Effects of Detraining on Fitness Performance in 7-Year-Old Children

Avery D. Faigenbaum,1 Anne C. Farrell,1 Marc Fabiano,1 Tracy A. Radler,2 Fernando Naclerio,3 Nicholas A. Ratamess,1 Jie Kang,1 and Gregory D. Myer4,5,6

1Department of Health and Exercise Science, The College of New Jersey, Ewing, New Jersey; 2Lore Elementary School, Ewing, New Jersey; 3Center for Sport Science, School of Science, University of Greenwich, Kent, United Kingdom; 4Human Performance Laboratory, Sports Medicine Biodynamics Center, Cincinnati Children’s Hospital Medical Center, Cincinnati, Ohio; 5Department of Pediatrics, College of Medicine, University of Cincinnati, Cincinnati, Ohio; and 6Departments of Family Medicine, Biomedical Engineering, and Cell Biology and Physiology, The Ohio State University Sports Medicine Center, The Ohio State University, Columbus, Ohio

ABSTRACT

Faigenbaum, AD, Farrell, AC, Fabiano, M, Radler, TA, Naclerio, F, Ratamess, NA, Kang, J, and Myer, GD. Effects of detraining on fitness performance in 7-year-old children. J Strength Cond Res 27(2): 323–330, 2013—The purpose of this study was to examine the effects of detraining on fitness performance in 7-year-old children after 8 weeks of muscular fitness training, which took place during the first 15 minutes of regularly scheduled physical education (PE) class. Children from 2 PE classes were cluster randomized into either an exercise group (n = 20) or a standard PE control group (n = 19). Performance on the long jump, single-leg hop, curl-up, and balance test was assessed at baseline, after training, and after an 8-week detraining period. A significant interaction of group by time noted in abdominal curl-up and single-leg hop performance (p < 0.05). After detraining, the exercise group maintained training-induced gains on the curl-up (group mean [95% confidence interval] posttraining of 27.9 [21.2–34.5] to detraining 27.3 [21.1–33.8] repetitions; p < 0.05) and single-leg hop (posttraining 79.8 [73.2–86.4] to detraining 79.7 [73.0–86.5] cm; p < 0.05). Conversely, long jump (posttraining 113.8 [108.2–119.5] to detraining 110 [102.6–117.5] cm; p < 0.05) regressed toward baseline values in both groups. After detraining, balance performance (1.5 [1.3–1.7] seconds) regressed relative to baseline (2.0 [1.7–2.4] seconds) and posttraining (2.0 [1.8–2.4] seconds; p < 0.05). These findings indicate that the phenomenon of detraining in children is complex and characterized by different adaptations and regressions in strength, power, and balance. Regular participation in fitness activities during PE may be needed to enhance and maintain performance in all measures of muscular fitness in 7-year-old children.

KEY WORDS resistance training, fundamental movement skills, physical education, physical activity, youth

INTRODUCTION

Global health recommendations suggest that school-age youth should participate in at least 60 minutes or more of moderate-to-vigorous physical activity daily (28). In addition to recreational activities and team sports, school-based physical education (PE) is recognized as an ideal setting to provide students with safe and sequential activities that will maintain or improve health- and skill-related components of physical fitness (20). Significant improvements in fundamental movement skills (e.g., jumping, throwing, and balancing) and physical fitness have been reported after regular participation in PE classes, which consisted of age-appropriate activities (5,13,27). However, the effects of detraining in children have not been extensively studied, and the precise nature of the detraining response that occurs during this period remains uncertain. Unlike adults, the evaluation of performance changes in children after the temporary or permanent reduction or withdrawal of a training stimulus is complicated by the concomitant growth-related increases during the same time period.

Several studies have reported the effects of detraining after exercise interventions on fitness-related performance measures in children and adolescents (7,10,11,25,26). Santos and Janeiro (25) examined the effects of detraining and reduced training on explosive strength in adolescent basketball players who participated in a 10-week strength and conditioning program. After 16 weeks of detraining or reduced training, young athletes in this study maintained performance on measures of upper- and lower-body explosive strength (25). Conversely, Tsolakis et al. (26) found that resistance
training-induced gains in preadolescent males decreased significantly at the end of an 8-week detraining period and regressed toward untrained control group values. Other researchers examined the effects of 4 weeks of balance training followed by detraining on postural control, plantar flexor strength, and jumping height in 6- to 7-year-old children (10). Although statistically significant, improvements in outcome measures were not observed in the aforementioned report (10), the length of the training period, and design of the intervention, which did not include resistance training may have influenced the results. At present, the effects of detraining or reduced training on children and adolescents have not been clearly established because contradictory results have been reported in the literature.

