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ORIGINAL ARTICLE

# The role of physical activity and body-related perceptions in motor skill competence of adolescents with autism spectrum disorder

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**ABSTRACT**

**Purpose:** This study assessed the associations of motor skill competence with physical activity and physical self-perception of adolescents with autism spectrum disorder (ASD).
**Study design:** Cross-sectional study.
**Methods:** A total of 63 male adolescents, aged 12–18 years, with ASD participated in the study. The Bruininks–Oseretsky Test of Motor Proficiency-Second Edition and the Chinese version of the Physical Self-Perception Profile were administered. Physical activity was assessed using a uniaxial accelerometer.
**Results:** The main findings were that (a) both moderate-to-vigorous physical activity and self-perceived physical condition were positively related to manual coordination (MC) and strength and agility (SA); (b) moderate-to-vigorous physical activity was the only predictor of MC and accounted for 14% of the variance; and (c) perceived physical condition explained 16% of the variance in SA, and moderate-to-vigorous physical activity and perceived physical condition together accounted for 26% of the SA.
**Conclusion:** Future interventions aimed at improving motor skill competence in adolescents with ASD should focus on improving the time spent on moderate-to-vigorous physical activity and developing a positive perceived physical condition.

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Adolescents; autism spectrum disorder; motor skill competence; physical activity; physical self-perception

➤ **IMPLICATIONS FOR REHABILITATION**

- Less than half of the participants with ASD accumulated at least 60 min of daily moderate-to-vigorous physical activity.
- Of the participants with ASD, only 19% had clinical levels of total motor impairments.
- Activities that promote successful moderate-to-vigorous physical activity and support positive physical self-perception (i.e., physical condition) are most likely to develop motor skill competency in adolescents with ASD.

## Introduction

Autism spectrum disorder (ASD) is an inclusive term for a group of neurodevelopmental disorders characterized by pervasive barriers in social interaction and communication, with repetitive and stereotyped patterns of behaviors and interests [1]. Given the defining symptoms of ASD, it is not surprising that individuals with this condition face a number of challenges throughout childhood and adolescence, beyond those experienced by their typically developing (TD) peers. These challenges include difficulty in demonstrating appropriate communication among peers, achieving relative flexibility in day-to-day activities, reaching behavioral and emotional maturity, developing age-appropriate peer relationships, and successfully interpreting and navigating the social world around them [2–4]. In addition to the core symptoms of ASD, individuals with the disorder often experience delayed or impaired motor development [5,6]. The confluence of difficulties with social, behavioral, and motor skills has the potential to influence long-term mental, physiological, and psychological health problems negatively. The social, physical, and mental health issues that many youths with ASD are already exposed to could be further compromised by the additional health condition of obesity and obesity-related secondary conditions, such as high blood pressure, diabetes, depression, and low self-esteem in adolescents with ASD [7]. Ample literature describes the variability of the impact of ASD on social and behavioral skills; yet, information about how ASD is expressed in motor skill competence is lacking. Motor skill competence is mastery of physical skills and movement patterns that enable enjoyable participation in physical activities [8]. Motor skill competence is necessary for engaging in physical activity and sports related to the development of a healthy lifestyle (e.g., changes in children physical activity and cardiorespiratory fitness); conversely, engaging in physical activity and sports leads to improvements in motor skill competence. Considering the lifelong health and economic implications associated with ASD a growing public issue, and understanding the factors that contribute to motor skill competence in adolescents with ASD is critical for developing strategies to improve the health of this population.

Motor skill impairments are common among individuals with ASD [6,9–15]. The substantial delayed or impaired motor skill development experienced by elementary school-age children with

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ASD [5] and the persistence of motor skill-related difficulties during adolescence [13,15] indicate the need to identify the determinants of motor skill competence in individuals with ASD. Physical activity has been identified as a crucial correlate of motor skill competence in TD children and adolescents [16,17] and in those with disabilities [18,19]; however, it is unclear whether such a correlation exists in individuals with ASD. Several studies have characterized physical activity in adolescents with ASD by using accelerometry, revealing that adolescents with ASD were less physically active compared with TD adolescents [20,21], and physical activity decreased with an increase in age [22,23]. Individuals with ASD who have poor motor skill competence may engage less in physical activity. Conversely, individuals with ASD who are physically active may develop high level of motor skill competence. As physical activity is a potentially modifiable lifestyle behavior, the nature of the relationship between physical activity and motor skill competence in adolescents with ASD must be ascertained; to the best of our knowledge, no research has been published on this association in this particular population.

Physical self-perception is another critical correlate of motor skill competence in children and adolescents. It refers to an individual's perception of his or her abilities and physical appearance, and is recognized as a health indicator, particularly during adolescence [24]. Having a positive physical self-perception is essential for proper personal and social development, given that physical self-perception has been identified as a key contributor to global self-esteem [25,26]. It has also proven to be positively linked to healthy lifestyle habits (i.e., high level of physical activity, intention to be physically active, and life satisfaction) in adolescents [27]. The relationship between motor skill competence and physical self-perception can be explained by Harter's competence motivation theory, a theory of achievement motivation based on a person's feelings of personal competence [28]. According to the theory, competence motivation increases when a person successfully masters a task, suggesting that individuals who perceive themselves as physically competent tend to exert greater effort in motor skills and mastery attempts than those who have poor self-perceived physical competence. Yu et al. [29] assessed the relationships between movement skills (i.e., locomotor and object control skills), self-report physical activity, and a select number of physical self-concept (i.e., health, coordination, sporting ability, strength, fitness, and self-esteem) in children with and without developmental coordination disorder aged 7–10 years, and observed that coordination was the only significant predictor of physical self-concept for object control skills. No chosen variables of physical self-concept were found to be significant predictors for locomotor skills. Self-report physical activity was not related to both locomotor and object control skills. The authors [29] suggest that physical self-concept of children with disabilities should be considered in attempting to understand the mechanisms that lead to movement-related behaviors.

