Astrid N. Sjølie and Erik Mønness

Does a 20 minute walk every day for one year produce benefits in physical performance of school children?

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Summary:

Background
There are theories that low levels of physical activity in childhood and adolescence may cause reduced physical performance. Walking for transport seems to be less now than before. The aim of the study was to assess health benefits of twenty minutes daily walking during one school year for children of age 6-14.

Methods
In a rural school in inland Norway all school children joined a project of walking for twenty minutes on different trails each day for one year. Measurements of low back static endurance, hamstrings flexibility, standing balance and cardio-vascular fitness were made before and after the intervention.

Results
Age-adjusted analyses showed eleven per cent increase in low back static endurance, eight per cent increase in hamstrings flexibility, 69% increase in balance, and six to thirteen per cent increase in cardio-vascular fitness. The effects were largest among those children who had the lowest performances before the intervention.

Conclusions
The results indicate that twenty minutes daily walking performed for one year may increase physical performance in school children.

Høgskolen i Hedmark

Tittel: Gir en tyve minutters daglig gåtur i ett år helsegevinster i form av fysisk ytelse hos skolebarn?

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Erik Mønness, Høgskolen Hedmark

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Oppdragsgiver:

Emneord: Fysisk ytelse, gåing, skolebarn

Sammendrag:

Bakgrunn
Det finnes teorier om at lav fysisk aktivitet in barndom og ungdom medfører redusert fysisk bevegelsesevne. Det å synes som om folk går mindre enn før for transport. Hensikten med dette arbeidet er å finne ut om det er en målbar helseeffekt av å gå tyve minutter daglig i skoletiden, for elever i alderen 6-14 år.

Metode
I en skole i Alvdal kommune i Norge deltok alle elever i et prosjekt som gikk ut på å gå tyve minutter daglig i et år. Turen gikk på ulike stier i terrenget. Det ble målt statisk ryggstyrke, hoftebevegelighet, stående balanse samt hjertefrekvens før og etter tiltaket.

Resultat
Aldersjustert analyse viser elleve prosent øking i ryggstyrke, åtte prosent øking i hoftebevegelighet, 69 % økt balanse, 6-13 % bedret hjertekapasitet. Effekten er størst blant de barna som hadde lavest ytelse i utgangspunktet.

Konklusjon
Resultatene indikerer at tyve minutters daglig gange i ett år bidrar til økt fysisk ytelse hos skolebarn

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BACKGROUND

As our lifestyle becomes increasingly passive in the industrialised world, there are some indications that physical health of young people is declining, although the literature is sparse on the subject. There are theories that the steadily increasing amounts of sitting in daily life may constitute a risk for poor physical health, including a variety of disorders (1, 2). Results from the cross-cultural Kraus-Weber-investigation in the 1950s indicated a reduction over time in trunk strength and mobility among school children (3). Findings in a recent Swedish study comparing 16-year old adolescents in 1974 and 1995 indicated a decrease in hip mobility over time (4). Several recent studies indicate a decrease in cardio-respiratory fitness among children and adolescents from 1980 till 2000 (5). A large Norwegian study comparing physical performance of 15-year old adolescents in 1968 and 1997 concluded that low back extension endurance, ankle mobility and co-ordination were poorer in 1997 than in 1968 (6). Cross-cultural differences in physical performance have been found between European and American school children (7), and between Arabs and Chinese adults versus Caucasians (8, 9).

Walking to school is a mode of physical activity that has been in decline from 1985 till 1992 according to British and Norwegian surveys (10, 11). Some studies indicate that use of school bus is associated with low levels of physical performance, and that regular walking is associated with higher levels of physical performance (3, 7, 12, 13). The headmaster at a small Norwegian rural school, where most children used school bus, was worried because of an impression of a decline in physical performance in the pupils over time, and wanted by simple means to improve their physical health.

Aims

The aim of the present study was to explore if short daily walking trips, performed for one year, would produce health effects in primary school children. The hypotheses were that walking would increase low back extension endurance, balance, hip mobility and cardio-vascular fitness.

