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Original Paper

Biomedical Human Kinetics, 14, 252–258, 2022
DOI: 10.2478/bhk-2022-0031

# Associations between device-measured physical activity and balance performance in children: Mediating role of motor self-efficacy

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## Abstract

*Study aim*: To examine the association between accelerometer-measured physical activity (PA) and balance performance among children with considering motor self-efficacy as a mediator.

*Material and methods*: The present study employed a correlational-comparative approach. The present study applied a correlational-comparative approach. Eighty-two children (40 girls) of Tehran city, Iran in 2020 participated in this study (mean age of 9.82 ± 1.64 years). Physical activity was measured using the ActiGraph wGT3X-BT accelerometer. Dynamic balance test was used to collect balance performance. Motor self-efficacy was measured using a standard questionnaire.

*Results*: On average, boys had higher moderate-to-vigorous PA (MVPA) than girls (47.28 vs. 36.74 minutes per day, respectively). MVPA was significantly and directly associated with children's balance performance, and here, motor self-efficacy acted as a significant mediator.

*Conclusions*: These findings underscore the need for targeted strategies and interventions for children, especially girls, to develop adequate levels of PA.

**Keywords: Children – Physical activity – Balance – Motor self-efficacy – Accelerometer**

## Introduction

Physical activity (PA) simply refers to any body movements produced by skeletal muscles and leads to the energy consumption. It can be performed in the form of sport activities, working activities, active transportation, household activities, and recreational activities [7, 37]. Evidence showed that regular PA leads to numerous physical and mental health benefits (e.g., improving physical fitness and strength, increasing self-confidence and quality of life, etc.) as well as prevents various diseases (e.g., cardiovascular disease, diabetes, cancer, osteoporosis, etc.) in different age-groups, including children [10, 15, 16, 19, 25, 30, 41]. Accordingly, the World Health Organization (WHO) recommended that children aged 6 to 17 years should participate in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) every day of the week [5].

Some other evidence showed that participating in regular physical and sport activities may affect the level of motor proficiency in children [4, 6, 20, 43]. For example, Carvalho et al. [6] found that total PA was significantly associated with fundamental motor skills including locomotor, object control, and gross motor skills. Wrotniak et al. [43] showed that MVPA was positively associated with children's motor proficiency including running, coordination, and strength. In addition, some evidence showed that participating in regular PA can enhance children's motor competence early in life and health promotion across the lifespan [13]. Longitudinal studies have also provided some evidence that motor competence levels during childhood positively influence PA levels in later years [39]. However, associations between PA and balance performance among children has been received little attention in the literature. Balance refers to the ability of retaining the center of mass of the body within the base of support while stationary (e.g., sitting at a table) or moving (riding a bike) with minimal postural sway [36], and is

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considered as a fundamental skill for children to practice daily activities as well as sport skills [14]. Oliveira et al. [29] showed that children who practiced more PA had better postural control than those who practice less PA. In addition, García-Soidán et al. [14] demonstrate that active children have better postural control than sedentary children. Stanek et al. [36] found that children who were more active in sports had better body balance. These findings clearly indicate that physical activity can play an important role in balance performance of children. Nevertheless, the findings of previous studies are limited in the sense that they have used questionnaire for measuring physical activity, which its validity remained questionable, mostly due to the large differences in time spent on MVPA measured by questionnaire and accelerometer in children [35]. Accelerometer data provide a great opportunity to determine levels of PA in children. Hence, the primary purpose of this study was to investigate the associations between accelerometer-measured PA and balance performance among children.

Other limitation to previous studies on the relationship between physical activity and balance performance is that they have not included psychological variables in this relationship. Therefore, it is not clear whether psychological status of children (e.g., self-efficacy, competence, etc.) may influence balance performance. In this study, we aimed also to include motor self-efficacy as a psychological variable in the relationship between physical activity and balance performance among children. Motor self-efficacy refers to the sense of competence that people employ to successfully cope with motor situations [28]. In a theoretical concept, Sallen et al [32] highlighted perceived motor competence as a mediator that influences the relationship between PA and motor competence over time. In this regard, several studies demonstrated that motor self-efficacy significantly affect the initiation or cessation of behaviors in contexts of physical practice [9, 25, 38]. Thus, it can be assumed that motor self-efficacy may affect balance performance, too. The second purpose of this study was, therefore, to investigate the mediating role of motor self-efficacy in the associations between accelerometer-measured PA with balance performance among children. Altogether, the present study was designed to examine the association between accelerometer-measured PA and balance performance among children with considering motor self-efficacy as a mediator.

