Effects of Reduced Training and Detraining on Upper and Lower Body Explosive Strength in Adolescent Male Basketball Players

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Abstract

Santos, EJAM and Janeira, MAAS. Effects of reduced training and detraining on upper and lower body explosive strength in adolescent male basketball players. *J Strength Cond Res* 23(6): 1737–1744, 2009—The purpose of this study was to assess and compare the effects of detraining and of a reduced training program on upper- and lower-body explosive strength in adolescent male basketball players. To study this, 15 subjects, aged 14 to 15 years old, were randomly assigned to 1 of the 2 following groups: reduced training (RT; $n = 8$) and detraining (DTR; $n = 7$). The participants were assessed on squat jump (SJ), countermovement jump (CMJ), Abalakov test (ABA), depth jump (DJ), mechanical power (MP), and medicine ball throw (MBT) after a 10-week in-season complex training program (T0) and at the end of 4 (T4), 8 (T8), 12 (T12), and 16 (T16) weeks of detraining and of the reduced training periods. Both groups showed maintenance of explosive strength values and statistical similarity between them whatever the moment of evaluation. In conclusion, 16 weeks of detraining or of reduced training allow for the maintenance of the gains previously achieved by the application of a 10-week in-season complex training program. However, the lack of differences between detraining and reduced training leads to the conclusion that regular basketball practice can sustain by itself the previously achieved explosive strength gains, considering its mainly explosive characteristics.

Key Words training cessation, complex training, young athletes, vertical jump, medicine ball throw

Introduction

Detraining initially was seen as the period during which there were no more training stimulus and the athlete was exposed to functional and psychic disturbance (21). According to other interpretations, detraining is not only the cessation of strength training, but also its reduction in terms of volume, intensity, and frequency (12,23). For these authors, detraining may occur as a result of an injury or as a function of the phases of the annual planning of training. Correct knowledge of the basic adaptations occurring on the neuromuscular system during detraining facilitates the design of training programs that may improve performance, power, and strength maintenance during detraining and reduced training periods (12,23). When there is a cessation or a reduction in training, losses occur in terms of physiological adaptations and athletic performance (11). Nevertheless, strength levels can be easily retained for up to 4 weeks of inactivity (28). In other words, muscular strength changes are more resistant to short detraining periods (22). Wilmore and Costill (37) consider it possible to maintain strength levels during 6 weeks of complete detraining and to preserve 50% of the gains during 1 year with no training stimulus. Some authors have reported the stability of muscular strength patterns following different detraining periods (8,17,19,24,26,27). However, other authors reported differentiated decreases in the final values of the tested variables during a detraining period (5,10,14–16,18,20,32,33).

To oppose the detraining effects, some authors recommend the inclusion of strength maintenance programs in the training planning (2,22). Specifically, Kroll (25) refers to significant losses in strength between weeks 2 and 4 in the absence of a maintenance training program. However, different authors suggest that the design of a maintenance training program should respect the initial levels of intensity and the reduction of weekly training volume and frequency (12,13,29,31).

It is possible to keep strength levels with a single high-intensity weekly workout (4,34). DeRenne et al. (7) proved this idea and concluded that the application of a maintenance program once a week during the competitive season was sufficient to retain strength levels in male pubescent baseball players. Others authors (13) also report that subjects who

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Table 1. Reduced complex training program (once a week).

Exercises	Resistance training
Pullover	3 × 10/12 RM
Leg press	3 × 10/12 RM
Decline press	3 × 10/12 RM
Rest between sets: 2'–3'; Rest between exercises: 45"–60"	
Exercises	**Plyometric training**
Depth jump 180-degree turn	4 × 6
MB power drop	4 × 10
Cone hops with change of direction sprint	4 × 6 + 5-m sprint right/left
Rest between sets: 3'–4'; Rest between exercises: 60"–90"	

RM, repetition maximum; MB, medicine ball; sets X reps.

reduced training frequency to once a week essentially managed to maintain all the strength gained during the initial training period.

The comparison between detraining and reduced training has been studied by different authors, with intragroup and intergroup results differing in the stability patterns of strength (7,13,31).

As a result of the contradictory findings, concerns emerge regarding the strength stability in response to different kinds of detraining and reduced training. Nevertheless, it seems reasonable to hypothesize that detraining and reduced training periods have similar effects in the maintenance of explosive strength levels. Thus, the aim of this study was to identify and compare the effects of both detraining and reduced training program application in the explosive strength levels in adolescent basketball players.

