Effect of 5-versus 3-lessons-a-week physical education program upon the physical development of 12 and 13 year old schoolboys

by

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Introduction

The importance of physical exercise in relation to the development of children in its widest sense has generally been accepted.[5 18 1 28] On one hand physical activity among young people in Western European countries continually decreases: amongst other reasons this hypokinesia is caused by the continually decreasing availability of play and recreation-grounds in and near the large cities. On the other hand the abundant uptake of foodstuffs with a high fat percentage does exceed the daily caloric intake above caloric output. This is the reason why it appears to be essential to raise the level of physical activity of the pupils by increasing the number of weekly lessons in physical education. At most schools in the Netherlands the number of lessons varies from 2 to 3 lessons a week. In the various curricula for physical education one finds the aims of physical education described as follows[21]: "The object of physical education is (a) to promote a favourable influence on the development of the body, (b) to promote a good bearing and stature, (c) to increase the willingness and ability to produce bodily achievements . . .". Whether it is, indeed, possible to realize these aims more fully if 5 lessons a week in physical education are given instead of 3 has never been scientifically examined in our country with 12 and 13 year old boys. In the literature the effects of extra lessons in physical education on growth and development of children have been investigated by many authors.[37 6 8 17 33 20 30 9 10 4 15 25 7 3 14 19 22 23 24 12 34 2 31] The inconsistancy in the results of these studies concerning the effectiveness of physical education can partly be explained by differences in content, duration and frequency of the physical education programs. Moreover most of the experiments deal with subjects who also differ in age and sex. In our opinion there could be other reasons that mask the possible effects.

The purpose of the present study was to investigate the effects of a 5 versus a 3-lessons-a-week physical education program during a whole schoolyear upon the development of 12 and 13 year old boys considering as interfering variables biological age, habitual physical activity of the subjects and teaching behaviour of the teachers of physical education.

For this project a grant had been awarded by the Foundation for Educational Research (SVO) and the Ministry of Health and Environmental Hygiene in The Hague, the Netherlands (project number 0185).

METHODS

Subjects

Subjects were boys of the 4 first forms of a secondary school, the St. Ignatius College, in Amsterdam. From 82 boys 12 boys dropped out of the study for medical and technical reasons. The physical characteristics of the 70 boys at the beginning of the school-year 1971-72 are presented in Table 1. The weight-for-height relation in our subjects was compared with Dutch boys.[35] Values lie within the normal range between the 90th and 10th percentile.

TABLE 1.—*Pretest scores (mean, standard deviation and range) of anthropometric and physiologic characteristics of the subjects* (n = 70).

Characteristics	Units	$\bar{x}$	S.D.	Range
Chronological age	year dec.	12.5	0.4	1.8
Weight	kg	41.5	6.3	27.3
Height	cm	155.0	7.4	38.9
Corrected upperarm diameter	cm	5.2	0.3	2.0
% fat	%	17.8	3.6	16.6
FEV%	%	87.1	6.3	25.0
W_{170}	Watt/kg	2.68	0.6	2.4
Handgrip	kg	21.8	4.8	21.0
Vertical jump	cm	29.0	5.0	29.0
Bent arm hang	sec	20.1	10.4	44.0
50 shuttle run	sec	14.1	0.7	3.0
Sit and reach	cm	27.3	6.0	24.0
Plate tapping	sec	20.7	2.2	12.6

Independent variable

The independent variable was the frequency of lessons of physical education a week. Two classes were assigned by lot as experimental and two classes as control group (Fig. 1). The usual number of 3 lessons of physical education a week were given to the control group and 5 lessons of physical education a week to the experimental group. The 2 extra lessons had been added to the time table in such a way that the experimental group received 34 instead of 32 lessons a week. The pupils themselves were not told of the difference in p.e.-program; in the course of the year they accepted this as a "normal" part of the curriculum.

The two extra lessons can be seen as quantitative extension of this curriculum.

