
The Prevention of Sports Injuries in High School Students Through Strength Training

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Editors Note: The use of strength training as a means of preventing athletic injury has long been proposed by strength and conditioning coaches. We believe this article offers significant evidence of this fact.

We urge every high school strength and conditioning coach to share this article with other coaches, athletic directors, school administrators, booster club members and the parents of athletes.

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Abstract

The introduction of variable resistance exercise (weight training) to athletic training for purposes of improving athletic performance is well known. The effect of such training on athletic injury in the younger athlete has not yet been well documented. A study was undertaken of injury rate and time lost to rehabilitation in a group of male and female high school athletes (ages 13-19). All athletes utilizing weight training as part of their exercise program suffered an injury rate of 26.2% while their counterparts who did not were injured at a rate of 72.4%. The rehabilitation ratio (time lost to rehabilitation due to injury per number of athletes performing in the studied group) was 4.82 days for control group athletes vs. 2.02 days in athletes who trained with variable resistance exercise. Male athletes suffered an injury rate of 37.0% and each player lost an average of 2.55 days of training or competition due to injury. Female athletes were injured at a rate of 17.5% and lost an average of 1.98 days.

Introduction

Over the past decade, the introduction of variable resistance exercise or weight training, as it is better known, has become extremely popular among both the American public and the competi-

tive athlete. Few studies exist to document the effect of such training on performance, injury pattern, or rehabilitation, particularly in young individuals. While studies among collegiate and professional athletes have demonstrated some changes in performance and injury pattern in individuals with weight training background, (1) few such studies have been performed in the high school level athlete. (2)

The recent emphasis on weight training in both the popular press (3, 4, 5) and among high school coaches (themselves steeped in the tradition of weight training from more advanced athletic participation in higher education) (6) has led to the routine institution of weight training as a means to increase fitness or improve performance in interscholastic competition in various high school sports. While there seems to be little doubt that in the post-pubescent athlete, a properly conducted weight training program may increase speed, endurance, strength, and flexibility, (7, 8) there remain many unanswered questions about the effect of such training on injury rate, time to rehabilitation from injury, and the incidence of injury due to the weight training related activities.

The investigation of such effects is merited in the younger athlete due to special considerations related to the adolescent's unique growth, development and changing physical characteristics. (9)

The incidence of injuries in high school sports is well known, (10, 11) and the economic as well as social impact is recognized. (12) In an attempt to determine the relationship of weight training to injury, a study was designed to investigate the role of weight training on injury patterns in the high school athlete as well as the effect of such conditioning on injury recovery time.

Methods and Materials

High school students participating in several sports were observed over a one year period. A closely supervised program of weight training was provided by experienced athletic trainers. Each athlete was examined prior to entry in the

study for range of motion of all major joints, and an accurate history of previous injuries was obtained. Each athlete was then given a program suited to his/her position and/or sport. All workouts were designed with the cooperation of the project supervisor, strength coach, athletic trainer and participating coaches.

A combination of diversified variable resistance isokinetic and isotonic exercises were utilized for each athlete. Equipment utilized included Nautilus, Universal, and Leaper as well as free weights. Aerobic conditioning as a concomitant benefit of weight training was emphasized along with strength, speed and endurance conditioning.

One group of athletes participated in the weight training during the pre-season and competitive season only, while another group participated in a regular year-round training program. A third group did not utilize weight training as part of their training program or participated once per week or less during the actual competitive season. The latter group was considered the control group, with either no lifting exposure or less than one time per week during the competitive season only.

The two study groups included a maximum weight lifting background group who participated in a regular training program during the off-season, the pre-season, and the competitive season; and those whose weight training program was limited to pre-season and intra-season training only. These groups were labeled SA and SB. In addition to careful monitoring of participation in the weight training program, attendance at both competition and individual sport practice sessions was carefully recorded as was injury to the athlete from training or actual competition. An injury was defined according to Garrick (10) as a medical problem resulting from athletic participation necessitating removal from a practice or competitive event and/or resulting in missing a subsequent practice or competitive event. Accurate records were kept of time off from practice due to injury. Injuries severe enough to warrant the attention of a physician were treated as

deemed appropriate by the athlete's personal physician.

