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ORIGINAL RESEARCH

Does motor skills training have permanent or temporary effects on children's motor development?

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Abstract
Background: Motor skill programs are effective in the development of children's fundamental motor skills (FMS). However, the key point that should be kept in mind here is the degree of the stability of the training effects on children's motor skills. **Objective:** The purpose of the present study is to observe the permanence of the effects of motor skills training on children's FMS aged 4–6 years for one year. **Methods:** The study was carried out among 39 preschool children, 17 girls (age 5.31 ± 0.23 years) and 22 boys (5.23 ± 0.20 years) without any previously-identified health problems. The participants were randomly chosen and divided into an experimental group trained motor skills with physical education specialists (n = 19) and a control group that performed ordinary preschool physical activities (n = 20). The Test of Gross Motor Development 2nd ed. was also used to measure children's FMS in the pre-test, the post-test, and the follow-up after 12 months. The training course was done 2 days a week. Each session lasted 45 minutes, too. In addition, mixed model repeated measure multiple analysis of covariance was used to examine the impact of the training. **Results:** Although the motor skills training helped improve the locomotor and object control skills among the children from pre-test to post-test (p < .001), a significant difference was not observed in the control group. Moreover, the development of boy subjects and girl participants was significantly different in the object control (p = .037). Finally, a significant difference was not observed between the post-test and follow-up in the object control and the locomotor skills of the experimental group. **Conclusions:** It seems that the FMS training under physical education specialists should be continuously done for 4–6 years old subjects, with more emphasis on developing girls' object control skills.

Keywords: fundamental motor skills, preschool children, physical activity, gender difference

Introduction

Early childhood is considered to be a crucial period for motor development in children. Experts recommend that children should take part in substantial amounts of physical activities (Mak et al., 2021). Motor development is the process of continuous, age-related changes in movement which are caused by interacting constraints or factors within the individual, environment, and task (Robinson & Goodway, 2009). To support this view, it is said that motor development is not only hooked into and suffered from growth and maturity but is also influenced by the precise environmental context (Zeng et al., 2019). Findings suggest that children's participation in motor skills program improve their motor development as well as fundamental motor skills (Robinson et al., 2018).

Fundamental motor skills (FMS) are considered to be the fundamental skills that lead to specialized movement sequences required to participate in a number of organized and non-organized physical activities from childhood and adolescence (Morgan et al., 2013). A recent review has shown that the most successful motor skills programs were those using FMS, led by an expert teacher because early childhood educators who are adequately trained and enabled with knowledge are ideally placed to promote physical activity engagement amongst their pupils (Mak et al., 2021).

However, less is known about whether participation in motor skill programs would make positive changes in preschoolers' FMS after the cessation of the program or not (Palmer et al., 2019). Although the findings suggest that the training improves FMS in healthy children, care should be taken into interpreting them because there is no quality evidence in this regard. The related effects have also been examined and no long-term follow-up has been done (Wick et al., 2017). Previous literature (Hardy et al., 2012; Robinson & Goodway, 2009; Roth et al., 2015) has provided evidence of the persistence of the beneficial effects on FMS for 8 to 12 weeks after the training course. While some other studies (Iivonen et al., 2011; Piek et al., 2013; Reilly et al., 2006) with a follow-up period of 3–12 months after the training did not find lasting effects on FMS. Also, a recent study by Coppens et al. (2021) has reported that after 30-week 'Multimove' program training, the experimental group outperformed the control group. However,

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when a 6-year follow-up was considered, the experimental group made less progress in motor competence than the control group.

Although in many developed countries of the world, physical education is one of the programs developed for children, Iran lacks a comprehensive physical education curriculum for preschoolers (Maliji et al., 2018). Therefore, families have to pay extra costs for their children's participation in motor skill programs under a physical education specialist, which sometimes may stop the child's participation in such programs due to financial limitations. On the other hand, a noticeable number of the children in Tehran had poor gross motor skills (Kordi, 2015). Moreover, most of the previous studies were not conducted on children from developing countries, which may preclude the generalized implementation in developing countries (Lopes et al., 2021). Therefore, we observed the effect of a one-year motor skill training program on 4 to 6 years old Iranian children FMS development and then assessed it again after a 12-month follow-up. This research seeks to explore the long-term effects of motor skill training in view of the fading effect.

