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Effects of Training Frequency on Strength Maintenance in Pubescent Baseball Players

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Reference Data

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ABSTRACT

This study examined the effects of training frequency on strength maintenance in 21 trained pubescent male baseball players (mean age 13.25 ± 1.26 yrs). The subjects completed 12 weeks of preseason, progressive strength training 3 days a week and were assigned to 1 of 3 experimental groups for an additional 12 weeks of in-season maintenance training. Group 1 ($n = 7$) lifted weights 1 day a week, Group 2 ($n = 8$) lifted weights 2 days a week, and a control group ($n = 6$) did not train during this 2nd 12 weeks. The preseason strength training program revealed significant increases ($p < 0.05$) for all groups in upper (bench press) and lower (leg press) body strength and dynamic upper body muscular endurance (pull-up). Following the 12-week in-season maintenance program, significant differences ($p < 0.05$) were observed between the control group and both training groups for the bench press. However, no significant differences were revealed between groups for the leg press or pull-up. It was concluded that for pubescent male athletes, a 1-day-a-week maintenance program is sufficient to retain strength during the competitive season.

Key Words: youth, sports, weight training, exercise, testosterone

Introduction

The growing number of youth sports programs in the U.S. has increased the participation of children in strength training. Pubescent baseball players are often required to use equipment, throw a ball, and play on a field with dimensions designed for more mature athletes. Therefore it appears that a strength training component would increase performance and possibly reduce the risk of injury. However, due to the relatively long competitive season, preseason strength gains may erode without an in-season maintenance program. Although studies have been done on strength training in children, there is still much we don't know. The present study was designed to address the area of strength maintenance in a trained pubescent population.

The literature supports the efficacy of resistance training in youth. Studies published as early as 1949 (11) reported the use of progressive resistance exercise in adolescents. More recently, researchers reported increases in voluntary strength gains in prepubescents and pubescents following isometric training (6, 18), hydraulic training (28), isotonic training (12, 19, 23, 25, 27), and plyometric (stretch-shortening cycle) training (26). Furthermore, the effects of resistive training have been related to improved performance (18, 24) and injury prevention (10, 13). Additionally, the American Medical Association, the American Academy of Pediatrics, and the National Strength and Conditioning Association endorse strength training as safe for prepubescents and adolescents and have developed position papers and guidelines to facilitate safety (1, 5, 17).

Although the literature addresses the effects of resistance training in young athletes, there is little information on strength maintenance during a competitive season. Morehouse (16) investigated the effects of isometric training programs in college age men and concluded that strength gains can be maintained by training once every 2 weeks or less during a maintenance training period. Similarly, Berger (3) studied the effects of different weight training loads after an initial strength training session and found that 5 of 6 college age groups increased isotonic strength using a 6-week maintenance resistance training protocol following an initial 3-week progressive resistance training program. However, these studies addressed adult populations. Therefore the purpose of this study was to examine the effects of two maintenance protocols on the retention of strength in trained pubescent baseball players during a competitive season.

Method

Subjects

Twenty-one pubescent male baseball players (mean age 13.25 ± 1.26 yrs) were recruited as subjects. All were actively participating in a junior high school baseball program; none had ever participated in formal weight training. The boys and their parents were informed of the scope and objectives of the study as well as potential risks associated with strength training. Written consent was obtained within the guidelines and policies of a university committee for study on human subjects.

The boys completed a medical history and underwent a comprehensive physical evaluation including a musculoskeletal examination. The examinations were performed by pediatric and orthopedic physicians to identify any preexisting condition (shoulder, elbow, wrist, knee, or ankle problems) that would limit participation. Under these criteria no subjects were eliminated.

Training Protocol

The strength training protocol for this study was divided into 2 phases. During the preseason phase all subjects trained for 12 weeks and completed 3 exercise sessions a week. Before the in-season (maintenance) phase 15 subjects were randomly assigned to 1 of 2 groups: Group 1 (n = 7) completed 1 exercise session a week while Group 2 (n = 8) completed 2 exercise sessions a week. The 6 boys in the control group were recruited and trained independently from the other 2 groups. That is, they followed exactly the same preseason protocol as the experimental groups but did not strength train for the 12-week in-season period. All training sessions were supervised and the boys were required to use correct form. To learn proper training technique, they participated in 3 low volume (2 sets of 15 reps at 50% of 10-RM for each exercise) training sessions 1 week before the formal preseason training protocol (20).

