Gross motor skills and sports participation of children with visual impairments
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Published in:
Research Quarterly for Exercise and Sport

DOI:
10.5641/193250307x13082490460229

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2007

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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Children with visual impairments (those who are blind or have low vision) are at risk for poor motor skill performance. Although a number of studies have examined gross motor skill performance of infants and preschoolers (e.g., Adelson & Fraiberg, 1974; Fazzi et al., 2002; Levtzion-Korach, Tennenbaum, Schnitzer, & Ornov, 2000; Prechtl, Cioni, Einspieler, Bos, & Ferrari, 2002; Sonksen, 1993; Tröster & Brambring, 1993; Tröster, Hecker, & Brambring, 1994), few have examined the performance of primary school-age children (e.g., Bouchard & Tetreault, 2000; Navarro, Fukujima, Fontes, Matas, & Prado, 2004; Pereira, 1990; Schneekloth, 1989). Fewer still have focused specifically on the quality of gross motor skills such as locomotor and object control skills. Insight into the qualitative aspects of motor skill performance is important, as it provides clues for intervention (Gallahue & Ozmun, 2002). As Winnick (1985) reported, adolescents with visual impairments still have difficulty in performing activities that involve gross motor skills; thus, it seems important to examine these skills in primary school-age children and the factors that might influence them.

Understanding motor skill performance in children with visual impairments requires at least understanding constraints from within the child, the environment, and the task (Newell, 1986; Shumway-Cook & Woollacott, 2001). First, the diminished vision of children with visual impairments still have difficulty in performing activities that involve gross motor skills; thus, it seems important to examine these skills in primary school-age children and the factors that might influence them.

Gross motor skill performance of children with visual impairments and its association with the degree of visual impairment and sports participation was examined. Twenty children with visual impairments ($M_{age} = 9.2$ years, $SD = 1.5$) and 100 sighted children ($M_{age} = 9.1$ years, $SD = 1.5$) from mainstream schools participated. The results showed that children with visual impairments had significantly lower object control but not locomotor skill scores than the sighted children. No significant differences were found between children with a moderate and severe visual impairment. Children with visual impairments who participated in sports had significantly higher object control skill scores than those who did not. No significant associations between motor skills and sports participation were found in the sighted children.
motor problems were due to limited experience, an implication would be that increasing and stimulating relevant experiences would improve motor skill performance. Participation in sports may provide an opportunity for children to improve their gross motor skills (Committee on Sports Medicine and Fitness and Committee on School Health, 2001).

The association between gross motor skills and physical activity, including sports participation, has not been studied extensively. Okely, Booth, and Patterson (2001) found an association between time spent participating in organized sports and fundamental motor skills in adolescents. This finding is in line with Ulrich (1987), who found that children ages 5–10 years who participated in organized sports performed sports-specific skills, like soccer dribble, ball dribble, softball throw, and soccer ball throw better than nonparticipants. Graf et al. (2004) reported that children with the greatest extent of sports activity had the highest gross motor skills scores. On the other hand, Raudsepp and Jürimäe (1997) reported no association between quantitative and qualitative assessment of overhand throw and participation in physical activity in children aged 7–10 years. To our knowledge, no study examined this association in children with visual impairments. It has been suggested that the association between motor skills and physical activity might be stronger for children who have the lowest motor skill scores (Fisher et al., 2005); therefore, it seems important to examine this association in children with visual impairments who generally have low motor skill scores. The aims of the present study, then, were to assess the qualitative gross motor skill performance of children with visual impairments and its association with the degree of visual impairment and sports participation.

**Method**

**Participants**

Twenty children with visual impairments ages 6–11 years, with a mean age of 9.20 years (SD = 1.54) participated; 11 were boys, and 9 were girls. They were recruited from mainstream schools in the northern Netherlands. Only children who attended age-appropriate classes at mainstream schools were selected, which implies cognitive and social development in the normal range. Schools were contacted through Visio in the city of Haren, The Netherlands. This organization offers children with visual impairments and their teacher’s ambulant educational support at their schools (i.e., providing visiting teaching support and resource service). The children’s medical records were reviewed, and it appeared there were no other impairments that may have interfered with the aims of the present study. According to the definition of the World Health Organization (WHO; 1992), the children were classified as having low vision. Seven children had a severe visual impairment, that is, acuity of less than 20/200 but greater than 20/400 (better eye provides vision from a distance of 20 feet that is equal to what a sighted child can see at 200 feet), and 13 children had a moderate visual impairment, that is, acuity of less than 20/60 but greater than 20/200. There were no apparent visual field restrictions in 19 children, according to their medical records. One child had a central visual field restriction.