A review of all athletes' attendance at weight training sessions, athletic practice, and competition was made. In addition, the time required for rehabilitation sufficient to allow the athlete to return to practice and competition was noted in each injury. All major long bone fracture injuries were excluded from this analysis. Our primary comparisons were made between groups on the basis of: 1) injury rate (calculated as the number of injuries reported for a given group divided by the number of subjects in the group), and 2) a rehabilitation ratio (the average number of days lost to practice from injury per number of athletes in the group, representing the average time lost to injury per athlete in the group).

Results

Table 1 represents the individual sports studied with the number of participants from each sport and the number of athletes in each of the respective study groups. Three male teams and three female teams were included. Male teams included basketball, gymnastics and volleyball. Men's basketball with 33 participants had three in the control group, 13 with a maximum weight lifting background and 17 with a moderate weight lifting background. Female basketball had 22 participants with only one in the control group, eight with a maximum weight lifting background and 13 with a moderate weight lifting background. Male football had the largest number of participants with 97 athletes participating. Fifteen of these were in the control group while 52 had a maximum weight lifting background and 30 a moderate background. Female gymnastics had 21 participants, five with a maximum weight lifting background and 16 with moderate weight lifting background. Female volleyball was represented by 37 participants, four in the control group, eight with maximum weight lifting background and 25 with moderate background. Male wrestling was represented by 51 athletes, six in the control group, 20 with maximum weight lifting background, and 25 with a moderate weight lifting background. Thus a total of 261 athletes were evaluated. Twenty-nine or 11.1% had no lifting background and were placed in the control group. One hundred and six (40.6%) had a maximum weight lifting background (Group A), while 126 (48.3%) had a moderate weight lifting background (Group B). Their ages ranged from 13 to 19.

An evaluation of injury patterns in male basketball (See Table 2) showed that of the three control athletes only

one suffered injury yielding a 33% injury rate during the season. This athlete lost four days of practice and consequently yielded a rehabilitation ratio of 1.33 for injuries in the control group. Thirteen individuals had a maximum weight lifting background and only one injury was suffered in this group yielding a 7.6% injury rate. This individual required 14.5 days of rehabilitation yielding a rehabilitation ratio of 1.1. Seventeen athletes had a moderate lifting background and suffered nine injuries. This yielded a 52% injury rate resulting in 100 days lost from practice. The rehabilitation ratio in this group was 5.8.

Female basketball players seen in Table 3 demonstrate one athlete only in the control group. This athlete did suffer an injury and required 18.5 days off from practice. Of the eight athletes with a maximum weight lifting background, only one suffered injury yielding an injury rate of 12.5%. This individual required 15 days rehabilitation yielding a rehabilitation ratio for the group of 1.88. Study Group B (moderate lifting background) had 13 participants with three injuries yielding an injury rate of 23%. These three injuries required a total of 29 days lost to rehabilitation yielding a rehabilitation ratio of 2.23.

Football (Table 4) had the largest number of athletes participating. Fifteen athletes had no weight training and were placed in the control group. In these players, 16 separate injuries were recorded yielding an injury rate of 106.6%. This resulted in 112 days lost to injury with a large rehabilitation ratio of 7.46. Fifty-two athletes playing football could be identified as having maximum lifting background. In these, 25 injuries warranted time off for rehabilitation. One hundred twenty-one and one-half days were lost to rehabilitation in this group yielding a rehabilitation ratio of 2.34 with a 48% injury rate. Thirty subjects had a moderate lifting background. Of these, 15 were injured yielding a 50% injury rate. Ninety-seven and one-half days were lost to practice with a resultant rehabilitation ratio of 3.20.

Girls' gymnastics (Table 5) showed no subjects whose weight lifting background was minimal enough to place them in the control group. Five girls were identified with maximum lifting backgrounds. Out of this group, one suffered injury yielding an injury rate of 20%. This resulted in 19 days lost to practice and a rehabilitation ratio of 3.8. Sixteen were identified with moderate lifting backgrounds. Of these three suffered injuries yielding an injury rate of 18.75% with 38.5 days lost to rehabilitation, or a rehabilitation rate of 2.4.

