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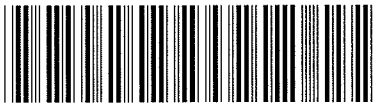

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Strength training for prepubescent males: Is it safe?*

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ABSTRACT

This study examined the safety of one type of strength training for prepubescent males. Eighteen males (average age, 8.3 ± 1.2 years) participated in a 45 min/session, three session/week, 14 week supervised strength training program with an attendance rate of 91.5%. Concentric work was done almost exclusively.

KinCom analysis showed significant strength gain in this group ($P < 0.05$), while an age, sex, and activity matched control group did not gain strength.

Safety was evaluated by injury surveillance, blood pressure and heart rate monitoring, scintigraphy, and creatine phosphokinase measurement. Effects on growth and development, flexibility, and motor performance were also investigated, as these are factors with an impact on sports injury occurrence.

Results showed that in the short term, supervised concentric strength training results in a low injury rate and does not adversely affect bone, muscle, or epiphyses; nor does it adversely affect growth, development, flexibility, or motor performance. As the safety question is multifaceted, this should not lead to the conclusion that strength training for prepubescents is uniformly safe. Further research is needed.

Strength training in prepubescent children is a controversial subject of great concern to parents, coaches, and the medical and scientific community. Prepubescents are increasingly involved in rigorous training and competition in individual as well as team sports activities. Potential benefits from strength training include enhanced sports performance and possibly a reduction in sports-related injuries. Potential risks include clinically apparent injuries incurred during strength training, as well as subclinical deleterious effects on the musculoskeletal, cardiovascular, or possibly other systems. Other concerns related to the safety question include the effects of strength training on growth and development, flexibility and motor performance, and overt cardiovascular complications such as weight lifter's syncope.

Almost no scientific information exists regarding the safety of prepubescent strength training. Thus a meaningful risk-benefit analysis is impossible with the current lack of data. Two recent studies, however, have provided some information. Sewall and Micheli studied 10 prepubescents (8 boys and 2 girls) using one isotonic thigh press machine and two pneumatic resistance machines under supervision for strength training over a 9 week period.[8] They found that the trained group had significant strength gains compared to their age, gender, and maturity-matched control group. Moreover they observed no strength training injuries and no decrease in flexibility.[8]

Servedio et al.[7] reported no injuries among six prepubescent males performing 8 weeks of Olympic-style lifting. No sustained hypertension was found in either their experimental or control group. Echocardiograms demonstrated increased left ventricular end-diastolic diameters but no increase in left ventricular wall thickness among the boys lifting weights. There was no change in resting heart rate, body composition, or flexibility. Both groups gained weight.

Beyond these studies there is no further data on injury rates or evidence to substantiate or deny subclinical effects on muscle, bone, bone growth tissue, articular cartilage, or other body tissues and systems in this age group. Information on the physiologic effects of strength training on prepubescents, as distinguished from safety analysis, is more easily found. A study performed concurrently with the present one complements this study by providing detailed physiologic data and references on this separate but related subject.[10]

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Opinions and position statements on the safety of prepubescent strength training can be found in the literature,[1,3] but are limited by the paucity of scientific information on this subject. The present study was designed to prospectively evaluate the safety of one type of strength training program in prepubescent males, in an effort to provide data toward a meaningful risk-benefit analysis.

MATERIALS AND METHODS

Thirty-two male subjects volunteered for strength training with informed parental consent. Three were rejected because of clinical evidence of pubescence (definite Tanner Stage 2). The remainder were Tanner Stage 1, with one very early Tanner Stage 2 who was included. The qualifying volunteers were consecutively assigned to experimental and control groups. The first 19 were assigned to the experimental (strength training) group and 10 more subjects were assigned to a control group. One subject moved to another city during the study, reducing the experimental group to 18. The groups were matched for age and activity. The mean age was 8.3 ± 1.2 years. All but one experimental and two control subjects participated in youth hockey during the study period.

The strength training program lasted 14 weeks. The attendance rate was 91.5%. This was a closely supervised circuit training program using eight hydraulic resistive machine stations (HydraFitness Industries, Inc., Belton, TX) and two additional stations, consisting of a bicycle ergometer and a sit-up station. Three sessions per week were conducted. Each session lasted 45 minutes and consisted of 7 minutes of warm-up exercises including stretching, 30 minutes of strength training, and 7 minutes of cool-down exercises including stretching. Each subject performed as many repetitions as possible for 30 seconds at each station, with 30 seconds of rest between stations. Each machine allowed *concentric* work only, and offered six resistance settings. Each subject started the program at the lowest setting and moved up one setting when he could perform 30 repetitions in 30 seconds. Repetitions were recorded in each session, after each station, by each subject.