The recognition of physical self-perception in people with ASD has not been reported so far. Although not specific to physical self-perception, research has indicated that students with ASD who undergo inclusion education realize their social inabilities, which leads to a decrease in self-concept [30]. Jamison and Schuttler [31] found that adolescents with ASD aged 14–19 years perceived themselves as having lower social competence and global self-esteem compared with their TD peers. Another study determined that students with ASD aged 7–13 years had increased awareness of their own social deficiencies; moreover, low self-perceived social competence was a significant predictor of high levels of depressive symptomatology [30]. Because the subdomains of physical self-perception (e.g., body attractiveness, physical condition, physical strength, and sports competence) collectively contribute to a person's physical self-worth, which in turn influences global self-esteem [25], the physical self-perception subdomains and physical self-worth in individuals with ASD should be evaluated. We believe that the identification of a relationship between motor skill competence and physical self-perception profiles in individuals with ASD would indicate the need for changes that might provide these individuals with adequate perceived competence in physical activity participation.

The aim of the current study was to determine the associations and predictors of motor skill competence with physical activity and physical self-perception in adolescents with ASD. We hypothesized that motor skill competence would be positively associated with physical activity and physical self-perception.

## Methods

### *Participants*

Adolescents with ASD ($n = 63$), aged 12–18 years, were recruited for this study. The recruitment was carried out through the dissemination of study flyers, autism-based programs, local schools, and word of mouth. To be included in this group, all participants with ASD were required to receive a diagnosis of ASD according to the Diagnostic and Statistical Manual of Mental Disorders criteria [1] from a pediatric psychiatrist or a hospital physician [32]. The diagnoses included Asperger's syndrome ($n = 20$) and mild autistic disorders ($n = 43$). The level of severity (mild, moderate, severe, and very severe) was based on social-adaptive functioning in skill areas and in language comprehension and expression [33]. The diagnosis of each mild autistic disorder was identified on the participant's disability card issued by the local government. Based on the diagnosis statement from the psychiatrist or the physician, none of the participants was identified to have a co-occurring intellectual disability, and none exhibited orthopedic dysfunction that could interfere with their physical movements. Furthermore, none had a history of treatment with psychotropic medications (e.g., antidepressants, medications used to treat attention deficit hyperactivity disorder, antianxiety medications, and mood stabilizers) that can alter activity.

In addition to the formal diagnosis made by the psychiatrist or physician, parent ratings were collected and confirmed through parental reports using the traditional Mandarin Chinese versions of the Autism Behavior Checklist [34] and the Autism/Asperger Behavior Rating Scale [35] to screen for autism and Asperger behaviors. All participants with ASD were usually assigned to the resource room (i.e., a classroom where the participants were given direct, specialized instructions and academic remediation, individually or in groups) on a regular basis while continuing their other studies in regular classes during most of each school day. They attended inclusive schools from the first grade, and typically lived at home.

The participants were divided according to age groups. These age groups were divided for the educational context (i.e., junior high and senior high school level) and sampling convenience to obtain proper descriptive results. Age group 1 included age group ranging from 12:0–13:11 (year:month), age group 2 included 14:0–15:11 (year:month), and age group 3 included 16:0–18:11 (year:month).

### Measures

#### Motor skill competence

The complete form of Bruininks–Oseretsky Test of Motor Proficiency–Second Edition (BOT-2) [36] was used to assess participant's motor skill competence. The BOT-2 is an individually administered test that uses engaging, goal-directed activities to measure a wide array of motor skills in individuals aged 4–21 years. The test consists of four motor-area composites, namely *fine manual control (FMC), manual coordination (MC), body coordination (BC),* and *strength and agility (SA)*; each composite comprises two subscales with 5–9 items. The eight subscales are *fine motor precision* (e.g., filling in shapes, cutting out a circle)*, fine motor integration* (e.g., copying a circle, copying a square)*, manual dexterity* (e.g., stringing blocks, sorting cards)*, upper–limb coordination* (e.g., dropping and catching a ball, throwing a ball at a target)*, bilateral coordination* (e.g., jumping in place–same sides synchronized, jumping in place–opposite sides synchronized)*, balance* (e.g., walking forward on a line, standing on one leg on a balance beam–eyes closed)*, running speed and agility* (e.g., shuttle run, stepping sideways over a balance beam), and *strength* (e.g., standing long jump, knee push-ups). The four composite scores were added together to generate a total motor composite (TMC) score (53 items, 8 subtests, and 4 four motor-area composites; score range =0–320 points). Participants were assessed for these tasks and these raw scores were converted to a numerical point score. Total point score was converted to obtain scale score, standard score, percentile rank, and descriptive category. The average age-adjusted scale score for the subtests was $15 \pm 5$, whereas composites that were derived by summing the subtest scale scores and converting them to a quotient had a mean of $100 \pm 15$. Only MC, BC, and SA standard scores were used for the data analysis in the current study because these 3 motor tasks were relevant to physical activity participation.

The BOT-2 is one of the most widely used performance-based measures and has demonstrated validity (i.e., content validity, construct validity, and criterion validity) and reliability (i.e., internal consistency, test–retest reliability, and interrater reliability) for the evaluation of children, adolescents, and young adults with developmental coordination disorders and intellectual disabilities [36]. Internal consistency, test–retest reliability, and interrater reliability are moderate to strong (>0.80), whereas content validity, internal structure, and relationships with other measures of motor performance are strong [36]. The BOT-2 has been used with individuals with ASD [37–39].

#### Physical activity

All participants wore a uniaxial GT1M Actigraph accelerometer (Pensacola, FL) on a belt at their right iliac crest during waking hours, with the acceleration recorded in 10-s epochs. To be included in the analyses, the participants were required to wear the accelerometer for a minimum of 10 h on at least 5 days, including one weekend day. The age-specific count thresholds in 1-min epochs corresponding to those at moderate-to-vigorous physical activity levels (≥3 metabolic equivalents) in children and adolescents were used [40]. Thus, the appropriate age-specific count cutoffs were divided by 6 to accommodate the 10-s epoch length. The age-specific count cutoffs for physical activity at an intensity of moderate-to-vigorous physical activity value ranged from ≥211 counts per minute (CPM) for 12-year-olds to ≥379 counts per minute for 18-year-olds. All the school programs were comparable in duration. Because of the differences in the daily total monitoring length (i.e., wearing time), the relative (percentage) durations spent engaging in daily total physical activity (measured in counts per minute) and in percentage of time spent in moderate-to-vigorous physical activity were calculated and used in the subsequent analyses. The counts per minute was calculated by summing the counts for all weekdays and weekend days separately and dividing the sums by the total monitoring time in minutes. Percentage of time spent in moderate-to-vigorous physical activity was calculated by summing the minutes of moderate-to-vigorous physical activity for all weekdays and weekend days separately and dividing the sums by the total monitoring time in minutes.