Researchers have examined the efficacy of different strength and conditioning interventions on school-age youth (6,12), and we recently reported the effects of an integrative fitness program (i.e., combined resistance and plyometric exercise) on primary school children (5). However, we are not aware of any investigation that tested empirically the effects of detraining on fitness performance in 7-year-old children after participation in a PE fitness lesson, which focused on enhancing muscular fitness and motor skill performance. A better understanding of the detraining phenomenon in children is critical for the maintenance of training-induced gains in fitness performance, and the promotion of planned exercise in the context of school, family, and community activities. This information is particularly important for PE teachers, youth coaches, and pediatric physical therapists who prescribe exercise for children and are expected to prepare school-age youth for a lifetime of healthful physical activity.

The main purpose of the current investigation was to assess the effects of detraining on fitness performance in healthy 7-year-old children who participated in a short-term fitness program during PE. A school-based fitness intervention that included planned instructional lessons was used to ensure compliance and enhance both muscular fitness and motor skill performance. In addition, PE classes provide an ideal setting to monitor changes in fitness performance throughout the school year. We hypothesized that training-induced gains in fitness performance in children would regress toward baseline values during the detraining period, which did not include specialized fitness training.

**Methods**

**Experimental Approach to the Problem**

To assess the effects of detraining on fitness performance in 7-year-old children who participated in a short-term fitness lesson during PE, students from 2 second-grade PE classes were cluster randomized into either an exercise group or a control group. Performance on the long jump, single-leg hop, curl-up, and balance test was assessed at baseline, after training, and after a detraining period. All testing and training occurred during regularly scheduled PE, and we selected age-appropriate fitness tests that are consistent with primary school PE curricula. An age-appropriate training program that focused on enhancing muscular fitness and motor skill performance was followed by an 8-week detraining period. All testing and training procedures were closely monitored by a PE teacher and certified strength and conditioning specialists. During the detraining period, subjects participated in 6 weeks of standard PE, which did not include specialized fitness training, and 2 weeks of winter vacation. Subsequent analyses of pretraining, posttraining, and detraining fitness measures allowed us to evaluate the effects of detraining on training-induced gains in selected fitness measures. This approach allowed us to carefully monitor the response of each young subject to the fitness training program during PE and individually assess performance throughout the study period.

**Subjects**

Thirty-nine children from 2 second-grade PE classes were cluster randomized into either an exercise group or a control group and were tested at baseline, posttraining, and after detraining by members of the research team. Twenty children (10 males and 10 females) were in the exercise group (mean age 7.5 ± 0.3 years; body mass index Z-score [BMIZ] score 1.2 ± 0.8); and 19 children (6 males and 13 females) served as controls (mean age 7.6 ± 0.3 years; BMIZ score 0.9 ± 1.0). All testing and training took place during PE classes in a public primary school. All study procedures were approved by the College’s Institutional Review Board, and all parents or caregivers provided written informed consent before the start of the study.

**Testing Procedures**

Testing at baseline, posttraining, and detraining took place in September, November, and January, respectively. During PE classes, children were evaluated by a PE teacher and certified strength and condition specialists who had experience testing and training school-age youth. Height and body mass were measured at baseline using standard techniques, and BMIZ was calculated. Standardized protocols for fitness testing were followed according to the methods previously described (3,17,23). Briefly, the curl-up was used to assess abdominal strength/endurance. The cadence of the curl-up test was set with a metronome (1 curl-up per 3 seconds). Lower-body power was evaluated by the standing long jump and single-leg hop tests. Participants were required to hold the landing of each jump and maintain postural control until the distance was measured. Each jump test was performed 3 times, and the best score was recorded to the nearest whole centimeter. Balance was assessed with the stork stand that required the participants to maintain a stable body position while standing (without sneakers) on one plantar-flexed foot with hands on hips and eyes open. Participants were required to hold this position for as long as possible, and the best time of 3 trials was recorded to the nearest 0.1 second. Test-retest reliability for the single-leg hop test in children from our lab is $R = 0.82$. Test-retest
reliability of other field-based fitness tests for youth have been reported (4,23).