Methods

Study design

The research questions were put using a two-arm study (experimental group and control group) involving pre-test, post-test and follow-up. To collect data, four preschools in the north of Tehran with similar socioeconomic status and family ethnicity were conveniently selected for the study population.

Participants

The G Power software was used to determine the sample size. According to Lorås (2020), the minimum effect size, which clearly pinpoints the impact of curriculum-based physical education on the development of motor skills, is ≥ 0.52. Therefore, in order to reach the statistical power of 0.80 in the pre-test, post-test, and follow-up measurements, a sample of 39 participants was required for both groups with an α level of .05.

The motor skill training began in September 2018 and concluded in September 2019. All children aged 4–6 years were invited to participate in the project (N = 143). Then they were asked to return the informed written parental consent and medical forms. A total of 56 children (age 5.2 ± 0.6 years, 65.7% male) agreed to participate in this course, 17 children were excluded from the research due to eligibility of exclusion criteria.

The children were randomly assigned into two study groups: An experimental group for motor skill training (n = 19; 10 boys, 9 girls; age 5.28 ± 0.45 [4.6–5.9] years) and a control group involved in ordinary physical activities (n = 20; 12 boys, 8 girls; age 5.27 ± 0.46 [4.4–5.8] years). The participants in this study met the following requirements:

1. Their age ranged from 4 years and 0 months to 5 years and 12 months.
2. They did not have a mental or physical disability before the study.
3. They had no diagnosed disease that impeded safe participation in the research (e.g., unstable heart condition).

The exclusion criteria were:

1. The disease or voluntary withdrawal from training.
2. Failure to complete the pre-test, post-test, and follow-up test.
3. Irregular attendance in the training sessions (being absent for 3–5 consecutive sessions during the course).
4. Participation in motor skill training with physical education specialists outside the process of this research (from pre-test to follow-up).

It should be noted that all ethical recommendations from the University Research Committee were completely fulfilled, too.

Procedures

First, the demographic characteristics, anthropometrics, and motor skills scores of all participations were measured in the pre-test. The total duration of the training phase was 12 months. Following the implementation of the training protocol for the experimental group, the post-test has been conducted. Next, a 12-month retention period was considered for both groups during which no training program was presented for both study groups and then motor development in the follow-up was measured the same pre-test and post-test. The control group only followed an ordinary preschool schedule and did not participate in any special sports programs during the research process.

Demographics and anthropometrics measurements

Parents were asked to fill out a survey questionnaire on demographic variables, including age, gender, race/ethnicity, parental degree and occupation, and household income. Measuring the participants' height and weight was undertaken in a private setting, with children wearing light clothes while they were barefooted. A portable stadiometer was utilized to determine the participants' height with a precision of 0.25 cm. Moreover, their weight was measured using a digital scale (Seca 769G21, Seca, Hamburg, Germany) with a precision of 0.1 kg while wearing the least amount of clothing possible.

Assessment of motor development

The assessment of the participants' motor development was implemented following the requirements of the Test of Gross Motor Development 2nd edition (TGMD-2). TGMD-2 is divided into two categories: locomotor skills (LS) and object control (OC). All the children were tested according to the TGMD-2 manual (Ulrich, 2000). TGMD-2 was validated in Iranian children aged 3–10 years (Farrokhi et al., 2014). The internal consistency reliability for LS and OC scores as well as total composite score averaged .78, .74, and .80, respectively. Test-retest reliability ranged from .65 to .81, and intra-rater reliability was above .95 (Farrokhi et al., 2014).

Motor skill training program

This program was run based on Gibsonian's ecological theory of development in which the interaction between the task, the individual, and the environment has been highlighted (Lopes et al., 2021). According to the recommendations made in recently-reviewed studies (Lopes et al., 2021; Mak et al., 2021), the main objective of this program was particularly focused on FMS improvement as well as the implementation of multidisciplinary training. Accordingly, this program has been designed and developed in group settings as part of children's participatory curriculum. This curriculum has been scheduled for an extended period (12 months) during which the children attended two sessions a week. Besides, the program has been supported by three specialists working as physical education teachers. Each session also lasted 45 minutes in this study. Furthermore, the curriculum was designed in accordance with the cultural and climatic conditions and welfare and educational facilities available to Iranian children (Kordi et al., 2017).