Methods

Experimental Approach to the Problem

Prior to the present investigation subjects had completed a twice a week in-season complex training program for 10 weeks. Subsequently, and to address the hypothesis previously presented, subjects were randomly assigned to either a detraining group (DTR; $n = 7$) or a reduced training group (RT; $n = 8$). The DTR group stopped the complex training program but maintained regular basketball practice. Complementarily to the basketball practice, the RT group was submitted to a reduced complex training program once a week. Therefore, it was our goal to identify and compare the effects of detraining or reduced training periods on the explosive strength levels of young male basketball players (aged 14 to 15 years old). All the subjects were tested on

Table 2. Comparison of explosive strength test results mean (± *SD*) between the 2 groups during 16 weeks.

Test	Groups	T0	T4	T8	T12	T16
SJ (cm)	DTR	28.71 ± 5.4	30.76 ± 5.5	27.79 ± 6.1	26.57 ± 4.6	26.28 ± 4.2
	RT	27.40 ± 4.1	29.30 ± 5.2	27.65 ± 4.8	26.23 ± 5.1	26.17 ± 4.9
CMJ (cm)	DTR	34.32 ± 6.5	35.23 ± 7.1	34.37 ± 4.7	33.04 ± 6.3	34.45 ± 6.35
	RT	31.89 ± 6.0	33.33 ± 7.2	33.81 ± 7.2	32.19 ± 7.7	33.70 ± 6.7
ABA (cm)	DTR	38.78 ± 8.2	39.73 ± 8.2	38.61 ± 7.8	38.86 ± 7.4	39.95 ± 8.8
	RT	38.13 ± 6.5	39.70 ± 7.6	39.60 ± 7.3	37.94 ± 7.8	39.65 ± 6.7
DJ (cm)	DTR	36.85 ± 9.8	38.37 ± 8.3	36.23 ± 7.6	37.25 ± 7.8	36.01 ± 8.2
	RT	36.45 ± 6.9	36.16 ± 6.9	37.16 ± 7.3	36.16 ± 7.9	36.37 ± 7.6
MP (W/kg)	DTR	23.53 ± 3.5	24.72 ± 4.8	22.37 ± 3.3	23.73 ± 4.2	24.99 ± 4.8
	RT	25.33 ± 4.3	25.12 ± 5.4	24.83 ± 3.3	23.76 ± 4.8	23.56 ± 4.1
MBT (m)	DTR	4.00 ± 0.63	4.31 ± 0.67	3.92 ± 0.45	3.95 ± 0.42	3.88 ± 0.58
	RT	4.27 ± 0.25	4.39 ± 0.36	4.12 ± 0.33	3.91 ± 0.22	4.03 ± 0.32

*SJ, squat jump; CMJ, countermovement jump; ABA, Abalakov test.
DJ, depth jump; MP, mechanical power; MBT, medicine ball throw.
DTR, detraining; RT, reduced training.

squat jump (SJ), countermovement jump (CMJ), Abalakov test (ABA), depth jump (DJ), mechanical power (MP), and medicine ball throw (MBT) at the end of the previous training (T0); after 4 (T4), 8 (T8), 12 (T12) weeks; and at the conclusion of the 16-week detraining/reduced training periods (T16). Intraclass correlation coefficient for all the assessed variables ranged from $r = 0.949$; $r = 0.992$ and $r = 0.918$; $r = 0.985$, respectively, for the detraining and reduced training groups.

Subjects

Fifteen adolescent male basketball players (14–15 years old) previously submitted to a 10-week in-season complex training program twice a week (30) were randomly assigned to 1 of 2 experimental groups: reduced training group (RT; n = 8; weight 75.6 ± 17.0 kg, height 177.5 ± 7.4 cm) and detraining group (DTR; n = 7; weight 69.3 ± 17.5kg, height 174.0 ± 11.5 cm). Prior to the complex training program, none of the subjects had training experience using resistance or plyometric training programs. All athletes were in Stages 3 or 4 for pubic hair growth and genital development for both groups (35). Athletes, parents, and coaches were informed about the purpose of the study, and informed consent was obtained from all subjects and parents before the study began. The Institutional Review Board of the Faculty of Sports/University of Porto approved all study procedures.

