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Can Kinesiological Activities Change »Pure« Motor Development in Preschool Children during One School Year?

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ABSTRACT

The purpose of this study was to evaluate the effects of an additional, organized, and more intensive kinesiological treatment on »pure« motor abilities in preschool children. In the present study an experimental treatment was carried out on a sample of 37 preschool boys by applying kinesiological activities. The 60 minute treatment was applied over a period of one school year (9 months), twice a week. A control group of 31 boys were trained according to the regular program for preschool institutions. Treatment effects were assessed by 8 motor ability tests and 5 anthropometric measures. The significant differences between the groups, which were observed after the final measurement and compared to the initial one, proved that the kinesiological treatment had a positive impact on the general development of »pure« motor abilities. The most significant effect of experimental kinesiological treatment was the improvement in whole body force, flexibility and coordination of preschool boys. These findings, obtained only in one school year, point to the importance of physical exercise and the application of additional kinesiological activities with various modalities, to improve motor development, even morphological growth and development in preschool children. The effects of the perennial application of kinesiological activities, under the supervision of kinesiological professionals, could be beneficial and could form the basis for a better biological and motor development in older age.

***Key words**: physical exercise, preschool age, motor abilities, covariates, effects*

Introduction

It is well known today that organized physical activity has a complex influence on complete human anthropological areas. Through systematic, well-guided, and focused physical exercise over a certain period, many adaptive changes in overall anthropological areas can be achieved. The effect is more significant if these periods coincide with certain sensitive stages in the development of motor abilities[1,2]. In its broadest sense, these effects of exercise are different and partly dependent on exercise duration[3]. It is known that longer exercise duration implies more specific and more permanent effects on psychophysical development in preschool children's bodies[4–7].

The preschool period is the best time to start implementing various training procedures, particularly challenging ones such as gymnastic exercises, swimming and rhythmical coordination accompanied by music[8,9], as well as exercises that include jumps or gaining balance elements[10]. During this period, the foundation for the basic movement skills is created, which should be specialized in later motor development. It is of high importance that children possess the best possible motor abilities and skills by the time they reach school age, because during the school period this development is slowed down, and further progress is greatly dependent on motor-ability-skill-base previously formed in preschool[11].

The relationship between anthropometric characteristics in preschool age children and their motor abilities is little-known, even when it has been suggested that preventive measures for overweight and motor deficits should start at this early age; a few studies analyzed this correlation and they presented conflicting results[12]. Because of all that, more research is needed in order to know the role of physical activity in motor abilities and body composition of preschool children, which could be used as a prevention

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tool for overweight or motor deficits at this age or in future stages. Anthropometric characteristics, especially of the extremities, and the physiological and neurological states of the muscles, and the distribution of subcutaneous fat tissues throughout the body, can significantly affect the positive or negative manifestation of motor abilities of children.

Because of the significant association of motor abilities and morphological characteristics, it often happens that the greater development of morphological characteristics »mask« the improvement or deterioration in the manifestation of children's motor efficiency. In doing so, the researchers recorded only motor efficiency in the children's performance of appropriate motor tasks and tests, not »pure« motor abilities, respectively the children's motor capacity. Of course, desirable and best situation in the physical education of children is one in which there is a significant improvement of the morphological characteristics and the »pure« motor capacity, i.e. general motor ability (common motor factor). The set of dimensions are attributed to the biological (physical) growth and development of children.

For the purposes of the project, it was necessary to analyze the relative independence of the motor development of morphological growth and development of preschool children in the course of one school year. According to therefore, the aim of this study was to determine the possibility of development »pure« motor abilities in preschool children (controlled by morphological development) using kinesiological activities during a school year (2012/2013, September–May).

Material and Methods

Participants

This longitudinal study was performed on a sample of 68 healthy preschool boys that were divided into two groups. Experimental group (N=37) consisted of children attending kindergartens, and who volunteered for the experiment. The control group (N=31) was randomly chosen from the cluster of kindergartens. The average age of the children in the experimental group at the beginning of the treatment amounted to 5.97±0.54, whereas the children of the control group had 5.87±0.43 decimal years. Written informed consents were obtained from the parents of all children, who gave their assent to participate in the study.

Measures

The set of anthropometric variables and the set of motor variables obtained by the use of the following measurements and tests, were analyzed at the beginning of both treatments, and after 9 months.