## Material and methods

### Participants

The present study applied a correlational-comparative approach. Eighty-two children (40 girls) of Tehran city, Iran in 2020 participated in this study (mean age of 9.82 ± 1.64 years). The participants attended in regular schools of District 5 in Tehran, Iran. The statistical sample was selected based on convenience sampling method. This study was approved by university ethical committee. The parents were told about the nature of the study and then they provided permissions and gave written consents. Children were free to refuse participation in any time during the study.

### Measures

*Physical activity*

PA was measured using the accelerometer ActiGraph wGT3X-BT (ActiGraph LLC, Pensacola, FL, USA) initialized at a 30 Hz frequency. Accelerometers are small, non-invasive, and easy-to-wear devices that measure the frequency, intensity, and duration of PA. In recent years, the ActiGraph accelerometer was the most frequently used in research and has consistently shown good validity and reliability in previous studies [27, 42]. To this end, the participants received detailed information about the accelerometer and were instructed to wear it on the right hip for seven consecutive days while awake and to remove it only for taking a shower, water-based activities, and while sleeping. They were also given a protocol to record when and why they did not wear the accelerometer and the time of waking up and going to bed. In order to enhance the commitment of the participants and to ensure the correct use of the accelerometer, he/she was regularly contacted via WhatsApp or mobile. After seven days, the accelerometers were collected from the participants. The accelerometer data were downloaded, processed, and analyzed using the ActiLife v6.13.4 software (Actigraph Inc, USA). Based on the cutoff points given by Evenson, Catellier, Gill, Ondrak, and McMurray [11], the total and daily time of MVPA and being sedentary were calculated. Time spent not wearing the accelerometer was identified by the algorithm by Choi, Liu, Matthews, and Buchowski [8] and subsequently matched with the information provided by the participants.

*Balance performance*

Balance beam walking was used to measure balance performance. This task was adopted from the Koperkoördinationstest für Kinder (KTK, body coordination test for children), a standardized normative instrument that measures gross motor coordination in children aged 5 to 14 years [22], which has good reliability in typically developing children (0.88) [11]. To this end, a balancing beam with a length of 4 meters and a width and height of 10 cm was used. In this way, at the beginning of the movement, the participant was placed at the beginning of the balance beam and started to move with the "go" sign. After walking, he/she put his/her foot on the ground and came back. The criterion of measurement was the time (in seconds) that a person gains balance on the beam once going back

and forth. This test was performed three times and its average was recorded as the final score of the participant for his/her balance performance. In this study, test-retest reliability of the balance beam walking test was 0.79.

*Motor self-efficacy*

Perceived motor self-efficacy was measured by using Motor Self-Efficacy Scale (MSES) which is an adaptation of the General Self-Efficacy Scale [3] to the specific domain of motor skills. Specifically, it evaluates the personal capacity to successfully carry out a motor action. It consists of 10 items, which report on various situations during the practice of physical sports activity, and a single factor (e.g., I am confident that I could effectively handle unexpected situations when practicing PA). It is answered with a four-option Likert scale, from 1 (strongly disagree) to 4 (strongly agree). The internal consistency analysis showed a Cronbach's alpha of 0.84 [28].