Testing Procedures

Subjects were assessed at the end of the 10-week in-season complex training program (posttraining; T0) and at 4 (T4), 8 (T8), 12 (T12), and 16 (T16) weeks of the detraining and reduced training periods (T16) for upper- and lower-body explosive strength, according to Cronin and Owen (6) and Bosco (3) protocols, respectively. This procedure allowed the assessment of squat jump (SJ, cm), countermovement jump (CMJ, cm), Abalakov test (ABA, cm), depth jump from a 40-cm platform (DJ, cm), mechanical power (MP, W/kg), and seated medicine ball throw (MBT, m). There was a previous familiarization with accurate test procedures. Tests followed a general warm-up consisting of running, calisthenics, and stretching. Except for mechanical power, which was assessed after 2 trials with a 60-second rest between trials, all the other tests were

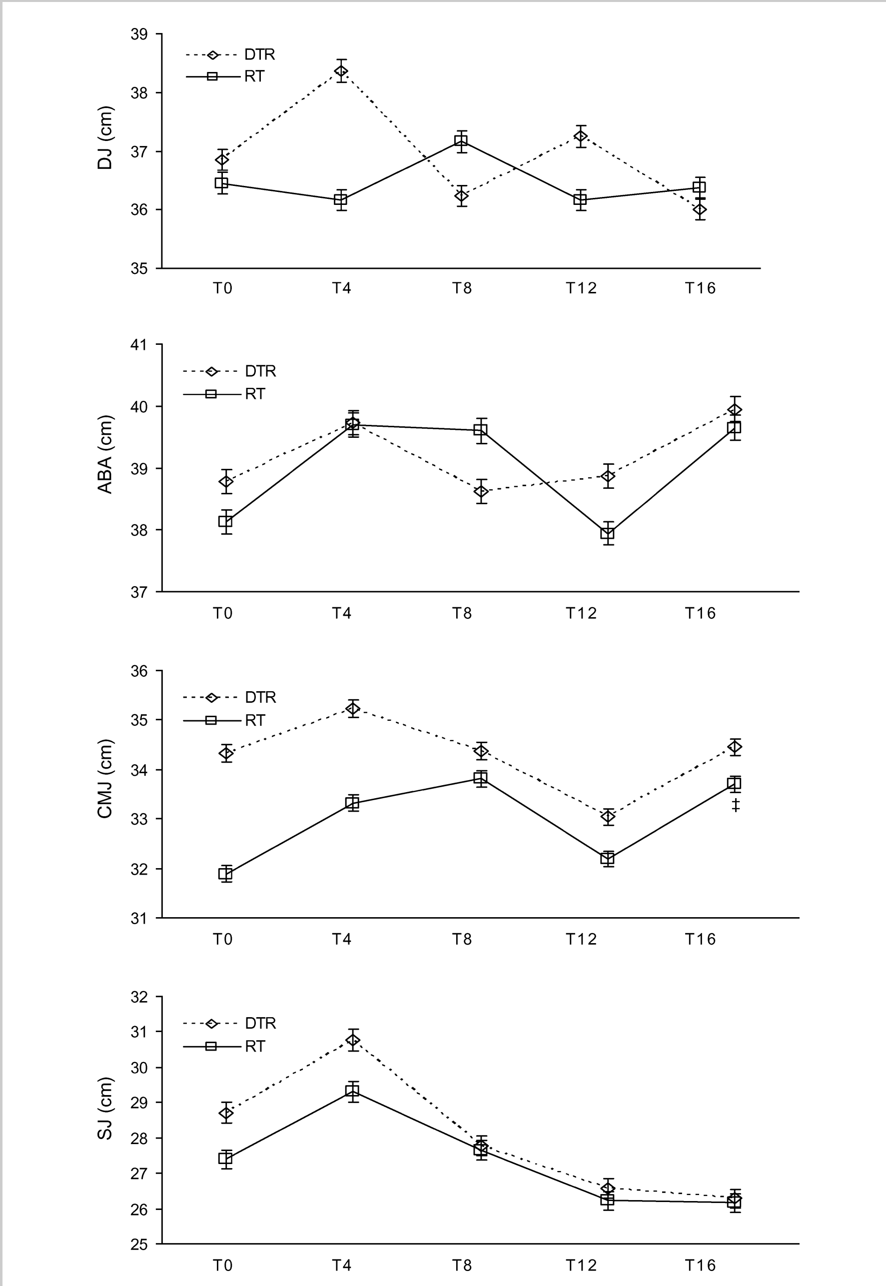

Figure 1. Squat jump (SJ), countermovement jump (CMJ), Abalakov test (ABA), and depth jump (DJ) mean heights from posttraining to 4, 8, 12, and 16 weeks. DTR, detraining group; RT, reduced training group.