The preseason training program consisted of 3 sets of the following core exercises: supine bench press, wide grip cable pull-downs, leg extension, leg curl, biceps curl, and triceps extension (1, 17). The boys also performed shoulder dumbbell exercises (rotator cuff), dumbbell wrist curls, and dumbbell reverse wrist curls. The training protocol using the core exercises for the preseason program involved 1 set of a 10-rep warm-up at 50% of a predetermined 10-rep maximum (RM), 1 set of 10 reps at 75% of 10-RM, and 1 set of 10 reps at 100% of 10-RM (7, 8, 19). The dumbbell exercise training consisted of 1 set of 10 reps of 2.3 kg for shoulder dumbbell exercises and 1 set of 10 reps (2.2 to 4.4 kg) for both the wrist curls and reverse wrist curls. When any boy could complete 12 reps at a weight corresponding to 100% of 10-RM on the last exercise day in the week (25), the weight was increased 2.3 kg the following week. The boys had 48 hrs of rest between exercise sessions (9, 15, 17).

The 12-week in-season maintenance program consisted of the same exercises, sets, and reps as used in the preseason program for Groups 1 and 2. In order to reduce the risk of injury during the maintenance period, the training weight was not increased. Also, the in-season training protocol was based on an intensity of 75% of 10-RM for Sets 2 and 3 (after a warm-up set of 50% of 10-RM). The control group abstained from the in-season maintenance program.

Strength Tests

Prior to the 12-week preseason training period, all subjects were tested for a 10-RM in the core exercises to be used during the pre- and in-season training periods (1, 2, 17). The boys were then evaluated for a 1-RM in the criterion exercises of supine bench press and leg press, and were also evaluated for dynamic upper body muscular endurance using the criterion exercise of pull-ups as reported by Rooks and Micheli (21). The 1-RM bench press was measured using the concentric strength supine bench press test as reported by Gilliam (12), and the 1-RM leg press was assessed using the leg press test as reported by Ramsay et al. (20). The evaluations were conducted before and after the 12-week preseason training session and at the end of the 12-week in-season training session.

Anthropometry, Body Composition, and Testosterone

All subjects were measured for height, weight, sum-of-7 skinfolds, and selected girths. Skinfold measures were taken at 7 sites with a Harpenden™ skinfold caliper (14). Two measurements were taken at each site, and if the variation was less than 1 mm, the average of both measurements was used to represent the skinfold thickness of each site. If the variation was greater than 1 mm, another measurement was obtained. Girth measures were obtained using a centimeter tape measure technique as described by Callaway et al. (4). Measurements were recorded at the chest, midbiceps (flexed), waist, midthigh, and midcalf. All anthropometric and body composition measures were done by the same investigator using standard anthropometric techniques (4). The boys were measured before and after the preseason and after the in-season training protocols.

Blood serum testosterone was measured on all subjects using radioimmunoassay kits (Diagnostic Products Corp., Los Angeles). Venous blood samples (approx. 5 ml) were drawn from a superficial vein in the antecubical space at the beginning of the preseason training program, at 12 weeks, and at 24 weeks (end of the training period). To obtain serum, samples were allowed to clot for 5 min and were then centrifuged at 1,350 rpm for 10 min. Serum was stored for later analysis at −20°C. A licensed laboratory technician performed all samplings and tests. All blood samples were obtained between 6 and 7 a.m. on days when the boys did not strength train.

Statistical Analysis

Descriptive statistics and a correlation matrix were generated on all data. To test for differences among the 3 groups, a one-way repeated measures ANOVA was performed for anthropometric data, body composition, testosterone levels, strength, and dynamic muscular endurance scores before and after the 12-week preseason training protocol. A Scheffé post hoc test was used to determine differences between groups. A paired *t*-test (2-tailed) was used to determine differences within groups for anthropometric data, body composition, testosterone levels, strength, and dynamic muscular endurance following the 12-week preseason training protocol.

