THE EFFECT OF PREVENTATIVE DRILLS ON STABILITY OF THE KNEE IN FEMALE BASKETBALL PLAYERS

G. C. L. Allen, M. N. Satern, G. Chen

Kansas State University
Manhattan, Kansas, USA

INTRODUCTION

Participation by females in the sport of basketball has dramatically increased from a few thousand to several hundred thousand since the 1972 passage of Title IX. A tragic side effect of this increased participation is injury. One of the most devastating injuries a female athlete can sustain is a tear of the anterior cruciate ligament (ACL) of the knee. Several authors have noted that females are two to four times more likely to encounter such an injury in the sport of basketball than their male counterparts (Henning et al., 1989; Chandy and Grana, 1985). Two reasons suggested for this startling statistic are a lower relative strength between the hamstrings and quadriceps and improper performance of basic basketball skills, particularly skills that involve sudden deceleration on a nearly straight leg (Henning et al., 1985; 1989). Prevention of ACL tears is a relatively new concept in sports science, however. In the past, science has placed the emphasis on rehabilitation of ACL tears rather than on prevention of the injury. Henning and colleagues (1985; 1989) suggest three injury prevention techniques in combination with improved strength relationships of the hamstrings and quadriceps to reduce risk of ACL tears. The three preventative techniques are: a) bent knee landings; b) rounded accelerated turns; and c) two/three step stops. The purpose of this investigation, therefore, was to study the effect of incorporating three preventative techniques into the practice sessions of an eighth grade girls' basketball team over the duration of one season on the players' knee stability. Knee stability was defined as: a) range of motion in extension and flexion; b) comparative strength of the hamstrings and quadriceps muscles; and c) joint laxity as an indicator of ACL strength.

METHODOLOGY

Nine females served as control subjects (mean age: 12.8 ± 1.3 yrs, height: 160.16 ± 8.53 cm, mass: 53.80 ± 14.48 kg) and 17 served as experimental subjects (mean age: 13.7 ± .7 yrs, height: 165.85 ± 6.32 cm, mass: 53.51 ± 6.47 kg). Subjects participated in two different basketball programs at local middle schools. Subjects and their guardians signed a consent form.

Pre-Season Testing

Prior to the beginning of the basketball season, all subjects were tested in the student health center located on campus. Height and weight on each subject were taken upon entering the clinic. Subjects then proceeded to a stationary bicycle for a five minute warm-up session at a relaxed speed. Knee flexion/extension and peak torques were measured with an Orthotron interfaced to an IBM-compatible computer using HUMAC software. Subjects performed knee flexion and extension at two speeds: six trials were performed at 60°/s followed by a 20 second trial at 180°/s. The first leg tested was alternated across subjects. Range of motion was then assessed with the subject in a supine position using a goniometer. Extension was measured with the heel on the table and the ankle dorsiflexed. Flexion was measured as the subject brought her heel to the soft tissue as far as her knee would allow.

In-Season

The researcher taught the three preventative techniques to the experimental subjects during the first two weeks of practice. Six drills in which the preventative techniques were incorporated were practiced on a regular schedule throughout the season: the circle lap and zig zag drills emphasized rounded accelerated turns; the baseline half court sprint, full court sprint, and passing defense drills emphasized two/three step stops; and the rebounding control drill emphasized bent knee landings. Using a nearly straight leg during landing, pivoting, and stopping were de-emphasized by stressing greater flexion of the knees.

Post-Season Testing

The same procedures were followed as in the pre-season testing with the addition of a test for knee laxity. Subjects were tested on a separate day and time with a KT-2000 interfaced to an X-Y Pin Plotter (Norma Goerz Instruments, Elk Grove, IL) for anterior knee laxity. Each subject assumed a supine position on a table with her knees resting over an elevation block placing her knees in 28° of flexion. Anterior displacement of the tibia was achieved by applying 15, 20, and 30 ft-lbs of pressure. The first leg tested was alternated across subjects.

STATISTICAL ANALYSIS

Pair-wise t-tests were used to compare all data for probabilities of the mean differences (MD) from the pre- and post-season tests of both control and experimental subjects for each variable using the general linear model procedure (GLM) in SAS. The hypothesis tested signifies the mean difference MD = 0. An analysis of variance was used to describe the mean difference between control and experimental subjects for knee laxity in post-season. Selected interactions were examined by using paired t tests. Significance was determined at an alpha level of $p<0.05$.

