The Relationship Between Motor Proficiency and Pedometer-Determined Physical Activity in Young Children

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The aim of this study was to examine the relationship between motor proficiency and pedometer-determined physical activity in 5–6 year-old children. Participants \( n = 232 \) were randomly recruited and assessed from 30 kindergartens in Northern Greece. Two trained researchers administered the measurements for the assessment of children’s motor proficiency by using the BOTMP-SF. Physical activity was assessed by OMRON pedometers. Significant relationships between BOTMP-SF standard score and steps (S), aerobic walking time (AWT) and aerobic steps (AS), \( p < .05 \) were found. When motor proficiency was divided into quartiles to assess the distribution of the relationship between motor proficiency and pedometer-derived variables, significant associations were found for AWT, S and AS \( p < .001 \). Young children with high levels of motor proficiency were more active in contrast to their peers with lower motor proficiency. The findings add to the growing body of evidence on the relationship between motor proficiency and physical activity in young children.
of literature that considers motor skills/abilities as important elements of physical activity participation. (Abbreviations: S-steps per day; AS-aerobic steps per day; AWT-aerobic walking time (minutes·day\(^{-1}\)); BOTMP-SF-Bruininks-Oseretsky Test of Motor Proficiency-Short Form (standard score))

Evidence suggests that today’s young children are less physically active than recommended (37), thus prone to obesity and early onset chronic health problems such as cardiovascular disease and type 2 diabetes (10,32). Obesity, that has become one of the major health hazards in the developed world, is now reaching epidemic levels in the pediatric population (26,29,39). It has been estimated that obesity prevalence in Greece for 1–5 year-old children is as high as 15–16% (29), while for 6–17 year-old children may be even higher (16–18%; 14). This obesity burst has prompted experts to recommend that young children should increase their activity level by accumulating at least 60 min of daily unstructured physical activity (33) or 12,000 steps per day for girls and 15,000 steps per day for boys aged 6–12 years (45).

Young children and especially those at preschool and primary school age constitute a critical target group because at this period eating habits and physical activity behavior patterns are established (5). Physical activity should be an integral part of children’s everyday life as there is strong evidence that leisure and exercise time declines dramatically when children reach adolescence and this decline may persist in adulthood (41), while obese children demonstrate a greater risk of being obese adults later in life (17). Fundamental motor skills, commonly developed in childhood, are considered a concrete basis upon which adequate physical activity participation and sport-specific skills refinement are built (20). Numerous lines of evidence suggest that motor proficiency as an outcome of the performance in selected representative motor skills may affect physical activity outcome (9,12,13,16,48,49). In addition, the proficiency of movement skills has been purported to provide the foundation for an active lifestyle (28,42), contributes to the physical, social and psychological wellbeing (37,42,49) and may predict physical activity participation (27), aerobic fitness (35) and body mass (36). This evidence essentially means that children with better developed motor skills may find it easier to engage in physical activity/sports and remain more active and lean during adulthood than their counterparts with less developed motor skills (38,42).

Although there is an emerging awareness that children with poor motor abilities may be less physically active as well as overweight, much of the research in this field has relied on self-report methods of children’s activity (2,3,16,18,30,35). Studies that have examined the relationship between motor proficiency and objectively measured habitual physical activity in preschool children using accelerometers conclude that there is a significant though sometimes weak relationship between motor proficiency and physical activity in young children up to 5 years old (9,12,13,48). No studies up to date have considered pedometer-determined physical activity in young children although they are a valid tool for the assessment of physical activity in this population (4,31). The advantages of the pedometers lie primarily in their low cost and ease of administration especially in young children as well as they provide easily evaluated health-related data (31,45). Considering that the largest proportion of young children everyday physical activity takes place during free playing and consists of locomotor activities including mainly steps (47), one could claim that pedometers record the main part of the total volume of daily physical activity.
The purpose of the current study was to examine the relationship between motor proficiency and pedometer-determined physical activity in 5–6 year-old children. The main hypothesis tested was that children with higher levels of motor proficiency would exhibit higher values of pedometer-determined physical activity variables, as opposed to children of lower motor proficiency.

**Methods**

**Participants**

Data were collected as part of the “Active Children-Active Schools” project (ACAS). The sampling frame included all kindergartens in north-eastern Greece \( (n = 180) \), from which 30 were randomly selected using a computer software. The data were collected from April to June 2009 and all experimental procedures were approved by the Institutional Review Board for investigations involving human subjects. Written informed consent was obtained from all participants and their legal guardians before they were allowed to participate in the study. Initially 580 children were recruited of which a total of 253 healthy children (130 girls and 123 boys) finally participated in the study. Nineteen children, who were above the 95th percentile for body mass index (BMI), were excluded to avoid semantic effects of obesity on motor proficiency and physical activity (23). In addition, two participants with more than one weekday and one weekend lost due to incomplete data were excluded from the final data set. Hence, 232 children \( (N = 232: 114 \text{ girls and } 118 \text{ boys}) \) completed the study protocol. Baseline characteristics are shown in Table 1.