Since the control group was recruited independently from the treatment groups, differences between groups in changes due to treatment (delta scores) for anthropometric data, body composition, testosterone levels, strength, and dynamic muscular endurance were compared using an analysis of covariance. The ANCOVA was performed using the respective initial preseason scores as the covariate. To demonstrate the amount of retention, the mean delta (Δ) score during the 12-week in-season maintenance program (y) was added to the mean strength scores following the 12-week preseason program (x) and then dividing by the post-12-week preseason means (x) (x + Δ y /x = % of mean retention) (Figure 1). An alpha level of $p < 0.05$ was set for all statistical procedures.

Results

Table 1 presents the anthropometric, testosterone, and body composition data for the 12-week preseason training protocol for all groups (mean ± *SD*). During preseason training all groups had significant ($p < 0.05$) increases in height. Groups 1 and 2 also had significant increases in weight.

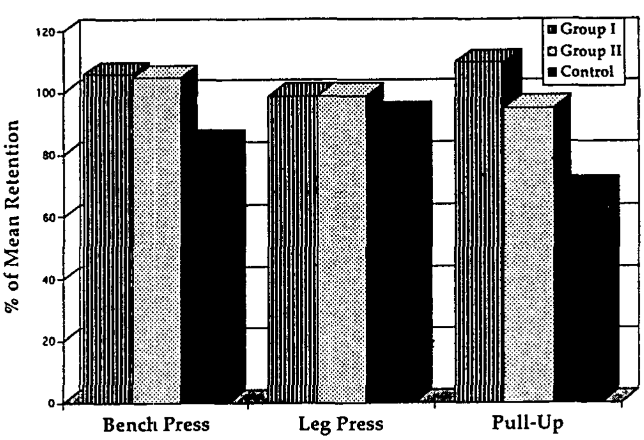

Figure 1. Mean retention of strength and dynamic muscular endurance, by group, over the 12-week in-season maintenance protocol. Values generated by adding the mean delta (Δ) score during the 12-week in-season maintenance program (y) to the mean strength scores following the 12-week preseason program (x), and then dividing by the post 12-week preseason means (x). (x + Δ y/x = % of mean retention).

Table 1
Mean Scores for Anthropometric Data, Testosterone, and Body Composition for the 12-Week Preseason Training Protocol

Variable	Pretest *M*	Pretest *SD*	Posttest *M*	Posttest *SD*	Delta score (post/pre) *M*	Delta score (post/pre) *SD*
Height[a]						
Group 1	162.71	8.22	164.81	7.19*	2.10	1.33
Group 2	164.62	8.88	167.48	8.63*	2.86	1.89
Control	153.88	12.11	156.11	12.06*	2.23	0.67
Weight[b]						
Group 1	54.65	11.17	56.07	11.87*	1.42	1.21
Group 2	53.81	3.35	55.73	3.50*	1.93	0.60
Control	48.87	9.93	49.77	9.96	0.91	2.92
Girth[a]						
Chest						
Group 1	81.54	6.63	82.24	7.04	0.70	2.24
Group 2	81.02	3.37	81.96	3.79	0.94	2.53
Control	74.67	7.25	76.43	5.62	1.77	2.80
Midbiceps (flexed)						
Group 1	27.74	2.42	27.67	2.57	–0.07	0.67
Group 2	27.31	1.54	27.75	1.33	0.44	0.66
Control	26.32	2.69	26.50	2.11	0.18	0.85
Waist						
Group 1	70.19	7.81	68.83	8.95	–1.36	2.45
Group 2	69.78	4.01	69.39	3.33	–0.39	2.74
Control	69.00	10.50	70.67	9.42	1.67	1.86
Midthigh						
Group 1	47.34	5.38	47.11	5.78	–0.23	1.05
Group 2	46.74	1.81	47.36	1.43	0.62	0.82
Control	45.13	4.37	46.02	4.55	0.88	1.76
Calf						
Group 1	34.16	2.88	33.94	3.16	–0.21	0.69
Group 2	33.55	1.91	33.38	1.58	–0.17	0.56
Control	32.55	2.62	34.42	5.35	1.87	4.78
Sum-of-7 skinfolds[c]						
Group 1	67.67	32.61	64.83	25.02	–2.84	20.95
Group 2	64.15	30.21	63.00	32.92	–1.15	5.84
Control	86.89	62.34	75.96	44.54	–10.93	21.03
Testosterone[d]						
Group 1	2.93	1.91	3.53	1.73	0.60	0.82
Group 2	2.47	1.32	2.87	1.29	0.40	0.49
Control	2.82	1.02	2.80	2.11	–0.02	1.16

