outperformed the boys in the static balance task (Bal 1) that requires standing on a balance board in the shape of a reverse letter "T". Olchowik et al. (2015) have explained that adolescent girls can use their ankle muscles more effectively than boys to control their balance. This could be due to the fact that girls wear shoes with high heels or shoes which reduce the surface area of the base support (Faraldo-García, Santos-Pérez, Crujeiras-Casais, Labella-Caballero, & Soto-Varela, 2012). Due to increased training of girls for maintaining body balance under conditions of reduced base support area a better ankle-joint stabilisation might be established in girls in comparison with boys (Faraldo-García et al., 2012). Besides, girls' most preferred sporting activities are dancing, roller skating and aerobic gymnastics (Badrić et al., 2015; Kudláček & Frömel, 2012). The greater involvement of girls in dancing lessons enhances their postural stability and balance ability (Cheng et al., 2011). Better multisensory input integration during postural control in girls may also partially explain differences in performance of static balance (Smith, Ulmer, & Wong, 2012). Yet, due to the small effect size of gender on performance in the Bal 1 task it is possible to expect that assessment of static balance by this task may be equally valid for both genders.

No gender differences have been found in the performance achieved in all the dynamic balance test tasks. Our finding is a little in contradiction to findings from younger children (Vedul-Kjelsås et al., 2013). This might be partly caused by the ceiling effect of the balance walk in the Bal 2 task and hopping in Bal 3 task that capture dynamic balance. Extreme skewness to the left and, concurrently, extreme peakedness of Bal 2 and Bal 3 scores in both genders, and, further, the results of descriptive statistics (see Table 3) indicate that almost all the participants from both genders achieved the maximum possible score of fifteen steps and five hops, respectively. These findings suggest that two dynamic balance tasks are probably too easy to complete for children of both genders. The assumption of a ceiling effect was supported by previous research (Borremans, Rintala, & McCubbin, 2009; Psotta, Hendl, Kokštejn, Jahodová, & Elfmark, 2014).

The second possible explanation for finding no significant difference in performance of boys and girls in both the dynamic balance tasks while performance in the static balance task was significantly different, could be based on a difference in motor control between static one-leg standing and balance walking and hopping. While one-leg standing is performed under the feedback control mechanism associated with on-going use of proprioceptive and vestibular information, execution of both dynamic balance actions is preferentially based on the feedforward control mechanism.

### Limitations

The current study was conducted in a specific country; hence, cross-cultural generalizability of the findings is limited. Because different cultural and socio-economic factors may influence motor patterns and outcome (Chow, Henderson, & Barnett, 2001; Chow, Yung-Wen, Henderson, Barnett, & Sing, 2006), further studies from different cultural regions are necessary to generalize the results of the study. Also future studies should consider development of gender differences from a long term perspective.

## Conclusion

This study brought evidence that a more probable risk of a significant gender factor in motor performance could be for the tasks associated with object control such as aiming and catching. Other domains such as manual dexterity and balance seem to be influenced by gender to a small extent.

## Acknowledgment

The study was supported by the internal grant of the Palacký University Olomouc (IGA_FTK_2015_001).

## Conflict of interest

There were no conflicts of interest.

## References

Abramov, I., Gordon, J., Feldman, O., & Chavarga, A. (2012). Sex & vision I: Spatio-temporal resolution. *Biology of Sex Differences, 3,* 20.

Alonso, A. C., Luna, N. M. S., Mochizuki, L., Barbieri, F., Santos, S., & Greve, J. M. D. A. (2012). The influence of anthropometric factors on postural balance: The relationship between body composition and posturographic measurements in young adults. *Clinics*, *67,* 1433–1441.

Badrić, M., Prskalo, I., & Matijević, M. (2015). Primary school pupils' free time activities. *Croatian Journal of Education – Hrvatski časopis za odgoj o obrazovanje, 17,* 299–319.

Barnett, A. L., Henderson, S. E., Scheib, B., & Schulz, J. (2011). Handwriting difficulties and their assessment in young adults with DCD: Extension of the DASH for 17 to 25 year olds. *Journal of Adult Development, 18*, 114–121.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2010). Gender differences in motor skill proficiency from childhood to adolescence: A longitudinal study. *Research Quarterly for Exercise and Sport, 81*, 162–170.

Borremans, E., Rintala, P., & McCubbin, J. A. (2009). Motor skills of young adults with Asperger syndrome: A comparative study. *European Journal of Adapted Physical Activity, 2,* 21–33.

