AD-A207 460 EFFECT OF A PROPHYLACTIC KNEE BRACE ON THE FREQUENCY AND SEVERITY OF ACUTE KNEE INJURIES IN FOOTBALL(U) MILITARY ACADEMY WEST POINT NY M R SITLER 01 JUL 88 1/1

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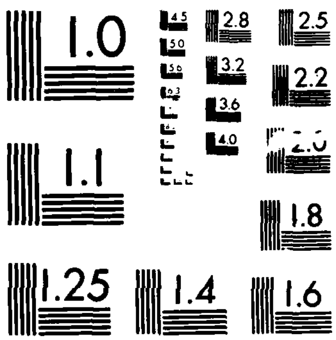

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EFFECT OF A PROPHYLACTIC KNEE BRACE ON THE FREQUENCY AND SEVERITY OF ACUTE KNEE INJURIES IN FOOTBALL

FINAL REPORT

MICHAEL R. SITLER

JULY 1, 1988

Supported by

U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Fort Detrick, Frederick, Maryland 21701-5012

PROJECT ORDER NO. 86PP6836

United States Military Academy
West Point, New York 10996-1694

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION United States Military Academy 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) West Point, New York 10996-1694	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Medical Research & Development Command 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER 86PP6836
8c. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, Maryland 21701-5012	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62777A	3E1-62777AB79	BD	182

11. TITLE (Include Security Classification)

(U) Effect of a Prophylactic Knee Brace on the Frequency and Severity of Acute Knee Injuries in Football

12. PERSONAL AUTHOR(S)

Michael R. Sitler

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 4/17/86 TO 4/30/88	1988 July 1	21

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	RA 3; Knee Injuries; Knee Brace; Prevention/Reduce Knee Injuries
05	09		
05	01		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The value of prophylactic knee brace use in the United States Military Academy intramural tackle football program was tested in a study of approximately 1300 subjects over a two year period. Subjects were divided into two groups; those with previous knee injuries, and those without previous knee injuries. Half the subjects from each of these groups wore the knee brace during the intramural football program. Data on the incidence and severity of musculoskeletal injuries were collected for all subjects. Keywords; [illegible], Medical equipment, Protective equipment, Safety; [illegible]

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
Mary Frances Bostian	301-663-7325	SGRD-RMI-S

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

Introduction

Various injury intervention systems have been implemented to reduce the incidence of knee injuries in American football. Dating back to the mid 1900's one of the first injury prevention measures implemented was the changing of the rules that governed the field of play. In 1969 prophylactic knee braces (PKBs) were introduced for the purpose of reducing the frequency and severity of knee injuries in football.

Limited research had been conducted concerning the efficacy of PKBs to reduce football knee injuries and the studies completed had conflicting results. Additional empirical testing of PKBs was needed. Accordingly, this prospective experimental study was conducted to determine the effects of a PKB on the frequency and severity of football knee injuries. In conjunction with the purpose of the investigation, additional variables were included in order that a better understanding of the significant effects associated with PKB use could be gained. The Statistical Package for the Social Sciences was used in the analysis of the data (SPSSPC, 1986). Pearson's chi-square test statistic for contingency tables was used to determine the agreement between theoretical expected frequencies and those observed.

Summary of Findings

Subject Participation

Subjects for the study consisted of those cadets who participated in the 1986 and 1987 intramural football (IMFB) program at the United States Military Academy (USMA). Of the 1396 subjects who volunteered to participate in the study, 1160 were identified as having no history of knee injury and were assigned to the non-injured knee group (NIK). Subjects identified as having a history of knee injury were assigned to the previous injured knee group (PIK). A total of 691 subjects wore PKBs and 705 served as controls. Braces were randomly assigned within the NIK and PIK group.

Exposure

During the two years of the study, 299 games and 895 practices were conducted. Over 21,500 athlete-exposures were experienced by the 1396 subjects. The PKB and control group experienced 10,672 and 10,898 exposures, respectively. Group differences in athlete-exposures were controlled statistically in order to normalize the risk of injury.