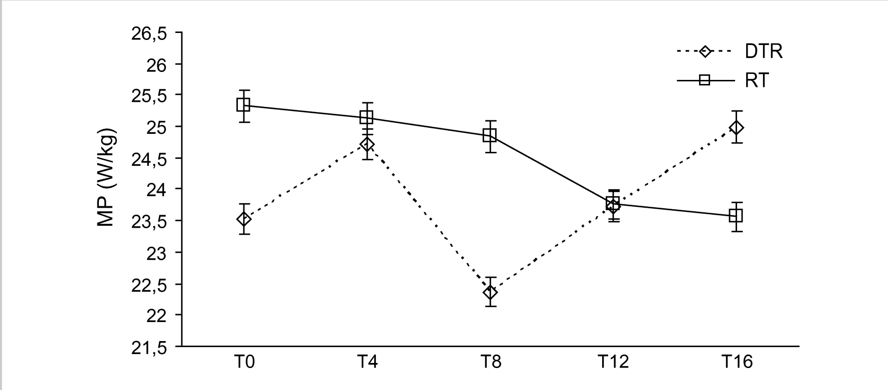

Figure 2. Mechanical power (MP) scores from posttraining to 4, 8, 12, and 16 weeks. DTR, detraining group; RT, reduced training group.

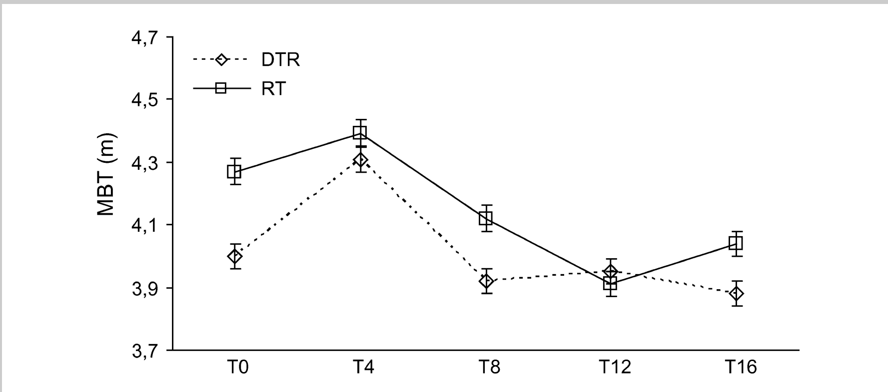

Figure 3. Medicine ball throw (MBT) mean distances from posttraining to 4, 8, 12, and 16 weeks. DTR, detraining group; RT, reduced training group.

performed with 3 trials and all the correspondent mean values were considered for statistical analysis. There was a 20-second and a 10-second rest between trials for the lower body and the sitting chest throw, respectively. All jumping tests were performed using a contact platform Globus Ergo Tester (Codogne, Italia), except for the DJ, which was performed on an electromechanic platform Ergojump (Digitest OY, Muurame, Finland).

Training Protocol

Initially the athletes performed a 10-week complex training program, which included plyometric exercises preceded by resistance exercises (30). At the end of this period all the subjects significantly increased their upper- and lower-body explosive strength levels ($p < 0.05$). The subjects then were randomly assigned to 1 of the 2 following groups: 7 subjects followed a 16-week in-season detraining period (completely cessation of strength training), and 8 subjects followed a reduced training program once a week in the same time period (Table 1). Both groups kept up the regular basketball practice. A standardized warm-up routine consisting of running, calisthenics, and stretching was used.

Nautilus machines were used in the weight room, except for the leg press, which was performed on a Technogym machine. Plyometric material included 3-kg medicine balls, 40-cm–high boxes, and 28-cm–high cones. The rest period between resistance training and plyometrics averaged 4 minutes.

Statistical Analyses

Means and standard deviations were used to describe the data. A repeated measure analysis of variance (ANOVA) with a fixed factor (group) was used to analyze changes in time, especially a significant interaction term (group by time). Significance level was set at 5%. SPSS was used in all analysis.