The circuit exercised the muscles responsible for the following motions: shoulder horizontal abduction/adduction, elbow flexion/extension, wrist flexion/extension, forearm supination/pronation, hip extension, hip abduction/adduction, knee flexion/extension, and shoulder abduction/adduction.

Our testing rationale was as follows: 1) to rule out medical or orthopaedic contraindications to strength training or exercise, 2) to establish prepubescence, 3) to evaluate the efficacy of the strength training stimulus, and 4) to evaluate various aspects of the safety issue in the setting of this strength training program.

To accomplish the first objective, a comprehensive history and physical examination was performed on each control and experimental subject. No subject was eliminated because of a contraindication to exercise or strength training. To establish prepubescence, Tanner's sexual maturity rating, gonadometry estimates of testicular volume, serum testosterone, and serum DHEA-S (dehydroepiandrosterone sulfate) were measured. Skeletal bone age was not used. It was important to establish that the strength training stimulus was sufficient to render safety analysis meaningful. This was accomplished by measurement of concentric work output during shoulder, elbow, and knee flexion/extension using an isokinetic dynamometer (KinCom, Chattecx, Inc, Chattanooga, TN).

Safety was evaluated using the following methods. Injury surveillance was conducted by a physician (the author), noting those injuries occurring during strength training separately from those occurring during sports and activities of daily living. Injuries were defined as those evaluated complaints which in the judgement of the physician necessitated incomplete circuit participation or complete absence from a session. An absence was recorded whenever a participant was not allowed to work on the entire circuit because of an injury. In most cases the subject was present to participate on the stations allowed. Only the strength training group was under injury surveillance, as it was not feasible to maintain identical contact with the control group.

Overt cardiovascular events such as syncope were monitored. Blood pressure and heart rate were measured by cuff *between* stations during three sessions, one each month during the 14 week period. No such measurements were made during exercise. Resting heart rate and blood pressure were recorded as part of the prestudy and poststudy examinations.

Other parameters germane to the safety issue were investigated as well, including those related to growth and development (height, weight, and body composition by densitometry and skinfold measurement), flexibility (sit and reach test), and motor performance (standing long jump and vertical jump).

Subclinical deleterious effects on the musculoskeletal system were investigated using biphasic musculoskeletal scintigraphy (bone, epiphyses, and muscle) as well as measurement of creatine phosphokinase, a muscle enzyme released in the setting of muscle necrosis. Creatine phosphokinase was not fractionated. Blood samples were drawn within 48 hours of the final strength training session in the experimental group. Hemoglobin was measured simply to rule out anemia. Scintigraphy was performed using a pediatric dose (Young's rule) of technetium-99m pyrophosphate with imaging by a long field of view camera of the appendicular skeleton at 5 minutes (muscle phase) and 2 hours (skeletal phase). Scintigraphy was done on 8/10 controls and 17/18 experimental subjects. All other measurements and tests were performed on all subjects. All tests were performed in identical fashion prior to and after the strength training program, in both control and experimental groups.

Results of quantitative measures were analyzed using 2 × 2 ANOVA with repeated measures. For the purposes of this study, the major concern was whether the experimental group changed to a greater degree than the control group.

Therefore the statistic of primary concern was a *significant two-way interaction* ($P < 0.05$).

RESULTS

Strength training resulted in strength gains, indicating that the strength training stimulus was sufficient to render safety analysis meaningful. Strength changes are shown in Table 1. The experimental group showed significant work output gains in each motion tested. Shoulder flexion/extension was tested, but results are not reported because of unreliability of the data ($r < 0.5$) The apparent explanation for this is that subjects had difficulty with slow speed shoulder testing, recruiting other muscle groups to accomplish the motion, a problem not observed with knee or elbow testing.

Results of safety analysis were as follows. Injury surveillance revealed one strength training injury; six injuries occurred in sports and activities of daily living. The strength training injury occurred during performance of the shoulder press. The subject complained of anterior shoulder pain. The physical examination was nonspecific; thus, the nonspecific diagnosis of "shoulder strain" was made. His symptoms resolved with 1 week of rest from the shoulder press, while completing the other stations. By our definition, however, he was considered absent, with absences numbering three. No other strength training injuries were found, though multiple complaints occurred. In every case except the shoulder strain, the musculoskeletal complaint was resolved by correction of technique. Many such corrections were required, indicating the high level of supervision necessary to avoid incorrect technique and potential injury.