Frequency of Knee Injury

A total of 53 subjects or 3.8 percent of the study's participants sustained knee injuries (Appendix A). A greater number of knee injuries occurred to the NIK group than to the PIK group; however, the knee injury case rate per 1000 athlete-exposures was higher for the PIK group than for the NIK group. The knee injury case rate was calculated by dividing the knee injury frequencies by the corresponding athlete-exposures. Every subject at a practice or game was counted as one athlete-exposure. The observed number of knee injuries for the NIK and PIK group were not significantly different ($p = .20$) and subsequent analyses were completed with the two groups collapsed.

A statistically greater number ($p = .005$) of knee injuries occurred to the control group than to the PKB group (Appendix B). Sixteen of the 53 knee injuries occurred to the PKB group and 37 occurred to the control group. A knee injury case rate of 1.50 and 3.40 per 1,000 athlete-exposures was calculated for the PKB and control group, respectively.

Structural Knee Injuries

The 53 injured subjects sustained a total of 71 ligamentous and cartilaginous structural injuries to the knee (Appendix C). For this study, a knee injury was defined as acute trauma to a ligament and/or meniscus structure of the knee that resulted in an athlete's inability to participate in football one day after injury. The greatest number of injuries occurred to the medial collateral ligament (MCL) which totaled 37 and accounted for 52.1 percent of the structural knee injuries. The second highest incidence of injury was to the anterior cruciate ligament (ACL) which total 16 and accounted for 22.5 percent of the knee injuries.

Medial collateral ligament sprains accounted for 78.6 percent of the grade I injuries and 55 percent of the grade II injuries. Sixty-four percent of the grade III sprains occurred to the anterior cruciate ligament (ACL). Within the MCL injury category, a significantly greater number ($p = .001$) of grade I injuries occurred than grades II or III.

A significantly greater number ($p = .04$) of MCL knee injuries occurred to the control group than to the PKB group. Although not tested for statistical significance due to a small sample size, a greater number of ACL injuries occurred to the control group than to the PKB group. A total of four and 12 ACL knee injuries occurred to the PKB and control group, respectively.

Knee Injury Severity

Three injury grades were used in categorizing the severity of knee injury. Within each of the three grades a greater number of MCL and ACL knee injuries occurred to the control group than to the PKB group. However, these differences were not statistically significant ($p = .18$) for the MCL knee injuries. No analysis of the ACL injury severity was completed due to a small sample size.

Frequency of Knee Injury by Position

Player positions were collapsed into the categories of offense, defense and kicking game. A total of 30, 20 and three knee injuries occurred to players while on defense, offense and kicking game, respectively. The statistical analysis was completed with the kicking game data excluded due to a small expected frequency. For the offense and defense the observed total knee injury ($p = .16$) and MCL knee injury ($p =.25$) frequencies were not significantly different.

Mechanism of Knee Injury

The injury mechanism categories of direct lateral knee contact (DLKC), direct anterior lateral knee contact (DALC), direct medial knee contact (DMKC), upper body contact with concurrent lower extremity rotation (UBCR), lateral knee contact with concurrent lower extremity rotation (LKCR), and non-contact deceleration-rotation-acceleration (NCR) were considered to be the six injury mechanism categories used in the study. The data were collapsed over the direct contact (DLKC, DALC, and DMKC) and rotation (UBCR, LKCR, and NCR) categories due to small sample sizes.

No significant difference ($p = .16$) existed between the collapsed knee injury mechanism categories of rotation and direct contact in the number of knee injuries. However, a significant difference ($p = .005$) in the injury mechanism of MCL knee injuries did exist. A statistically greater number of MCL knee injuries occurred as a result of direct contact to the knee than from rotation.

Direct lateral blows to the knee (DLKC) resulted in a greater number of MCL knee injuries occurring to the control group than to the PKB group. The difference was not statistically significant. However, the exact probability $p = .07$ was close to the .05 significance level of the test.

Medical Treatment

Of the 53 subjects who sustained knee injuries, twenty had knee surgery. Thus, one out of every 2.65 subjects who sustained a knee injury and one out of every 70 study participants had knee surgery. Four times as many control subjects as PKB subjects had knee surgery. Although the control group had a statistically greater number ($p = .008$) of knee surgeries (16 cases) than the PKB group (four cases), the use of surgery as an indicator of knee injury severity has been criticized. This is due to variability in patient compliance to undergo surgery and because of the criteria and treatment variability within the medical community of surgical intervention.