The motor skills training program was implemented by the individual and group indoor games after preschool working hours. In each session, the experimental group performed three parts: warming up for 20 minutes, practicing FMS activities for 20 minutes, and cooling down with fun games for 5 minutes. The warm-up consisted of stretching and joint movements, active and funny group games such as tag games, and moving objects like different animals, dodgeball games, jump rope, and freeze dance. Then, the participants' training the balance, locomotor, and manipulation skills were performed based on the simple-to-hard principle in motor learning (Magill & Anderson, 2007). The training program was appropriate to both the developmental level of each child and their desire to play or repeat the game. To reach this objective, the physical education teachers used a flexible method in the implementation of the training. It means that the children were not forced to play the games, rather the physical education teachers tried to make the play seem interesting for children by making changes such as height, size of the ball, speed of movement, and the number of repetitions in the context of the game. To reduce the additional costs, inexpensive, simple and portable tools and equipment like yoga bricks, step boards, balls, tapes, and balloons were used in the training program. First, children learned each movement in the context of closed skills, and then with the passing of the training sessions, the program moved towards more complex and open skills (Schmidt & Wrisberg, 2008). For example, as for the ball games, playing with balloons and in situ, playing with balloons with body movement, playing with the ball in situ, and playing with the ball with body movement were done respectively. The last five minutes of each session were also dedicated to cooling down using stretching movement along with storytelling and relaxation.

Data analysis

Descriptive statistics (mean and standard deviation) were applied for the description of each of the three experimental phases i.e., pre-test, post-test, and follow-up. The normality assumptions were verified by the Kolmogorov-Smirnov test and Levene's test for homogeneity of variances ($p > .05$). The student's t-test for independent samples was used to compare height, weight, body mass index, LS, and OC scores of both boys and girls at the pre-test between the experimental group and control group. The assumption of the equality of covariance with Box's M test ($p > .05$) and variance with Mochli's sphericity test ($p > .05$) was maintained constant. A 2 (group: experimental, control) × 3 (time: pre, post, follow-up) multiple analysis of covariance was applied to determine the effect of motor skill training on changes in FMS. Then, post hoc Bonferroni analysis has been used to compare the scores. The statistical analyses were performed using IBM SPSS Statistics (Version 26; IBM, Armonk, NY, USA) and significance was assessed at $\alpha \leq .05$.

Results

The mean and standard deviation of the anthropometric factors of the participants' scores have been given in Table 1. The results of the t-test showed that there was no significant difference in age, $t(37) = 0.043$, $p = .966$; height, $t(37) = 0.640$, $p = .526$; weight, $t(37) = 0.644$, $p = .524$; or body mass index, $t(37) = 0.387$, $p = .701$ between the experimental and control groups in the pre-test. A comparison between the experimental and control groups in the pre-test also revealed that there was no significant difference in LS, $t(37) = 1.934$, $p = .061$; or OC, $t(37) = 0.181$, $p = .857$ scores (see Figures 1 and 2).

Also, a comparison between the experimental and control groups in the pre-test showed that there was no significant difference in LS, $t(37) = 1.934$, $p = .061$; or OC, $t(37) = 0.181$, $p = .857$ scores (see Figures 1 and 2).

The improvement of both boy subjects and girl participants in this research study was significantly different from the pre-test to the follow-up, $F = 4.704$, $p = .037$, $\eta^2 = .116$. Therefore, a mixed model multiple analysis of covariance was performed to test the significant differences in LS and OC performance between both the experimental group and control group from the pre-test to follow-up after controlling the gender variable as a covariate (see Table 2).

Table 1 Means and standard deviations of age, body height, body weight and body mass index

Variable	Experimental group			Control group		
	Boys (n = 10)	Girls (n = 9)	Total (n = 19)	Boys (n = 12)	Girls (n = 8)	Total (n = 20)
Age (years)	5.22 ± 0.23	5.36 ± 0.32	5.28 ± 0.28	5.25 ± 0.17	5.28 ± 0.45	5.27 ± 0.46
Body height (cm)	118.80 ± 1.93	117.00 ± 2.12	117.95 ± 2.17	118.67 ± 1.77	115.75 ± 1.48	117.50 ± 2.18
Body weight (kg)	23.03 ± 1.30	21.30 ± 1.07	22.21 ± 1.46	22.73 ± 1.33	20.60 ± 1.46	21.88 ± 1.72
Body mass index (kg/m^2)	16.31 ± 0.79	15.57 ± 0.95	15.96 ± 0.92	16.15 ± 0.94	15.37 ± 0.88	15.84 ± 0.97