Of the 20 children with low vision, one each had nystagmus, microphthalmos, and coloboma of the iris; cone dystrophy; retinoschisis and strabismus; cone dystrophy and achromatopsia; nystagmus and optic atrophy; ocular albinismus; strabismus, myopia, and nystagmus; albinismus and nystagmus; myopia and cone-rod dystrophy; dominant optic atrophy; congenital cataract; corneal disease; ocular albinismus and nystagmus; macular degeneration, cone dystrophy, and nystagmus; corneal neovascularization due to Steven-Johnson’s syndrome; 2 had myopia and nystagmus; and 3 were diagnosed with congenital nystagmus.

From two mainstream schools in the northern Netherlands, 100 sighted children with an age appropriate to their grade level were selected for participation. Children ranged in age from 6 to 11 years (Mage = 9.13 years, SD = 1.45); 49 were boys, and 51 were girls. The children’s parents provided informed consent for participation. The procedures were in accordance with the ethical standards of the Faculty of Medical Sciences of the University of Groningen.

**Instrument**

Test of Gross Motor Development-Second Edition (TGMD-2). The TGMD-2 (Ulrich, 2000) was used to assess the gross motor skills of the children with visual impairments and sighted children. This test is a qualitative measure to assess the gross motor skills of children ages 3–10 years. The 12 gross motor skills are subdivided into two skill areas: locomotor (run, gallop, hop, leap, jump, and slide) and object control (two-hand strike, stationary bounce, catch, kick, overhand throw, and underhand roll)

Skill performance is evaluated by the scores on qualitative performance criteria (3–5, depending on the skill). A criterion is scored with a 1 or 0 to indicate its presence or absence. The participant executes each skill twice. For example, if a skill is composed of three performance criteria, the raw scores vary from 0 to 6 points. The highest total subtest raw score for the locomotor as well as object control skills is 48 points. The raw scores can be converted in standardized scores per age group. In the present study, the raw scores were used for the analyses, because the normative TGMD-2 data collected on chil-
Children in the U.S. may not be valid for Dutch children (Kuiper, Niemeijer, & Reynders, 2000). Furthermore, children 11 years of age were included, which is outside the range of TGMD-2 normative data.

In the present study, the test was slightly adapted to enable the children with visual impairments to perform the test. Big, bright, orange-colored cones were used instead of normal cones to indicate the beginning and end of a course for the locomotor skills and to indicate the child’s position for the object control skills. For the object control skills, bright yellow-colored balls were used. Furthermore, the children were allowed to feel the items, if appropriate, before the test was administered. When necessary, the examiner let the child “feel” the required movement and gave additional instruction before the two test trials were administered.

In an earlier pilot study, test-retest reliability of the locomotor subtest, evaluated by testing 20 children with visual impairments from special schools, was good (intraclass correlation [ICC] > .80). The interrater reliability, evaluated by having two researchers score the children’s performance from the present study, was .83 (ICC) for the total test.

Sports Participation. A self-report measure assessed the children’s individual sports participation. Of primary interest was whether or not a child participated in at least one sport regularly during the previous year. Specifically, children were asked, “Do you participate in sports regularly?” to which they could answer yes or no. In the Netherlands, sports are interpreted as any form of leisure-time exercise, including dancing or aerobics (Stubbe, Boomsma, & De Geus, 2005). Those answering yes were asked three more questions, namely the kind of sports in which they were involved, whether it was organized or nonorganized, and how much time they spent on these sports. Organized sports were defined as those performed under the supervision of a trainer on a regular weekly basis, more likely within a sports club setting. Nonorganized sports were defined as not being embedded in a formal structure, not involving regular training or competition, and not having a coach or instructor (Okely, Booth, & Patterson, 2001). Sports participation excluded all travel to and from school and all sports played in physical education class at school. Dutch children are obliged to participate in 60–180 min of physical education at school per week. A pilot study was done on 23 sighted children to examine the 2-week test-retest reliability of the self-report measure. In the pilot study, ICC for the total minutes of activity was .84.