Bivariate Analysis

Total Knee Injuries

Bivariate analysis consisted of a series of dual cross classifications of PKB-control group, position, knee injury history group and injury mechanism. The chi-square test statistic was used to determine the agreement between the observed frequencies and those expected. Of the six bivariate cross classifications completed, only the PKB-control group by position analysis was statistically significant (p = .004). Risk of knee injury was therefore dependent on position and whether or not PKBs were worn. The non-braced players while on defense and the braced players while on offense were associated with the highest risk of knee injury. An injury rate of .09 and .04 per player position was calculated for the control subjects while on defense and for the PKB subjects while on offense, respectively. Of the subjects who were injured, the probability of being on the defense and serving as a control was .50.

By repartitioning the offense and defense categories, additional insight to the dependent relationship between the PKB-control group and position was gained. For the offense, the differences between the PKB and control group were not statistically significant since p = .50. However, for the defense, the PKB group had statistically fewer knee injuries than the control group since p = .003.

MCL Knee Injuries

Bivariate analysis of the MCL knee injuries consisted of a series of dual cross classifications of PKB-control group, knee injury history group, position, knee injury mechanism and knee injury severity. Statistical analysis resulted in only the

PKB-control group by position analysis being significant (p = .03). Significantly fewer MCL knee injuries occurred to PKB subjects than to control subjects while on defense; however, this difference did not exist for the offense.

Discussion

The most sigrificant contribution of this study to the field was to statistically verify that a unilateral, biaxial PKB significantly reduced the total number of knee injuries and MCL knee injuries in football. Additionally, the reduction in knee injuries was dependent on player position. While on defense, subjects who wore PKBs had statistically fewer knee injuries than subjects who served as controls. This was not true on offense where subjects who served as controls had statistically no difference in the number of knee injuries from subjects who wore PKBs.

The positional dependence of PKBs to reduce knee injuries was not attributed to group differences in height, weight, football playing experience and exposure to injury as no significant differences existed. Thus, these factors were not believed to have contributed to the differences that were encountered. The differences are indeed positionally related to the actual playing activity differences on defense verses offense that cause knee injuries.

The results of this investigation contradict the results of the studies completed by Rovere et al. (1985), Hewson et al. (1985) and Teitz et al. (1987). They reported increases in the total number of knee injuries when PKBs were worn. However, only Teitz et al. reported that the increases were statistically significant. These researchers did not control for prior knee injury and exposure to injury, which may explain the differences in the results of their studies.

The results of Schriner (1985) and Quillian et al. (1987) studies support the general findings of this investigation: PKBs significantly reduce knee injuries in football. Additionally, Schriner reported a significant reduction in direct lateral knee contact (DLKC) knee injuries as a result of PKB use. For this investigation the number of DLKC MCL knee injuries were numerically reduced with the use of PKBs. Although this difference was not statistically significant at the .05 level, the exact level was .07.

Concern that the use of PKBs may predispose a football player to knee injuries had been raised by Paulos et al. (1985). Hewson et al. (1985) and Rovere et al. (1985) reported that the frequency of ACL knee injuries increased when PKBs were worn; however, their studies were limited due to small sample sizes.

For this investigation a numerically greater number of ACL knee injuries occurred to the control group than to the PKB group. The differences were not tested for statistical significance due to a small sample size. A total of 12 and four ACL knee injuries occurred to the control and PKB group, respectively. Two of the PKB and seven of the control group were grade III ACL knee injuries. Teitz et al. (1987) reported that no significant difference in the incidence of ACL knee injuries existed between the PKB and control group. Exemplified by all of these studies is the need for a large sample size in order that reliable inferences can be made from the data.

Concurrent analysis of injury severity of all of the knee injuries was not possible since the assumption of mutual exclusiveness would have been violated. This was due to the occurrence of several subjects sustaining multiple structural injuries. Inferential analysis of knee injury severity was limited to the MCL knee injury category since no subjects incurred more than one such injury and because the MCL was the most frequently injured knee ligament during the two years of the study.

Within each of the three injury grades, a greater number of MCL knee injuries occurred to the control group than to the PKB group. Due to small expected cell values, injury grades II and III were collapsed. No significant differences in the severity of MCL knee injuries were determined to exist. The ability to demonstrate statistical significance may have been mitigated as a result of collapsing. Hewson et al. (1985), Rovere et al. (1985) and Teitz et al. (1987) reported similar results that PKBs do not significantly decrease the severity of MCL knee injuries in football.