**Data analysis**

The data were analyzed with SPSS Statistics 26 and Lisrel software. Means and standard deviations were calculated to describe the data for all variables. Normality of data was evaluated using Kolmogorov-Smirnov test. Independent t-tests were computed to identify gender differences in research variables. In addition, we conducted Pearson correlation tests to determine the associations between research variables. Structural equation modelling was employed to assess structural associations between variables. Finally, we divided the sample into three groups according to the amount of daily MVPA. Participants who met the recommended daily MVPA (i.e., 60 minutes of MVPA per day and above) were assigned to the high daily MVPA group, participants with MVPA of 30 to 60 minutes per day were classified as moderate daily MVPA, and those with less than 30 minutes of daily MVPA formed the low daily MVPA group. One-way analysis of variance (ANOVA) was then used to examine whether the students in these groups differ in terms of their balance performance and motor self-efficacy. Tukey HSD test was employed as post-hoc test to follow a significant F test of ANOVA. Level of significance was set at $\alpha = 0.05$.

## Results

**Demographic data**

A total of 82 children consisted of 42 boys (51%) and 40 girls (49%) participated in this study. Boys and girls had almost identical age (9.55 vs. 9.42 years, respectively), height (129.67 vs. 125.71 cm, respectively), and weight (34.97 vs. 33.84 kg, respectively). Demographic data showed that most of parents were at medium level of financial status, and had a college education. Finally, most of students woke up between 6:00 to 7:00 a.m. and slept between 22:00 to 23:00.

**Descriptive data**

Table 1 presents the mean and standard deviation of research variables along with gender differences. Regarding PA pattern, the accelerometer data demonstrated that girls spent significantly much time in sedentary than boys (67.28% vs. 72.55%, respectively). We found no significant gender differences in light PA (20.62% for boys and 19.96% for girls). Again, boys significantly spent much time than girls in MVPA% (12.10% vs. 7.49%, respectively) and daily MVPA (47.28 min vs. 36.74 min, respectively). These findings clearly show that both boys and girls in our sample did not meet the WHO guideline of 60 minutes of MVPA per day. Our data showed that only 29% (n = 12) of boys and 20% (n = 8) of girls fulfilled the guideline. Moreover, 47% (n = 20) of boys and 53% (n = 21) of girls had a range of 30-to-60 minutes of daily MVPA. In addition, 24% (n = 10) of boys and 27% (n = 11) of girls had a range of <30 minutes of daily MVPA.

Regarding balance performance, our data showed that girls could gain much time on the stick than boys (21.88 vs. 20.53 second, respectively), however, gender differences were not significant. Concerning motor self-efficacy, data revealed that boys significantly perceived their motor self-efficacy higher than girls (3.18 vs. 2.58, respectively).

Finally, the results of Kolmogorov-Smirnov test showed that our data was normally distributed (all $P > 0.05$).

**Table 1.** Descriptive data and gender differences

| | | Mean ± SD | Comparison |
|---|---|---|---|
| Sedentary Time% | Boys | 67.28 ± 5.72* | t = –1.937 |
| | Girls | 72.55 ± 6.26 | P = 0.038 |
| Light PA% | Boys | 20.62 ± 2.65 | t = –1.071 |
| | Girls | 19.96 ± 2.93 | P = 0.267 |
| MVPA% | Boys | 12.10 ± 2.48** | t = –7.691 |
| | Girls | 7.49 ± 3.18 | P < 0.001 |
| Daily MVPA [min] | Boys | 47.28 ± 12.61** | t = 8.593 |
| | Girls | 36.74 ± 14.20 | P < 0.001 |
| Balance [second] | Boys | 20.53 ± 1.45 | t = 1.016 |
| | Girls | 21.88 ± 2.14 | P = 0.245 |
| Motor self-efficacy | Boys | 3.18 ± 0.52** | t = 3.626 |
| | Girls | 2.58 ± 0.21 | P < 0.001 |

Different than girls: * – $P < 0.05$; ** – $P < 0.001$

**Associations between variables**

The results of Pearson correlation tests showed that daily MVPA was directly and significantly associated with balance performance ($r = 0.674$, $P = 0.000$) and motor

self-efficacy (r = 0.539, P = 0.000). Moreover, motor self-efficacy was directly and significantly associated with balance performance (r = 0.374, P = 0.000).