Injuries occurring during activities of daily living included a gastrocnemius strain, a clavicle fracture, a contusion of the knee, and a contused iliac crest. Sports injuries included a contusion of the clavicle and a contusion of the first metatarsal, in both cases caused by contact in hockey. Absences from strength training necessitated by these injuries numbered 47 of a total 756 subject/sessions, compared to the 3 absences caused by the strength training injury. This is a 16-fold difference.

There were no overt cardiovascular events. Syncope did not occur. Resting blood pressure and heart rate did not change in either group. There were no instances of resting hypertension in either group before or after the strength training program. Exercise heart rate, as measured between stations, increased an average of 31 beats/minute. Blood pressure, measured by cuff between exercise stations, showed an average systolic increase of 5 mmHg and an average diastolic decrease of 9 mmHg. No cardiovascular parameters were measured during actual performance of exercise.

Growth and development changes are shown in Table 2. Height increased to a greater degree in the experimental group, but this was *not* statistically significant. Weight increase was significant, but there was no change in body composition. Prepubescent status did not change in either group. There was no change in hemoglobin concentration.

Flexibility and performance changes are shown in Table 3. Flexibility was significantly increased in the strength training group. Vertical jump also significantly increased in the strength training group. Neither group showed a change in the standing long jump.

Scintigraphy revealed no evidence of muscle damage in any subject. Creatine phosphokinase levels were not elevated in either group either before or after the strength training program. Radiopharmaceutical avidity at epiphyseal plates was compared before and after strength training and between control and experimental groups. No differences were found by visual or computer-assisted interpretation. Two experimental subjects had abnormal scans after strength training in anatomical locations that were scintigraphically normal prior to training. The left tibia of the first subject is shown in Figure 1. It was normal prior to training (Fig. 1A) and abnormal after training (Fig. 1B). The abnormality is seen as a subtle increase in activity at the junction of the middle and distal tibia. Two other strength training subjects showed similar abnormalities *before* training. The right tibia

TABLE 1
Strength changes observed (% change in average work (joules)/repetition)

	Experimental	Control	Significance
Elbow flexion	+32.8	+2.5	$P < 0.05$ Significant 2-way interaction
Elbow extension	+25.3	+14.6	$P < 0.05$ Significant 2-way interaction
Knee flexion	+22.3	−3.3	$P < 0.05$ Significant 2-way interaction
Knee extension	+21.6	+2.3	$P < 0.05$ Significant 2-way interaction

TABLE 2
Growth and development changes

	Experimental (%)	Control (%)	Significance
Height	+1.5	+0.7	Post > Pre, $P < 0.05$ No significant 2-way interaction
Weight	+5.5	+2.2	Post > Pre, $P < 0.05$ Significant 2-way interaction
Body composition	NC[a]	NC	NS
Hemoglobin	NC[a]	NC	NS
Sexual maturity rating	NC[a]	NC	
Gonadometry	NC[a]	NC	
Testosterone	NC[a]	NC	NS
DHEA-S	NC[a]	NC	NS

[a] No change.

TABLE 3
Flexibility and performance changes

	Experimental (%)	Control (%)	Significance
Sit and reach test	+8.4	−1.2	$P < 0.05$ Significant 2-way interaction
Vertical jump	+10.4	−3.0	$P < 0.05$ Significant 2-way interaction
Standing long jump	0.0	0.0	NS

