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Strength Training for Children

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Summary: The indications for progressive resistive strength training for prepubescent children in sports training and rehabilitation have been a source of controversy. Eighteen prepubescent children, two at Tanner Stage II and the remainder at Tanner Stage I, were studied. Examination included anthropometric upper and lower extremity strength and flexibility measurements. The study group participated in progressive resistive strength training sessions on machines three times per week. The study group had a mean increase in strength of 42.9%, whereas strength in the control group increased 9.5% ($p < 0.05$). The study group had a mean increase in flexibility of 4.5% compared with 3.6% in the control group. The study group showed a mean decrease in body weight during the training period of 0.51% and then gained 3.48% over the subsequent 9 weeks. The control group's body weight increased an average of 6.66% during the 18 weeks. There were no injuries during the training period. It is concluded that prepubescent children can make significant gains in muscle strength in response to progressive resistive training. **Key Words:** Muscle strength—Prepubescent children—Progressive resistive training.

The use of resistive weight training to improve strength has been shown to benefit athletes by enhancing sports performance and decreasing susceptibility to injury (3,7,8). The demonstration of these dual benefits in adult male athletes and, more recently, in adult female athletes and adolescents of both sexes has resulted in the use of strength training in a variety of sports, including distance running, gridiron football, and gymnastics (5,9,13).

The use of strength training in prepubescent children, however, remains controversial (1,2,4,11). Opposition to strength training for prepubescent children has been based on three contentions: first, that the prepubescent child, lacking adequate levels of circulating androgens, is incapable of significant strength gains in response to progressive resistive exercise; second, that strength gains, if attainable, would not benefit performance or reduce the risk of injury in children's sports; and, third, that resistive weight training is dangerous for children, having an unacceptable risk of injury (6).

It is the purpose of this study to monitor the response of a group of prepubescent children to resistive weight training and to compare this response with that of a group of age-matched controls over the same interval. In addition, injury rate and flexibility changes were also monitored during the test period.

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SUBJECTS AND METHODS

Eighteen boys and girls 10–11 years of age participated in the study. The volunteers were divided into two groups. Group 1 (the study group) consisted of eight boys and two girls. Group 2 (the control group) consisted of seven boys and one girl. All volunteers were given a physical examination by a physician, which included a rating on the Tanner scale of pubescence. The first group comprised nine Tanner Stage I and one Tanner Stage II ratings. The second group comprised six Tanner Stage I and two Tanner Stage II ratings.

Testing

The testing sessions consisted of a physical examination and measurements of weight, flexibility, and strength. Participants were tested before and after each 9-week period. The physical examination was conducted by a physician, the weight and flexibility measurements by a registered physical therapist, and the strength measurements by an athletic trainer.

The physical examination included a complete physical checkup and an assessment for skeletal maturation by the Tanner rating scale (10). Subjects with Tanner ratings of greater than II were excluded from the study.

Weight was measured on a Toledo Balance scale; figures were recorded to the nearest 0.1 kg. Flexibility measurements were done with a Leighton Flexometer using the original protocol described by Leighton (12). Shoulder flexion, knee flexion, and hip flexion were all measured to the nearest degree.

A cable tensiometer was used to measure strength (3). Strengths of knee extension, knee flexion, shoulder flexion, and shoulder extension were recorded to the nearest 1 kg.

Training

The training sessions, lasting 25–30 min, were conducted every Tuesday, Thursday, and Saturday for 9 consecutive weeks. Each session began with a flexibility routine concentrating on the shoulder girdle, lower back, hamstrings, and calves. The children then slowly warmed up with an easy jog or by riding a stationary bicycle for 5 min.

Following the warm-up, the children performed three sets of 10 repetitions of resistive weight training on the Nautilus thigh press machine, the CAM II [R] chest press machine, and the CAM II Back Row machine (8). The Nautilus machine uses a cam shaft design, with cable and weight plates for resistance. The purpose of the cam shaft design is to attempt to deliver a uniform resistance throughout the range of motion of a joint by compensating for differences in resistance with differences in joint angle. The CAM II System uses a pneumatic resistance system, with increasing resistance attainable by a valve system, and resistance is measurable in psi. During each of the succeeding sessions, three sets on each machine were performed as follows: first set at 50% of maximum for 10 repetitions, second set at 80% of maximum for 10 repetitions, and third set at 100% of maximum for as many repetitions as possible.

When the child was capable of performing 12 repetitions at 100%, then the resistance was increased by addition of 2.2 kg to the leg press machine or 1–2 psi pressure on the chest press and back row machines.