**Measures**

*Anthropometry.* Height and weight were measured, and BMI was determined using standard procedures (1). Body mass was measured to the nearest 0.5 kg (Beam Balance 710, Seca, UK) with participants wearing their underclothes and barefooted. Standing height was measured to the nearest 0.5 cm (Stadiometer 208, Seca, UK).

**Table 1** Physical Characteristics, Motor Proficiency and Physical Activity of All Participants \( (N = 232; 114 \text{ girls, } 118 \text{ boys}) \)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>64.4</td>
<td>3.4</td>
<td>60–71</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>113.6</td>
<td>5.2</td>
<td>101.3–126.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>19.9</td>
<td>1.9</td>
<td>17.4–23.5</td>
</tr>
<tr>
<td>BMI</td>
<td>15.6</td>
<td>.77</td>
<td>14.6–17.1</td>
</tr>
<tr>
<td>BOTMP-SF</td>
<td>58.8</td>
<td>8.8</td>
<td>36–75</td>
</tr>
<tr>
<td>AWT</td>
<td>12.8</td>
<td>17.5</td>
<td>0–48</td>
</tr>
<tr>
<td>S</td>
<td>7676</td>
<td>1893</td>
<td>3921–13040</td>
</tr>
<tr>
<td>AS</td>
<td>1486</td>
<td>1995</td>
<td>0–7149</td>
</tr>
</tbody>
</table>

*Note.* BOTMP-SF: BOTMP-SF standard core, AWT: Aerobic Walking Time (minutes·day\(^{-1}\)), S: Steps·day\(^{-1}\), AS: Aerobic Steps·day\(^{-1}\)
Motor Proficiency. The Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOTMP-SF) was used to assess children’s motor proficiency (6). The BOTMP-SF involves only 14 of the 46 items of the full test battery (6 from the gross motor skills subtests, 6 from the fine motor skills subtests and 2 from the gross and fine motor skills subtests): running speed and agility, standing on preferred leg on balance beam, walking forward heel-to-toe on balance beam, tapping feet alternately while making circles, jumping up and clapping hands, standing broad jump, catching a tossed ball with both hands, throwing a ball to a target, response speed, drawing a line through a straight path, copying a circle, copying overlapping pencils, sorting cards and making dots.

The BOTMP-SF is valid enough to estimate the motor proficiency of boys and girls within the same age range as the long form of the battery (6). In a previous preliminary study we found that BOTMP-SF is a valid screening tool and age appropriate to test the motor proficiency of normal preschool and primary school children in Greece (25). The measurements of motor proficiency in the current study were administered by two trained researchers using the standardized equipment of BOTMP-SF (6). The interrater reliability was controlled in an unpublished pilot study with a sample of 60 children (\(N = 60\): 33 girls and 27 boys, mean age: 65.19 ± 2.95 months), and was found high (ICC = .94). Children attempted each task on an individual basis and a total standard score, adjusted for child age, was used to interpret test performance.

Physical Activity. Physical activity was assessed using a pedometry-based methodology. There is evidence that daily step counts in young children give valid information for daily physical activity levels (19). Pedometers are simple, reliable and valid tools for assessing free play physical activity in young children (19) while they provide an adequate assessment of general physical activity (37). In this study the Omron Walking style pro HJ-720IT-E2 pedometer was used. This is a new generation pedometer with two piezoelectric sensors that use multiple position sensing technology. The HJ-720IT-E2 provides better accuracy and precision than the “gold standard” Yamax Digiwalker (15). The specific pedometer model demonstrates high validity and reliability at various mounting positions under prescribed and self-paced walking conditions with both healthy and overweight subjects (24), while it may measure validly steps in individuals of various BMI levels during constant- and variable-speed walking (21). The HJ-720IT-E2 offers the additional benefits of a 41 days memory function and an “aerobic steps” function. Aerobic or “steady steps” are counted separately when walking more than 60 steps per minute for more than 10 min successively. If a rest of less than 1 min was taken after a continuous walk of more than 10 min, this was regarded as part of “continuous walk”. Time spent in aerobic steps is considered as “aerobic walking time”. Results were plotted as steps·day\(^{-1}\) (S) aerobic steps·day\(^{-1}\) (AS), and aerobic walking time (minutes·day\(^{-1}\); AWT).