Each class had its own teacher of physical education. To prevent differences in the content the program was controlled by way of predesigned lessons. These lessons were given in the same working order as uniform as possible. Independent experts stated that the quality of the lessons was rather good and only minor differences between teachers could be demonstrated.

Dependent variables

In a pretest-posttest control group design groups of dependent variables were measured at the beginning (pretest) and at the end (posttest) of the schoolyear. According to the recommendations of the International Biological Program [35]

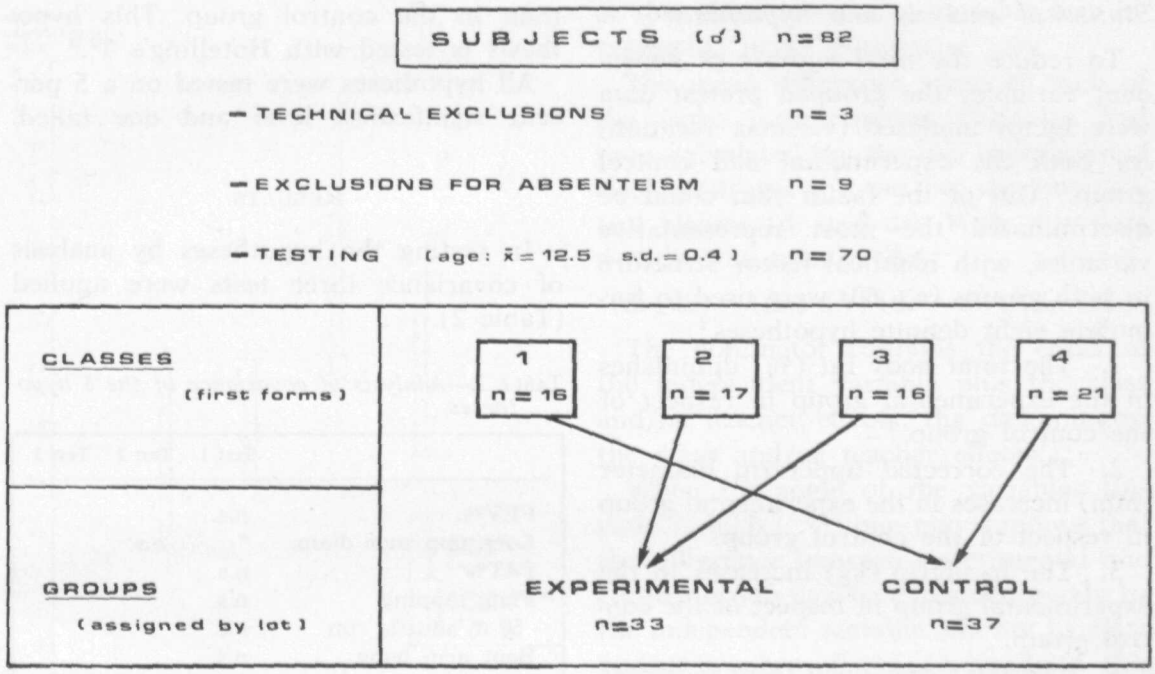

Fig. 1.—Design of the study with number of subjects divided in classes and groups.

(IBP) the following variables have been measured:

1. Anthropometric variables, measuring body build and body composition: height, weight, biacromial and biiliocristal diameter, upper arm, thigh and calf circumference, wrist breadth, bicondylar femur, bicipital, tricipital, subscapular and supra iliacal skinfold, corrected upperarm diameter,[17] %fat.