Results

The results from the comparison between the explosive strength mean scores during a 16-week period for the detraining and reduced training groups and the comparison between groups in different moments of assessment are presented in Table 2. A detailed analysis from Table 2 shows changes in some variables during the 16-week detraining and reduced training periods. However, there were no significant group-by-time interactions for all the assessed variables.

Figures 1 through 3 graphically illustrate the behavior of the studied indicators in both groups during the 16-week detraining and reduced training periods.

Discussion

To our knowledge, the current study is the first to investigate the detraining and reduced training effects subsequent to a complex training program with adolescent male basketball players (30). In general, our data showed maintenance of explosive strength values during 16 weeks of detraining and reduced training.

Strength performance is kept during 4 weeks of inactivity (28). However, the maintenance of training intensity seems to be a key factor in adaptation retention, independently of frequency and volume training reduction (29). Our results meet these opinions because both experimental groups managed to keep the levels achieved in the previous training phase. Nonsignificant increments were observed in the test scores, which is in line with the understandings of Fleck (11) and Kraemer and Häkkinen (23), suggesting an increase in strength subsequent to short detraining periods after a high-intensity strength training.

Twelve power athletes enhanced, although nonsignificantly, CMJ and DJ heights, despite a light reduction (nonsignificant) in SJ height, after 14 days of resistive exercise detraining (19). Another study reported small and nonsignificant increases in SJ and CMJ during 2 weeks of detraining in physical education students previously submitted to 4 weeks of plyometric or electromyostimulation training (17). The authors attributed these changes to a possible "rebound effect," which occurs when training is stopped for a short period. These findings are consistent with our data.

During 4 weeks of detraining, Maffiuletti et al. (27) identified a significant enhancement in CMJ scores and stability in SJ levels in male basketball players. In the present investigation similar changes were observed–that is, we noticed stability on SJ and CMJ values. The idea of muscular attitude maintenance attributed by these authors to standard basketball training is also evident from our data. Significant increments on vertical jump were observed following 4 weeks of recovery period characterized by plyometric training cessation (26). In a similar way, and consistent with our findings, Faigenbaum et al. (10) demonstrated a light enhancement (nonsignificant) in vertical jump height on prepubertal subjects after a 4-week detraining period. During 6 weeks of detraining, no changes occurred on vertical jump height in recreationally strength-trained men. However, the assessments taken on the third and sixth weeks showed absolute values higher than those at the baseline (24).

In a broader way Santos et al. (31) reported stability on SJ, CMJ, and MP scores in pubescent male basketball players assessed during 4 weeks of detraining and reduced training. No changes were observed between the detraining and the reduced training groups at the end of the evaluation period. These findings are consistent with the present data and, according to the conclusions of the previous study, it can be stated that both a reduced training program and detraining contribute equally to the maintenance of explosive strength levels. Thus, these data show the unique power that specific training in basketball may have to the maintenance and retention of motor performance.

Based on previous studies and according to Wilmore and Costill (37), it can be concluded that short detraining periods (up to 6 weeks) are suitable to retain previously achieved strength levels.

Presuming that after exercise cessation the previous training results disappear within a certain period (36), the detraining and the reduced training periods were extended up to 8 weeks in an attempt to understand the changes occurring intragroup and intergroup.

During this period, a general stability was evident on the posttraining values; moreover, a single reduced training workout and the absence of strength training showed similar effects.

In the available literature, no investigations assessing explosive strength changes during reduced training periods were found. However, our results confirm maintenance through reduced training periods.

No significant changes were observed in SJ, CMJ, and DJ in prepubescent soccer players following 8 weeks of detraining (also called reduced training by the authors) (8). The authors suggested that the maintenance of athletic performance was probably a result of the continuation of specific soccer training and to the short-term detraining period. The present data also can be explained by the explosiveness that characterizes basketball, which, combined with a short period of specific stimulus absence, is responsible for the maintenance of explosive performance levels. The complex program quality to which our subjects were previously submitted created solid basis for the maintenance of vertical jump values and MBT distance.

In a previous study (10) the extension up to 8 weeks of the detraining period demonstrated vertical jump height stability. During a similar period, another investigation reported SJ height stability, despite a slight decrease of this variable (16). In our research, there was equal maintenance in the SJ and ABA test values at the end of an 8-week detraining period.