Note. [a] = cm, [b] = kg, [c] = mm, [d] = µg/l.
*t test within groups revealed signif. diff. ($p < 0.05$) for absolute scores; ANOVA revealed no diff. between groups for these data ($p < 0.05$).

Table 2 presents the differences in strength and dynamic muscular endurance gains during the 12-week preseason training protocol. Absolute pretraining strength scores for Groups 1 and 2 in the bench press and leg press differed significantly ($p < 0.05$) from those of the controls. At the end of the 12-week preseason training, only Group 2 had significantly different ($p < 0.05$) absolute strength scores in the bench press com-

Table 2
Mean Scores in Strength and Dynamic Muscular Endurance for the 12-Week Preseason Training Protocol

Variable	Pretest *M*	Pretest *SD*	Posttest *M*	Posttest *SD*	Delta score (post/pre) *M*	Delta score (post/pre) *SD*
Bench press[a]						
Group 1	39.61	7.29†	48.70	7.52*	9.09	2.27
Group 2	44.32	2.98†	51.99	4.11*†	7.67	2.08
Control	27.27	7.19	39.02	9.47*	11.74	5.65
Leg press[a]						
Group 1	119.81	18.36†	151.30	18.64*	31.49	31.17
Group 2	134.66	20.82†	153.69	23.83*	19.03	12.91
Control	83.33	28.99	134.09	34.94*	50.76	21.59
Pull-up[b]						
Group 1	6.86	5.73	8.71	5.47	1.86	2.91
Group 2	4.88	2.75	8.00	3.46*	3.12	1.81
Control	3.00	3.46	4.33	3.50	1.33	1.37

Note. [a] = kg, [b] = rep.
**t* test within groups revealed signif. ($p < 0.05$) changes in absolute strength scores.
†ANOVA between groups for absolute strength scores revealed signif. diff. ($p < 0.05$) from the control; ANOVA between groups for delta scores revealed no diff. ($p < 0.05$).

pared to the control. All groups demonstrated significant strength gains ($p < 0.05$) for 1-RM in the bench press and leg press. However, only Group 2 had significant increases ($p < 0.05$) in dynamic muscular endurance (pull-up). Therefore, significant differences in absolute strength and dynamic muscular endurance occurred within groups. However, no significant differences occurred between groups for strength gains (delta scores) during the 12-week preseason training phase.

Table 3 presents the mean (±*SD*) for the anthropometric, testosterone, and body composition data for the 12-week in-season training protocol. Group 1 and the control group increased significantly ($p < 0.05$) in height; Group 2 increased significantly ($p < 0.05$) in weight, calf circumference, and sum-of-7 skinfolds. Only Group 1 increased significantly ($p < 0.05$) in testosterone. An ANCOVA revealed no differences between groups for these variables during the maintenance protocol.

Table 4 presents the strength and dynamic muscular endurance data for the 12-week in-season training protocol. An ANOVA revealed significant differences ($p < 0.05$) in absolute strength scores between Group 2 and the control group prior to the maintenance protocol for bench press. At the conclusion of the 12-week in-season protocol, both Groups 1 and 2 differed significantly ($p < 0.05$) from the control group in absolute bench press strength scores. Additionally, an ANCOVA revealed significant differences in delta scores between Groups 1 and 2 and the control group. No other differences were observed between groups. During the 12-week maintenance protocol, Group 1 had significant increases in strength in the bench press ($p < 0.05$) while the control group had significant decreases in the bench press and pull-ups.