METHODS

Material

The study population included all the 105 pupils in January 2001 at Plassen primary school, which is one of the two primary schools in the Alvdal municipality of Eastern Norway. The children's age varied from six to fourteen years in school year one to seven, respectively. Approximately three quarters of the children were bussed to school, due to long distances and a heavy traffic on the surrounding roads. However, the bussing pattern was varied, making it impossible to incorporate this effect in the project. A green area of forest and a river surrounds the school, with good opportunities for hiking. The headmaster insisted that all children at the school should join the project, and gave ethical and practical reasons for that decision. The school council was informed about the study and gave their consent in spring 2000. All parents and children were informed by several information letters and in several meetings about the project during the year 2000. As the study was initiated and conducted by the school, passive informed consent from the children and their parents was sufficient, according to Norwegian law at that time. One child informed in a letter, signed by the parents and herself, that she did not want to be measured. Another child was excluded due to a hip fracture in December 2000 that resulted in wheel chair use at the start of the project. One hundred and three pupils were measured in January 2001 a few days before the project started, and 85 were re-measured in January 2002. Three pupils had moved to other municipalities, and all pupils in school year seven had moved to the junior secondary school in the municipality. Thus the data consist of 100 measurements before the project started and 85 measurements afterwards.

Physical measurements

The procedure of the measurements followed a written manual, which described in detail the measurements. The tests were performed in the same sequence between 9am and 2pm in two adjoining rooms at the school, where the temperature was kept at 21°C. The same equipment was used for all children, and was identical at both occasions except for a pulse measure. None of the pupils had joined physical education classes or swimming the day they were examined. The tests of the low back, hip mobility and standing balance was performed by a trained physiotherapist, while the fitness test was done by a teacher of physical education.

Low back extension endurance *was measured as static endurance in accordance with Alaranta´s modification of Sorensen´s test (14). From a prone forward bent position, with the iliac crest on the edge of the couch while stabilized by the ankles with one strap, the children elevated the upper half of their bodies to the horizontal plane, as marked by a measure stick. The elevated position of the trunk should be kept as long as possible up to 4 minutes. Endurance time was measured in seconds by a stopwatch.*

Hip mobility *was measured as hamstrings flexibility by Active Knee Extension Test (15) with a prolonged steel goniometer which displayed singular degrees. The right hip was measured, or the left hip in case of minor traumas on the right side that could influence the performance. The knee was stabilized with a locked Don-Joy–orthosis, and the lumbar region was stabilized with the pupils' own hands in the back.*

Standing balance *was measured as time spent standing fixed on one foot up to one minute, while the eyes were closed (16). Standing time was measured in seconds by a stopwatch.*

Cardio-vascular fitness *was measured by the step-test (17). The heart rate was measured electronically after the pupils had ceased walking up and down on a 25 cm bench for four min, keeping a steady speed in accordance with a metronome set at 120 beats per min. The heart rate was measured. The heart rate was measured immediately after the performance, one minute afterwards, and two min afterwards. The measure device was Polar*

Accurex + in 2001, and Timex Ironman in 2002, because the Polar device was out of function in January 2002.

The intra-tester reproducibility of the testing physiotherapist was previously assessed by two measurements on 11 healthy persons, made at two weeks interval. The correlations (Pearson's **R**) between the tests of low back endurance, hamstrings flexibility and balance were 0.98, 0.89 and 0.95, respectively, and the corresponding coefficients of variance (standard deviation of difference divided by the mean of the means) were 4.8%, 9.6% and 19.8%, respectively. The correspondence between the two heart rate measure devices was tested by simultaneous measurements on eight pupils immediately after they had performed the stepping for four min, and repeated one min afterwards. The correlation was 1.0 for both occasions, and the corresponding coefficients of variance were 1.8% and 3.5%.

Statistical methods

Each property is measured on each pupil at the start of the experiment, and one year later, as a repeated measurement design. However, "intervention" and "age increase" will be confounded. Since body control and strength are in major development in these age groups this issue must be addressed. Establishing a control group is both unethical and impractical. Unethical, because the headmaster did not want to divide the class and exclude some children from the walking, impractical, since any control group probably would have seen it as a competition and started to practice for themselves. However, it is possible to adjust for any age effect by utilization the data as explained below.