Anthropometric characteristics were assessed by the method of International Biological Program (IBP). The sample of anthropometric measures was as follows: Body height (mm), Body weight (0.1 kg), Chest girth (mm), Forearm girth (mm), Triceps skinfold (0.1 mm). Motor tests were performed according to Bala's recommendations[13]. The following test battery was used in motor ability assessment: Obstacle course backwards – restructuring of movement stereotype, Arm plate tapping – frequency speed, Seated straddle stretch – flexibility, One-leg test – whole body balance, Crossed-arm sit-ups – repetitive trunk strength, Bent-arm hang – static strength of arms and shoulder girdle, Standing broad jump – explosive leg strength, Speed of arm movement – reaction time with arm movement.

The reliability of these motor tests, as composite tests with 3 items (replications), was previously analyzed in a sample of 64 children aged 6–7 years by calculating the Cronbach α reliability coefficient. Good reliability coefficients were obtained for all these motor tests, as follows: Obstacle course backwards α=0.96, Arm plate tapping α=0.90, Seated straddle stretch α=0.97, Standing broad jump α=0.88, Crossed-arm sit-ups α=0.92, Bent arm hang α=0.91[13] and Speed of arm movement α=0.87[14].

Procedures

The basic characteristics of experimental training process were the following:

1) Means of exercising to develop and improve co-ordination, timing, agility, balance, speed, flexibility, strength, endurance, cardiovascular recovery, speed of solving complex motor problems, etc.: perceptual-motor activities, creative movements, rhythms and dances, stunts, tumbling, and apparatus activities, running, jumping, throwing, games and basic elements of team sports. This model contained many problem activities in which the children had to use mostly coordinative, balance and agility abilities and the activities that required the use of both arms, or both legs, or the whole body;
2) Methods of teaching: synthetic (whole) and combined (whole-part-whole);
3) Methods of exercising: repetition, play and competitive;
4) Class organization: frontal work, group work, work with stations, circuit work and obstacle courses;
5) Elements of training: volume: 60 min, frequency: 2 times a week, intensity: according to the usual external signs (sweat, blush, spontaneous breaks), and according to the heart rates (maximum between 170 and 180 in min);
6) Structure of training: I) introductory part – 5 min. warm-up, various movement with changeable speed, exercises that correct and prevent flat-feet); II) preparation part – 10 min. stretching, corrective and preventive exercises from bad posture, proper sense of good performance; III) main part – 40 min. revision and practice of previous skills, teaching and practice new skills, competitive practice, conditioning; IV) cool-down part – 5 min. stretching, coaching comments, conversation. Every part of the training lesson was run in positive and warm, friendly mood, with proper music (particularly in the introduction and preparation) (Figure 1).

Fig. 1. *Some typical exercises of the children in experimental group.*

The experimental treatment was conducted in two connected training rooms, which were equipped for gymnastics and dance. Implementers of the experimental treatments were four kinesiology professionals. The specifics of this treatment compared to the standard group treatment in kindergartens were in an extra work out twice a week for 60 minutes, in better conditions, training with experts in physical education of children, and a set of specific applied kinesiological activities.

The control treatment included means of exercising, learning methods, and exercising itself, the purpose of which was to fulfill the requirements of the formal plan and program of preschool institutions, which is presented in the »Model of the Fundamentals of the Work Program with Preschool Children« part VII, under the title Physical Development and Physical Activities[15]. The control treatment was conducted in a small kindergarten gymnasium, typical of all gymnasiums in preschool institutions. The treatment was conducted by two kindergarten teachers, who were not experts in physical education. The gymnasium was modestly equipped with the most necessary props.

All measurements and treatments were performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

Statistical analysis

Statistical analyses were performed using IBM SPSS software, version 20 (ID: 729225). Morphological and motor development within groups during one school year was analyzed by Paired samples t test. Quantitative differences between experimental and control groups in initial and final measurements within the applied variables were determined by multivariate (MANOVA) and univariate analysis of variance (ANOVA), whereas the significance of quantitative changes, i.e. effects of the applied treatments, were defined by means of multivariate (MANCOVA) and univariate analysis of covariance (ANCOVA). The same procedure was applied for the analysis of the effects of the treatments on the »pure« motor abilities, but controlled by covariates of the anthropometric characteristics of children in both groups. The level of statistical significance was set at 0.05 in all analyses.