2. Physiologic variables: W_{170}, FEV%, 12 min run walk, handgrip, vertical jump, bent arm hang, 50 m shuttle run, sit and reach, plate tapping.[29]

3. Gymnologic variables, measuring progress in performance of physical education in a narrower sense. A total of 31 objective performance tests were developed. Every test was scored on a 5 point rating scale. To obtain an impression of the progress in skills, the schoolyear was divided in 4 periods. The sum of the scores on the tests was considered as the schoolgrade in physical education for that period.[13]

Interfering variables

As interfering variables were considered:

1. Biological age measured as skeletal age on pretest by X-ray photography of left hand and wrist of the subjects, according to the bone specific method of Tanner-Whitehouse-Healy.[32]

2. Habitual physical activity measured by pedometers. Pedometers, attached to the waist of our subjects measure vertical displacements. The totalised scores was used as a measure of the amount of physical activity. Assuming physical activity during school hours as being quite comparable for each of the subjects we measured the leisure activity systematically in 3 periods of the week: from Monday afternoon till Tuesday morning: from Wednesday noon till Thursday morning and from Friday afternoon till Monday morning (during the weekend). To avoid seasonal and weather influences each measurement was done twice a year (during Autumn and Spring) and only one measurement a week.

Statistical analysis and hypotheses

To reduce the total number of dependent variables the grouped pretest data were factor analysed (varimax rotation) for both the experimental and control group.[11] Out of the factor that could be discriminated the most representative variables, with identical factor structure in both groups ($r > .60$) were used to formulate eight definite hypotheses:

1. The total body fat (%) diminishes in the experimental group in respect of the control group.
2. The corrected upperarm diameter (mm) increases in the experimental group in respect of the control group.
3. The handgrip (kg) increases in the experimental group in respect of the control group.
4. The bent arm hang (sec) increases in the experimental group in respect of the control group.
5. The 50 m shuttle run (sec) diminishes in the experimental group in respect of the control group.
6. The plate tapping (sec) decreases in the experimental group in respect of the control group.
7. The physical working capacity (W_{170} in Watt/kg body weight) increases in the experimental group in respect of the control group.
8. The Forced Expiratory Volume (FEV%) increases in the experimental group in respect of the control group.

In order to investigate the effect of the independent variable (α)—the two extra lessons—the mean difference scores of experimental and control group were compared by means of analysis of covariance[26] while making allowance for the influence of the two interfering variables habitual physical activity (β) and skeletal age (γ) and interaction of α and β.

9. The scores of gymnologic tests are at least on one of the four points of time higher in the experimental group than in the control group. This hypothesis is tested with Hotelling's T^2.[16]

All hypotheses were tested on a 5 percent significance level and one tailed.

Results

In testing the hypotheses by analysis of covariance three tests were applied (Table 2).

Table 2.—*Analysis of covariance of the 8 hypotheses.*

	Test 1	Test 2	Test 3
FEV%	n.s.		
Corr. upp. arm diam.	*	n.s.	
FAT%	n.s.		
Plate tapping	n.s.		
50 m shuttle run	n.s.		
Bent arm hang	n.s.		
Handgrip	**	*	n.s.
W_{170}	n.s.		

*$p \leq .05$.
**$p \leq .01$.
n.s. = not significant $p > .05$.

Test 1: $H_0: \alpha = \beta^{(exp)} = \beta^{(contr.)} = \gamma = 0$

If test 1 is significant there is a difference between experimental and control group caused either by the extra lessons (α) and/or habitual physical activity (β) and/or skeletal age (γ). The results in Table 2 did reveal that there was a significant effect upon handgrip ($p \leq .01$) and corrected upperarm diameter ($p \leq .05$).

Test 2: $H_0: \alpha = 0$ and $\beta^{(exp)} = \beta^{(contr.)}$

If test 2 is significant there is an effect caused either by the extra lessons (α) and/or by habitual physical activity (β). The results in Table 2 did show for handgrip a significant effect ($p \leq .01$) but not for corrected upperarm diameter ($p > .05$).