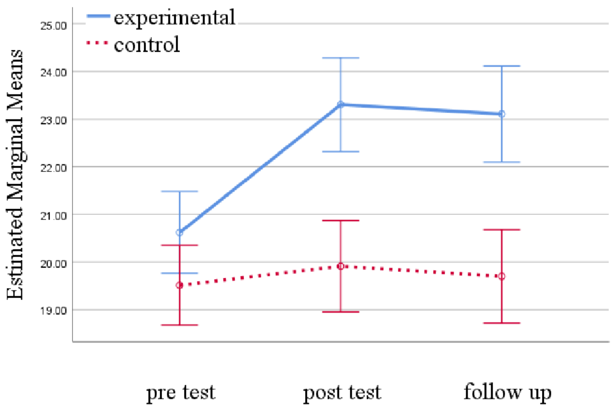

Figure 1 Mean score with standard deviation (error bar) of locomotor skills from the pre test to follow-up

Table 2 Results of the of mixed-model multiple analysis of covariance of locomotor skills and object control by time, group and gender

	Mean square	*F*	*df*	*p*	η^2_p
Locomotor skills					
Time	4.360	11.722	2	.001	.246
Group	202.009	17.134	1	.001	.322
Gender	1.146	0.097	1	.757	.003
Time x Group	17.017	45.754	2	.001	.560
Time x Gender	0.478	1.285	2	.283	.034
Object control					
Time	13.186	29.211	2	< .001	.448
Group	248.417	6.821	1	.013	.159
Gender	171.317	4.704	1	.037	.116
Time x Group	48.599	107.666	2	< .001	.749
Time x Gender	1.739	3.852	2	.026	.097

The results of the post hoc Bonferroni analysis indicated that the development of the experimental group's LS in the post-test was significantly better than the pre-test (mean difference = –2.686, $p < .001$). However, no significant difference was observed between the post-test and follow-up (mean difference = 0.197, $p = .812$). The results of the post hoc test only showed a significant difference in the LS of the control group, between the pre-test and post-test (mean difference = –0.565, $p = .024$).

In addition, the results of the post hoc Bonferroni analysis displayed that the changes in the OC of the experimental group were significant from the pre-test to the post-test (mean difference = –3.871, $p < .001$), but there was not a significant difference between the post-test and follow-up (mean difference = –0.208, $p = .987$). Moreover, the results of the post hoc test did not show any significant difference in the OC of the control group, in none of the pairwise comparisons (all *ps* > .05).

Discussion

The motor skills program in this research study significantly helped improve the LS and OC of the participants in the experimental group. Thus, compared to those who took part in ordinary physical activities without a physical education expert teacher in preschools, the development

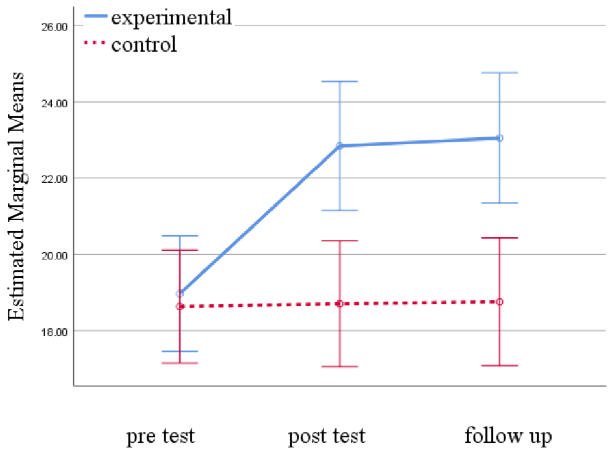

Figure 2 Mean score with standard deviation (error bar) of object control at the pre-test to follow up

was highly significant. Therefore, it can be said that a motor skill program with specialists is significantly more effective than ordinary physical activities in preschools. This finding is consistent with the results of the previous research mentioned that the quality of instruction, FMS knowledge, and education support for teachers can positively affect the FMS level of the children (Mak et al., 2021; Palmer et al., 2019; Wick et al., 2017).