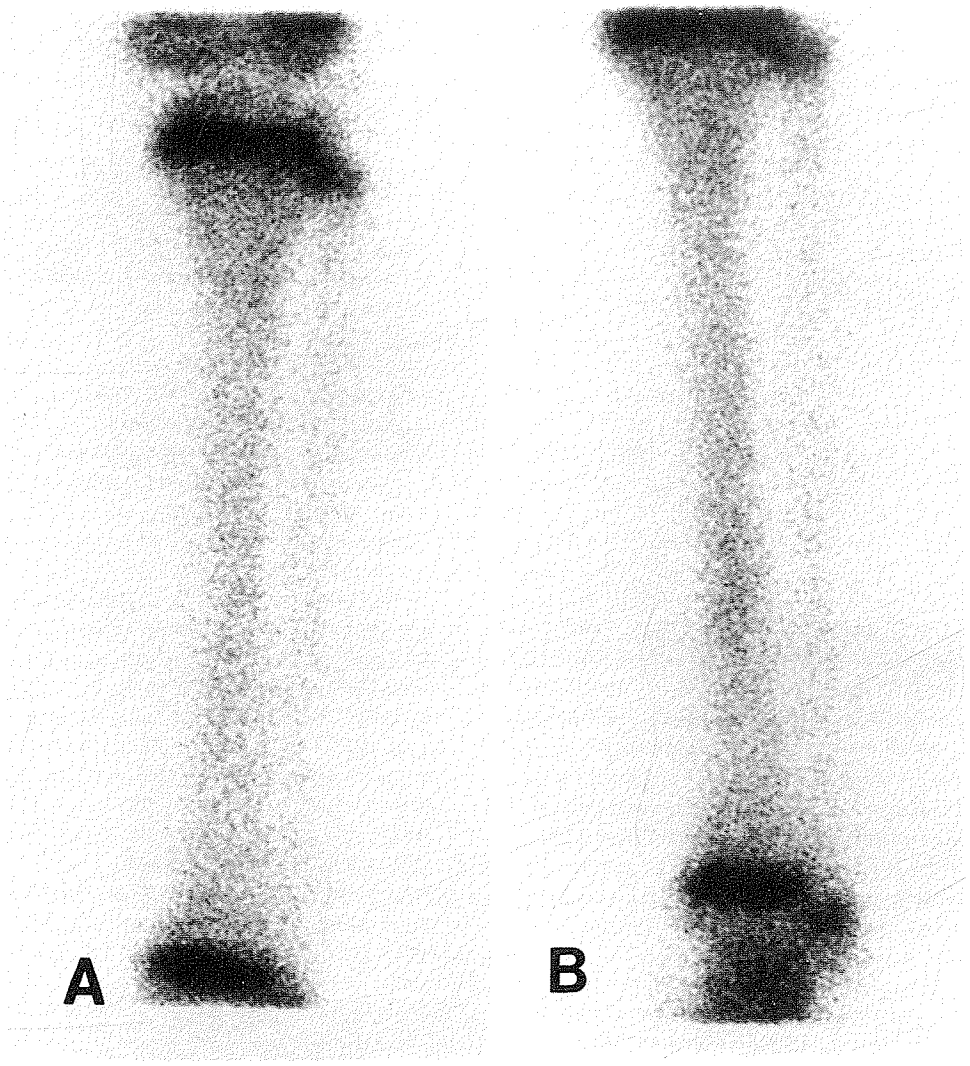

Figure 1. A, normal pretraining scan in strength training subject, left tibia. B, abnormal posttraining scan in same strength training subject, showing mild increase in avidity at the junction of the middle and distal thirds, left tibia.

of one of these subjects is shown in Figure 2. It shows increased activity prior to strength training (Fig. 2A), which nearly resolved in spite of 3.5 months of strength training (Fig. 2B). The other subject showed complete resolution of his scan in spite of strength training. All three subjects were hockey players. In our judgement the abnormality of the tibia after strength training in one subject is likely to be the result of trauma incurred in activities of daily living and sports activity, since strength training did not prevent the resolution of similar abnormalities in two other subjects. The low level of bone avidity, as well as the sports activities of the participants, supports this conclusion as well. None of these subjects complained of pain in their shins and none had tenderness over the affected tibia on the poststudy physical examination.

The second abnormality is shown in Figure 3. The normal scintigraphic study of the forearm of an experimental subject is shown in Figure 3A. The same forearm shown adjacent is abnormal on the follow-up study (Fig. 3B). It shows increased activity in the distal ulna and radial epiphysis. This youngster had no complaints and no tenderness on the poststudy physical examination. When the scintigraphic abnormality was discovered, his parents were interviewed and he was reexamined. This subject had a history of repeated falls on the outstretched hand during basketball competition which was ongoing during the strength training program. Reexamination with firm pressure over the affected area resulted in mild tenderness only, and a roentgenogram showed only a very subtle periosteal reaction along the distal ulna. His tenderness had resolved 1 month after stopping basketball, in spite of continuing strength training. In view of this clinical evidence, it is our judgement that strength training had little or nothing to do with this abnormal scan. A similar abnormality was found in a control subject prior to the study. His scan also resolved during this period. Like the experimental subject, he had no symptoms or findings on examination either before or after the study.