RESULTS

No significant differences ($p<0.05$) were found between pre- and post-season testing for knee range of motion mean differences (Table 1).

Table 1. Knee Range of Motion

Group	N	Leg	Range of Motion (°)		% Change	p*
			Pre-Season	Post-Season		
Control	9	L	148.33±5.29	146.11±7.07	-1.50	0.128
		R	144.33±6.82	145.00±7.81	+0.46	0.663
Experimental	17	L	143.82±5.63	145.18±5.14	+0.94	0.200
		R	143.53±5.47	144.53±5.15	+0.69	0.372

Note: * = MD between pre-season and post-season tests.

No significant differences were found with the analysis of variance t-test for the mean difference from pre-to post-season on knee laxity in the control and experimental subjects (Table 2).

Significant increases ($p<0.05$) were revealed between pre- and post-season testing in flexion and extension in both legs at both 60°/s and 180°/s for the experimental group (Table 3). The left leg improved 14% for both speeds while the right leg improved 13% and 8% for 60°/s and 180°/s, respectively.

Table 2. Knee laxity (Post-Season).

Group	N	Leg	Force (ft-lbs)	Laxity (mm)	Group	N	Leg	Force (ft-lbs)	Laxity (mm)	p (Pr>T)
Con.	9	R	15	4.64±2.30	Exper.	16 *	R	15	4.50±1.90	0.874
	9	R	20	6.00±2.88		16 *	R	20	5.55±1.94	0.651
	9	R	30	6.86±2.89		16 *	R	30	6.60±2.08	0.799
	9	L	15	5.36±2.12		17	L	15	5.34±1.71	0.940
	9	L	20	6.69±2.51		17	L	20	6.22±1.78	0.558
	9	L	30	8.03±2.61		17	L	30	7.30±1.94	0.409

Note: * = One subject broke her right distal tibial epiphysis prior to this test but after completion of all other post-season tests.

Table 3. Flexion/Extension ratios compared to body weight

Group	N	Leg	Speed (°/s)	Flexion/Extension* Pre-Season	Flexion/Extension* Post-Season	% Change**	p***
Con	9	L	60	65.78±8.33	64.78±8.29	-1.52	0.751
	9	R	60	64.44±10.97	69.11±12.22	+6.76	0.104
	9	L	180	79.44±15.88	77.44±6.77	-2.52	0.526
	9	R	180	80.00±15.88	74.44±7.73	-6.95	0.054
Exper	17	L	60	60.82±6.07	70.47±8.85	+13.69	0.000
	17	R	60	60.88±8.35	70.00±12.82	+13.03	0.000
	17	L	180	67.41±13.95	78.18±10.39	+13.78	0.000
	17	R	180	67.29±12.23	73.24±11.94	+8.12	0.006

Note: * = Flexion and extension values used to determine these ratios are expressed relative to body weight.
** = + indicates increase and - indicates decrease
*** = MD between pre-season and post-season tests.

Significant differences ($p<0.05$) were revealed between pre- and post-season testing for peak torque values (Table 4). Significant improvements for the experimental group were noted in flexion of the left leg at 60°/s by 8% and at 180°/s by 17%. Left leg improvement was noted in extension at 180°/s by 14%. Right leg extension improvements were revealed at 60 and 180°/s by 13% and 8%, respectively, for the experimental subjects. The control subjects revealed one significant difference in right leg flexion at 60°/s by improving 8%.

DISCUSSION

Significant differences were noted in flexion/extension ratios for both legs at both speeds for the experimental subjects from pre- to post-season (Table 3). It would appear, therefore, that the preventative techniques were effective in improving this measure of knee stability. The hamstrings are naturally weaker than the quadriceps muscles. Weak hamstrings may result in increased anterior displacement of the tibia on the femur when the knee flexes, thereby increasing one's risk for ACL tears and injuries (Henning et al., 1989). Henning and colleagues (1985; 1989) developed the preventative techniques of bent knee landings, accelerated rounded turns, and two/three step stops as a means of strengthening the weaker hamstrings by emphasizing knee flexion. Recall that the practice drills emphasized knee flexion in landing, pivoting, and stopping maneuvers. It would appear, therefore, that the findings of this study support their hypothesis. Further inspection of Table 3, however, reveals that all subjects had ratios within acceptable limits of >0.60 (hamstrings to quadriceps) as suggested by Wyatt and Edwards (1981). Although the control subjects' values were still within acceptable limits post-season, their ratios decreased over the season whereas the experimental subjects' values increased.