In this research study, gender differences in OC skills have existed. Besides, the findings of the study are in line with those of the previous studies, where boys are typically recognized as having better OC skills than girls (Barnett et al., 2016; Niemistö et al., 2019). Similarly, it reveals that the boys are more social and more likely to be involved in ball games, while the girls are more likely to play in smaller groups, involving more conversation, sedentary play, jump-skipping, and verbal games. These differences may reflect the gender differences in motor development as well (Niemistö et al., 2019). The gender differences for FMS seem to be clear in this research. They are especially related to the differences in physical activity behaviors or cultural norms that may foster enhanced FMS in boys (e.g., kicking) or girls (e.g., balancing). In addition, the reach and responsiveness of the girls and boys in the activities targeting FMS may be different as well (Iivonen et al., 2011; Niemistö et al., 2019; Wick et al., 2017).

The within-group comparisons demonstrated that the children who participated in the control group significantly improved LS in the post-test compared with the pre-test, but this improvement was less than in the experimental group. It means that ordinary physical activities in preschools led to improving LS among these children. These findings are in line with Bonvin et al.'s results (2013) in which the children had received no planned or formalized instruction and found LS improvement as well. Also, Palmer et al. (2019) reported the lack of changes in the OC during ordinary physical activities in the control group so that the children in the motor skill program demonstrated greater rates of the changes and higher scores on all motor skills at the later assessment compared with the control group. This result may be due to the limited environmental facilities associated with the development of the OC or the greater interest of the children participating in activities in the control group such as running, climbing, and jumping while playing ordinarily. Moreover, this may be a result of the effect of aging on the level of motor activities (Robinson & Goodway, 2009), and consequently, the development of the functional status of the children in the control group in LS.

The OC skills of the control group did not differ significantly in the post-test compared to the pre-test phase. These findings support the views of Zeng et al. (2019) suggesting that the improvement of the OC among young children is highly correlated with the kind of skills applied by teachers and health professionals throughout a child's skill development journey. On the other hand, heightening the development of the OC is only attained through a child's participation in specific contexts under the availability of accurate instructions (Brian et al., 2018). Therefore, the lack of changes in the OC during ordinary physical activities can be attributed to the teacher-student interactions on the playground (Palmer et al., 2019). It has been found that a broad range of correlates at the child, family, and environment levels are primarily associated with OC skills as well as strength.

However, it should be noted that no significant differences in the children's motor skills (both LS and OC) between the post-test and follow-up were observed in both the experimental group and the control group. The current study demonstrated that the improvement in FMS did not occur after stopping a motor skill training program in the experimental group. These results are in line with the assumption that motor skills development is made possible through continuous interaction with a stimulating and supportive social and physical environment (Niemistö et al., 2019), just like the training of fundamental motor skills by specialized physical education teachers for children. These findings also confirm the opinion of the children's physical education experts stating that FMS should be continuously trained, practiced, and reinforced because it does not seem to develop and sustain naturally without training and practice (Morgan et al., 2013). This kind of physical-social environment should look particularly attractive and provide a sufficient amount of space as well as stimulating social attitudes. Besides, the whole process must follow a professional instructional approach (Greeno, 1994). Additionally, the findings of the study can be explained in light of the mutual interaction between the biological conditions and the physical environment in which the participants are involved. Moreover, it can be regarded as a dynamic developmental system composed of both perception and action (Lopes et al., 2021). A good example happens when all the instinctive prerequisites to learn a new skill are endowed within a child himself/herself, but he/she is incapable of the acquisition on his/her own. The reason behind this is that he/she can be supported by either the surrounding environment or the people around him/her such as teachers or peers to achieve this targeted level of competence. However, while this research study was being done, there were some limitations that should be mentioned here. First, this sample is not representative of all Iranian children. Second, the validity and reliability of the latest version of the TGMD test (TDMD-3) in Tehran were not examined. That is why the second version was used to conduct the research. Third, the physical activities were only performed during the preschool days; therefore, we were unable to assess the impact of the other after-school factors on motor development. Finally, there are a relatively small number of children in each gender group to compare them.

Conclusions

It seems that providing motor skills programs by specialists within the framework of the multidisciplinary approach can lead to the development of locomotor skills and object control in preschool children. However, to achieve continuous improvement in children's motor skills, they need to constantly participate in motor activities with their peers. It is suggested that a more in-depth study be carried out on the longitudinal impacts of motor skill programs to determine the factors affecting the maintenance of its training effects in the long run in future research.

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Conflict of interest

The authors report no conflict of interest.

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