Girls' volleyball (Table 6) showed four subjects in the control group suffering

no injuries. Those with a maximum lifting background numbered eight with one injury which did not result in time lost to rehabilitation. Of the 25 female athletes identified as having a moderate lifting background, four suffered injuries yielding an injury ratio of 16%. These injuries required 38.5 days lost to rehabilitation yielding a rehabilitation rate of 1.54.

The sport with least injuries was male wrestling (Table 7). In this sport, six athletes could be identified in the control group. Of these, two were injured yielding an injury rate of 33%. Five and one-half days were lost from practice yielding a rehabilitation ratio of .91. Of those 20 athletes identified with maximum weight lifting backgrounds, two suffered injuries yielding an injury rate of 10%. Only five days were lost to practice from this group yielding a rehabilitation ratio of .25. Those 25 athletes seen with a moderate weight lifting background suffered only three injuries yielding an injury ratio of 12%. These three injuries resulted in 17.5 days lost due to competition or practice and yielded a rehabilitation ratio of .70.

A summary chart examining all male athletes is seen in Table 8. Here we can see that the 85 athletes with maximum weight lifting background suffered 28 injuries yielding an injury rate of 32.9%. One hundred forty-one days of practice were missed yielding a rehabilitation ratio of 1.66. Seventy-two athletes with a moderate background yielded a slightly higher injury rate of 37.5% with 27 injuries. In addition, they missed 214.5 days of practice yielding a higher rehabilitation ratio of 2.98. Most impressive is the number of injuries seen in the 24 athletes who had no weight training experience at all with a 79.1% injury rate, and 121.5 days missed from practice yielding a rehabilitation ratio of 5.6. It appears then that those male athletes with maximum weight lifting background appeared to spend approximately one day less per man out of practice with injury than those with moderate background. The number of days missed per man due to injury (the rehabilitation ratio) was much higher in those athletes who had no weight training experience.

Table 9 is a summary of all female athletes. Twenty-one female athletes had maximum weight lifting background. Of these, only three suffered injuries yielding an injury rate of 13.3%. These three individuals missed 34 days of practice yielding a rehabilitation ratio of 1.61. Fifty-four female athletes had a moderate weight lifting background and suffered 10 injuries with an injury rate of 18.5%. These 10 injuries resulted

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in 106 days missed from practice and a rehabilitation ratio of 1.96. As among males, the highest injury rate and rehabilitation ratios occurred among those athletes with no weight lifting background at all. Though they only suffered one injury, this resulted in 18.5 days missed from practice, an injury rate of 20%, and a rehabilitation ratio of 3.7.

A final comparison was made of injury and rehabilitation time in the control group versus the combined study groups representing all athletes who participated in a weight training program (Table 10). Two hundred thirty-two athletes participated in moderate or year-round weight training backgrounds. These athletes suffered 61 injuries resulting in a 26.2% injury rate. The 29 athletes who had little to no weight lifting background developed 20 injuries during the course of the athletic season, resulting in a 72.4% injury rate for this group. Equally impressive was the difference in rehabilitation ratio found between athletes who had weight training versus those who did not with ratios of 2.02 in the lifting group compared to 4.82 in the group with no training.

Discussion

There appears to be a difference in both the percentage of athletes suffering injury and the amount of time lost due to injury per athlete amongst the three groups. Though several groups have only a small number of participants, male wrestling and football along with female basketball and volleyball show the highest injury rate and rehabilitation ratio in those athletes with least weight training background and the lowest injury rate and rehabilitation ratio in those with maximal weight training background.

Evaluation of all male athletes, while showing a slightly higher injury rate for those with moderate weight training background compared to those with maximum background, showed a much higher rate for those with no weight training experience. Rehabilitation ratios showed that those with maximum background lost the least amount of time to injury while the control group showed the greatest amount of time lost. Female athletes as a group show a similar relationship with highest injury rates and rehabilitation ratios in the control group and the lowest values found in those girls who participated in a year-round training program.

Evaluation of athletic injury patterns according to sex may or may not be important. Shively et al has recently shown that in comparable sports, there was no difference in overall or individual injury patterns. (11) However, Garrick in 1978 found for all sports that male high school athletes suffered injury at a rate of 39 per 100 participants and females at a rate of 22 per 100. (10) This is quite similar to our findings of 37% and 17.5% respectively (Table 11).