Table 4. Peak torque values compared to body weight (peak torque/body weight).

Group	N	Leg	Speed (°/s)	Action	Torque Ratios (% Body Weight)		%Change*	p**
					Pre-Season	Post-Season		
Con	9	L	60	Ext	0.60±0.13	0.60±0.11	0.0	0.810
	9	R	60	Ext	0.76±0.16	0.74±0.17	-2.63	0.502
	9	L	180	Ext	0.38±0.07	0.41±0.08	+7.32	0.075
	9	R	180	Ext	0.48±0.08	0.48±0.10	0.0	0.858
	9	L	60	Flex	0.38±0.09	0.40±0.06	+5.0	0.394
	9	R	60	Flex	0.47±0.11	0.51±0.09	+7.84	0.027
	9	L	180	Flex	0.30±0.08	0.31±0.06	+3.23	0.760
	9	R	180	Flex	0.37±0.10	0.37±0.10	0.0	0.951
Exper	17	L	60	Ext	0.59±0.08	0.58±0.08	-1.69	0.599
	17	R	60	Ext	0.65±0.06	0.75±0.10	+13.33	0.006
	17	L	180	Ext	0.37±0.07	0.43±0.06	+13.95	0.001
	17	R	180	Ext	0.47±0.07	0.51±0.06	+7.84	0.051
	17	L	60	Flex	0.37±0.07	0.40±0.11	+7.5	0.014
	17	R	60	Flex	0.47±0.06	0.50±0.08	+6.0	0.533
	17	L	180	Flex	0.25±0.06	0.30±0.04	+16.67	0.001
	17	R	180	Flex	0.32±0.06	0.35±0.06	+8.57	0.079

Note: * = + indicates an increase and - indicates a decrease
** = MD between pre-season and post-season tests.

Peak torque extension and flexion ratios were computed relative to each subject's body weight. These values were then used to compute flexion/extension ratios. Therefore, one would expect to find similar results to those previously discussed. Indeed, inspection of Table 4 reveals significant increases from pre- to post-season for the experimental subjects and non-significant changes for the control subjects.

Non-significant changes were revealed in knee range of motion. Flexibility exercises for the knee were not emphasized in the experimental subject group's practice sessions. Therefore, it was not surprising that pre- to post-season values of flexibility were similar. A measure of range of motion was included in this study, however, to investigate the possible effect of the emphasis on knee flexion during the practice drills on knee range of motion. It would appear that the practice drills used in this study did not result in a statistically significant change in knee flexibility.

Henning et al. (1989) and Feagin (1979) suggest that the ACL will not lengthen from pre- to post-season unless an injury occurs. Hence, anterior knee displacement was taken post-season and is presented as a description of the subjects' knee laxity.

CONCLUSIONS

It was concluded that inclusion of the three preventative mechanical principles into practice sessions of eighth grade female basketball players improved flexion/ extension ratios and peak torque values. Therefore, the findings of this study suggest that learning the preventative mechanical principles for landing, pivoting, and stopping skills may increase knee stability and reduce female basketball players' predisposition for knee injuries.

REFERENCES

Chandy, T. A. and Grana, W. A. (1985). Secondary school athletic injuries in boys and girls: a three-year comparison. Phys Sports Med 13(3):106-111.

Feagin, J. A. (1979). The syndrome of the torn anterior cruciate ligament. Ortho Clin of North America 10(1):81-90.

Henning, C. E., Lynch, M. A., Glick, K. R. (1985). An in vivo strain gage study of the elongation of the anterior cruciate ligament. Am J Sports Med 13(1):22- 26.

Henning, C. E., Griffis, N. D., Vequist, S. W., Yearout, K. M., Decker, K. A. (1989, June). Injury prevention of the anterior cruciate ligament in basketball: a preliminary report. Symposium conducted at the meeting of the American Orthopaedic Society for Sports Medicine, Transverse City, MI.

Wyatt, M. P. and Edwards, A. M. (1981). Comparison of quadriceps and hamstring torque values during isokinetic exercise. J Ortho Sports Phys Ther 3:202-210.