Let Y_{cji} be the property in question, measured at school year c, $c=1\ldots7$, on pupil j, $j=1\ldots100$. The index $i=0$ indicate "before intervention", and $i=1$ indicate "after the intervention". The measurements have the following pattern (Table 1):

	School year 1	School year 2	School year 3	School year 4	School year 5	School year 6	School year 7
Before intervention, *i=0*	Y_{1j0}	Y_{2j0}	Y_{3j0}	Y_{4j0}	Y_{5j0}	Y_{6j0}	Y_{7j0}
After intervention, *i=1*		Y_{2j1}	Y_{3j1}	Y_{4j1}	Y_{5j1}	Y_{6j1}	Y_{7j1}

Table 1. The measurement pattern. Y_{1j0} and Y_{2j1} are the measurements before and after the intervention on the same pupils, Y_{2j0} and Y_{3j1} are the measurements before and after the intervention on the same pupils, etc.

There are of course no measurements after intervention corresponding to school year 1, and we do not know how the pupils in school year *7* measured before the intervention performed a year later, as they have left the school. The development of the “Before intervention” data, from school year to school year, can mimic a control group, yielding an estimate of the average effect of growing up, with no intervention effect involved. This effect can thus be subtracted to allow for a measure of intervention effect that is not confounded with the average age effect.

Let $\Delta Y_{cj} = \left(Y_{cj1} - Y_{c-1j0}\right) - \left(\overline{Y_{c\bullet 0}} - \overline{Y_{c-1\bullet 0}}\right)$, *c=2…7* and *j=1…85.*

(There are only 85 “after intervention” measurements). $\overline{Y_{c\bullet 0}}$ is the mean of the pupils in school year *c* before intervention. The first set of brackets $\left(Y_{cj1} - Y_{c-1j0}\right)$ measure the change of an individual pupil’s performance, including his individual intervention effect and his individual ageing effect. This measures the “change from baseline”. The second set of brackets $\left(\overline{Y_{c\bullet 0}} - \overline{Y_{c-1\bullet 0}}\right)$ estimate the average ageing effect. The ΔY_{cj} thus estimate the individual pure intervention effect when the average effect of aging has been removed. Any gender effect on the property level Y_{cji} has also been removed from ΔY_{cj}. However, any effect of “society change during a year” is not addressed by this method.

If the intervention does not have any effect the expectation of ΔY_{cj} will be zero.

Between school years, the ΔY_{cj} will only be statistically dependent between adjacent school years. This dependence is the penalty of not having an independent control group. Within a school year, there is dependence since $\left(\overline{Y_{c\bullet 0}} - \overline{Y_{c-1\bullet 0}}\right)$ is constant for all pupils within the school year, but this does not

alter the individual differences. It is possible but tedious and extensive to adjust for the dependence when calculating the significance levels and we believe the statistical correction to be of minimal effect. Only the standard errors of the estimated effects are slightly underestimated, not the estimated effects themselves. Thus the significances are as if the ΔY_{cj} s are statistically independent. We will use ΔY_{cj} as the dependent variable a linear model with intervention, school year, gender and the individual before intervention performance level (Y_{cj0}) as the independent variables.
All calculations are performed by ordinary least squares regression, using SYSTAT 9.0 (18).

Intervention

The intervention consisted of 20 minutes daily walking during school hour. Different rugged forest trails, 1.5-2 km long were used, providing opportunities for a variety of gradients, steepness, climbing and balancing. The pupils walked in class groups, lead by their teacher. The walk was performed for every school day from 2.2.2001 till 2.2.2002, except for three days when the walking was substituted by indoor physical activity because the weather was too cold (-30ºC or below). All pupils joined the walking all days; no one ever tried to withdraw or had letters from the parents claiming non-participation any time.

RESULTS

Mean values before and after the intervention in total and for the different school years are displayed in Table 2.

	Intervention	School year means 1	2	3	4	5	6	7	School mean	St. error of the mean
Balance,	before	7	10	10	15	16	21	31	16	1.51
Seconds	after		14	27	25	28	39	35	29	2.23
Hamstrings,	before	66	79	67	65	74	76	75	72	1.17
Degrees	after		74	84	73	80	78	80	78	1.12
Back endurance,	before	58	97	89	111	139	183	209	130	7.64
Seconds	after		97	160	138	148	188	191	155	8.10
Heart rate 0 min.	before	157	142	154	164	158	157	149	155	1.75
after step-test	after		154	144	143	150	143	143	146	1.66
Heart rate 1 min.	before	95	99	96	100	90	94	88	95	1.69
after step-test	after		83	81	81	85	82	80	82	1.38
Heart rate 2 min.	before	92	86	95	93	84	86	84	89	1.46
after step-test	after		73	75	74	80	77	75	76	1.27
No. of pupils	before	6+5	6+6	13+2	7+11	12+2	5+10	9+6	58+42	
Boys+ girls	after		6+5	6+6	13+2	7+11	12+2	5+10	49+36	

Table 2: Means of physical performance before and after the intervention by school year, and number of pupils

There was a clear significant intervention effect on all measured properties (Table 3).