Procedure

The same examiner tested the children individually at their school gym and playground. The examiner was a research assistant in human movement sciences and received training in the test’s assessment procedures. The examiner administered and scored the test as each child performed it.

Data Analysis

The dependent variables were locomotor and object control subtest raw scores and total raw score on the TGMD-2. Descriptive statistics of the children with visual impairments and sighted children were calculated. Due to slight deviations from normal and the low number of children with visual impairments, the nonparametric Mann-Whitney U test was used to compare the TGMD-2 performance of these with that of sighted children.

For those with visual impairments, all within-group comparisons, such as between children with a moderate and a severe visual impairment or between children with visual impairments who participated or did not participate in sports, were performed using the Wilcoxon matched-pairs signed rank test. To compare children with a moderate and a severe visual impairment, children were matched as closely as possible for sex and age, which are related to the outcome variables of interest, as well as sport participation. Therefore, a matched-pair analysis is appropriate. Because of the small sample size, the Wilcoxon test was used to test differences between two groups. This nonparametric procedure ranks the differences between matched medians and tests the overall significance of the sum of these differences (Siegel & Castellan, 1998). For the 13 children with a moderate visual impairment and 7 with a severe visual impairment, seven pairs could be matched. To compare the 10 children who did and the 10 who did not participate in sports, they were matched for age, sex, and vision. Here, eight pairs could be matched. The remaining 4 children could only be matched on one of the vision, sex, or age factors and were judged as differing too much; thus, they were excluded from the analysis.

To determine the meaningfulness of group effects, correlational effect size statistics for the nonparametric data were calculated for each dependent variable (Field, 2005). Effect size was calculated by dividing the z score by the square root of the number of children contributing to the analyses (Rosenthal, 1991). An effect size of $r = .10$ was defined as small, $r = .30$ as medium, and $r = .50$ as large.

For the sighted children, all within-group comparisons with respect to the TGMD-2 raw scores, such as between children who participated in sports and those who did not, were performed using multivariate analysis of covariance (MANCOVA), while controlling for age and sex. For the sighted children, matching for age, sex, and sports participation would lead to using only part of the data. MANCOVA accomplishes much the same “controlling for” but uses all the data. All the assumptions for
this parametric analysis were met, and, therefore, MANCOVA was preferred to a matched-pair design. Where appropriate, analyses of covariances on each dependent variable were conducted as follow-up tests to the MANCOVA. Adjusted means were calculated controlling for age and sex. Correlational effect size statistics were calculated according to the procedures for unequal sample sizes described by Rosnow, Rosenthal, and Rubin (2000). The statistics were performed using SPSS software (version 11.0), and the probability level was set at .05 for results to be regarded as significant.

Results

Sports Participation

Of the 20 children with visual impairments, 10 were classified as participants in sports and 10 as nonparticipants. Of the participants, 5 engaged in one organized sport (soccer, hockey, basketball, aerobics). Four children pursued at least two different sports. One participated only in a nonorganized sport (swimming). Of the 100 sighted children, information was available about the sports participation of 94 children. Seventy-seven (82%) were classified as participants in sports, 17 (18%) as nonparticipants. Fifty children participated in one organized sport (soccer, swimming, tennis, badminton, ballet, club gymnastics, hockey, basketball).

Gross Motor Skills of Children With Visual Impairments Compared to Sighted Children

In Table 1, the means, standard deviations, medians, and range of raw scores for the locomotor and object control subtest as well as the total test of children with visual impairments and sighted children are shown. Children with visual impairments (Mdn = 39) did not seem to differ in locomotor scores from sighted children (Mdn = 39), Z = -3.89, p < .05, r = .42. For the object control subtest, children with visual impairments (Mdn = 31) scored significantly lower than sighted children (Mdn = 39), Z = 4.576, p < .001, r = .42.