Test 3: $H_0: \beta^{(exp)} = \beta^{(contr.)}$

If test 3 is not significant it can be said that the difference between experi-

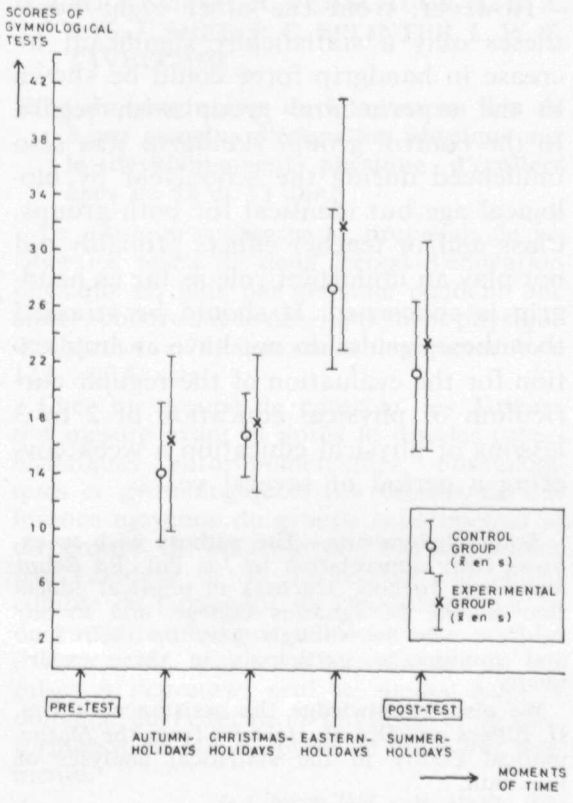

Fig. 2.—Mean and standard deviation of gymnologic scores of experimental and control group during the four periods of measurement.

mental and control group is caused only by the extra lessons. This test, applied to handgrip resulted in a non significant effect ($p>.05$).

Out of 8 hypotheses, tested by analysis of covariance, only the handgrip force proved to increase significantly ($p\leq.01$) in the experimental group with regard to the control group as a result of the two extra lessons in physical education.

Analysis of the data of gymnologic tests showed a significantly higher score ($p<.009$) of the experimental group in respect of the control group (Fig. 2).

Discussion

Because class and/or teacher effects could not be taken directly into the analysis of covariance, the possible influence of this third interfering variable was investigated in an explorative way.

The mean difference score of each of the eight representative variables had been calculated for the two experimental classes (d_2 and d_3) and for the two control classes (d_1 and d_4). With this data a ratio was calculated:

$$(d_2+d_3)-(d_1+d_4) \,/\, (d_2-d_3)+(d_1-d_4)$$

The nominator contains the effect of the independent variable plus the class and/or teacher effects, the denominator the class and/or teacher effects.

When for some of the variables this ratio is high (>3) one may suppose that the difference between experimental and control group can be explained partly by the independent variable and not by class and/or teacher effects. In handgrip this ratio was very high so that there was no reason to assume any class and/or teacher effects. Therefore the results of the analysis of covariance concerning this variable were consolidated.

In bent arm hang, corrected upperarm diameter, % fat, 50 m shuttle run and W_{170} this ratio was very small (<1) indicating a possible class and/or teacher effect. The possibility of a teacher effect was supported by results from the different judgements in professional and social aspects of teaching behaviour of the four teachers.[13]

Although only the effect of two extra lessons in physical education was hypothesized we also analysed the influence of habitual physical activity and biological age.

Upon the handgrip beside the effect of the independent variable an influence of biological age, identical for both groups could be demonstrated ($p<.05$). Habitual physical activity however had no significant influence ($p>.05$).

Upon the corrected upperarm diameter a significant influence could be proved in

the experimental group ($p<.05$) caused either by the independent variable and/or habitual physical activity and/or biological age identical for both groups ($p<.10$). The influence of habitual physical activity could not be demonstrated ($p>.05$). So the significant difference found in test 1 (Table 2) upon the corrected upperarm diameter must be caused by other unknown factors.