				95% CI		% performance increase
	Means	SD	P value	Lower	upper	
Δ Balance, seconds	11.11	2.09	0.00	6.95	15.27	69%
Δ Hamstrings, degrees	5.59	1.10	0.00	3.41	7.77	8%
Δ Back endurance, seconds	13.89	6.31	0.03	1.34	26.45	11%
Δ Heart rate 0	-8.99	1.49	0.00	-11.96	-6.03	-6%
Δ Heart rate 1	-12.17	1.71	0.00	-15.57	-8.78	-13%
Δ Heart rate 2	-12.03	1.54	0.00	-15.10	-8.97	-14%
Δ Heart rate 0-1	-3.20	2.03	0.12	-7.23	0.83	5%
Δ Heart rate 2-1	-3.04	1.91	0.12	-6.84	0.76	5%

Table 3: Overall intervention effect on physical performance of the entire examined population: Means, Standard Deviations (SD), 95% confidence interval (CI), and performance increase in per cent. “Hart rate *number*” means “number minutes after step-test”**.**

Balance was improved by 69%, heart rate one and two minutes after the step test was reduced by about 14%, and low back endurance was increased by eleven per cent. However, the decline in heart rate was not significant with this model.

The next hypothesis is that the intervention effect also varies with school year, sex and the property level before the intervention (Table 4).

Δ Balance	Estimate	df	F-ratio	p-value
Intervention		1	20.03	0.00
School year		5	1.25	0.29
Gender		1	0.29	0.59
Balance before	-0.35	1	3.08	0.08
Δ Hamstrings	Estimate	df	F-ratio	p-value
Intervention		1	42.43	0.00
School year		5	15.86	0.00
Gender		1	4.02	0.05
Hamstrings before	-0.41	1	30.74	0.00
Δ Back endurance	estimate	df	F-ratio	p-value
Intervention		1	11.81	0.00
School year		5	3.59	0.01
Gender		1	0.20	0.66
Endurance before	-0.23	1	5.87	0.02
Δ Heart rate 0	estimate	df	F-ratio	p-value
Intervention		1	13.68	0.00
School year		5	11.31	0.00
Gender		1	2.92	0.09
Heart rate 0 before	-0.34	1	19.25	0.00
Δ Heart rate 1	estimate	df	F-ratio	p-value
Intervention		1	44.84	0.00
School year		5	3.61	0.01
Gender		1	5.92	0.02
Heart rate 1 before	-0.64	1	72.92	0.00
Δ Heart rate 2	estimate	df	F-ratio	p-value
Intervention		1	34.78	0.00
School year		5	5.19	0.00
Gender		1	8.71	0.00
Heart rate 2 before	-0.61	1	59.00	0.00
Δ(Heart rate 1-heart rate 0)	estimate	df	F-ratio	p-value
Intervention		1	76.51	0.00
School year		5	12.34	0.00
Gender		1	1.00	0.32
(Heart rate1 –Heart rate0) before	-0.85	1	67.44	0.00
Δ(Heart rate2-Heart rate0)	Estimate	df	F-ratio	p-value
Intervention		1	51.75	0.00
School year		5	8.05	0.00
Gender		1	0.34	0.56
(Heart rate2 –Heart rate0) before	-0.73	1	45.41	0.00

Table 4: Testing the intervention effect by school year, gender and initial performance

The intervention effect on balance was not affected by school year. Else the intervention effect was depended by school year and performance level before the intervention, giving more effect for those displaying lower values of physical performance initially. Gender was of minor influence.

DISCUSSION

The main findings in this study were that physical activity in the mode of daily walking for twenty min during one school year increased significantly low back extension endurance, hamstrings flexibility, standing balance and cardio-vascular fitness in children. The health effects were strongest among those children who had the poorest physical performance before the intervention.