To check if Dutch children score similarly to the U.S. standardization sample of the TGMD-2, the scores of the children ages 6–10 years are converted into U.S. standard scores. The children with visual impairments (age range: 6–10 years) received mean scores of 8.2 (SD = 1.4, Mdn = 9.0) for the locomotor subtest, 5.0 (SD = 2.3, Mdn = 5.0) for object control subtest, and 79.7 (SD = 9.2, Mdn = 79.0) for the total test. The Dutch reference group (age range: 6–10 years) received mean scores of 7.7 (SD = 1.5, Mdn = 8.0) for the locomotor subtest, 8.2 (SD = 1.6, Mdn = 8.0) for object control subtest, and 87.5 (SD = 6.8, Mdn = 88.0) for the total test.

Gross Motor Skill Performance and Association With the Degree of Visual Impairment and Sports Participation

In Table 2, the locomotor and object control raw scores, and the total raw score of the children with a moderate visual impairment and a severe visual impairment are shown. The final columns in the table give the mean differences in the seven matched pairs and the p-values based on Wilcoxon’s matched-pairs signed rank test. No significant differences (p > .05) were found between the two groups for the locomotor and object control subtests and for the total test.

Table 3 shows the locomotor and object control raw scores and the total raw score for children who participated in sports and those who did not. The final columns report the mean difference in the eight matched pairs and the p-values of Wilcoxon’s matched-pairs signed rank tests. Comparisons between the two groups revealed that children who participated in sports obtained significantly higher object control scores and total scores than children who did not. The effect size statistics represents large effects. The differences for the locomotor subtest were nonsignificant (p > .05).

The Association Between Gross Motor Skills and Sports Participation in Sighted Children

There was no significant main effect of sports participation on the TGMD-2 raw scores of the sighted children, Wilks’ Lambda: F(3, 88) = .288, p > .05, controlling

<p>| Table 1. Locomotor and object control scores and total score for children with visual impairments and sighted children |
|----------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|</p>
<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>Mdn</th>
<th>Range</th>
<th>M</th>
<th>SD</th>
<th>Mdn</th>
<th>Range</th>
<th>Z</th>
<th>p</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM</td>
<td>39.4</td>
<td>2.4</td>
<td>39.0</td>
<td>36.0–44.0</td>
<td>39.1</td>
<td>3.2</td>
<td>39.0</td>
<td>32.0–46.0</td>
<td>- .39</td>
<td>.697</td>
<td>.04</td>
</tr>
<tr>
<td>OC</td>
<td>32.1</td>
<td>5.6</td>
<td>31.0</td>
<td>24.0–44.0</td>
<td>38.9</td>
<td>3.6</td>
<td>39.0</td>
<td>29.0–46.0</td>
<td>- .58</td>
<td>.000</td>
<td>.42</td>
</tr>
<tr>
<td>Total</td>
<td>71.4</td>
<td>6.8</td>
<td>71.0</td>
<td>61.0–86.0</td>
<td>78.0</td>
<td>5.3</td>
<td>78.0</td>
<td>64.0–89.0</td>
<td>- .69</td>
<td>.000</td>
<td>.34</td>
</tr>
</tbody>
</table>

Note: ES = effect size; M = mean; SD = standard deviation; Mdn = median; LM = locomotor; OC = object control.
for age and sex. The MANCOVA revealed that age and sex were significant covariates, age: Wilks’ Lambda, $F(3, 88) = 16.606, p = .000$; sex: Wilks’ Lambda, $F(3, 88) = 14.267, p = .000$. Children’s age was a significant covariate for the locomotor, Wilks’ Lambda: $F(1, 90) = 20.644, p = .000, r = .43$, and object control subtests, Wilks’ Lambda: $F(1, 90) = 34.498, p = .000, r = .52$, with older children doing better on the tests. Sex was a significant covariate for the object control subtest, Wilks’ Lambda: $F(1, 90) = 40.976, p = .000, r = .55$, with boys doing better than girls. Adjusted means and standard error are shown in Table 4.