Training and Detraining

The training program was purposely designed to address common barriers to implementing school-based programs (e.g., lack of resources and insufficient time) and was based on previous reports (2,16,19). The program was performed twice per week (Monday and Wednesday) in the afternoon during the first 15 minutes of each regularly scheduled 43-minute PE class. The regular PE teacher and a certified strength and conditioning specialist provided guided instruction and corrective feedback to enhance the development of desired movement patterns. The training program included practice of fundamental movement skills, which are required to perform more complex actions. The training program consisted of primary exercises that focused on enhancing muscular strength and power, and secondary exercises that aimed at improving fundamental movement skills. The progressive program alternated between relatively intense primary exercises (e.g., squat jump) and less intense but challenging secondary exercises (e.g., single-leg balance and twist), which provided a continuous training stimulus. Participants performed 2 sets on all exercises, and the repetitions (7–10) or set duration (10–30 seconds) was gradually progressed over the 8-week training period. The general structure and content of the fitness program is outlined in Table 1. Details of the training program are available elsewhere (5). Children performed all exercises with a durable punch balloon (minus the rubber band) that was blown up to the size of a basketball. Balloons can add an element of fun and excitement to primary school PE and were used to slow down catching and kicking movements to a controllable level so children would be more likely to master new skills and experience success (8).

After approximately 15 minutes of fitness training, children in the exercise group participated in a variety of standard PE activities (e.g., stick handling, ball dribbling, and group games) as directed by the PE teacher for the remainder of the class. Participants in the control did not perform specific fitness training but attended their regular PE class twice per week during the study period and participated in the same PE activities. During the 8-week detraining period, children in both groups participated in

Table 1. General structure of the training program.*

<table>
<thead>
<tr>
<th>Primary exercises</th>
<th>Secondary exercises</th>
</tr>
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<tbody>
<tr>
<td>Weeks 1–8</td>
<td>Weeks 1–2</td>
</tr>
<tr>
<td>Front squat</td>
<td>SL balance</td>
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<tr>
<td>Squat jump</td>
<td>OH press and catch</td>
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<tr>
<td>90° jump</td>
<td>Knee tap and catch</td>
</tr>
<tr>
<td>Plank</td>
<td>Hip twist</td>
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<tr>
<td>Balloon drop and catch</td>
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<tr>
<td>Weeks 3–5</td>
<td>Weeks 6–8</td>
</tr>
<tr>
<td>SL balance</td>
<td>SL balance and OH press</td>
</tr>
<tr>
<td>OH press and catch</td>
<td>SL OH press and catch</td>
</tr>
<tr>
<td>Knee tap and catch</td>
<td>ALT knee tap and catch</td>
</tr>
<tr>
<td>Hip twist</td>
<td>OH chop</td>
</tr>
<tr>
<td></td>
<td>Get up and catch</td>
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<tr>
<td></td>
<td>Knee tap, turn, and catch</td>
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<tr>
<td></td>
<td>Diagonal chop</td>
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*SL = single leg; OH = overhead; CP = chest press; ALT = alternate right and left knee.

Figure 1. Performance changes for the abdominal curl-up test after the 8-week training and detraining period in the exercise group (EX, black line; n = 20) and control group (CON, dashed line; n = 19). Values mean ± SE. Significant interaction of group by time with increased performance improvement in EX (a) and increased performance by EX at detraining follow-up (b).
standard PE activities (e.g., basketball skills and group games) for 6 weeks (2 times per week) followed by 2 weeks of winter vacation without PE. During the detrain- ing phase of the study, children did not participate in school-based activities that focused on enhancing muscular fitness.

**RESULTS**

Participants completed the study according to aforementioned procedures, and no injuries were reported. The exercise group had a participation rate of 100% during the training period. A significant interaction of time by group was observed after the training period for the curl-up exercise, which indicates that training-induced gains were observed over time, and these responses were different between the exercise and control groups. Specifically, the exercise group made greater gains (relative to control) in the maximum number of curl-ups at a posttraining measure \( (p < 0.05) \) (Figure 1). After the detraining period, curl-up performance did not change in the exercise group (group mean \[95\% confidence interval\] post- training of 27.9 \[21.2–34.5\] to detraining 27.3 \[21.1–33.6\] repetitions; \( p < 0.05 \)) and was still increased relative to the pretest measurement (Figure 1).