All statistical significances are from a two sided test. Since a negative effect (in body sense) could be disregarded, the significance is even stronger. As the sample is small the results must be interpreted with caution. We have tried to adjust the data for the age effect on body development. Even if this introduces dependence in the data, we believe this is better than just ignoring this effect, as one would do applying a plain repeated measurement design. The adjustment is based on the assumption that there is some kind of monotone ageing trend in body strength and control. However, the data from “school year 2 before intervention” shows the highest hamstring value, they have a high back strength and they have the lowest pulse rate just after the step test. All these values are better than expected if one anticipate a monotone age trend. Also (not shown), the girls entering “school year 7 after the intervention” had worse balance results than they did in “school year 6 before intervention”. Our adjusting method is vulnerable to such odd pattern.

The reliability and validity of the test of low back extension endurance was tested previously among adolescents (19). An identical test of hamstrings flexibility among school children showed good reliability and validity (20),[and Active Knee Extension Test was also tested for reliability and validity among adults (15). The balance test had the poorest reliability in our test of adolescents. The test was also easy to remember and to perform, and the pupils may have practiced the test for themselves. These factors may have influenced the high effect value on balance.

Leisure physical activity was not measured, and may have been another error source, as the mentioned bussing pattern. The opinions of the teachers were that organised physical activity was comparable in 2001 and 2002. There is a possibility that the experiences of walking at school may have induced more unorganised leisure activity among the children, like walking or bicycling for transport or for fun. As could be expected, the pupil's individual physical performance before the intervention influenced the effect of intervention, as the effect was highest among those needing it most. For every reduction of one unit of hamstrings flexibility, low back static endurance and heart rate before the intervention, the intervention effect was increased by 0.4, 0.2 and 0.3 units, respectively (Table 4).

Our data confirm theories from the Kraus-Weber-investigations, which postulated that a passive lifestyle of seldom walking and much time spent in cars, buses and in front of a television were the main causes of cross-cultural differences in physical performance in the 1950s between American and European children, and of a secular trend in European children of poorer physical performance (3, 7). Regular walking or bicycling was associated with increased low back endurance and hip mobility in a Norwegian cross-sectional study of 15-year old adolescents (13). School children who walked or bicycled 2-4 km one way to school had better cardio-vascular fitness than those walking or bicycling shorter distances in a large Norwegian study (12).

Walking is postulated to enhance physical performance and prevent a variety of disorders (21). Walking to school was inversely associated with low back pain in a Belgian prospective study (22). The increase of low back static endurance and hamstrings flexibility may reduce the risk for the development of low back pain, as these factors were inversely associated with low back pain in some studies (23, 24).

Studies of adults have also found health benefits from walking. Eight km walking on a golf course 2.5 times a week for 20 weeks increased low back static extension and cardio-vascular fitness, but not balance in a Finnish trial of sedentary 45-65 year-old males (25). One hour walking or bicycling to work for ten weeks increased cardio-vascular fitness in inactive middle-aged Finnish men and women (26).

The need for more physical activity during childhood and adolescence seems to be urgent, as recent studies indicate a sedentary lifestyle in both youngsters and adolescents. A Scottish study following three year-old children two years ahead showed by using objective measures that median percentage time spent in moderate to vigorous physical activity of monitored waking hours was only two per cent at the age of three and four percent at the age of five (27). A recent Norwegian study of 15-year old adolescents found that 45% participated less than one hour per day in moderate physical activity (28). The low levels of physical activity constitute risks also for e.g. development of obesity, cardio-vascular diseases, a high blood pressure, diabetes, type 2 and osteoporosis (1). Various health promotion initiatives are planned in US to inspire people to increase light physical activity like some daily walking (29). Motivational strategies of walking are probably insufficient and should be accompanied by environmental planning in the communities of walking trails (30).

CONCLUSION

Our findings indicate good health effects of short, but frequent and persistent walking. The effects were largest among those with an initial poor physical performance. The model of daily walking for short periods during school time may thus be a relevant means to improve physical performance in children.

CONTRIBUTIONS

Astrid N Sjølie has elaborated the study, made the field work and elaborated the manuscript. Erik Mønness has done the statistical modelling, calculations and partly written the manuscript, after the field work was finished.

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