Results

By improvement analysis of the measurement results and testing within the group during the school year, according to the results of paired t test, it was found that the morphological development was significantly increased in both groups. However, the same t test has shown that motor development was not even, and therefore, statistically significant improvement and very large effect size, based on the recommendations of Cohen[16], in the experimental group was found in: coordination (Obstacle course backwards; $t=4.16$; $\eta^2=0.32$), flexibility (Seated straddle stretch; $t=-6.52$; $\eta^2=0.45$), balance (One-leg test; $t=-8.16$; $\eta^2=0.65$) and explosive leg strength (Standing broad jump; $t=-6.78$; $\eta^2=0.56$). There were no statistically significant improvements found in other motor abilities. As far as motor abilities of the control group are concerned, statistical significance was found only in frequency speed (Arm plate tapping; $t=-2.83$; $\eta^2=0.18$) and balance (One-leg test; $t=-5.53$; $\eta^2=0.46$). Of course, one should take into account that the analysis of the development for boys in each group had different levels of the initial measurement and testing, as shown in Table 1 and Table 2 for means (M) and standard deviations (SD). In the final state, the experimental group was significantly better in the general motor ability, especially by performing the following tests: Obstacle course backwards, Standing broad jump and Bent arm hang.

Based on the results of the initial measurements (Table 1) it can be determined that there were no statistically significant differences in overall motor functioning between boys in the experimental and control group ($F_{8.59}=2.01$; $p=0.06$). With more detailed univariate analysis of variance it has been determined that significantly better results had boys from the experimental group in test Arm plate tapping, while boys from the control group were better at the One-leg test. However, those differences did not influence the overall motor behavior of children from both groups.

After experimental and control treatment (Table 1) motor testing showed that there was a statistically significant improvement in overall motor behavior of the boys from the experimental group ($F_{8.59}=5.23$; $p=0.001$) with large effect size ($\eta^2=0.42$). This was mostly due to signifi-

TABLE 1
DIFFERENCES IN MOTOR[1] AND ANTHROPOMETRIC[2] VARIABLES AT INITIAL AND FINAL STATE

Variable	Initial state				Final state			
	Experimental group		Control group		Experimental group		Control group	
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
[1] Obstacle course backwards (0.1 s)	238.87	60.98	253.62	80.79	200.44[a]	56.77	244.32	76.58
Arm plate tapping (freq.)	19.15[b]	3.67	17.10	3.97	18.53	3.60	18.68	3.44
Seated straddle stretch (cm)	36.08	6.83	35.71	6.43	40.76	6.51	35.35	7.66
Standing broad jump (cm)	121.01	16.13	115.99	18.76	137.85[a]	17.66	115.29	19.24
Bent-arm hang (0.1 s)	121.08	64.69	112.33	79.65	149.24[a]	146.34	100.16	70.91
Crossed-arm sit-ups (freq.)	22.73	6.36	25.52	15.19	23.41	9.33	22.97	10.20
One-leg test (0.1 s)	188.51	128.92	289.83[b]	244.59	932.29	610.12	885.39	659.39
Speed of arm movement (0.001s)	657.50	122.67	666.55	74.71	648.57	85.30	666.19	82.27
[2] Body height (mm)	1200.21	61.94	1194.35	72.59	1231.67	64.35	1219.00	74.38
Body weight (0.1 kg)	229.38	41.66	229.29	46.44	241.62	42.38	245.94	54.93
Chest girth (mm)	601.24	38.94	595.89	50.15	609.57	39.52	608.39	49.69
Forearm girth (mm)	174.81	11.79	175.39	15.28	178.04	12.16	177.03	16.65
Triceps skinfold (mm)	8.01	2.55	9.14	3.12	8.77	2.24	9.75	3.32

$\overline{X}$ – Mean; SD – standard deviation; [a] $p\leq 0.01$, [b] $p\leq 0.05$ – level of significance of differences in individual variables in favor of the corresponding group

TABLE 2
THE FINAL STATE OF MOTOR VARIABLES CONTROLLED BY FINAL ANTHROPOMETRIC VARIABLES

Variable	Experimental group		Control group	
	$\overline{X}^*$	SE	$\overline{X}^*$	SE
Obstacle course backwards (0.1 s)[b]	201.07	11.42	243.57	12.59
Arm plate tapping (freq.)	18.62	0.57	18.57	0.66
Seated straddle stretch (cm)	40.49	1.08	35.68	1.19
Standing broad jump (cm)[a]	136.60	2.63	116.78	2.90
Bent-arm hang (0.1 s)[a]	148.93	19.96	100.53	22.00
Crossed-arm sit-ups (freq.)	23.03	1.69	23.42	1.86
One-leg test (0.1 s)	892.30	105.82	933.12	116.67
Speedof arm movement (0.001 s)	646.88	14.39	668.21	15.86

