Effects of Increased Physical Activity and Motor Training on Motor Skills, Attention and Learning

An intervention study in school years 1–3 in Sweden

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Abstract

Effects of an extension of Physical Education and extra motor training were studied in a Swedish compulsory school (n=251). The study was hypothetic-deductive and had three hypotheses: 1. Children's motor skills, 2. attention and 3. academic achievements in Swedish and Mathematics will improve with extended physical activity and extra motor training in school. Results showed positive effects on motor skills, attention and academic achievements in Swedish and Mathematics.

Key words: Balance, cognition, coordination, physical education, cognition, screening.

This article is a summary of the doctoral thesis *Motor skills, attention and academic achievements*, written in Swedish with the title Motorik, koncentrationsförmåga och skolprestationer, (Ericsson, 2003). The aim of the thesis was to add to the knowledge about relationship between motor skills and cognition. Effects of an extension of Physical Education and motor training in school were studied in two intervention groups and one control group. The study was hypothetic-deductive and had three hypotheses: 1. Children's motor skills will improve with extended physical activity and extra motor training in school. 2. Children's attention will improve with extended physical activity and extra motor training in school. 3. Children's academic achievements in Swedish and Mathematics will improve with extended physical activity and extra motor training in school.

Materials and methods

All pupils in three school years at one compulsory school were studied until school year three. The two intervention groups had Physical Education and physical activities on the schedule five lessons per week and also if needed one extra lesson (45 minutes) of motor training per week. Physical Education was increased from two to three lessons per week and different local sports clubs had physical activities based on playful motor training two lessons per week.

An important goal of the intervention was for pupils to feel motivated and enjoy taking part in physical activities. Children who needed extra motor training were offered this according to the *MUGI model* - Motor skills as Foundation for Learning (in Swedish: Motorisk Utveckling som Grund för Inlärning) (Ericsson, 1985-87), an education program, which started in Lund in the early 1980s. An evaluation of the MUGI model had shown that the motor training had positive effects on children's motor control, perception and ability of remembering details (Ericsson & Lindström, 1987).

The control group had only the school's regular Physical Education two lessons per week. As the project started in the autumn of 1999 school year one consisted of three classes (intervention group 1), school year two of four classes (intervention group 2) and school year

three of five classes (control group). All parents were informed and gave their written consent; only two pupils did not participate in the study. In total 251 pupils were included in the study; 152 and 99 in intervention and control group respectively.

In order to study development of motor skills in relation to physical activity in school, motor skill observations with the MUGI observation scheme (Ericsson, 1998) were conducted by the school nurse and the children's teachers at project start, in school year two and in school year three. How children with difficulties in motor skills and attention were affected by the intervention was studied with special interest. The MUGI observation scheme consists of nine gross motor tasks measuring two variables of motor skills: *balance/bilateral coordination,* e.g. hopping and balancing on one leg and *eye-hand coordination* with tasks like throwing, bouncing and catching a ball.

Conners´ 10-item abbreviated questionnaire (Conners, 1999) concerning the pupils' attention was answered by the teachers every year and by the parents at the project start and in school year three.

School results in Swedish and Mathematics were also studied in relation to motor skills. Results from Reading development tests were obtainable for most of the pupils in the control group (n=62) already from autumn term in 1997 when they started school. Results from the national tests in Swedish and Mathematics were collected during spring term in school year two. In school year three the pupils were given a word test and a reading test, consisting of five short essays with questions about the contents.

Validity and reliability

The Reading development tests used in this study is a commonly used test in Swedish schools as are the national tests in Swedish and Mathematics. Also the word test and the reading test given in school year three had earlier been used in a national evaluation. These tests were considered to be valid for measuring academic achievements in the age groups of this study.

After motor skill observations with the MUGI motor observation scheme of 245 pupils in the school years 1-2, an exploratory factor analysis was carried out, i.e. 9 items were rotated to a varimax solution. Two components were found: Component 1 measuring *balance/bilateral coordination* (item 3, 4, 5, 6, 7 and 8) and component 2 measuring *eye-hand coordination* (item 1, 2 and 9). All variables had a loading between 0.50 and 0.80, which means that all tasks were relevant to measure the two components of motor skills. The balancing tasks 4, 5 and 8 grouped together, with static and dynamic balance not separated. The lack of separation was consistent with findings in other studies and indicated that there was no need for separate subtests to measure balance (Bruininks, 1978; Keogh & Sugden, 1985).

A test of reliability with Cronbach´s alpha showed the following values for the two components of motor skills: 0.76 for balance/bilateral coordination and 0.65 for eye-hand coordination. A sum of all items gave the value 0.80. One would have wished for higher reliability values, especially for the component eye-hand coordination. However, the values show that the MUGI observation scheme is reliable enough for comparing groups. The sum value of 0.80 is quite acceptable, considering the number of tasks in the observation scheme being so few.