As to the results of the analysis of covariance, there are, because of statistical considerations reasons to reckon with the possibility that the two lessons of physical education, biological age and habitual physical activity had been of minor importance on a number of dependent variables. The reasons might be found in the relatively small increase in total physical activity of only two extra lessons a week during one schoolyear. Comparison of the measurements with pedometers during lessons of physical education and during leisure time has pointed out that the increase of two extra lessons of physical education a week, appeared to induce an increase of the total weekly physical activity of the schoolboys varying from 3-25%, calculated from the observed minimum and maximum scores. In the light of these figures it is obvious that if any, not the same training effect can be expected.

Conclusions

In conclusion it can be stated that in general the expectations about the effects of two extra lessons of physical education upon 12 and 13 year old boys could not be confirmed.

In a five versus three lessons-a-week physical education programme a significant increase of the achievement in physical education was found in the experimental group.

However, from the other eight hypotheses only a statistically significant increase in handgrip force could be shown in the experimental group with regard to the control group. Handgrip was also influenced during the schoolyear by biological age but identical for both groups. Class and/or teacher effects probably did not play an important role as far as handgrip is concerned. It should be stressed that these results do not have an implication for the evaluation of the regular curriculum of physical education of 2 to 3 lessons of physical education a week covering a period of several years.

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Summaries

H. C. G. KEMPER, R. VERSCHUUR, K. G. A. RAS, J. SNEL, P. G. SPLINTER, L. W. C. TAVECCHIO

Effect of 5-versus 3-lessons-a-week physical education program upon the physical development of 12 and 13 year old schoolboys.

The purpose was to investigate the effects of two extra lessons in physical education a week during a schoolyear upon the physical development of school boys ($n=70$) with chronological age of 12.5 (± 0.4) year.

In a pretest-posttest control group design we measured anthropometric, physiologic and gymnologic characteristics. The mean difference scores of experimental and control group were compared by way of analysis of covariance while making allowance for the influence of biological age and habitual physical activity.

Many hypotheses were tested; only achievement in physical education and performance in handgrip increased significantly.

[« J. Sports Med. », 16, 319-326, 1976]

H. C. G. KEMPER, R. VERSCHUUR, K. G. A. RAS, J. SNEL, P. G. SPLINTER, L. W. C. TAVECCHIO

Effet du programme de 5 leçons au lieu de 3 par semaine d'éducation physique sur le développement physique d'écoliers âgés de 12 et 13 ans.

La présente recherche se proposait de vérifier les effets de deux leçons d'éducation physique en plus par semaine pendant une année scolaire sur le développement physique d'écoliers (n=70) âgés chronologiquement de 12,5 (±0,4) ans.

Chez un groupe de contrôle, les Auteurs ont mesuré avant et après le test les caractéristiques anthropométriques, physiologiques et gymnologiques. Les valeurs de différence moyenne du groupe expérimental et du groupe de contrôle ont été comparées par l'analyse de la covariance en tenant compte de l'influence de l'âge biologique et de l'activité physique habituelle.

Un certain nombre d'hypothèses ont été mises à l'épreuve; seul le succès dans le domaine de l'éducation physique et la performance en fait de prise de main ont augmenté.

[« J. Sports Med. », 16, 319-326, 1976]

H. C. G. KEMPER, R. VERSCHUUR, K. G. A. RAS, J. SNEL, P. G. SPLINTER, L. W. C. TAVECCHIO

Efectos del programa de 5 lecciones en vez de 3 por semana de educación física sobre el desarrollo físico de escolares entre 12 y 13 años de edad

Esta investigación se ha propuesto de verificar los efectos de dos lecciones de educación física en más por semana durante un año escolar sobre el desarrollo físico de escolares (n=70) con edad cronológica de 12.5 (±0.4) años.

En un grupo de control, los autores han medido antes y después del test las características antropométricas, fisiológicas y gimnológicas. Los valores de diferencia medios del grupo experimental y del grupo de control se han comparado por medio del análisis de la "covariance" teniendo en cuenta la influencia de la edad biológica y de la actividad física habitual.

Se probaron varias hipótesis; sólo el éxito en la educación física y la performance en cuanto a toma de la mano han aumentado.

[« J. Sports Med. », 16, 319-326, 1976]

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