The children worked in groups of three or four, with one instructor supervising each group. Turns were taken at a particular machine until all had completed their three sets. The group then mo[illegible] on to the next machine with the order of tra[illegible] changing with each session. Following the wor[illegible] the machines, a brief warm-down activity of [illegible] ging or bicycling was conducted.

On completion of the 9-week training period, [illegible] children were instructed to resume normal ac[illegible] ties (no weight lifting). They were then rete[illegible] after a 9-week period of normal activities (n[illegible] lifting period).

RESULTS

The changes in strength over the 9-week per[illegible] in the control group and the study group for k[illegible] extension, knee flexion, shoulder flexion, an[illegible] shoulder extension were computed and then tes[illegible] for statistical significance. An analysis of varia[illegible] and covariance with repeated measures was pe[illegible] formed using body weight as the covariant. Tab[illegible] shows the adjusted cell means for both groups b[illegible] fore and after testing of strength. Table 2 shows t[illegible] changes in strength, measured in kg, that to[illegible] place over the 9-week period. Figure 1 presents t[illegible] data in Table 2 in graph form. As can be seen fro[illegible] Table 2, the test group recorded strength gains [illegible] each motion greater than the control group. A de[illegible] nite pattern is evident at each site. Of these resu[illegible] gains in shoulder flexion for the study group we[illegible] statistically significant ($p < 0.05$).

Overall, the study group showed a mean increa[illegible] of 4.45% compared with the control group's i[illegible] crease of 3.57% (Table 3). The difference betwe[illegible] these two figures was not statistically significa[illegible] confirming the fact that there was no loss of fle[illegible] bility while these subjects were undergoing streng[illegible] training.

Body weight was also monitored during the te[illegible] period. As recorded in Table 4, the study gro[illegible] showed a mean decrease of 0.51% of body wei[illegible] during the test period and then gained 3.48% du[illegible] the 9-week period after testing. The control grou[illegible] weight increased an average of 6.66%. Once ag[illegible] there was no significant difference in wei[illegible] changes between the test group and the con[illegible] group during the period of weight training.

TABLE 1. *Adjusted cell means*

	Knee extension		Shoulder flexion		Shoulder extension	
	L	R	L	R	L	R
Group 1						
Pretesting	19.8	18.2	5.8	5.1	16.3	14.9
Posttesting	24.1	22.6	7.7	8.2[a]	21.2	19.8
Group 2						
Pretesting	20.1	21.1	9.8	10.5	19.6	18.5
Posttesting	21.8	20.6	12.1	10.1	19.3	17.6

L, left; R, right.
[a] Statistically significant ($p < 0.05$).

TABLE 2. *Percentage changes in strength*

	Knee extension	Knee flexion	Shoulder flexion	Shoulder extension	Mean
Training period					
Group 1	30.3	12.6	95.8[a]	32.9	42.9
Group 2 (control)	12.3	12.1	17.9[a]	−4.1	9.5
Nontraining period					
Group 1	−1.3	−2.5	65.5	−0.4	15.3

[a] Statistically significant ($p < 0.05$).

Finally, no injuries were incurred by the test subjects over the 9-week training period.

DISCUSSION

As previously noted, there are three major controversies regarding strength training in prepubescent children: first, whether the prepubescent child is capable of strength gains from resistive weight training; second, whether resistive weight training is dangerous for children, particularly because of the presence of growth cartilage; and third, whether strength gains, if attainable, will benefit performance or reduce the risk of injury in children's sports. Our present study would seem to support the contention that strength gains are indeed possible when children are placed on a proper progressive resistive exercise program. Of the four motions studied (knee extension, knee flexion, shoulder flexion, and shoulder extension), the three that were being specifically strengthened (i.e., knee extension, shoulder flexion, and shoulder extension) all showed an increase in the study group over the value for the control group. Of the three motions, the increase in shoulder flexion was statistically significant ($p < 0.05$). Of equal significance was the finding that the motion of knee flexion, which was not directly strengthened by any of the equipment used and which was added as a control, increased in both the control and study groups by almost exactly the same amount. These results support the contention that prepubescent children will make strength gains in response to a progressive resistive exercise program.

Clinical observations of children being treated for various injuries or neuromuscular disorders have long supported the impression that prepubescent children can indeed achieve strength gains through progressive resistive exercises. Therefore, the results of this study were not unexpected. Knee flexion strength did not increase because the hamstrings were not worked directly on any of the resistive machines. The observed decrease in strength during the final nontraining phase was, of course, expected, as it is well known that the physiologic characteristics of muscle tendon tissue—strength, flexibility, and endurance—can only be maintained by progressive overload training techniques.