According to the methodology suggested by Tudor-Locke and Myers (44), all pedometers were fully tested before use (observed the recorded step count after walking 100 paces; 46). To determine instrumental error, two investigators recorded actual steps taken with a hand counter (Basch SJ-504). All trials were
recorded simultaneously by a camera. Instrumental error did not exceed 3% in any of the pedometers used. This value was selected according to Hatano’s standards (22). Parents and children were fully instructed how to operate the pedometers. Participants wore the pedometer from the time they woke up in the morning until they went to bed at night (except when they were asleep) for seven consecutive days. On the eighth day, pedometers were collected by the researchers resulting in seven full days of data collection (five weekdays and two weekend days).

Statistical Analysis

Descriptive statistics were used to compute the mean and SD for age, height, weight, motor proficiency (standard score), BMI, S, AS and AWT. Pearson product-moment correlations with adjustment for “age” were computed to examine relationships between motor proficiency and physical activity variables (S, AS, and AWT). To examine the distribution of the relationship between motor proficiency and the variables of physical activity (S, AS, and AWT), BOTMP-SF standard scores were sorted in quartiles and the differences in physical activity variables between the quartiles, were tested using one-way analysis of variance. Post hoc comparisons were performed using the Bonferroni test, with the alpha level set at .05. Effect size measured by Eta Squared ($\eta^2$) values, was also computed for data interpretation. According to Cohen (11), only $\eta^2$ of >.14 was considered sufficiently large to be of any consequence. All analyses were performed using SPSS (version 15.0, SPSS Inc., Chicago, Illinois, USA).

Results

Baseline characteristics and descriptive statistics of all the variables used in this study are presented in Table 1. No statistical differences between girls and boys were found in any of the variables. There were positive associations between BOTMP-SF standard score and S, AS and AWT (Table 2). The examination of correlations between BOTMP-SF single items and pedometer measured physical activity variables revealed significant correlations. Steps per day were positively associated with running speed and agility ($r = .31$, $p < .05$), standing on preferred leg on balance beam ($r = .36$, $p < .05$) and catching a tossed ball with both hands ($r = .33$, $p < .05$) tasks. Aerobic steps per day were positively associated with running

| Table 2 Correlations between Physical Activity, Motor Proficiency ($N = 232$) |
|-----------------|----|----|----|----|
|                 | BOTMP-SF | AWT | S  | AS |
| BOTMP-SF        | 1     |     |    |    |
| AWT             | .356*  | 1   |    |    |
| S               | .368*  | .562** | 1  |    |
| AS              | .473*  | .968** | .614** | 1  |

Note. BOTMP-SF: BOTMP-SF standard core, AWT: Aerobic Walking Time (minutes·day$^{-1}$), S: Steps·day$^{-1}$, AS: Aerobic Steps·day$^{-1}$, *p<.05, **p<.01
speed and agility ($r = .32, p < .05$), standing on preferred leg on balance beam ($r = .39, p < .05$), catching a tossed ball with both hands ($r = .35, p < .05$), throwing a ball at a target with preferred hand ($r = .30, p < .05$) and copying overlapping pencils with preferred hand ($r = .37, p < .05$) tasks. Moreover, the faster the children completed the speed and agility task, the higher they scored on static balance and visual-motor coordination tasks and the greater was their average AS. On the contrary the lower they scored on the visual-motor fine coordination task the higher was their average AS. Dynamic balance item associated positively with AWT ($r = .401, p < .05$). No significant correlations were found between the other variables.

When motor proficiency was divided into quartiles to assess the distribution of the relationship between movement abilities and physical activity, significant differences were found for S ($F = 22.7, p < .001, h^2=.717$), AS ($F = 296.7, p < .001, h^2=.971$) and AWT ($F = 507.2, p < .001, h^2=.983$). Children in the highest (4th) BOTMP-SF standard score quartile had significantly more AWT compared with children in the 3rd (MD = 11.6, $p < .05$), in the 2nd (MD = 28.1, $p < .05$) and the lowest (1st; MD = 46.2, $p < .05$) quartile (Figure 1). The children in the 4th BOTMP-SF standard score quartile had significantly more average S compared with children in the 3rd (MD = 4980.33, $p < .05$), in the 2nd (MD = 5518, $p < .05$) and in the 1st (MD = 6416, $p < .05$) quartile (Figure 2). Children in the 4th BOTMP-SF standard score quartile had significantly more AS compared with children in the 3rd (MD = 15943.3, $p < .05$), the 2nd (MD = 3978, $p < .05$), and in the 1st quartile (MD = 5053, $p < .05$; Figure 3).