Similar to the curl-up, performance on the single-leg hop provided a significant interaction of time by group after...
training indicating that training adaptations were different between the exercise and control groups. Specifically, the training program resulted in greater improvements in the single-leg hop compared with the control condition ($p < 0.05$) after the training period (Figure 2). Measurements taken after the detraining period indicated that single-leg hop performance in the exercise group did not change from posttraining (posttraining 79.8 [73.2–86.4] cm; $p < 0.05$) but was still increased relative to the pretraining measurement (Figure 2).

For the long jump test, a significant main effect of time was observed for the repeated test measures, which indicate that training responses in long jump performance were identified over time; however, this training response was not different between the exercise and control groups. After the training period, long jump distance increased in both groups from a mean pretest score at posttraining ($p < 0.05$, Figure 3). After the detraining period, long jump performance decreased (posttraining 113.8 [108.2–119.5] cm; $p < 0.05$) and regressed back to measures similar to baseline for both the exercise and control groups (Figure 3).

After the training period, balance performance did not change for both the exercise and control groups ($p > 0.05$; Figure 4). After the detraining period, balance performance (1.5 [1.3–1.7] seconds) regressed relative to baseline (2.0 [1.7–2.4] sec) and posttraining (2.0 [1.8–2.4] seconds; $p < 0.05$; Figure 4).

**DISCUSSION**

The main finding from our study was that gains in muscular fitness consequent to a short-term training intervention performed during PE class are characterized by different adaptations and regressions during the detraining period. In our study, training-induced gains in abdominal strength/endurance and single-leg hop performance were maintained during the detraining period, whereas performance on the long jump and balance test seemed to regress during the detraining phase. These findings provide new insights into the effects of detraining on children and suggest that the degree of strength, power, or neuromuscular skill required to perform a selected movement may influence the detraining response in young children. These results offer needed data for PE teachers, youth coaches, and pediatric physical therapists regarding the importance of regular fitness training or some type of maintenance training to preserve training-induced gains in selected measures of physical fitness in young children.

Although there are only limited data in the pediatric literature against which to conceptualize our findings, a few studies have evaluated the effects of detraining on youth after resistance training (7,11,24,26). In the present investigation, children maintained their training-induced gains in abdominal strength/endurance after the detraining period, which included 6 weeks of standard PE and 2 weeks of winter vacation. However, others reported training-induced gains in muscular strength were impermanent and tended to regress toward untrained control group values during the detraining period (7,11,26). For example, Faigenbaum et al. (7) reported significant decreases in upper- and lower-body strength after 8 weeks of detraining in children and similar observations were noted by Tsolakis et al. (26) who found regressions in upper-body isometric strength in preadolescent boys after the detraining period.

Subjects in our study made significant gains in curl-up performance after the training period, and these gains were maintained during the detraining period. These observations suggest that abdominal strength and function may be more resistant to regression if achieved with fitness training that includes a variety of exercises that focus on enhancing muscular power, muscular strength, and motor skill performance. Because a strong and stable core (i.e., abdomen, trunk, and hip) allows for optimal force production during the performance of selected motor skills (21), the maintenance of the observed gains in abdominal strength/endurance after a fitness program may have important implications for the design of training protocols.
Detraining

of PE lessons. Furthermore, the maintenance of training-induced gains during a detraining period seems to be influenced, at least in part, by the magnitude of the initial strength gain.

Subjects in our study also maintained performance on the single-leg hop during the detraining period. Although training-induced gains in skill-related fitness measures, such as the vertical jump and basketball chest pass, tend to decline toward baseline values after detraining (11); the single-leg hop is an explosive movement that requires coordination and postural control during the landing phase of the movement. Muscle strength is an essential component of many motor skills (15), and therefore it is possible that the maintenance of training-induced gains in abdominal strength/endurance may have been synergistic with these observations. In our study, children were required to hold the landing after each hop and maintain balance and postural control for about 2 or 3 seconds until the distance was measured. Because subjects received regular instruction and feedback regarding proper exercise technique and body mechanics throughout the training period, the maintenance of single-leg hop performance that was refined with practice may be because of improvements in learning and neuromuscular adaptive mechanisms. It is also possible that participation in traditional PE games and activities throughout the training and detraining period may have influenced these observations.