Maintenance of flexibility was another goal of the training program. Slight gains in flexibility were seen at the hip and knee. Shoulder flexibility may not have shown as great a gain as that in the hip and knee because more time was spent stretching lower back and legs than the shoulder girdle. More important was that the concern that there is loss of flexibility during resistive weight training program was once again disproved. It must be emphasized, however, that specific stretching exercises must be incorporated into a training program such as this to ensure that range of motion and flexibility are maintained.

The fact that our strength measurements were done with the cable tensiometer, which measures isolated strength at a fixed angle for each joint, whereas the actual strengthening techniques were done with dynamic concentric strengthening techniques on machines further supports the contention that we were observing true strength gains and not simply neuromuscular adaptation to patterned motion. We can conclude that the observed strength increases in the exercised muscle groups were a reflection of the progressive resistive exercise program.

The results of this study in no way support the institution of indiscriminant resistive weight

TABLE 3. *Percentage changes in range of motion*

	Shoulder flexion	Hip flexion	Knee flexion	Mean
Training period				
Group 1	−0.47	10.34	3.48	4.45
Group 2 (control)	2.72	−0.76	8.73	3.57
Nontraining period				
Group 1	3.18	−2.32	2.54	1.14

TABLE 4. *Percentage changes in weight*

	Training period	Nontraining period
Group 1	−0.51	3.48
Group 2 (control)	6.66	—

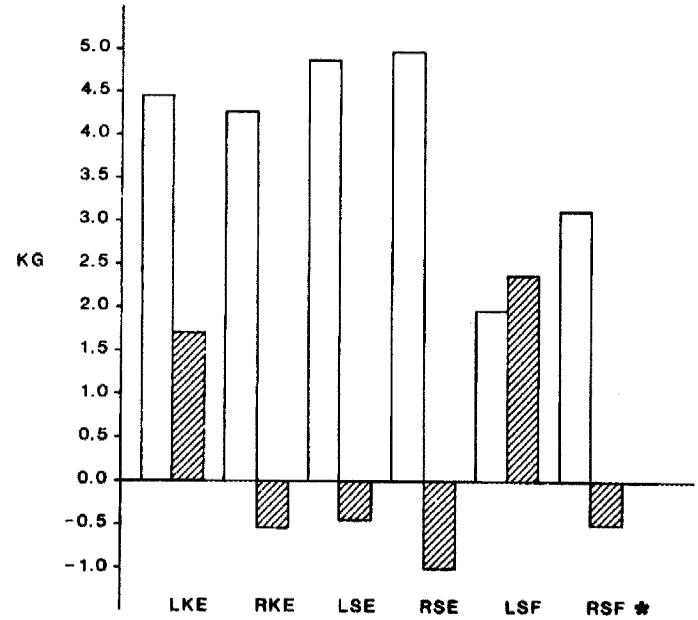

FIG. 1. Changes in strength over the training period in the study group (□) and control group (▨). LKE, left knee extension; right knee extension; LSE, left shoulder extension; RSE, right shoulder extension; LSF, left shoulder flexion; RSF, right shoulder flexion. The indicates a statistically significant difference 0.05).

training in prepubescent children. If a child is to participate in progressive resistive weight training, it should be done only after a careful preparticipation evaluation to ensure that there are no constitutional or anatomic contraindications to the specific exercises. Furthermore, prepubescent children, who may still theoretically have an increased risk of special growth-related injury, should participate only in carefully supervised resistive weight training programs. Movements at this age should be slow and controlled with adequate spotting at all times. Emphasis should be placed on correct form and techniques and not on lifting the maximal amount of weight. In addition, ballistic movements, as are seen in the Olympic weight lifting competitions, should be avoided until skeletal maturity has been attained, because the great majority of injuries recorded in the prepubescent child participating in resistive weight training have occurred with these ballistic motions (6).

CONCLUSIONS

Weight training for prepubescent children is controversial, as some believe that prepubescents are not capable of achieving strength gains through progressive resistive strength training. The results of this study, however, seem to indicate that children with Tanner ratings of Stages I and II can achieve strength gains in response to progressive resistive training.

An increase in strength of >40% was noted over a 9-week training period with no injuries and no loss of flexibility. In comparison, a control group gained <10% in strength over the same period.

Providing the program is well supervised, all movements are done in slow controlled motion, and excessive weights are avoided, resistive training can benefit prepubescent children.

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