The ability of weight training to decrease the incidence and severity of high school athletic injury is most clearly seen in the comparison of those athletes male and female who utilized weight training versus those who did not. Those athletes with weight training background suffered injury at a rate almost a third that of their non-weight training counterpart. In addition, they averaged less than one-half the amount of time lost from practice or competition due to rehabilitation from injury. This supports the findings of Cahill et al who found that pre-season conditioning could decrease the incidence and severity of knee injuries in high school football players.

It is difficult to separate the effect of training from the effects of individual motivational factors and one might expect the more competitive, aggressive athlete to miss fewer days of practice due to a given injury because of a higher motivation and willingness to endure musculo-skeletal symptoms. Further, the athlete with less "spirit," willingness to return to practice with minor pain, and less desire to compete might be expected to be the same athlete who is not willing to devote himself to weight training. On the other hand, the athlete who participates in the training may be the same athlete who is most frequently utilized in competition, thus increasing his risk of injury.

It must be mentioned that in this carefully supervised group only one injury (a ligamentous knee strain) was reported as being due to weight training alone. This point is significant in light of recent surveys of weight lifting and its related injuries presenting to hospital emergency rooms which indicate that almost half were in children between 10 and 19 years of age. It would seem likely that these injuries may have occurred in unsupervised settings. In this regard, a recent report by the ad hoc committee on weight training of the American Orthopedic Society demonstrated weight training related injuries in 80 athletes over a four year period. (13)

These injuries included multiple back problems requiring hospitalization and occasional surgery for herniated lumbar discs. In addition, several torn menisci were excised and several athletes suffered ischial spine avulsions. If we assume that the athlete who utilizes weight training will perform at a higher level in his sport, then one thing which this study shows clearly is that with proper supervision and training the process of weight training itself contributes very little to the morbidity of athletic competition. In addition, we have been able to show through the rehabilitation ratio and injury rate that those athletes participating in supervised weight training suffer a lower injury rate as well as losing less days of practice to injury rehabilitation. ◦

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Table 1. Sports and Number of Participants

	Number Participating	Maximum Moderate Control		
		A	B	C
Basketball (male)	33	13	17	3
Basketball (female)	22	8	13	1
Football	97	52	30	15
Gymnastics	21	5	16	0
Volleyball	37	8	25	4
Wrestling	51	20	25	6
Total	261	106	126	29

Table 2. Boys Basketball

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	13	1	7.6%	14.5	1.10
Study B	17	9	52.0%	100.0	5.80
Control	3	1	33.0%	4.0	1.33

Table 3. Girls Basketball

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	8	1	12.5%	15.0	1.88
Study B	13	3	23.0%	29.0	2.23
Control	1	1	100.0%	18.5	18.50

Table 4. Football

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	52	25	48.00%	121.5	2.34
Study B	30	15	50.00%	97.5	3.20
Control	15	16	106.60%	112.0	7.46

Table 5. Girls Gymnastics

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	5	1	20.00%	19.0	3.80
Study B	16	3	18.75%	38.5	2.40
Control	0	0	—	—	—

Table 6. Girls Volleyball

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	8	1	12.50%	—	—
Study B	25	4	16.00%	38.5	1.54
Control	4	0	—	—	—

Table 7. Boys Wrestling

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	20	2	10.00%	5.0	.25
Study B	25	3	12.00%	17.5	.70
Control	6	2	33.00%	5.5	.91

Table 8. Boys Football, Basketball and Wrestling

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	85	28	32.94%	141.0	1.66
Study B	72	27	37.50%	214.5	2.98
Control	24	19	79.10%	121.5	5.60

Table 9. Female Athletes

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A	21	3	13.3%	34.0	1.61
Study B	54	10	18.5%	106.0	1.96
Control	5	1	20.0%	18.5	3.70

Table 10. All Athletes

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Study A & B	232	61	26.2%	272.0	2.02
Control	29	20	72.4%	140.0	4.82

Table 11. All Male vs. All Female Athletes

	No. of Athletes	No. of Injuries	Percent Injured	No. of Days Off	Rehabilitation Ratio
Male	181	67	37.0%	453.5	2.55
Female	80	14	17.5%	158.5	1.98