An exploratory factor analysis was also carried out of Conners´ 10-item abbreviated questionnaire. Teacher's ratings of 245 pupils in school years 1-2 were rotated to a varimax solution. Two components were found: Component 1 measuring *attention/hyperactivity* (item 1, 3, 4, 5 and 6) and component 2 measuring *impulse control* (item 2, 7, 8, 9 and 10). All variables had a loading between 0.70 and 0.91, which means that all questions are highly relevant to measure the two components of attention ability.

A test of reliability with Cronbach´s alpha showed the following values for the two components of attention: 0.89 for attention/hyperactivity and 0.88 for impulse control. A sum of all items gave the value 0.92. The values show that Conners´ 10-item abbreviated questionnaire is reliable. The sum value 0.92 is very high, considering that the questionnaire has only 10 questions.

Statistical Analyses

Collected data have been analysed in the program Statistical Package for the Social Sciences SPSS (Aronsson, 1994). Non parametric tests (Kruskal-Wallis and Mann-Whitney U test) were used to study differences in motor skills, attention and academic achievements between the groups. The Wilcoxon Signed Ranks Test was used to compare pre to post changes. All comparisons between intervention and control group were made when the pupils were the same age. To make presentation of the results easier to follow, the two intervention groups are considered as one (n=152) when comparing results with the control group (n=99).

The sample in the study was not randomised, which means that the sample is not strictly representative of a larger population. However, since the study included all pupils in the school years 1-3 at one compulsory school and since base line data concerning motor skills and attention were consistent with other studies the results may still be generalised to other similar populations. According to this, analyses of significance (One-Way ANOVA) have also been used to study differences between intervention and control group. An alpha level of 0.05 has been used for all statistical tests.

In order to estimate differences between the groups, Cramér´s index and values of eta squares have been used. Cramér´s index lower than 0.22 is considered to be a small difference, 0.22-0.30 a rather large/moderate and above 0.30 means a large/major difference. Differences with values of eta squares smaller than 0.05, between 0.05-0.09, and greater than 0.09 are considered small, rather moderate and large/major respectively.

Base line data, external and internal validity

The pupils in the intervention group and in the control group were as alike as possible concerning the following demographic aspects. They all lived in the same area and 15 of the children in the intervention group had the same parents as 15 children in the control group. 11% of both groups spoke another language at home than Swedish. There were no significant differences between the groups concerning the pupil's age or mothers´ or fathers´ education. Circa 40% of both fathers and mothers in both the intervention and the control group had higher education (from university). Parents´ attitudes to physical activity and reported time spent in physical activity were not significantly different between the groups.

Contextual school factors were similar for intervention and control groups. All pupils were educated by the same teachers and the school's three special teachers gave the same amount of special education in Swedish and Mathematics in both groups. Education in motor skill observation and motor training was given to the teachers in the same way in both intervention and control group. The pupils in the control group took part in all the school's health promoting activities except for the increased physical activity and the extra motor training.

All together the pupils in the intervention group and the control group were considered to be alike, concerning school situation and demographic background.

Base line data concerning motor skills and attention were consistent with results from other studies (e.g. Hendersen & Sugden, 1992; Gjesing, 1997, Gillberg, 1981; Kadesjö & Gillberg, 1999; Kadesjö, 2000).

Results

The results from motor skill observations confirmed the first hypothesis of the study that children's motor skills improve with extended physical activity and extra motor training in school. The Wilcoxon Signed Ranks test showed significant improvement from pre to post test in the intervention, but not in the control group. After one year, the pupils in the intervention group had better motor skills than pupils in the control group and the differences between the groups were rather large (Cramér's index 0.24). In school year three the differences were very large (Cramér's index 0.37) and largest in the variable balance/bilateral coordination. When the project started, the pupils in the control group had significant better motor skills than the pupils in the intervention group (which is logical since they then were older than the pupils in the intervention groups).

Both boys and girls improved significantly in motor skills and the differences between them decreased with extended physical activity and extra motor training in school. In the control group, however, differences between boys´ and girls´ motor skills increased from school year two to school year three. But in the intervention group there were no significant differences, neither in balance/bilateral coordination nor in eye-hand coordination between boys and girls in school year three. At this point, 90% of the boys and 94% of the girls had good motor skills. The corresponding values in the control group were 46% and 83% respectively.

In the intervention group, pupils with deficits in attention improved significantly in motor skills, while motor skills for pupils with similar difficulties in the control group did not improve.