#### Physical self-perception

The Chinese version of the Physical Self-Perception Profile [26], originally developed by Fox and Corbin [25], was used to measure physical self-perception in the current study. It consists of five 6-item scales that measure perceptions of *physical self-worth* (example item statement: 'Some kids are very satisfied with themselves physically, but other kids are often dissatisfied with themselves physically'), *sports competence* (e.g., 'Some kids feel that they do very well at all kinds of sports, but other kids do not feel that they are very good when it comes to sports'), *physical condition* (e.g., 'Some kids don't feel that they are physically fit, but other kids feel that they have excellent fitness'), *physical strength* (e.g., 'Some kids feel that their muscles are stronger than other kids their age, but other kids feel that they lack strong muscles as compared to others their age'), and *body attractiveness* (e.g., 'Some kids think that having a body that looks in good physical shape is difficult, but other kids think that having a body that looks in good physical shape is easy'). In addition, six items are included to measure *global self-esteem* (e.g., 'Some kids are very satisfied with themselves in every aspect, but other kids are very dissatisfied with themselves at all points'). The instrument uses a 4-point, paired forced-alternative response format [41]. Respondents must first decide which side of the statement pertains to them and then decide whether the side they have chosen is 'really true for me' or 'sort of true for me.' Half of the items were reverse scaled. This format was used because it is proposed to control for social desirability effects [41] and has been reported to control for the reference group effect often reported in cross-cultural studies [42]. The Chinese version of the Physical Self-Perception Profile has been used in Chinese children and adolescents with [29] and without developmental coordination disorder [26,43] and has demonstrated good reliability with subscales having Cronbach's alpha values ranging from 0.62 to 0.92 [29,43]. In the present study, the internal consistency for the subscales ranged between 0.50 and 0.80.

### Procedures

Following approval from the university ethics board, the primary researcher met with the parents and adolescents to describe the study and distribute consent forms. Parental consent and student assent were obtained for all the participants. Heights and weights were measured in a private setting in which participants wore light clothing and no shoes. Body mass index was determined by dividing the body mass in kilograms by the stature in meters squared ($kg/m^2$).

All the tests were conducted on weekend days. First, the Chinese version of the Physical Self-Perception Profile was completed in the classroom immediately before the BOT-2 test. Before the start of the session, the administrator explained carefully how the questionnaire was to be completed, read each statement twice, and then allowed the participant sufficient time to answer each question. The participants were allowed to ask questions if they were unable to understand any part of the questionnaire. The participants were also provided specific or concrete examples if they have difficulty with self-other representation or generalization of their physical activity/sport participation. Next, the participants were administered the BOT-2 in a quiet and isolated gymnasium at the primary researcher's university. Before on the participants started the test, every item was explained and demonstrated according to the BOT-2 manual. The participants were tested individually, and the tests were organized such that the participants were unable to compare their performance with each other. The tests were conducted by trained research assistants, and all participants completed the tasks. Finally, prior to the physical activity measurement, the participants were instructed to attach the accelerometer at the right-hand side of the waist, removing it only during showering, bathing, swimming, and sleeping, and reattaching it each morning upon awakening and dressing. They were also instructed to maintain normal levels of physical activity and not to tamper with the accelerometer during the monitoring period. The participants were provided a simple log to record the times when they put on the Actigraph each morning and removed it in the evening. They were also instructed to wear the accelerometer for no less than 10 h a day for 7 consecutive days, except during activities in water. To ensure data completeness and quality, a research assistant collected the accelerometer prior to the participants' bedtime every 2–3 days during the monitored days and provided them with another initialized accelerometer for the following days (i.e., a behavioral technique to ensure that the participants were wearing the monitor). Data were immediately downloaded and examined; data sheets were reviewed, and missing and odd values were queried the next day.

### *Statistical analysis*

The means and standard deviations are provided for all variables. One-way analyses of variance were performed to evaluate the statistical significance of age-group differences in motor skill competence, physical activity, and physical self-perception. Tukey's post-hoc tests were undertaken if significant age-group differences were observed. Partial correlations with control for age and body mass index were computed to assess the associations of motor skill competence with physical activity and physical self-perception measures for the whole sample. The correlations were graded on the following scale according to a previously described method [44]: (a) 0 to 0.25 = little; (b) 0.26 to 0.49 = low; (c) 0.50 to 0.69 = moderate; (d) 0.70 to 0.89 = high; and (e) 0.90 to 1 = very high. Stepwise multiple regression was used to predict the variance in the chosen variables of physical activity and physical self-perception. Only variables that were significantly associated with motor skill competence were entered into the regression models. The chosen physical activity and physical self-perception variables were included in the multiple regression analysis to compare their strength in predicting motor skill competence. The dependent variables were MC, BC, and SA. Preliminary analyses were performed to ensure that no violations in the assumptions of normality, linearity, multicollinearity, and homoscedasticity were present. All statistical analyses were performed using SPSS software (version 18.0; SPSS Inc, Chicago, IL), and the probability level was set at $p < 0.01$ for all tests.

## Results

All the participants completed the study. No significant differences in weight (age group 1 vs. age group 2 vs. age group 3: $57.57 \pm 11.87$ vs. $64.47 \pm 9.59$ vs. $63.91 \pm 19.03$; $F = 1.96$; $p = 0.15$) and body mass index (age group 1 vs. age group 2 vs. age group 3: $22.05 \pm 5.92$ vs. $22.35 \pm 3.38$ vs. $21.81 \pm 4.88$; $F = 0.06$; $p = 0.94$) were observed by age-group. A significant group effect in age was revealed with the age group 1 having a significantly younger age than the age group 2 and age group 3; and with the age group 2 having a significantly younger age than the age group 3 ($p < 0.01$).

### *Motor skill competence*

Descriptive statistics for the motor skill competence as measured by the BOT-2 is presented in Table 1. No significant age-group differences on all four composite scores and the total motor composite.