Bruininks, R. H., & Bruininks, B. D. (2005). *Bruininks-Oseretsky Test of Motor Proficiency*. Minneapolis, MN: AGS Publishing.

Cheng, H. S., Law, C. L., Pan, H. F., Hsiao, Y. P., Hu, J. H., Chuang, F. K., & Huang, M. H. (2011). Preliminary results of dancing exercise on postural stability in adolescent females. *The Kaohsiung Journal of Medical Sciences, 27,* 566–572.

Chow, S. M. K., Henderson, S. E., & Barnett, A. L. (2001). The Movement Assessment Battery for Children: A comparison of 4-year-old to 6-year-old children from Hong Kong and the United States. *American Journal of Occupational Therapy, 55,* 55–61.

Chow, S. M. K., Yung-Wen, H., Henderson, S. E., Barnett, A. L., & Sing, K. L. (2006). The Movement ABC: A cross-cultural comparison of preschool children from Hong Kong, Taiwan, and the USA. *Adapted Physical Activity Quarterly, 23,* 31–48.

Davies, P. L., & Rose, J. D. (2000). Motor skills of typically developing adolescents: Awkwardness or improvement? *Physical & Occupational Therapy in Pediatrics, 20,* 19–42.

De Bellis, M. D., Keshavan, M. S., Beers, S. R., Hall, J., Frustaci, K., Masalehdan, A., ... Boring, A. M. (2001). Sex differences in brain maturation during childhood and adolescence. *Cerebral Cortex, 11,* 552–557.

Faraldo-García, A., Santos-Pérez, S., Crujeiras-Casais, R., Labella-Caballero, T., & Soto-Varela, A. (2012). Influence of age and gender in the sensory analysis of balance control. *European Archives of Oto-Rhino-Laryngology*, *269,* 673–677.

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General, 141,* 2.

Gidley Larson, J. C., Mostofsky, S. H., Goldberg, M. C., Cutting, L. E., Denckla, M. B., & Mahone, E. M. (2007). Effects of gender and age on motor exam in typically developing children. *Developmental Neuropsychology, 32,* 543–562.

Green, D., Lingam, R., Mattocks, C., Riddoch, C., Ness, A., & Emond, A. (2011). The risk of reduced physical activity in children with probable developmental coordination disorder: A prospective longitudinal study. *Research in Developmental Disabilities, 32,* 1332–1342.

Haapala, E. A. (2013). Cardiorespiratory fitness and motor skills in relation to cognition and academic performance in children: A review. *Journal of Human Kinetics, 36,* 55–68.

Harrell, J. S., Pearce, P. F., Markland, E. T., Wilson, K., Bradley, C. B., & McMurray, R. G. (2003). Assessing physical activity in adolescents: Common activities of children in 6th–8th grades. *Journal of the American Academy of Nurse Practitioners, 15,* 170–178.

Henderson, S. E., & Sugden, D. A. (1992). *Movement Assessment Battery for Children*. London, United Kingdom: Psychological Corporation.

Henderson, S. E., Sugden, D. A., & Barnett, A. L. (2007). *Movement Assessment Battery for Children – 2nd edition*. London, United Kingdom: Harcourt Assessment.

Hue, O., Simoneau, M., Marcotte, J., Berrigan, F., Doré, J., Marceau, P., ... Teasdale, N. (2007). Body weight is a strong predictor of postural stability. *Gait & Posture, 26,* 32–38.

Ingalhalikar, M., Smith, A., Parker, D., Satterthwaite, T. D., Elliott, M. A., Ruparel, K., ... Verma, R. (2014). Sex differences in the structural connectome of the human brain. *Proceedings of the National Academy of Sciences, 111,* 823–828.

Kauderer, S., & Randler, C. (2013). Differences in time use among chronotypes in adolescents. *Biological Rhythm Research, 44,* 601–608.

Křen, F., Kudláček, M., Wąsowicz, W., Groffik, D., & Frömel, K. (2012). Gender differences in preferences of individual and team sports in Polish adolescents. *Acta Universitatis Palackianae Olomucensis. Gymnica, 42*(1), 43–52.

Kudláček, M., & Frömel, K. (2012). *Sportovní preference a pohybová aktivita studentek a studentů středních* škol [Sport preferences and level of physical activity in high school students]. Olomouc, Czech Republic: Palacký University Olomouc.

Largo, R. H., Fischer, J. E., & Caflisch, J. A. (2002). *Zurich Neuromotor Assessment*. Zurich, Switzerland: AWE Verlag.