During the 12-week preseason training protocol there was a significant ($p < 0.05$) correlation between changes in testosterone and height for Group 1 (r = 0.89). In addition, a significant ($p < 0.05$) negative correlation was observed between changes in bench press

Table 3
Mean Scores for Anthropometric Data, Testosterone, and Body Composition for the 12-Week In-Season Training Protocol

Variable	Pretest *M*	Pretest *SD*	Posttest *M*	Posttest *SD*	Delta score (post/pre)	
Height[a]						
Group 1	164.81	7.19	167.46	7.24*	2.65	1.63
Group 2	167.48	8.63	168.75	8.16	1.27	1.66
Control	156.11	12.06	158.65	12.08*	2.54	1.66
Weight[b]						
Group 1	56.07	11.87	57.34	11.81	1.27	1.61
Group 2	55.73	3.50	57.15	3.97*	1.41	1.24
Control	49.77	9.96	50.76	9.62	0.98	2.08
Girth[a]						
Chest						
Group 1	82.24	7.04	81.87	6.33	−0.37	1.28
Group 2	81.96	3.79	81.85	2.63	−0.11	1.37
Control	76.43	5.62	77.40	5.69	0.97	2.06
Midbiceps (flexed)						
Group 1	27.67	2.57	28.10	2.82	0.43	0.98
Group 2	27.75	1.33	28.06	1.32	0.31	0.51
Control	26.50	2.11	26.33	1.83	−0.17	0.80
Waist						
Group 1	68.83	8.95	68.80	8.08	−0.03	2.66
Group 2	69.39	3.33	71.18	3.51	1.79	2.19
Control	70.67	9.42	70.10	9.26	−0.57	2.86
Midthigh						
Group 1	47.11	5.78	46.69	5.45	−0.43	1.64
Group 2	47.36	1.43	46.84	2.00	0.52	1.08
Control	46.02	4.55	45.80	3.79	0.22	1.22
Calf						
Group 1	33.94	3.16	34.27	2.97	0.33	0.54
Group 2	33.38	1.58	34.11	1.65*	0.74	0.04
Control	34.42	5.35	32.95	2.33	−1.47	3.77
Sum-of-7 skinfolds[c]						
Group 1	64.83	25.02	63.87	21.40	−1.45	13.95
Group 2	63.00	32.92	67.68	36.03*	4.68	5.34
Control	75.96	44.54	73.61	40.12	−2.35	7.58
Testosterone[d]						
Group 1	3.53	1.73	3.83	1.60*	0.30	0.31
Group 2	2.87	1.29	3.08	1.53	0.21	0.61
Control	2.80	2.11	2.99	2.11	0.91	0.54

Note. [a] = cm, [b] = kg, [c] = mm, [d] = μg/l.
**t* test within groups revealed signif. diff. ($p < 0.05$) in absolute scores; ANOVA revealed no diff. between groups for absolute scores ($p < 0.05$); ANCOVA revealed no diff. between groups for delta scores ($p < 0.05$).

Table 4
Mean Scores in Strength and Dynamic Muscular Endurance for the 12-Week In-Season Training Protocol

Variable	Pretest *M*	Pretest *SD*	Posttest *M*	Posttest *SD*	Delta score (post/pre)	
Bench press[a]						
Group 1	48.70	7.52	51.62	8.28*†	2.92	2.85§
Group 2	51.99	4.11†	54.55	6.43†	2.56	3.31§
Control	39.02	9.47	32.95	8.23*	–6.06	2.35
Leg press[a]						
Group 1	151.30	18.64	149.35	28.20	–1.95	20.89
Group 2	153.69	23.83	152.84	32.18	–0.85	24.78
Control	134.09	34.94	125.00	25.35	–9.09	14.66
Pull-up[b]						
Group 1	8.71	5.47	9.57	5.50	0.86	1.77
Group 2	8.00	3.46	7.62	4.60	–0.38	2.07
Control	4.33	3.50	3.00	3.22*	–1.33	1.21

Note. [a] = kg, [b] = rep.
**t* test within groups revealed signif. ($p < 0.05$) changes in absolute strength scores.
†ANOVA between groups for absolute strength scores revealed signif. diff. ($p < 0.05$) from controls.
§ANCOVA between groups for delta scores revealed signif. diff. ($p < 0.05$) from controls.

and chest circumference ($r = -0.71$), and between changes in weight and sum-of-7 skinfolds ($r = -0.92$).