In addition to the standard scores on the four motor-area composites and the total motor composite showed in Table 1, Figure 1 presents the five descriptive categories with their corresponding standard scores. *Average* category corresponding to the range from 1 standard deviation below the mean to 1 standard deviation above. *Above Average* corresponds to scores 1–2 standard deviations above the mean, and so on. The BOT-2 standard scores range from 20 to 80, and have a mean score of 50 and a standard deviation of 10. Of our participants with ASD, 8% had a mean FMC composite score that was equal to or more than 2 standard deviations below the standard mean. According to the BOT-2 performance descriptors, five males with ASD would be placed in the *Well-Below Average* category of performance (Figure 1(a)). Nineteen percent of the participants with ASD had a mean MC composite scores that placed 12 males with ASD in the *Well-Below Average* category of performance (Figure 1(b)), and so did the BC composite scores (Figure 1(c)). Thirteen percent of the participants with ASD had a mean SA composite scores that placed eight males with ASD in the *Well-Below Average* category of performance (Figure 1(d)). Figure 1(e) shows that 19% of the participants with ASD had a mean total motor composite score that placed 12 males with ASD in the *Well-Below Average* category of performance (Figure 1(e)). Overall, age 12 and 13 years showed the highest prevalence of developmental coordination disorder ($n = 5$) followed by age 16–18 years ($n = 4$) and age 14 and 15 years ($n = 3$).

**Table 1.** Composite and total motor composite standard score by age group.

| | | FMC | | MC | | BC | | SA | | TMC | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age group (year:month) | *N* | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum |
| 1(12:0–13:11) | 23 | 44.48 ± 8.65 | 26.00–58.00 | 41.52 ± 9.78 | 27.00–63.00 | 43.26 ± 10.48 | 25.00–60.00 | 41.78 ± 8.94 | 26.00–56.00 | 40.78 ± 9.52 | 26.00–61.00 |
| 2(14:0–15:11) | 26 | 42.88 ± 7.05 | 30.00–54.00 | 41.50 ± 10.59 | 30.00–80.00 | 45.58 ± 11.13 | 27.00–66.00 | 42.00 ± 10.41 | 29.00–66.00 | 41.04 ± 9.48 | 27.00–65.00 |
| 3(16:0–18:11) | 14 | 39.14 ± 7.07 | 27.00–51.00 | 36.29 ± 9.24 | 26.00–58.00 | 35.71 ± 8.24 | 26.00–52.00 | 34.86 ± 7.05 | 25.00–50.00 | 34.50 ± 6.71 | 24.00–50.00 |
| Total | 63 | 42.63 ± 7.82 | 26.00–58.00 | 40.35 ± 10.09 | 26.00–80.00 | 42.54 ± 10.85 | 25.00–66.00 | 40.33 ± 9.55 | 25.00–66.00 | 39.49 ± 9.22 | 24.00–65.00 |

FMC: fine manual control; MC: manual coordination; BC: body coordination; SA: strength and agility; TMC: total motor composite.

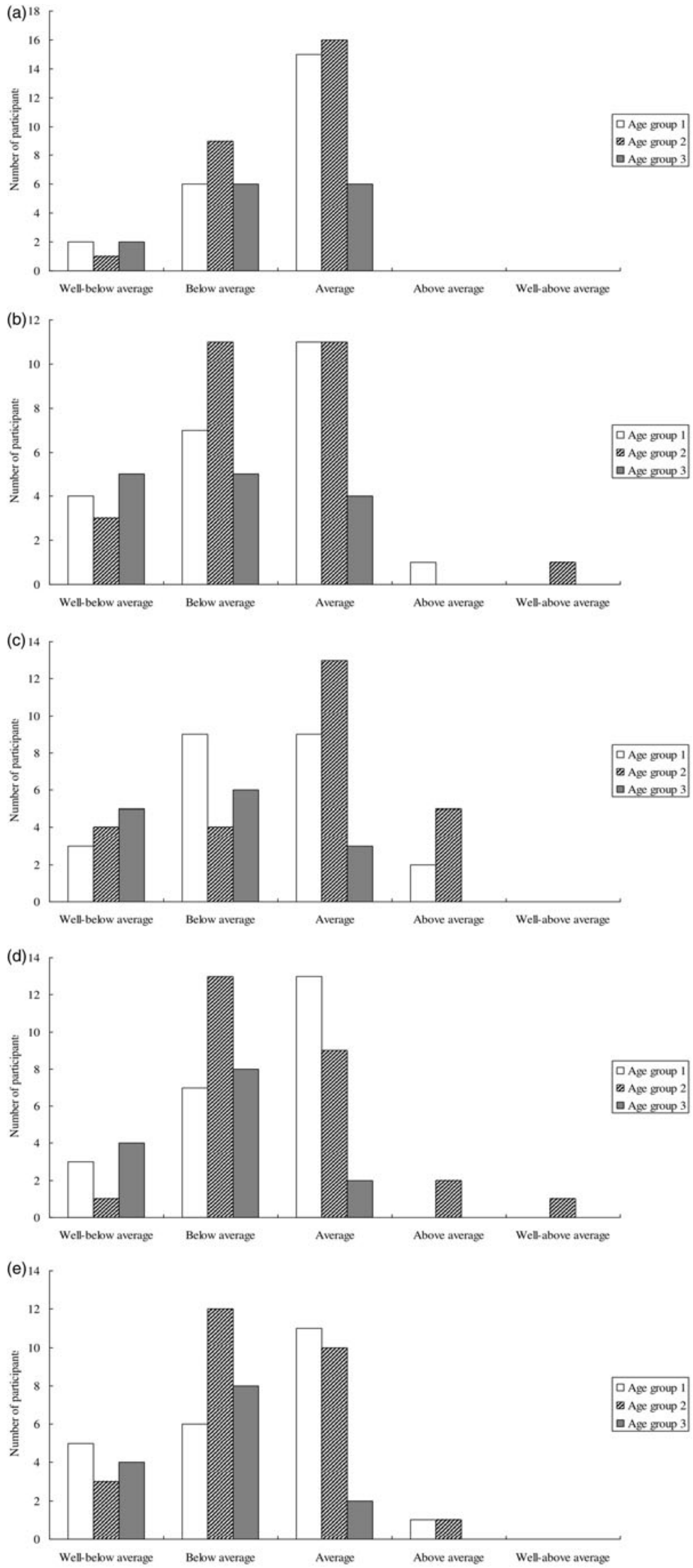


**Figure 1.** Descriptive category for the subtests by age group (percentile rank range 2 or less = well-below average; 3–17 = below average; 18–83 = average; 84–97 = above average; 98 or greater = well-above average). (a) fine manual control subtest, (b) manual coordination subtest, (c) body coordination subtest, (d) strength and agility subtest, and (e) total motor composite.