In brief and keeping in mind the literature indications, it can be concluded that detraining does not cause significant decreases in the values of vertical jump. Short detraining periods do not seem to affect vertical jump in a significant way; however, longer detraining periods imply a decrease of this component (12).The experimental confirmation of that point of view is stated in 2 studies conducted during 12 weeks of detraining (14,15). In the first study, the authors reported a significant decrease in CMJ jump and stability in SJ and DJ values when compared to posttraining scores (14). In the other study (15), significant decreases in the CMJ and DJ and a nonsignificant slight reduction in SJ have been observed. In conclusion, the authors highlighted the relevance of detraining in the values of the strength income as a result of the induced neural activation (study 1); they also referred to the stressing character of the later weeks of the entire training period as being responsible for the observed decreases (study 2). These results differ from those obtained in the current study because no significant changes in any of the assessed variables were identified. We believe that the regular basketball practice was, in fact, responsible for the neural adaptations maintenance during detraining. In our opinion, this practice did not imply increased levels of either physical or sport stress.

In a 12-week detraining period, a slight nonsignificant decrease in the vertical jump height was observed in groups previously submitted to either concentric or concentric/eccentric resistance training (5).

The values reported in vertical jump height and basketball chest pass distance came back to the baseline levels at the end of 12 weeks of detraining (20); these results differ from the ones obtained in the present investigation. According to the authors, the regression tax is probably explained by the neural deterioration showing similar values to the regression taxes observed in other training modalities. These data differ from ours, probably because of the subjects' maturational characteristics and sports practice experience. Actually, our subjects were in Stages 3 and 4 of Tanner's maturational status, contrasting with Stages 1 and 2 of the referenced study (20). However, our subjects were basketball players who had only stopped strength training but continued regular basketball practice, whereas the sample of the another study included active subjects who were students from a basic school. It is our conviction that in the present study, the maintenance of explosive strength levels, over the detraining period, was largely a result of the continued basketball practice. Moreover, we believe that this procedure may have avoided the neural deterioration reported by Ingle et al. (20) as responsible for the strength values regression.

No significant decreases were observed in the subjects' isometric strength submitted to 12 weeks of reduced training (once and twice a week), contrasting with the detraining group, which showed a significant reduction in the isometric strength values in a similar period (13). When "forcing" a comparison with our study (different training regimens and strength types), similarities emerge from that comparison concerning the reduced training domains. It is our conviction that despite the differences in performed exercises, a single workout of strength training allows the maintenance of previous achieved levels. As far as detraining is concerned, differences between the 2 studies are relevant. In fact, our explosive strength levels remained steady, whereas decreases in the isometric strength values were observed in the subjects of the investigation carried out by Graves et al. (13). We strongly believe that the responsibility for the strength-level maintenance of our subjects during detraining lies in a regular basketball practice.

Pubescent male baseball players retained, in different percentages, upper- and lower-body strength gains when submitted to a 12-week maintenance training program with no workout (control group–detraining), a once-a-week session (group 1), and twice-a-week sessions (group 2) (7). According to the authors, the strength-level retention displayed by the detraining group is a result of the subjects' involvement in a sport requiring running. This relationship between strength gains maintenance and the type of activity performed during detraining periods is consistent with our results, and, as previously mentioned, basketball is responsible for the retention of the scores observed in our detraining group.

Finally, the absence of significant differences between our treatment groups at the end of the 12-week evaluation should be noted.

Few investigations have studied the behavior of explosive strength indicators during a longer (16 weeks) detraining and reduced training periods (18,32). Schneider et al. (32) intended to know the detraining effects according to the football player's position (linemen vs. nonlinemen). The authors reported decreases in vertical jump for both groups over a 16-week competitive season, which was statistically relevant only in nonlinemen. Nevertheless, the authors noted, "[T]o counter any possible detraining effect, the Huskie in-season training employs a twice-a-week strength maintenance program…" (p. 42). Based in these results they argued that such strength training frequency would not have induced the necessary intensity for the subjects to fully retain the pick strength levels achieved during preseason. These data differ from those displayed in our study because a single workout was enough to maintain CMJ and ABA test values.