Group 2 demonstrated a significant ($p < 0.05$) negative correlation between changes in testosterone and sum-of-7 skinfolds ($r = -0.76$). These boys also displayed a significant ($p < 0.05$) correlation between changes in midbiceps (flexed) circumference and changes in waist circumference ($r = 0.87$), thigh circumference ($r = 0.76$), and calf circumference ($r = 0.82$). A significant ($p < 0.05$) correlation was also observed between changes in thigh circumference and calf circumference ($r = 0.77$). These boys exhibited significant ($p < 0.05$) correlations for changes in height with bench press ($r = 0.86$), and for changes in height with changes in thigh circumference ($r = 0.69$).

The control subjects displayed a significant ($p < 0.05$) correlation between changes in midbiceps (flexed) circumference and changes in sum-of-7 skinfolds ($r = 0.79$) and height ($r = 0.82$). A significant ($p < 0.05$) correlation was also observed between changes in leg press and changes in thigh ($r = 0.86$) and calf circumference ($r = 0.84$). The control subjects also demonstrated a significant ($p < 0.05$) correlation between changes in bench press and weight ($r = 0.81$).

During the 12-week in-season maintenance protocol there was a significant ($p < 0.05$) negative correlation between changes in pull-ups and changes in chest ($r = -0.76$) and midbiceps (flexed) circumference ($r = -0.73$) for Group 1. There was also a significant ($p < 0.05$) negative correlation between changes in bench press and chest circumferences ($r = -0.82$) for these boys. Group 2 demonstrated significant ($p < 0.05$) correlation between changes in pull-ups and chest circumference ($r = 0.75$). There was also a significant ($p < 0.05$) relationship between midbiceps (flexed) and thigh circumference ($r = 0.72$), and between changes in bench press and midbiceps (flexed) circumference ($r = 0.73$).

The control group exhibited significant ($p < 0.05$) correlation between changes in testosterone and changes in chest circumference ($r = -0.76$) and leg press ($r = 0.89$). They also demonstrated a significant ($p < 0.05$) relationship between midbiceps (flexed) and thigh circumferences ($r = 0.82$) during the 12-week in-season training protocol.

Discussion

The results of the present study indicate that trained male pubescent athletes can retain approximately 99% of lower body and 105% of upper body strength gains, and at least 95% of dynamic upper body muscular endurance (pull-ups) during a 12-week, submaximal in-season strength maintenance program (Figure 1). Furthermore, the control group maintained 93% of lower body and 84% of upper body strength gains, and 69% of dynamic upper body muscular endurance, without a maintenance program. Although the mean data indicated that all groups retained at least 84% of strength gains for both upper and lower body, the ANCOVA indicated that the treatment groups differed significantly ($p < 0.05$) from the control group for changes in upper body strength retention (Table 4). The ANCOVA did not reveal any differences between groups for changes in lower body strength and retention of upper body dynamic muscular endurance (Table 4).

An unexpected finding was that upper body strength gains occurred in male pubescent athletes as a result of a submaximal, in-season maintenance program. The submaximal load was set at 75% of 10-RM to reduce the chances of injury during the competitive season. The protocol was successful in that strength was maintained in the 2 training groups.

In previous isotonic strength retention studies on adults, strength had been retained or increased during maintenance programs (3, 22). Rose et al. (22) showed that once a maximal isotonic strength plateau was attained, strength gains could be maintained using a 1-RM (1 set; 6-sec muscular contraction) training protocol as seldom as once a month. Further, Berger (3) found that isotonic strength was increased after an initial training program during a subsequent 6-week training period combining submaximal and maximal loads. In his study, each experimental group trained with submaximal loads (66, 80, and 90% of 1-RM for 1 set of 1 rep) twice a week and with maximal loads of 1-RM once a week to increase strength. Berger also reported no strength gains in subjects using a submaximal load of 66% of 1-RM when performed 3 times a week. However, Berger did find strength increases with 1-RM loads performed only once a week. Therefore he concluded that the strength gains from training were due primarily to the training with the 1-RM.