Table 2. Physical activity measures of participants.

| Age group (year:month) | n | MVPA (min/day) | | CPM | | MVPA% | | Daily 60 min MVPA (n, %) | |
|---|---|---|---|---|---|---|---|---|---|
| | | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | Yes | No |
| 1(12:0–13:11) | 23 | 94.45 ± 56.94 | 34.38–231.59 | 355.26 ± 102.54 | 195.59–538.76 | 10.37 ± 5.72 | 4.15 ± 24.01 | 15, 65.22% | 8, 34.78% |
| 2(14:0–15:11) | 26 | 51.83 ± 18.16 | 19.82–87.12 | 337.29 ± 120.13 | 180.66–603.88 | 8.22 ± 5.87 | 2.19–29.09 | 10, 38.46% | 16, 61.54% |
| 3(16:0–18:11) | 14 | 41.74 ± 19.63 | 14.36–80.12 | 313.71 ± 135.24 | 188.70–629.05 | 5.41 ± 2.25 | 2.17–10.54 | 3, 21.43% | 11, 78.57% |
| Total | 63 | 65.15 ± 43.37 | 14.36–231.59 | 337.88 ± 116.64 | 180.66–629.05 | 8.38 ± 5.48 | 2.17–29.09 | 28, 44.44% | 35, 55.56% |

MVPA: moderate-to-vigorous physical activity; CPM: daily average counts per minute; MVPA%: daily average percentage of time spent in moderate-to-vigorous physical activity.

Table 3. Physical self-perception measures of participants.

| | Age group 1 (12:0–13:11), $n = 23$ | | Age group 2 (14:0–15:11), $n = 26$ | | Age group 3 (16:0–18:11), $n = 14$ | | Total, $N = 63$ | |
|---|---|---|---|---|---|---|---|---|
| | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum | M ± SD | Minimum–maximum |
| Attractive body | 15.52 ± 4.37 | 6.00–24.00 | 15.85 ± 3.40 | 9.00–21.00 | 13.86 ± 2.38 | 9.00–17.00 | 15.29 ± 3.64 | 6.00–24.00 |
| Physical strength | 14.57 ± 3.99 | 6.00–21.00 | 14.12 ± 3.59 | 7.00–22.00 | 13.71 ± 2.97 | 10.00–22.00 | 14.19 ± 3.58 | 6.00–22.00 |
| Physical condition | 12.74 ± 3.77 | 6.00–19.00 | 13.42 ± 4.40 | 6.00–23.00 | 13.00 ± 3.46 | 8.00–19.00 | 13.08 ± 3.93 | 6.00–23.00 |
| Sports competence | 15.39 ± 3.80 | 9.00–23.00 | 14.92 ± 3.94 | 8.00–21.00 | 13.93 ± 3.87 | 8.00–21.00 | 14.87 ± 3.85 | 6.00–23.00 |
| Physical self-worth | 17.83 ± 4.41 | 6.00–24.00 | 16.54 ± 3.49 | 11.00–23.00 | 15.71 ± 2.33 | 12.00–19.00 | 16.83 ± 3.69 | 6.00–24.00 |
| Global self-esteem | 17.17 ± 4.01 | 6.00–24.00 | 16.73 ± 2.74 | 12.00–23.00 | 17.29 ± 2.20 | 12.00–21.00 | 17.02 ± 3.13 | 6.00–24.00 |

Table 4. Partial correlation coefficients between motor skill competence, physical activity, and physical self-perception measures in adolescents with autism spectrum disorder ($n = 63$).

| | Manual coordination | Body coordination | Strength and agility |
|---|---|---|---|
| Physical activity | | | |
| CPM | −0.02 | 0.10 | −0.11 |
| MVPA% | 0.38** | 0.14 | 0.34** |
| Physical self-perception | | | |
| Attractive body | 0.05 | −0.08 | 0.01 |
| Physical strength | 0.17 | 0.11 | 0.16 |
| Physical condition | 0.27 | 0.24 | 0.43** |
| Sports competence | 0.11 | 0.09 | 0.36** |
| Physical self-worth | −0.02 | −0.15 | −0.09 |
| Global self-esteem | −0.01 | −0.09 | −0.06 |

CPM: daily average counts per minute; MVPA%: daily average percentage of time spent in moderate-to-vigorous physical activity; after controlling age and body mass index; the correlation is graded as: (a) 0 to 0.25 = little; (b) 0.26 to 0.49 = low; (c) 0.50 to 0.69 = moderate; (d) 0.70 to 0.89 = high; and (e) 0.90 to 1 = very high [44]; level of significance $^{*}p < 0.05$, $^{**}p < 0.01$.

### Physical activity

Descriptive statistics for the physical activity is presented in Table 2. All 63 participants in the current study provided at least 4 weekdays and 1 weekend day of at least 10 h of recorded physical activity per day. Daily total monitored length for the whole sample was 782.61 ± 83.04 (min/day), ranged between 615.60 and 941.00 min/day. We observed that 44% of participants with ASD accumulated at least 60 min of daily moderate-to-vigorous physical activity.

Results revealed a significant age-group effect in daily accumulated minutes of moderate-to-vigorous physical activity with the age group 1 having significantly higher minutes than both the age group 2 and age group 3 ($F = 11.36$, $p < 0.01$). There were no age-group differences in daily average total monitored length, counts per minute, and percentage of time spent in moderate-to-vigorous physical activity.

### Physical self-perception profile

Descriptive statistics for the physical self-perception profile is presented in Table 3. No significant statistics were evident for the variables by age group.