$\overline{X}^*$ – adjusted mean, SE – standard error of $\overline{X}^*$, [a] $p\leq0.01$, [b] $p\leq0.05$ – level of significance of differences in individual variables in favor of the corresponding group

TABLE 3
THE FINAL STATE OF MOTOR VARIABLES CONTROLLED BY INITIAL MOTOR AND FINAL ANTHROPOMETRIC VARIABLES

Variable	Experimental group		Control group	
	$\overline{X}^*$	SE	$\overline{X}^*$	SE
Obstacle course backwards (0.1 s)[b]	201.95	56.77	243.57	76.58
Arm plate tapping (freq.)	18.21	3.60	18.57	3.44
Seated straddle stretch (cm)[a]	40.13	6.51	35.68	7.66
Standing broad jump (cm)[a]	137.56	17.66	116.78	19.24
Bent-arm hang (0.1 s)[a]	167.03	146.34	100.53	70.91
Crossed-arm sit-ups (freq.)	23.81	9.33	23.42	10.20
One-leg test (0.1 s)	941.10	610.12	933.12	659.39
Speed of arm movement (0.001 s)	657.49	85.30	668.21	82.27

$\overline{X}^*$ – adjusted mean, SE – standard error of $\overline{X}^*$, [a] $p\leq0.01$, [b] $p\leq0.05$ – level of significance of differences in individual variables in favor of the corresponding group

cant improvement in the coordination of the whole body, especially movements for the explosive strength (Standing broad jump; η^2=0.28), restructuring of stereotypes (Obstacle course backwards; η^2=0.10) and flexibility (Seated straddle stretch; η^2=0.13). Furthermore, the improvement is seen in other variables as well, all of which contributed to the improvement of the overall motor behavior under the experimental treatment influence.

It was determined that there was no statistically significant difference in the overall motor variables between the groups in the initial motor testing. However, because the state was on the verge of statistically significant border of conclusion (p=0.06), authors used the multivariate and univariate analyses of covariance to control the impact of any significant differences from the initial to the final state in the two groups of boys. After controlling of results in the motor variables of final state, using the set of initial motor variables, obtained the actual effects of the application of the experimental and control treatments. This analysis showed that the experimental group was indeed significantly better in overall motor abilities ($F_{8.51}$=5.95; p=0.001) with really large effect size (η^2=0.48).

This was mainly influenced by the variables Standing broad jump (η^2=0.40), Seated straddle stretch (η^2=0.12), Obstacle course backwards (η^2=0.07) and Bent-arm hang (η^2=0.10).

Although there were no major morphological differences in pre-school age boys, there was a suspicion that the anthropometric characteristics contributed to the differences in motor behavior, both in experimental and in the control group. Therefore, the analysis of the significant differences in anthropometric variables in the initial and final state was made, as well as the analysis of motor behavior based on the applied motor variables, to eliminate the impact of anthropometric characteristics in the two groups of boys (Tables 1 and 2). There were no statistical differences found in the anthropometric variables for initial state, whereas in the final state differences were found ($F_{5.62}$=2.84; p=0.02; η^2=0.19). At the final measurement boys of the experimental group were not significantly different in individual variables, but they had systematically better results in overall anthropometric variables. This has contributed to a better morphological structure, which is probably caused, in addition to regular biological growth and development, by the influence of physical exercise using the experimental treatment.

In Table 2 there are the results of controlling of the motor variables in the final state using anthropometric variables in the same time period. This analysis assumes that the boys both groups had similar anthropometric characteristics. Based on the adjusted means (M*) and their standard errors (SE), it was found that the overall motor development, estimated by applied a set of motor variables, was actually significantly better in children in the experimental group with large effect size ($F_{8.54}$=4.46; p=0.001; η^2=0.40). This proves that the experimental treatment produced significant positive effects on motor development, and that happened without significantly impact of morphological development. The positive effect of the experimental treatment had particularly on the development of explosive strength (Standing broad jump; η^2=0.28), body coordination (Obstacle course backwards; η^2=0.09) and flexibility (Seated straddle stretch; η^2=0.12).