In contrast, the present study revealed significant increases in upper body isotonic strength during maintenance using submaximal loads (Table 4). Perhaps these differences in the findings between Berger (3) and the present study are because the subjects in Berger's study were male college students enrolled in weight training courses, whereas our subjects were male pubescent athletes who had not reached their full growth (Tables 1 and 3) and/or used submaximal loads of 10-RM rather than the submaximal loads of 1-RM used in Berger's (3) study.

It has also been reported that isometric strength may be retained as a result of a maintenance program following isometric strength training. In a study by Morehouse (16), adults trained isometrically 4 days a week for over 9 weeks. During an 8-week maintenance phase they performed a single isometric contraction twice a week, once a week, or once every 2 weeks. Morehouse reported that the subjects retained strength gains during the first 4 weeks of the maintenance program. He concluded that strength may be retained when the maintenance training protocol consists of at least 1 set of 1-RM performed every 2 weeks or less.

It should be noted that the subjects in the studies by Rose et al. (22), Berger (3), and Morehouse (16) all used a form of 1-RM in their maintenance programs. However, the use of 1-RM is contraindicated for strength training programs involving children because of the increased risk of injury (1, 2, 15, 17). Therefore, submaximal loads (75% of 10-RM) were used in the maintenance phase of the present study and resulted in retention of strength gains (Table 4).

Since no significant differences were observed between groups for the leg press and pull-up exercises, the null hypothesis was accepted. Considering the small sample size in this study, there is a possibility of a type II error for these variables. However, these findings may also be attributed to the fact that the boys did not specifically train in these exercises. Furthermore, during the preseason program all boys had significant strength gains in these exercises. Perhaps if they had specifically trained in the leg press and pull-up, the results may have been similar to those of the bench press. This was a limitation in the present study. In addition, although there were no significant differences between groups in leg press and pull-ups, strength was maintained for both training groups (Figure 1). The strength maintenance demonstrated by the control group for the leg press may have been due to the fact that these boys were involved in a sport that required running (Figure 1).

Mean serum testosterone for the groups in the present study ranged from 2.80 ± 2.11 to 3.83 ± 1.60 μg/L during the 24-week study. Data from Winter (29) suggest that pubescent boys with Tanner stages (5-point scale) between 3 and 4 have serum testosterone levels ranging from 1 to 5 μg/L. Therefore the mean serum testosterone for the boys in the present study fall within the normal range for pubescent boys. Weltman et al. (28) reported increases in strength without muscular hypertrophy in prepubertal boys.

In the present study all 3 groups demonstrated significant increases for upper and lower body strength without significant increases in chest, midbiceps (flexed), thigh, calf circumferences, or testosterone during the 12-week preseason program (Tables 1–4). Therefore it can be concluded that male pubescent athletes can gain strength without marked muscular hypertrophy or increases in testosterone.

The anthropometric data in the present study indicated that during the 12-week preseason program the boys in all 3 groups had significant ($p < 0.05$) increases in height and strength. Although nonsignificant, the mean data for sum-of-7 skinfolds decreased in each group. During the same period of time, subjects in Groups 1 and 2 showed significant ($p < 0.05$) increases in weight. Additionally, during the 12-week preseason training protocol, the boys in Group 1 exhibited a negative correlation between changes in height and sum-of-7 skinfolds ($r = -0.92$). Therefore the preseason training protocol in the present study had a beneficial effect on strength and body composition for these pubescent boys.

Practical Application

The present study demonstrated there were no significant differences in strength changes between training 1 day or 2 days a week during an in-season maintenance program. Furthermore, the lack of significant differences for the leg press suggests that lower body strength training may not be necessary during the season. Therefore it was concluded that if practice time is limited, a 1-day-a-week upper body maintenance protocol may be sufficient for strength retention in pubescent baseball players.

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