**Structural equation modelling**

Figure 1 demonstrate the results of structural equation modelling. Our findings reveled that MVPA had a significant effect on balance performance (β = 0.408, T = 6.634) and motor self-efficacy (β = 0.320, T = 5.172). Moreover, motor self-efficacy significantly affected balance performance (β = 0.419, T = 6.983). Finally, motor self-efficacy significantly mediated the association between MVPA and balance performance (Z = 5.681, P = 0.000). Results of model fit showed that the conceptual model has good fit (RMSEA = 0.06; $X^2$/df = 2.71; RMR = 0.03; NFI = 0.93; CFI = 0.95).

**Balance performance and motor self-efficacy across high, moderate, and low MVPA**

Figure 2 shows the means and standard deviations of balance performance and motor self-efficacy across high, moderate, and low daily MVPA. Regarding balance performance, the results of ANOVA showed that there were significant differences between different intensity of MVPA ($F_{2,79}$ = 8.169, P < 0.001). Post-hoc analysis revealed that children with high daily MVPA had significantly higher balance performance than those with moderate (P < 0.001) or low (P < 0.001) daily MVPA. Moreover, the children with moderate daily MVPA had significantly better balance performance compared with those with low daily MVPA (P = 0.013). In addition, concerning motor self-efficacy, our data showed that differences between different intensity of MVPA were significant ($F_{2,79}$ = 6.248, P < 0.001). Post-hoc analysis showed that children with high daily MVPA had significantly higher perception of motor self-efficacy than those with moderate (P < 0.001) or low (P = 0.000) daily MVPA. Furthermore, the children with moderate daily MVPA had significantly higher perception of motor self-efficacy in comparison to those with low daily MPVA (P = 0.005). These findings clearly reveal that children with higher MVPA have better actual and perceived physical condition.

## Discussion

Evidence showed that participating in regular PA may affect the level of motor proficiency in children [4, 6, 20, 43]. However, associations between PA and balance performance among children has been rarely investigated. Therefore, the present study was designed to examine the association between accelerometer-measured PA and balance performance among children with considering motor self-efficacy as a mediator. Regarding PA pattern, our findings revealed that boys spent 67.28% of the total time in sedentary, 20.62% in light PA, and 12.10% in MVPA, while girls spent 72.55% of the total time in sedentary, 19.96% in light PA, and 7.49% in MVPA. Moreover, boys engaged 47.28 minutes in MVPA per day and that was 36.74 minutes for girls. These findings clearly