**Discussion**

The aims of the present study were to investigate the qualitative gross motor skill performance of children with visual impairments and its association with the degree of the visual impairment and sports participation. Compared to their sighted peers, there was no difference in performance on locomotor skills, but the children with visual impairments didn’t perform as well on the object control skills. The small adaptations made in the TGMD-2 for the children with visual impairments may have elicited optimal performance and, if anything, reduced the magnitude of differences between the children with visual impairments and the sighted children. Compared to the American norm population, it appeared that Dutch children scored lower for both locomotor and object control skill (each age group). Some skills (criteria) are more typical of the American sport culture than for the Dutch, this may have caused lower performance of Dutch children compared to American children (Kuiper et al., 2000). These results indicate that the use of standardized norms of the TGMD-2 collected on children in the U.S. cannot just be generalized to the Dutch population.

Children with visual impairments often use locomotor skills in nonorganized play and sports activities (Wyatt & Ng, 1997), which may explain the comparable performance of children with visual impairments and sighted children. Children with visual impairments are able to use and practice these skills in the common and familiar environments of the playground, gym, or home, which may have lead to ample movement experience in these skills. Successful performance of these skills in a relatively stable environment, then, seems less dependent on visual information. However, when children with visual impairments are placed in novel or demanding environments (e.g., avoiding obstacles), performance of the locomotor skills will be more difficult. Therefore, it would be interesting to measure these skills in play activities via authentic assessment procedures (Block, Lieberman, & Connor-Kuntz, 1998).

**Table 2. Locomotor and object control scores of children with moderate visual impairment and severe visual impairment**

<table>
<thead>
<tr>
<th></th>
<th>Moderate visual impairment (n = 7)</th>
<th>Severe visual impairment (n = 7)</th>
<th>$W^*$</th>
<th>$p^*$</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>SD</td>
<td>Mdn</td>
<td>Range</td>
<td>$M$</td>
</tr>
<tr>
<td>LM</td>
<td>39.6</td>
<td>2.9</td>
<td>39.0</td>
<td>36.0–44.0</td>
<td>39.3</td>
</tr>
<tr>
<td>OC</td>
<td>30.4</td>
<td>3.7</td>
<td>30.0</td>
<td>24.0–35.0</td>
<td>32.7</td>
</tr>
<tr>
<td>Total</td>
<td>70.0</td>
<td>5.5</td>
<td>69.0</td>
<td>61.0–76.0</td>
<td>72.0</td>
</tr>
</tbody>
</table>

*Note. ES = effect size; $M$ = mean; SD = standard deviation; Mdn = median; LM = locomotor; OC = object control.

*Mean differences in the seven matched pairs and $p$ values according to Wilcoxon’s matched-pairs signed rank test.

**Table 3. Locomotor and object control scores of children with visual impairments who participate in sports and who do not participate in sports**

<table>
<thead>
<tr>
<th></th>
<th>Sports participation (n = 8)</th>
<th>No sports participation (n = 8)</th>
<th>$W^*$</th>
<th>$p^*$</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>SD</td>
<td>Mdn</td>
<td>Range</td>
<td>$M$</td>
</tr>
<tr>
<td>LM</td>
<td>40.6</td>
<td>2.9</td>
<td>42.0</td>
<td>36.0–44.0</td>
<td>37.9</td>
</tr>
<tr>
<td>OC</td>
<td>38.3</td>
<td>5.1</td>
<td>35.5</td>
<td>30.0–44.0</td>
<td>28.9</td>
</tr>
<tr>
<td>Total</td>
<td>76.9</td>
<td>6.4</td>
<td>76.0</td>
<td>66.0–86.0</td>
<td>66.8</td>
</tr>
</tbody>
</table>

*Note. ES = effect size; $M$ = mean; SD = standard deviation; Mdn = median; LM = locomotor; OC = object control.

*Mean differences in the eight matched pairs and $p$ values according to Wilcoxon’s matched-pairs signed rank test.
With respect to the object control skills, the children with visual impairments had lower scores than the sighted children. This was not surprising given that object control skills are less natural for children with visual impairments than they are for sighted children (Winnick, 1985). These skills are more complex, and object control skills are generally used and practiced in situations with (fast) changing conditions in which visual information is the most important source for necessary information about the environment. However, some children with visual impairments obtained high scores on the object control subtest. Thus, it seems these children were able to learn, to a certain standard, the required coordination pattern of most object control skills when environmental and task factors were relatively stable; they would be at a disadvantage compared to sighted children when using these skills, because object control skills are generally practiced and used in play and sport situations that require fast adaptation to changing environmental circumstances. Therefore, it seems plausible that children with visual impairments have less movement experience with object control skills.