Regressions toward baseline values were observed in the long jump and balance test after detraining, which suggests that the effects of detraining on strength, power, and balance are multifarious in children. Although these findings are consistent with other reports that assessed power performance and postural control in children and adolescents after detraining (9,11), the decline in long jump performance and the maintenance of single-leg hop performance during this phase of our investigation are provocative. Because the single-leg hop required more balance and coordination than the standard long jump, perhaps the trainability of a single-leg skill along with the practice and instruction the children received during the training program contributed to longer-lasting maintenance of single-leg hop performance during the detraining period. To maintain standing long jump performance, it seems that children must repeatedly produce adequate levels of lower-body power to effectively train this movement.

Similarly, because static and dynamic balance are essential for most activities of daily living and the proficient performance of various motor skills, regular exposure to progressive balance training (e.g., static and dynamic stabilization) seems to be needed to maintain basic motor patterns in children. Of interest, Granacher et al. (10) investigated the effects of a short-term balance training program on 6- to 7-year-old children and found no significant improvements in postural control. While the immaturity of the postural control system in prepubertal children could account for these observations (22), the authors also noted that the attentive focus required to perform the balance exercises and the design of the intervention, which only included balance training, should be considered when evaluating their findings (10).

The detraining phase of our study occurred during the winter months when children tend to spend less time outside participating in recreational activities characterized by short bursts of running and jumping. Thus, environmental factors may have contributed to the observed regressions in power performance and balance during the detraining period. It is also possible that our approximately 15-minute fitness program during regularly scheduled PE was not of the magnitude required to stimulate sustainable gains in lower-body power and balance in 7-year-old children.

Although our findings tend to support the theoretical construct proposed by other observers which outlines the effects of growth, resistance training, maintenance training, and detraining on strength development during childhood (1), the assessment of both health- and skill-related fitness measures in the present investigation suggest that not all training-induced gains in children are transient and reversible. Although training-induced gains in muscular strength and motor skill proficiency during childhood are primarily due to neuromuscular adaptations, it is possible to speculate that some of the neuromuscular adaptive mechanisms that underpin changes in performance during detraining (e.g., reduced motor unit activation) may vary depending upon the type of exercise (e.g., strength or power), the complexity of the motor skill (single-leg hop or double-leg jump), and the musculature involved in the movement (e.g., upper body vs. trunk). Additionally, the duration of the detraining period and the amount and type of activity during this phase will likely influence changes in performance. During the detraining phase of our study, subjects participated in standard PE twice per week but did not perform strength-building games and activities.

Our findings demonstrate the necessity of habitual participation in physical activities that are purposely designed to enhance muscle strength and fundamental movement skills if continual improvements in these performance measures are desired. Although many factors including genetics can influence muscle strength and fundamental movement skills performance in youth (14,15), opportunities to participate regularly in meaningful activities with qualified instruction are needed to optimize and maintain adaptations during this critical period of life (18). Of note, based on the high compliance and enthusiastic participation from the subjects in our study, flexible delivery options including shorter lessons and inexpensive equipment are noteworthy contextual issues to consider when fitness activities are incorporated into PE lessons.

A strength of our study stems from the fact that we performed this study on 7-year-old children in a public primary school and compliance with our exercise
intervention was 100%. On the other hand, there are limitations. Our population sample is limited, and our data may not be applicable to adolescents nor do our results provide insight into the long-term effects of detraining on fitness performance in children. Also, it was not possible to include a no-PE control group because of ethical concerns associated with such a group.

**Practical Applications**

Children who participate in structured fitness activities often undergo periods of reduced training or inactivity because of injury, rehabilitation, school vacations, changes in academic schedules, or decreased motivation. The results of our study emphasize the importance and necessity of regular participation in strength and conditioning activities during PE. Our findings suggest that the effects of detraining are complex in children, and the degree of strength, power, or neuromuscular skill required to perform a selected movement may influence the detraining response. Also, the amount and type of activities performed during the detraining period may influence training regressions. Based on our findings, the discontinuance of structured fitness training during PE will reduce the likelihood that desired or optimal adaptations in all health- and skill-related measures of physical fitness will continue to be observed.

Research evidence indicates a beneficial role for early exposure to fitness activities that enhance muscular strength and motor skill performance. However, professionals who prescribe this type of training for children should consider the negative consequences of detraining or reduced training on performance. To develop and maintain fitness proficiency, children should be encouraged to participate regularly in fitness lessons that include qualified instruction and adequate time for practice. Long-term studies are needed to examine the effects of school-based fitness interventions on muscular fitness in school-age youth and to explore the neuromuscular mechanisms that underpin changes in performance during periods of detraining.

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**References**