Table 5. Stepwise multiple regression analysis results for adolescents with autism spectrum disorder ($n = 63$).

| | MVPA%, β | Physical condition, β | Sports competence, β |
|---|---|---|---|
| Manual coordination | 0.37** | – | – |
| Model 1: $R = 0.37$; $R^2 = 0.14$; $\Delta R^2 = 0.13$, $F_{(1, 61)} = 9.92$, $p < 0.01$ | | | |
| Strength and agility | 0.32** | 0.39** | – |
| Model 1: $R = 0.39$; $R^2 = 0.16$; $\Delta R^2 = 0.14$, $F_{(1, 61)} = 11.24$, $p < 0.01^{a}$ | | | |
| Model 2: $R = 0.51$; $R^2 = 0.26$; $\Delta R^2 = 0.23$, $F_{(2, 60)} = 10.32$, $p < 0.01$ | | | |

Stepwise criteria: probability-of-F-to enter ≦ 0.05, probability-of-F-to remove ≧ 0.10.
MVPA% = daily average percentage of time spent in moderate-to-vigorous physical activity.
[a]Predictor: physical condition.
$^{**}p < 0.01$

### Associations and predictors of motor skill competence

Table 4 shows the correlation coefficients between all variables for all the adolescents with ASD. Percentage of time spent in moderate-to-vigorous physical activity was positively correlated with MC and SA. In addition, perceived physical condition and sports competence were positively correlated with SA, respectively.

Stepwise multiple regression analysis indicated that percentage of time spent in moderate-to-vigorous physical activity was positively correlated with MC and SA (Table 5). Perceived physical condition was positively correlated with SA. Both percentage of time spent in moderate-to-vigorous physical activity and perceived physical condition were predictors of SA. Perceived physical condition explained 16% of the variance in SA. Percentage of time spent in moderate-to-vigorous physical activity and perceived physical condition together accounted for 26% of the SA. Percentage of time spent in moderate-to-vigorous physical activity was the only significant predictor of MC and explained 14% of the variance. Perceived sports competence was not a predictor of any measured variables.

## Discussion

Motor abnormalities and impairments in motor skill competence of adolescents with ASD have been noted in our findings, and are consistent with those of previous studies where adolescents with ASD exhibited inferior motor skill performance [6,9–15]. A specific composite of motor abnormalities observed includes FMC, MC, BC, and SA. However, it should be acknowledged that not all adolescents with ASD show motor difficulties, and our findings are in accordance with those of previous research [45,46]. The physical activity results indicated that only 44% of participants with ASD met the daily 60 min or more of moderate-to-vigorous physical activity standard in the present study. These results are lower than previous reports on TD peers [21]. Physical self-perception in individuals with ASD has received limited attention in the literature. This study is the first attempt to examine physical self-perception in individuals with ASD, and therefore, how physical self-perception of individuals with ASD differs from TD counterparts remains uncertain. Nevertheless, poor motor skill competence and low levels of physical activity may restrict the participation of adolescents with ASD in physical activities [13,21], and consequently, they may be at a risk of developing low physical self-perception and general self-esteem during adolescence.

Findings from the present study add new evidence in the field of motor skill competence with physical activity and physical self-perception in people with ASD. Table 4 shows that the percentage of time spent in moderate-to-vigorous physical activity was positively and significantly related to MC and SA in participants with ASD. These positive relationships, albeit low and ranging from $r = 0.34$ to 0.49, could be interpreted as indications that participants with ASD exhibiting high motor skill competence tend to be slightly more physically active in daily life, and the opposite suggesting that short, intermittent bouts of percentage of time spent in moderate-to-vigorous physical activity might be crucial in promoting the motor skill competence of participants with ASD. Previous studies have demonstrated positive relationships between physical skill performance and physical activity and between physical skill performance and motor skill competence in adolescents with ASD [13,21] and in TD adolescents [47,48]. In addition, regression modeling revealed that percentage of time spent in moderate-to-vigorous physical activity was a significant predictor of motor skill competence (i.e., MC and SA) in the adolescents with ASD of the present study. These findings are consistent with those of previous studies, which have suggested that active children and adolescents tend to be more skillful than their less active counterparts [16–19,49,50].

We also observed that self-perceived physical condition and sports competence were positively and significantly related to actual performance of SA in adolescents with ASD. High SA abilities of participants with ASD indicated increased perceptions of physical condition and sports competence during physical activity participation, and vice versa. Links of motor skill competence with physical self-perception are well known in the TD population [27,51]. The present study confirms the close relationship between motor skill competence (i.e., MC and SA) and physical self-perception (i.e., physical condition and sports competence) in adolescents with ASD; however, the only physical condition was found to be a predictor of SA in the adolescents with ASD. Studies have indicated that individuals with ASD preferred individual activities such as walking, running, and swimming, which were performed in continued practice or repetitions that were less stressful for them [22]. Physical activity participation in adolescents with ASD seems to depend on factors such as development of health-related behaviors (e.g., physical conditioning) or support from family and caring adults [52]. Nevertheless, these findings partially support the hypothesis in this study, and may be relevant during the development of therapeutic programs.

Rehabilitation professionals and educators working with adolescents with ASD should consider activities that promote successful moderate-to-vigorous physical activity and support positive physical self-perception (i.e., physical condition). Schools are potentially attractive settings in which to promote moderate-to-vigorous physical activity due to the large amounts of time spent by the students in this environment. Physical educators should strive to engage students with ASD in developmentally appropriate practices and take the time to explore the different physical activities that they may enjoy. Adolescents with ASD can be provided with opportunities to participate in appropriate physical activity settings where their level of physical activities can be perceived as a strength and prove fruitful for their physical self-perception. This may result in the cultivation of the required amount of confidence in these adolescents to subsequently perform other physical activities, thereby refining their motor skill competence. Generally, a high perception of competence contributes to motivation for both engagement and strong effort in activities [53,54]. Stodden et al. [55] suggested that varied activities of sport and play with others are important for children's development, and increased physical activity was observed to have a positive impact on both physical and social perception in children and adolescents [56]. When adolescents with ASD perceive themselves as more competent, their motor skill competence may be developed through increased opportunities for practice and training.