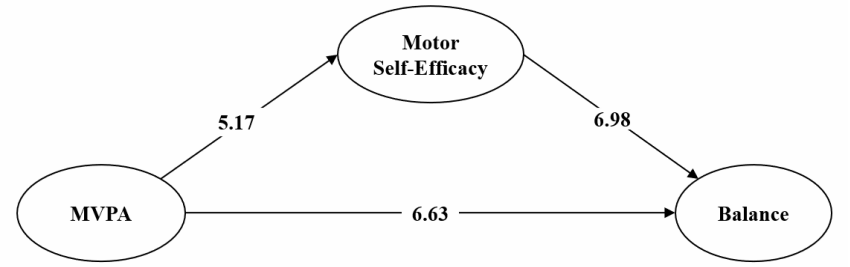


**Figure 1.** Conceptual model in the form of T-values

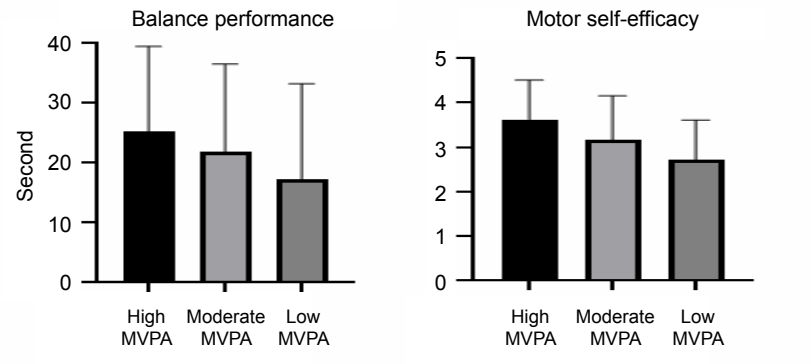


**Figure 2.** Mean and SD of balance performance and motor self-efficacy across different levels of daily MVPA

indicate that our sample did not meet the WHO guidelines of doing 60 minutes MVPA per day. Our findings are in accordance with the findings of previous studies indicating that children are less active than recommended [1, 2, 31, 34]. Based on these findings and due to the benefits of regular PA for health, it is essential to apply appropriate strategies and interventions to enhance engagement of children in PA. Regarding gender differences in PA, generally boys significantly engaged in more health-related PA than girls. Our findings confirm the results of previous studies [18, 24, 41], demonstrating that enhancing PA in children should focus mostly on girls. To explain gender differences in PA, it can be sated that generally girls have fewer chances for engaging in PA at school and leisure-time, participate less in sport activities, and receive less support from parents [18, 24, 41].

Concerning associations between PA and balance performance, our findings showed that daily MVPA was significantly and directly associated with balance performance in children. Moreover, children who had more daily MVPA performed better balance than those with lower amount of daily MVPA. These findings confirm the results of very few studies which were based on self-reported PA [14, 29, 36], indicating that active children tend to balance more than the passive one. It can be stated that children who engage in more PA have more ideal body compared with those who engage in less PA. Balance performance takes place mostly in lower part of body and it seems that participating in PA leads to strengthening and enduring the muscles, including muscles of lower limbs, in children [14]. During childhood, participating in PA gives optimal contribution in coordination ability and sufficient motor experiences [14]. Thus, it can be expected that improving PA in children results in better balance performance.

Finally, regarding motor self-efficacy, which simply refers to the sense of competence that people employ to successfully cope with motor situations, our findings showed that motor self-efficacy acts as a positive and significant mediator in the association between PA and balance performance in children, indicating that children's perceptions of their motor self-efficacy contribute to their PA and motor performance, and conversely, if they do not have a positive perception of their motor self-efficacy, they possibly participate less in PA and show lower motor performances. Meanwhile, boys reported higher motor self-efficacy than girls, which could be due to their more experiences of successfully performing motor skills. Participating in PA and sport activities may result in development of their motor abilities and it may consequently lead to higher level of their perception in motor abilities [9, 26, 28, 40].

Among the strengths of this study, it can be stated that we employed modern accelerometers to measure objectively PA of children, which possibly avoid typical biases in self-reporting questionnaires. Second, we included a psychological variable (i.e., motor self-efficacy) in the study, which made it possible to find out its associations with PA and balance performance in children. On the other hand, as a limitation in this study, we did not measure possible influential factors on PA, motor abilities, and motor self-efficacy such as environmental (e.g., availability of sports facilities near to the residence) or individual factors (e.g., motivation, attitudes). In this regard, research has shown that some biological variables such as parents may influence the level of PA and motor abilities in children [17, 23]. In addition, several studies have demonstrated that self-efficacy may be increased via different interventions such as pedometer-based walking intervention [21]. Future studies should focus on assessing the effects of these variables on PA, balance performance, and motor self-efficacy among children.

## Conclusion

In summary, the present study is one of the first studies to investigate the associations between objective PA (i.e., measured using an accelerometer) and balance performance with a mediation by motor self-efficacy. First of all, it should be noted that the PA of the children participated in this study was lower than the recommended rate of the WHO for 60 minutes of MVPA per day, and also girls had less PA than boys, indicates that applying the strategies and interventions to improve PA of children is of particular importance. Moreover, PA was significantly and directly related to children's balance performance, and here, motor self-efficacy acted as a significant mediator, which highlights the role of children's actual and perceived physical abilities in performing motor abilities such as balance. These findings can have practical implications, too. For example, physical education teachers and parents can focus on engagement of children in PA in order to improve their motor abilities, especially in girls.

**Conflict of interest: Authors state no conflict of interest.**

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**Received 09.04.2022**
**Accepted 27.06.2022**



**Acknowledgments**

**We are grateful to all teachers, administrators, students and their parents who helped us in this research.**