The results of analysis of the real effects from the experimental and control treatment, by controlling of the motor variable results in the final state and by the set of initial motor variables and the final state of anthropometric variables at the same time, are shown in Table 3. This analysis showed that the experimental group was indeed significantly better in overall motor behavior ($F_{5.62}$=4.98; p=0.001). The overall effect of the changes, which can probably be attributed to the influence of the experimental treatment, was η^2=0.47. The highest statistically significant differences were found in the variables: Standing broad jump (η^2=0.40), Bent-arm hang (η^2=0.15), Seated straddle stretch (η^2=0.11) and Obstacle course backwards (η^2=0.09).

The final state of motor variables with controlling by initial motor and final anthropometric variables, shows that there has been a significant change in the »pure« motor status of children in the experimental group, compared to the control group.

Discussion and Conclusion

Significant differences that were observed after the final measurement compared to the initial one, prove that the effect of kinesiological treatments had an impact on the general development of motor abilities, as in some previous cases[17–19].

The most significant effect of experimental kinesiological treatment was recorded in force (static strength of the shoulder girdle and explosive leg strength), coordination of the whole body and flexibility of the preschool boys. These results were expected because the preschool period is a sensitive period for the development of motor behavior of children[20,21]. Also, children in the experimental group, during the experimental treatment, were subjected to exercises in which they overcame the weight of their own body in different situations, which contributed to the development of a larger force.

A specific feature of the survey is that there were no differences found in variable Arm plate tapping, as compared to the initial measurement. Some of the reasons for such occurrence can be the influence of previous children's experiences, the functional features, and the hand use preference relative to the handedness[22,23].

Interestingly, there was no significant change under the influence of experimental treatments in repetitive strength of trunk (Crossed-arm sit-ups) and balance (One-leg test), as would be expected. These results could be explained by the lack of suitable exercise in the experimental treatment, as well as with the lower motivation of boys in testing. In addition, no significant change was observed in the speed of simple movements (Speed of arm movement) nor in the speed of the frequency (Arm plate tapping) of the dominant hand. This can be interpreted by the state of motor pathways in the central nervous system, primarily by the nerves conductivity, which is a significantly more genetic characteristic, and therefore, it is difficult to significantly improve it in a relatively short time, such as one school year.

Based on the abundance of theoretical and empirical experiences, it becomes a unique and widely accepted conclusion that regularly organized physical exercise has positive effects on biological growth and development, as well as on the motor development of children[13,24]. This is particularly evident when the perennial application of kinesiological activities under the supervision of kinesiological professionals is being used.

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MOGU LI KINEZIOLOŠKE AKTIVNOSTI PROMIJENITI »ČISTI« MOTORIČKI RAZVOJ U PREDŠKOLSKE DJECE TIJEKOM JEDNE ŠKOLSKE GODINE?

SAŽETAK

Cilj ovoga istraživanja bio je procijeniti učinke dodatnoga, organiziranoga i intenzivnijega kineziološkog tretmana na »čiste« motoričke sposobnosti u predškolske djece. U istraživanju je proveden eksperimentalni tretman na uzorku od 37 predškolskih dječaka upotrebom konezioloških aktivnosti. Šezdesetominutni je tretman primjenjivan tijekom jedne školske godine (9 mjeseci), dva puta tjedno. Kontrolna skupina od 31 dječaka bila je trenirana prema redovnom programu za predškolske institucije. Učinci tretmana bili su procjenjeni pomoću 8 testova motoričkih sposobnosti i 5 antropometrijskih mjera. Značajne razlike između skupina, koje su zamijećene nakon konačnog mjerenja i uspoređene s inicijalnim, dokazale su da je kineziološki tretman imao pozitivan utjecaj na opći razvoj »čistih« motoričkih sposobnosti. Najznačajniji učinak eksperimentalnog kineziološkog tretmana bilo je poboljšanje u ukupnoj tjelesnoj snazi, fleksibilnosti i koordinaciji predškolskih dječaka. Ovi rezultati, prikupljeni u samo jednoj školskoj godini, ukazuju na važnost tjelesne vježbe i primjene dodatnih kinezioloških aktivnosti s različitim modalitetima kako bi se poboljšao motorički razvoj te čak i morfološki rast i razvoj u predškolske djece. Učinci dugotrajne primjene kinezioloških aktivnosti, pod nadzorom profesionalnih kineziologa, mogli bi biti korisni i stvoriti temelje za bolji biološki i motorički razvoj u starijoj dobi.