### *Study limitations and strengths*

First, the current data are cross-sectional and, therefore, do not reflect developmental changes in motor skill competence, physical activity, and physical self-perception. Future research adopting a multicohort, multioccasion design to measure these constructs in the same participants at multiple time points would provide robust support for these developmental changes. Second, the current analyses were conducted using a small sample for each group; hence, prospective longitudinal or experimental studies with larger sample sizes are required to test the causal nature of the associations found in this preliminary investigation. Third, the presence of comorbidity with ASD (e.g., attention deficit hyperactivity disorder, developmental coordination disorder, specific language impairment) was not accounted for. Cross-syndrome comparisons may represent an important method for uncovering specificity of motor atypicalities in ASD.

Apart from these limitations, using objective measures of physical activity, testing actual motor skill competence, and controlling for the effects of age and body mass index on motor skill competence are some of the advantages of the present study. Measuring adolescents with ASD over multiple days was another strength that allowed estimation of the variability of activity levels over time. Furthermore, this is the first published investigation to examine motor skill competence and correlations that may affect the motor skill competence of adolescents with ASD in Taiwan. This study reports data from a specific age group in a particular society and provides data that will allow comparisons among other samples.

## Conclusions

To the best of our knowledge, this is the first study to examine the association of motor skill competence with physical activity and physical self-perception in adolescents with ASD. The study demonstrated that moderate-to-vigorous physical activity and self-perceived physical condition were positively correlated with MC and SA, and both moderate-to-vigorous physical activity and self-perceived physical condition acted as predictors of SA in the adolescents with ASD. Given the current knowledge about the positive effect of physical activity on both physical and mental health, it is imperative to initiate interventions that increase physical activity and physical perceptions as part of a plan for adolescents with ASD. Specifically, future interventions aimed at improving motor skill competence in adolescents with ASD should focus on improving the time spent in moderate-to-vigorous physical activity and developing a positive perceived physical condition through motor skill or physical activity participation. Professionals in the fields of sports, education, and health should be aware of the importance of developing positive physical self-perception with a high level of physical activity involvement in order to improve motor skill competence in adolescents with ASD.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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## References

[1] American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. Washington (DC): American Psychiatric Association; 2013.

[2] Seltzer MM, Krauss MW, Shattuck PT, et al. The symptoms of autism spectrum disorders in adolescence and adulthood. J Autism Dev Disord. 2003;33:565–581.

[3] Yoon PO, Ze JT, Cui XL, et al. Prevalence of behavioural and emotional problems in children with high-functioning autism spectrum disorders. Aust N Z J Psychiatry. 2011;45: 370–375.

[4] Storch EA, Larson MJ, Ehrenreich-May J, et al. Peer victimization in youth with autism spectrum disorders and co-occurring anxiety: relations with psychopathology and loneliness. J Dev Phys Disabil. 2012;24:575–590.

[5] Staples KL, Reid G. Fundamental movement skills and autism spectrum disorders. J Autism Dev Disord. 2010;40: 209–217.

[6] Green D, Charman T, Pickles A, et al. Impairment in movement skills of children with autistic spectrum disorders. Dev Med Child Neurol. 2009;51:311–316.

[7] Rimmer JH, Yamaki K, Davis Lowry BM, et al. Obesity and obesity-related secondary conditions in adolescents with intellectual/developmental disabilities. J Intellect Disabil Res. 2010;54:787–794.

[8] Castelli DM, Valley JA. Chapter 3: The relationship of physical fitness and motor competence to physical activity. J Teach Phys Educ. 2007;26:358–374.

[9] Bhat AN, Landa RJ, Galloway JC. Current perspectives on motor functioning in infants, children, and adults with autism spectrum disorders. Phys Ther. 2011;91:1116–1129.

[10] Wuang YP, Wang CC, Huang MH, et al. The effectiveness of simulated developmental horse-riding program in children with autism. Adapt Phys Activ Q. 2010;27:113–126.

[11] Ament K, Mejia A, Buhlman R, et al. Evidence for specificity of motor impairments in catching and balance in children with autism. J Autism Dev Disord. 2015;45:742–751.

[12] Whyatt CP, Craig CM. Motor skills in children aged 7-10 years, diagnosed with autism spectrum disorder. J Autism Dev Disord. 2012;42:1799–1809.

[13] Pan CY. Motor proficiency and physical fitness in adolescent males with and without autism spectrum disorders. Autism. 2014;18:156–165.

[14] David FJ, Baranek GT, Giuliani CA, et al. A pilot study: coordination of precision grip in children and adolescents with high functioning autism. Pediatr Phys Ther. 2009;21: 205–211.

[15] Abu-Dahab SMN, Skidmore ER, Holm MB, et al. Motor and tactile-perceptual skill differences between individuals with high-functioning autism and typically developing individuals ages 5–21. J Autism Dev Disord. 2013;43:2241–2248.

[16] Jaakkola T, Kalaja S, Liukkonen J, et al. Relations among physical activity patterns, lifestyle activities, and fundamental movement skills for Finnish students in grade 7. Percept Mot Skills. 2009;108:97–111.

[17] Barnett LM, van Beurden E, Morgan PJ, et al. Childhood motor skill proficiency as a predictor of adolescent physical activity. J Adolesc Health. 2009;44:252–259.

[18] Houwen S, Hartman E, Visscher C. Physical activity and motor skills in children with and without visual impairments. Med Sci Sports Exerc. 2009;41:103–109.

[19] Houwen S, Visscher C, Hartman E, et al. Gross motor skills and sports participation of children with visual impairments. Res Q Exerc Sport. 2007;78:16–23.

[20] Borremans E, Rintala P, McCubbin JA. Physical fitness and physical activity in adolescents with Asperger syndrome: a comparative study. Adapt Phys Activ Q. 2010;27:308–320.

[21] Pan CY, Tsai CL, Chu CH, et al. Objectively measured physical activity and health-related physical fitness in secondary school-aged male students with autism spectrum disorders. Phys Ther. 2016;96:511–520.

[22] Pan CY, Frey GC. Physical activity patterns in youth with autism spectrum disorders. J Autism Dev Disord. 2006;36: 597–606.

[23] MacDonald M, Esposito P, Ulrich D. The physical activity patterns of children with autism. BMC Res Notes. 2011;4: 422

[24] Fox KR. Self-esteem, self-perceptions and exercise. Int J Sport Psychol. 2000;31:228–240.