In the control group, which had the school's ordinary Physical Education, there were no significant differences between pre and post test for pupils with small and large deficits in motor skills. This indicates that motor skill deficits do not disappear by themselves, and that the school's two lessons of Physical Education per week are not sufficient to stimulate improvements in motor skills for these pupils. These results are in line with other studies (Cratty, 1997; Cantell, 1998; Kadesjö & Gillberg, 1999; SEF, 2000), which confirm that without any remediation program many children with deficits in motor skills will keep these problems for many years.

Attention

The second hypothesis of the study, that children's attention will improve by extended physical activity and extra motor training in school, could only be confirmed by the results regarding girls and children with large motor skills deficits. The pupils in the intervention group improved significantly (Wilcoxon Signed Ranks test, $p<0.05$) and had significant better attention according to teachers, after one and two years of intervention than the pupils in the control group (Mann Whitney U test, $p<0.05$). This was true for both pupils with good attention and pupils with small or large deficits in attention at the start of the project. In school year two, there were significant differences between the intervention and control group in both variables attention/hyperactivity and impulse control, as well as in total attention. But the differences were small and did not remain in school year three, which makes it hard to draw any conclusions about whether the pupil's attention had been affected by the intervention or not.

For girls there was a positive change in attention according to parents' opinions. In school year three there were no significant differences between girls in intervention and control group, although girls in the intervention group had significant worse base line values for attention when the project started than the girls in the control group.

Additionally, for children with large motor skills deficits who received extra motor training, positive effects on attention remained from school year two to three according to both parents and teachers.

Academic achievements in Swedish and Mathematics

The third hypothesis of the study, that children's academic achievements in Swedish and Mathematics will improve with extended physical activity and extra motor training in school,l could be confirmed by several parts of results in the study.

In school year two the pupils in the intervention group had better results than the pupils in the control group in the national tests of Swedish, especially when it comes to writing and reading. In reading and writing ability there were clear connections (Cramér's index 0.27) between results and group belonging, which means that the pupils in the intervention group performed significantly better than the pupils in the control group. Also in Swedish overall, the difference between results for pupils in intervention group and control group were rather large (Cramér's index 0.29).

Pupils who had extended physical activity and extra motor training in school also had better results in national tests of Mathematics than pupils who had only the school's ordinary Physical Education. This was especially true concerning room conception/spatial ability and number conception/thinking proficiency, where the differences were significant. The largest difference in Mathematics between intervention and control group was in the results concerning room conception/spatial ability (Cramér's index 0.22). Also in Mathematics overall, the differences were significant (Cramér's index 0.21).

For boys, the results indicated that extended physical activity and extra motor training in school could be of importance for achievements in Mathematics. Apart from room conception, i.e. spatial ability, and number conception/thinking proficiency, there were also significant differences between boys in the intervention and control group in logical thinking and creativity; in other words, in all parts of the national tests of Mathematics being investigated in this study.

For pupils with deficits in motor skills, the results showed significant differences between the groups. Pupils with small and large deficits in motor skills at the project start, who had extended physical activity and extra motor training in school, had significantly better results in all measured parts of the national tests of Mathematics and in three of four measured parts of the national tests of Swedish than pupils in the control group with similar deficits, but who had only the school's ordinary Physical Education.

Discussion

The results of the study are encouraging. However, the studied groups of pupils were not randomized samples and therefore not strictly representative of a larger population. We also don't know whether the positive effects in academic achievements noticed in this investigation will be sustained beyond school year three. Therefore more controlled studies are required in order to be able to make general conclusions about the effects of increased motor training in school.

One effect of the project could be that more physical activity and movement enjoyment in school have led to a spirit of community and a general increase in comfort with school work, which could have had positive effects also for the pupil's academic achievements. Furthermore it cannot be excluded that the teachers have expected a positive intellectual development and therefore been more attentive and encouraging to the pupils in the intervention groups than usual. This positive attention could have made the pupils more motivated so that they also learnt more. In this case however, the teachers' expectations are

still caused by the intervention, which then have had indirect effects on the pupils´ academic achievements.

The results indicate that extended physical activity and extra motor training in school are of great importance to pupils with small and major deficits in motor skills, but also to pupils with small and major deficits in attention when it comes to their development in motor skills. Motor training seems to be more important the larger the deficits in motor skills displayed by the pupils; similarly when it comes to academic achievements in Swedish and Mathematics. One may assume that motor skill observations at the school start could be a useful pedagogic instrument to predict academic achievements in Swedish and also in Mathematics during the first three school years. Furthermore, the results indicated that differences in academic achievements between pupils with good motor skills and pupils with deficits in motor skills may decrease with extended physical activity and extra motor training in school.

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