For the object control skills, one would expect the advantage of more residual vision to increase, as the complexity of these skills is greater than that of the locomotor skills. However, in this study no differences were found between children with moderate visual impairment and those with severe visual impairment. As for the locomotor skills, a possible explanation may be that the items were tested in a stable environment. In addition, most of the object control items have a more projectile rather than interceptive nature. The use of visual information to perform these items may be less important than for items with a more interceptive character. Another explanation for not finding differences between children with a moderate and a severe visual impairment is that the use of small adaptations, like brightly colored balls, may aid children with a severe visual impairment so they could perform more like the others. Furthermore, classifying children as having a moderate or severe visual impairment may not have been discriminatory enough with respect to the association between the degree of impairment and motor performance and both groups of relatively few children.

Our results indicated that children with visual impairments who participated in sports had higher object control skill scores than children who did not. The present study is partly in line with other studies that investigated the association between physical activity and motor skills in sighted children (Graf et al., 2004; Okely et al., 2001; Ulrich, 1987). However, a possible causal mechanism still remains unclear. It is possible that participation in sports might aid motor development, but it is equally plausible that motor development might stimulate sports participation. We hypothesize that both explanations are partially true and that gross motor skill performance and sports participation are reciprocally related. Further research is needed to investigate the association between sports participation and gross motor skills performance in children with visual impairments by examining the role of prior movement experience or by using a longitudinal design. As Warren (1994) suggested, an important factor in determining the performance of children with visual impairments is opportunity for having movement experience.

In the sighted children, no significant associations were found between motor skills and sports participation. One possible explanation is that sighted children have had plenty of opportunities to practice the skills measured by the TGMD-2, for example, in playing activities. Participation in sports, then, will not lead to clear beneficial effects on developing locomotor and object control skills. Furthermore, we did not specifically focus on the specificity and amount of sports participation and sports-specific motor skills that might have led to finding no associations. As we did find an association between object control skills and sports participation in the children with visual impairments, we speculated that one reason for the results found may have been the extra time children with visual impairments spent on motor skills through sports participation in relation to the limited movement experience in object control skills. Furthermore, these results are in line with Fisher et al. (2005), who suggested that a relationship between motor skills and physical activity would be more important in children with lower motor skill performance.

In conclusion, children with visual impairments have poorer quality object control skills than sighted children. In this investigation, the degree of the visual impairment was not associated with poor gross motor skills performance. Although vision is important for motor skills performance, it is certainly not the sole factor in determining

Table 4. Locomotor and object control scores of sighted children who participate in sports and those who do not participate in sports

<table>
<thead>
<tr>
<th></th>
<th>Sports (n = 77)</th>
<th>No sports (n = 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SE</td>
</tr>
<tr>
<td>LM</td>
<td>39.4</td>
<td>.33</td>
</tr>
<tr>
<td>OC</td>
<td>39.0</td>
<td>.32</td>
</tr>
<tr>
<td>Total</td>
<td>78.3</td>
<td>.48</td>
</tr>
</tbody>
</table>

Note. M = mean; SE = standard error; LM = locomotor; OC = object control
*Group means adjusted for age and sex.
the gross motor skill performance of children with visual impairments. Indeed, continuous interaction exists between factors within the child, the environment, and the task. We suggest that task factors primarily influence the coupling between (visual) information and movement. Hence, the performance of the children with visual impairments depends on the task characteristics. Furthermore, an association between object control skills and sports participation was found in the children with visual impairments.

References


**Authors’ Notes**

The University Center for Sport, Movement, and Health is a joint venture between the Center for Human Movement Sciences and the Center for Sports Medicine of the University Medical Center Groningen, established through grants from the Dutch Ministry of VWS. We wish to express our sincere appreciation to Marijtte van Duijn for advising us in the statistical analyses and to Anita van der Heide and Nanne Bos for their assistance in this research project. We also thank Visio and all the teachers and children who participated in this study.

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