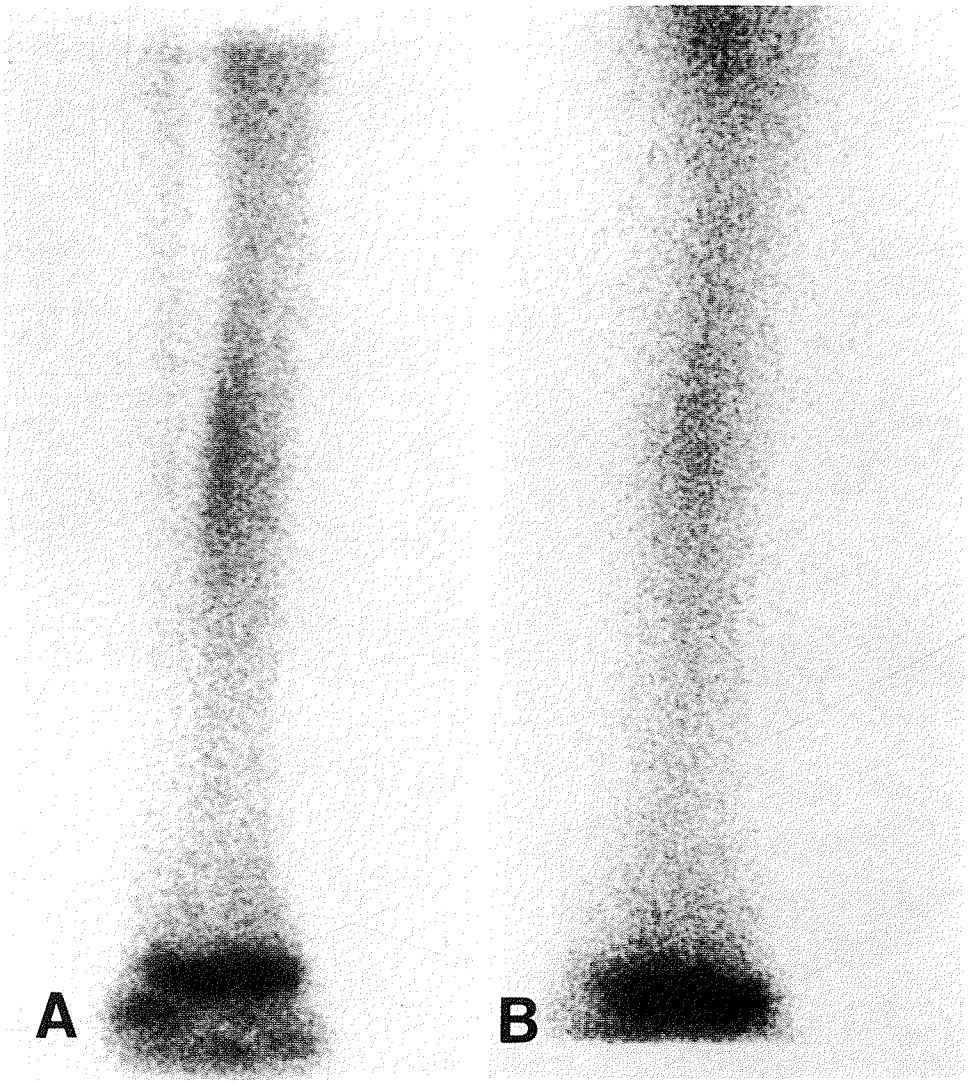

Figure 2. A, abnormal pretraining scan in another strength training subject, showing increased avidity at the right midtibia. B, abnormal, but improved posttraining scan in same strength training subject.

DISCUSSION

It is important to define which aspects of the safety question are addressed by these data, and which remain for further research. It can be concluded from this study that a *closely supervised,* primarily concentric strength training program for prepubescent males results in a low musculoskeletal injury rate. Scintigraphy, a sensitive method for detecting damage to bone, bone growth tissue, and muscle[4,6,9] showed no such damage in the short term. Weight lifter's syncope does not appear to be a threat to prepubescents in this type of program, nor does sustained hypertension occur. There appears to be no risk of growth retardation in the short term. Finally, there is no decrease in flexibility and no deleterious effects on gross motor performance when using this type of program. It cannot be emphasized enough, however, that *close supervision* was the rule during this study, and was likely a major factor in the low injury rate observed.