Lissek, S., Hausmann, M., Knossalla, F., Peters, S., Nicolas, V., Güntürkün, O., & Tegenthoff, M. (2007). Sex differences in cortical and subcortical recruitment during simple and complex motor control: An fMRI study. *Neuroimage, 37,* 912–926.

Livesey, D., Coleman, R., & Piek, J. (2007). Performance on the Movement Assessment Battery for Children by Australian 3- to 5-year-old children. *Child: Care, Health and Development, 33,* 713–719.

Lytton, H., & Romney, D. M. (1991). Parents' differential socialization of boys and girls: A meta-analysis. *Psychological Bulletin, 109,* 267–296.

Meyers-Levy, J., & Loken, B. (2015). Revisiting gender differences: What we know and what lies ahead. *Journal of Consumer Psychology, 25,* 129–149.

Moreno-Briseño, P., Díaz, R., Campos-Romo, A., & Fernandez-Ruiz, J. (2010). Sex-related differences in motor learning and performance. *Behavioral & Brain Functions, 6,* 74–77.

Mota, J., Santos, M. P., & Ribeiro, J. C. (2008). Differences in leisure-time activities according to level of physical activity in adolescents. *Journal of Physical Activity & Health, 5,* 286–293.

Nolan, L., Grigorenko, A., & Thorstensson, A. (2005). Balance control: Sex and age differences in 9 to 16 year olds. *Developmental Medicine & Child Neurology, 47,* 449–454.

Olchowik, G., Tomaszewski, M., Olejarz, P., Warchoł, J., Różańska-Boczula, M., & Maciejewski, R. (2015). The human balance system and gender. *Acta of Bioengineering & Biomechanics, 17,* 69–74.

Psotta, R., & Hendl, J. (2012). Movement Assessment Battery for Children – second edition: Cross-cultural comparison between 11–15 year old children from the Czech Republic and the United Kingdom. *Acta Universitatis Palackianae Olomucensis. Gymnica, 42*(3), 7–16.

Psotta, R., Hendl, J., Frömel, K., & Lehnert, M. (2012). The second version of the Movement Assessment Battery for Children: A comparative study in 7–10 year old children from the Czech Republic and the United Kingdom. *Acta Universitatis Palackianae Olomucensis. Gymnica, 42*(4), 19–27.

Psotta, R., Hendl, J., Kokštejn, J., Jahodová, G., & Elfmark, M. (2014). Development of the motor functions in 7–15 year old children: The Czech national study. *Acta Universitatis Carolinae: Kinanthropologica, 50*(2), 87–97.

Ruiz, L. M., & Gutierrez, M. (2003). The assessment of motor coordination in children with the Movement ABC test: A comparative study among Japan, USA and Spain. *International Journal of Applied Sports Sciences, 15,* 22–35.

Sigmundsson, H., & Rostoft, M. S. (2003). Motor development: Exploring the motor competence of 4-year-old Norwegian children. *Scandinavian Journal of Educational Research, 47,* 451–459.

Smith, A., Ulmer, F., & Wong, D. (2012). Gender differences in postural stability among children. *Journal of Human Kinetics, 33*, 25–32.

Smits-Engelsman, B., Schoemaker, M., Delabastita, T., Hoskens, J., & Geuze, R. (2015). Diagnostic criteria for DCD: Past and future. *Human Movement Science, 42,* 293–306.

Vašíčková, J., & Kalman, M. (2013). *Zdraví a* životní *styl dětí a* školáků [Health and life style of children and pupils]. Olomouc, Czech Republic: Palacký University Olomouc.

Vedul-Kjelsås, V., Stensdotter, A. K., & Sigmundsson, H. (2013). Motor competence in 11-year-old boys and girls. *Scandinavian Journal of Educational Research, 57,* 561–570.

Viel, S., Vaugoyeau, M., & Assaiante, C. (2009). Adolescence: A transient period of proprioceptive neglect in sensory integration of postural control. *Motor Control, 13,* 25–42.

Wicks, L. J., Telford, R. M., Cunningham, R. B., Semple, S. J., & Telford, R. D. (2015). Longitudinal patterns of change in eye–hand coordination in children aged 8–16 years. *Human Movement Science, 43,* 61–66.

Wight, V. R., Price, J., Bianchi, S. M., & Hunt, B. R. (2009). The time use of teenagers. *Social Science Research, 38,* 792–809.