![Figure 1](image.png)

**Figure 1** — Aerobic walking time (minutes·day$^{-1}$; AWT; mean± SEM) for quartiles of BOTMP-SF standard score.
**Figure 2** — Steps·day\(^{-1}\) (S; mean±SEM) for quartiles of BOTMP-SF standard score. (1: 0% to ≤25%; 2: >25% to ≤50%; 3: >50% to ≤75%; 4: >75% to ≤100)

**Figure 3** — Aerobic steps·day\(^{-1}\) (AS; mean±SEM) for quartiles of BOTMP-SF standard score.
Discussion

This is the first study to date to examine the relationship between motor proficiency of 5–6 year old children and pedometer-determined physical activity. Results show that motor proficiency is positively associated with physical activity variables such as S, AS and AWT. Children who did more steps and spent more time in continuous walking had higher motor proficiency scores. When this association was examined by quartiles of motor abilities, preschoolers in the highest quartile were the most physically active group, compared with their peers in the lower quartiles. Children in the highest quartile of BOTMP-SF standard score had an average of 46.25 min·day⁻¹ more time spent in aerobic walking and 5.053 steps·day⁻¹ more than their peers in the lowest quartile.

Findings of the current study concerning the relationship of BOTMP-SF standard score, and physical activity variables derived from pedometers fully support the results of studies in preschoolers that objectively measure physical activity through accelerometers (9,13,48). Those studies mainly found positive correlations between percentage of time spent in moderate to vigorous physical activity and motor skills, although associations were rather weak. Total physical activity and percent time spent in moderate to vigorous physical activity were significantly correlated with total movement skills score in Fisher et al. (13). In addition, Williams et al. (48) and Cliff et al. (13) found that preschooler’s physical activity was mainly associated with object control related skills. Positive associations between several fundamental motor skills and physical activity are also mentioned in studies that used self-report measures of physical activity (16,18,35) or both pedometers and self-reported physical activity (8), however those studies refer to older children and adolescents. Although there is mounting evidence from cross sectional studies to show a connection between physical activity and motor skills, this is not enough to infer causality between the two variables. Longitudinal studies, that are designed to find causal relationships, show that motor skills development may enhance later physical activity participation and perceived sports competence (2,3), although this association is not always clear (30).

The findings of marked differences in S, AS and AWT between children in upper and lower quartiles may indicate that the associations of motor proficiency and physical activity are of greater significance at the extremes of the distribution. Zimmer (50) was the first to describe this phenomenon when she talked about the “Devil’s Circle”. This concept refers to children with poor motor coordination who develop a negative engagement in physical activity, which results in hindering motor development which in turn restricts physical activity and vice versa. This pattern equalizes the importance of fundamental motor skills development alongside with the encouragement for greater physical activity participation at a young age. If the reciprocal connection of physical activity and motor proficiency exists, the increase of structured and unstructured activity patterns at the preschool age should become a priority. On the particular sample of children in this study we should note the relatively low number of S and AS undertaken per day (S: 7676 ± 1893; AS: 1486 ± 1995 steps·day⁻¹). Only 6.8% of children had 10,000 steps or more per day of which 10 were boys and 7 were girls, with some children achieving zero AS. These results are similar to other studies where the daily step count of preschoolers averaged 7529 ± 1539 steps·day⁻¹ (34) and 9980 ± 2605 steps·day⁻¹ (7). Although children in our study were not overweight or obese, this is particularly alarming since the balance of evidence from preschool children is supportive of the hypothesis that low levels of physical activity promote later obesity (40).
The sample of the current study was drawn from Kindergartens in northern Greece. For this reason caution should be taken when generalizing these results to the 5–6 years old Greek population. The small age range of children taking part in this study is a limiting factor too; however a relatively large sample was recruited. One of the strengths of this study were the use of a new generation pedometer that was found to be more accurate than the gold standard in measuring step-counts independent of speed used under laboratory conditions (15). Furthermore, the long monitoring period of daily physical activity (7 days) allowed better accuracy of the pedometer results.

To summarize, the association between fundamental movement skills and physical activity is sufficiently strong to warrant investment in further research aimed at characterizing cause-and-effect relationships. However, since parameters affecting lifelong physical activity are various and numerous, more research is needed in different settings and different age groups. Taking under consideration the specific characteristics of preschool and primary school age, the aim of future studies should be in the direction of determining the relation between motor proficiency, physical activity, and sedentary behavior. To do so, longitudinal designs seem to be more appropriate along with product-oriented and process-oriented assessment tools specialized for young children.

**Conclusion**

The purpose of this paper was to provide scientific evidence supporting a link between motor proficiency and physical activity in youth. The findings add to the growing body of literature that showed motor skills/abilities as important elements of physical activity. Findings support the need for the development of more effective strategies that simultaneously target movement skills and increase physical activity patterns in youth.

**References**