There are several aspects of the safety issue which were *not* addressed by our methodology. We cannot draw conclusions regarding the effect of strength training on articular cartilage; nor can we assess the effect on the axial skeleton, as this area was not imaged. We did not test a similar group of youngsters in a nonsupervised but otherwise identical setting; however, our clinical experience suggests that a lack of supervision invites injury. The use of free weights and commonly available isotonic weight machines involves eccentric work. Concentric and eccentric work have different effects on adult muscle, eccentric work causing changes at the ultrastructural level.[5] We cannot speculate on the subclinical effects of eccentric work on the prepubescent musculoskeletal system as assessed by scintigraphy or other methods, since this study has not been done. Blood pressure elevates markedly in adults during actual performance of

Figure 3. A, normal pretraining scan in strength training subject, right wrist/forearm. B, abnormal posttraining scan in same subject, showing increased avidity in the right distal ulna and radial epiphysis.

both hydraulic resistive and free weight bench press, rapidly decreasing upon cessation of the exercise.[2] No such measurements *during* exercise were done in this study, so that no comment can be made on the prepubescent blood pressure response *during* exercise or its possible effects. The effect of strength training on the injury rate in sports for this age group cannot be determined by our results, as we did not compare sports injuries in the control group. It was simply not feasible to maintain identical injury surveillance of the control group.

Finally, our methodology did not address or measure in any way the psychologic impact of strength training on these youngsters. Our clinical impressions, however, suggested to us that this was a learning experience involving socialization, motor learning, and mental discipline, comparable to the experience of participation in organized sports. The boys indeed seemed to enjoy themselves and in fact wished to continue strength training at the conclusion of the formal study.

This closely supervised, primarily concentric strength training program for prepubescent males was safe in the short term with regard to the parameters discussed. No conclusion can be stated based on these data, nor should any be inferred, regarding the safety of strength training that involves eccentric work, such as occurs with free weights or commonly available isotonic machines. Our experience would dictate that prepubescent children should not be allowed to undertake *any* form of strength training without

adequate supervision, the definition of "adequate supervision" being open to debate. These children were supervised by a team consisting of professionals experienced in the fields of sports injury and exercise physiology. Whether coaches, fitness instructors, and parents could manage this task is subject to doubt. Further research is obviously needed before strength training for these young children can be encouraged at a community level. Even if strength training in its various forms were shown sufficiently safe for males and females, an intensive educational process would be necessary to ensure adequate supervision.

A meaningful risk-benefit analysis will require data in addition to that provided here. Until such information is available, we must remain cautious in our advice to parents and coaches regarding strength training for prepubescent children.

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REFERENCES

1. American Academy of Pediatrics Policy Statement: Weight Training and Weight Lifting: Information for the Pediatrician. AAP, July 1982
2. Freedson P, Chang B, Kroll J, et al: Intraarterial blood pressure during free weight and hydraulic resistive exercise (abstract). *Med Sci Sports Exerc 16:* 131, 1984
3. Legwold G: Does lifting weights harm a prepubescent athlete? *Physician Sportsmed 10:* 141–144, 1982
4. Matin P: Bone scanning of trauma and benign conditions, in *Nuclear Medicine Annual,* New York, Raven Press, 1982, pp 81–117
5. Newham DJ, McPhail KR, Edwards RHT: Ultrastructural changes after concentric and eccentric contractions of human muscle. *J Neurol Sci 61:* 109–122, 1983
6. Rosen PR, Micheli LJ, Treves S: Early scintigraphic diagnosis of bone stress and fractures in athletic adolescents. *Pediatrics 70:* 11–15, 1982
7. Servedio FJ, Bartels RL, Hamlin RL, et al: The effects of weight training using Olympic style lifts on various physiological variables in prepubescent boys (abstract). *Med Sci Sports Exerc 17:* 288, 1985
8. Sewall L, Micheli LJ: Strength training for children. *J Pediatr Orthop 6:* 143–146, 1986
9. Siegel B, Engel W, Derrer E: 99m-Tc-diphosphonate uptake in skeletal muscle: A quantitative index of acute damage. *Neurology 25:* 1055–1058, 1975
10. Weltman A, Janney C, Rians C, et al: The effects of hydraulic resistance strength training in prepubertal males. *Med Sci Sports Exerc 18:* 629–638, 1986