[25] Fox KR, Corbin CB. The physical self-perception profile: development and preliminary validation. J Sport Exerc Psychol. 1989;11:408–430.

[26] Hagger MS, Biddle SJH, Chow EW, et al. Physical self-perceptions in adolescence: generalizability of a hierarchical multidimensional model across three cultures. J Cross Cult Psychol. 2003;34:611–628.

[27] Grao-Cruces A, Nuviala A, Fernández-Martínez A, et al. Association of physical self-concept with physical activity, life satisfaction and mediterranean diet in adolescents. Kinesiology. 2014;46:3–11.

[28] Harter S. The determinants and mediational role of global self-worth in children. In: Eisenberg N, editor. Contemporary topics in developmental psychology. New York: Wiley; 1987. p. 219–242.

[29] Yu J, Sit CHP, Capio CM, et al. Fundamental movement skills proficiency in children with developmental coordination disorder: does physical self-concept matter?. Disabil Rehabil. 2016;38:45–51.

[30] Vickerstaff S, Heriot S, Wong M, et al. Intellectual ability, self-perceived social competence, and depressive

symptomatology in children with high-functioning autistic spectrum disorders. J Autism Dev Disord. 2007;37: 1647–1664.

[31] Jamison TR, Schuttler JO. Examining social competence, self-perception, quality of life, and internalizing and externalizing symptoms in adolescent females with and without autism spectrum dirsoders: a quantitative design including between-groups and correlational analyses. Mol Autism. 2015;6:53.

[32] Taiwan Ministry of Health and Welfare. Hospitals for the identification of disabilities 2013 [cited Dec 27]. Available from: http://www.mohw.gov.tw/cht/DONAHC/DM1.aspx?f_list_no=588.

[33] Taiwan Disability Information Network. Levels of disabilities 2013 [cited Dec 27]. Available from: http://disable.yam.org.tw/node/551#p.

[34] Krug DA, Arick JR, Almond PJ. Autism Behavior Checklist-Taiwan version, ABCT. Wu YY, Huang GY, translators; Austin (TX): PRO-ED, Inc.; 2008. (Wu YY, Huang JY, editors.).

[35] Chang CF, Wu YY. Early development and current condition in children with Asperger syndrome and high-functioning autism: a comparative study. Bull Spec Educ. 2006;31: 139–164.

[36] Bruininks RH, Bruininks BD. Bruininks-Oseretsky test of motor proficiency. 2nd ed. Minneapolis (MN): NCS Pearson; 2005.

[37] Hilton CL, Cumpata K, Klohr C, et al. Effects of exergaming on executive function and motor skills in children with autism spectrum disorder: a pilot study. Am J Occup Ther. 2014;68:57–65.

[38] Pan CY, Chu CH, Tsai CL, et al. The impacts of physical activity intervention on physical and cognitive outcomes in children with autism spectrum disorder. Autism. 2017;21: 190–202.

[39] Gabriels RL, Agnew JA, Holt KD, et al. Pilot study measuring the effects of therapeutic horseback riding on schoolage children and adolescents with autism spectrum disorder. Res Autism Spectr Disord. 2012;6:578–588.

[40] Trost SG, Ward DS, Moorehead SM, et al. Validity of the computer science and applications (CSA) activity monitor in children. Med Sci Sports Exerc. 1998;30:629–633.

[41] Harter S. Manual for the self-perception profile for adolescents. Denver (CO): University of Denver; 1988.

[42] Heine SJ, Lehman DR, Peng K, et al. What's wrong with cross-cultural comparisons of subjective Likert scales? The reference group effect. J Pers Soc Psychol. 2002;82: 903–918.

[43] Marsh HW, Hau KT, Sung RY, et al. Childhood obesity, gender, actual-ideal body image discrepancies, and physical self-concept in Hong Kong children: cultural differences in the value of moderation. Dev Psychol. 2007;43:647–662.

[44] Domholdt E. Statistical analysis of relationships: the basics. Physical therapy research: principles and applications. Philadelphia (PA): Saunders; 2000.

[45] Ming X, Brimacombe M, Wagner GC. Prevalence of motor impairment in autism spectrum disorders. Brain Dev. 2007; 29:565–570.

[46] Pan CY, Tsai CL, Chu CH. Fundamental movement skills in children diagnosed with autism spectrum disorders and attention deficit hyperactivity disorder. J Autism Dev Disord. 2009;39:1694–1705.

[47] Júdice PB, Silva AM, Berria J, et al. Sedentary patterns, physical activity and health-related physical fitness in youth: A cross-sectional study. Int J Behav Nutr Phys Act. 2017;14:10.

[48] Luz C, Rodrigues LP, Meester AD, et al. The relationship between motor competence and health-related fitness in children and adolescents. PLoS ONE 2017;12:1–11.

[49] Wrotniak BH, Epstein LH, Dorn JM, et al. The relationship between motor proficiency and physical activity in children. Pediatrics. 2006;118:e1758–e1765.

[50] Fisher A, Reilly JJ, Kelly LA, et al. Fundamental movement skills and habitual physical activity in young children. Med Sci Sports Exerc. 2005;37:684–688.

[51] Vedul-Kjelsås V, Sigmundsson H, Stensdotter AK, et al. The relationship between motor competence, physical fitness and self-perception in children. Child Care Health Dev. 2012;38:394–402.

[52] Obrusnikova I, Miccinello DL. Parent perceptions of factors influencing after-school physical activity of children with autism spectrum disorders. Adapt Phys Activ Q. 2012;29: 63–80.

[53] Valentini N, Rudisill M. Motivational climate, motor-skill development, and pereived competence: Two studies of developmentally delayed kindergarten children. J Teach Phys Educ. 2004;23:216–234.

[54] Robinson LE, Rudisill ME, Goodway JD. Instructional climates in preschool children who are at-risk. Part II: perceived physical competence. Res Q Exerc Sport. 2009;80: 543–551.

[55] Stodden DF, Goodway JD, Langendorfer SJ, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. Quest. 2008;60:290–306.

[56] Stein C, Fisher L, Berkey C, et al. Adolescent physcial activity and perceived competence: does change in activity level impact self-perception?. J Adolesc Health. 2007;40: 462.e1–462.e8.