In the other study (18) the responses of various performance tests related to strength, speed, endurance, and quickness over the duration of a Division I basketball season were investigated. After a 5-week in-season resistance training program, the subjects stopped the strength training process, continuing periodic evaluations at the 10th and 20th detraining weeks. According to these scores (significant decreases in vertical jump in the 10th week and stability in the 20th week), the authors concluded that it is possible for an athlete to maintain most of his or her preseason conditioning levels during the course of a college basketball season. This is also our opinion based on the maintenance, in general terms, of the explosive levels displayed by our sample subjects all over 16 weeks.

Taking into account the present discussion, we can clearly identify studies (although scarce) concerning the influence of maintenance programs in explosive strength levels. In what concerns the investigations on detraining, the conclusions are different and point out both the maintenance and the reduction of the previously achieved explosive strength levels.

To our knowledge, the present investigation is the first to study the behavior of explosive strength variables in adolescent basketball players over short and long detraining and reduced training periods. That analysis enabled us to confirm the hypothesis of a general stability in the assessed indicators in the different evaluation moments. The reason for that evidence lies in the fact that basketball has a strong explosive component, allowing the maintenance of strength levels obtained from the application of specific training programs. Other authors (18) share our point of view, stating that it is usual for college basketball teams to take part in a short-term preseason strength training program, after which coaches assume that high-intensity basketball practice is by itself sufficient to maintain the previously achieved strength levels.

Moreover, the magnitude of the maintenance or the decrease in the explosive strength levels during detraining depends on the load volume and intensity, the type of the preceding training program, the kind of physical activity performed during detraining, and its temporal length (23). In the present study, our detraining group had been previously submitted to a 10-week complex training program displaying significant increments in the explosive strength scores. By the end of this process, the subjects continued the regular basketball practice. As suggested by Kraemer and Häkkinen (23), the combination of the previous strength training effects with the quality of the developed physical activity (the regular basketball practice) may have contributed to the final scores obtained by the detraining group.

In this process, the strength-level maintenance resulting from the regular basketball practice is relevant. The preservation of the precedent training effects may be explained by the so-called "muscular memory" (33). The authors observed significant increases in maximal dynamic strength in women submitted to a 20-week resistance training program. Throughout 30 to 32 detraining weeks these values significantly decreased, although they remained higher than those of the baseline. In a subsequent 6-week phase, the subjects retrained, increasing the maximal dynamic strength values to levels identical to posttraining. The authors admit that their data show a retention effect, which elicits previously trained women to increase maximal dynamic strength in a relatively short period. This fact may be explained by a "muscular memory" phenomenon enabling increased neural activation or muscular hypertrophy to be retained during detraining (33). It is our conviction that this phenomenon may be responsible, among others, for the strength values maintenance identified in the present investigation. That is, when previously stimulated in a specific way, the muscles involved in a strength regimen will "keep in memory" the produced adaptations, which then will be "reactivated" throughout the sport preparing plan. In our study, the strength maintenance program along with regular basketball practice promoted a constant appeal to this "muscular memory" with visible effects in the explosive strength values stability.

Literature highlights the fact that pre- and early-pubertal boys do not appear to sustain training-induced strength gains during detraining (1). In the same way, a once-a-week maintenance training program is not effective in preserving prior strength gains (1). Similarly, training-induced strength gains in preadolescents are impermanent and tend to regress toward untrained control group values during the detraining period; similar findings probably also would be observed in adolescents (9). These understandings are opposite to the results of the present study. Because our athletes were in III and IV Tanner stages, we have not underestimated the important role that growth and maturation may have had on the maintenance of explosive levels identified on our studied groups (detraining and reduced training). Some authors have reported that relevance on the evaluation of strength levels in detraining groups (8,20).

Practical Applications

The present study showed that generally a 16-week in-season detraining or reduced training allows for the maintenance of the gains previously achieved by the application of a 10-week in-season complex training program. In other words, there was a close similarity between the effects resulting from the application of an explosive strength maintenance training program and the absence of this type of training-specific stimulus. This fact highlights the indistinct contribution of either detraining or reduced training on the maintenance of explosiveness levels in adolescent male basketball players. However, the normal growth in adolescents also may have contributed to the maintenance of upper- and lower-body explosive strength. Considering its mainly explosive characteristics, a regular basketball practice combined with such factors as growth and maturation can sustain by itself the previously achieved explosive strength gains. These data can be a good orientation for coaches because the inclusion of such detraining phases (instead of reduced training phases) in the sport season planning makes possible a greater focus–allowing more training time–on technical-tactical process development.

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