Intended as a subproblem within the study, limited analysis of the PIK group was completed due to a small sample size. Univariately, the knee injury history groups were collapsed since the observed frequencies within the NIK and PIK group were not significantly different from what was expected based upon exposure. Bivariately, the NIK and PIK group were determined not to be significantly different in their proportions of PKB-control subjects who sustained knee injuries.

In addition to a small sample size, the composition of subjects comprising the PIK group may also have contributed to the relatively small number of knee injuries sustained by this group. With participation in the study limited to subjects who did not have prior anterolateral instability, the PIK group consisted of subjects who were limited in their knee dysfunctions.

Conclusions

1. No significant difference existed between the NIK and PIK group in the total number of knee injuries and MCL knee injuries.

2. The use of a unilateral, biaxial PKB significantly reduced the frequency of knee injuries in football.

3. Medial Collateral ligament and ACL knee injuries were reduced in frequency with the use of a unilateral, biaxial PKB; however, only the reduction in MCL knee injuries was statistically significant.

4. The reduction in the frequency of knee injuries and MCL knee injuries was dependent on player position. Braced subjects while on defense had significantly fewer knee injuries than subjects who served as controls. This was not true on offense, as no significant difference in knee injuries existed between the PKB and control group.

5. No significant reduction in the severity of MCL knee injuries occurred with the use of a unilateral, biaxial PKB.

6. Medial Collateral Ligament knee injuries

occurred more frequently as a result of direct contact to the knee than from rotational injury mechanisms .

7. Direct lateral blows to the knee resulted in fewer MCL knee injuries when PKBs were used. The reduction was not statistically significant at the .05 level, but the exact p was .07.

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Appendix A

1986 and 1987 IMFB Knee Injury Frequencies and Exposure Rates by Injury History Group Assignment

	1986			1987			2-year Total		
	PKB	C	Total	PKB	C	Total	PKB	C	Total
Non-injured knee group									
N of Injuries	4	14	18	8	15	23	12	29	41
Rate/1000 A-E	1.11	3.63	2.37	1.52	2.87	2.20	1.33	3.19	2.27
Previously Injured Knee Group									
N of Injuries	3	3	6	1	5	6	4	8	12
Rate/1000 A-E	2.99	2.71	2.85	1.53	7.67	4.60	2.42	4.55	3.52
Total Knee Injuries									
N of Injuries	7	17	24	9	20	29	16	37	53
Rate/1000 A-E	1.50	3.42	2.50	1.52	3.41	2.46	1.50	3.40	2.46

N of Injuries = Number of Injuries
Rate/1000 A-E = Case Rate per 1,000 Athlete-Exposures
PKB = Prophylactic Knee Brace Wearer
C = Control, Non-brace Wearer

Appendix B

1986 and 1987 IMFB Knee Injury Frequencies
and Exposures Rates for Practices
and Games

	1986			1987			2-year Total		
	PKB	C	Total	PKB	C	Total	PKB	C	Total
Practice									
N of Cases	2	2	4	2	3	5	4	5	9
Rate/1000 A-E	.62	.59	.60	.52	.79	.65	.57	.69	.63
Games									
N of Cases	5	15	20	7	17	24	12	32	44
Rate/1000 A-E	3.31	9.45	6.46	3.31	8.07	5.69	3.31	8.66	6.01
Seasonal Total									
N of Cases	7	17	24	9	20	29	16	37	53
Rate/1000 A-E	1.48	3.42	2.47	1.51	3.38	2.44	1.50	3.40	2.46

N of Cases = Number of Cases
Rate/1000 A-E = Case Rate per 1000 Athlete-Exposures
PKB = Prophylactic Knee Brace Wearer
C = Control, Non-brace Wearer

Appendix C

1986 and 1987 IMFB Structural Knee Injury
Frequencies by PKB and Control
Group Assignment

	1986						1987						2-Year Total					
	PKB		C		Total		PKB		C		Total		PKB		C		Total	
Structural Injury	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
MCL	6	66.7	11	47.8	17	53.1	6	54.5	14	50.0	20	51.3	12	60.0	25	49.0	37	52.1
LCL	0	0.0	2	8.7	2	6.3	1	9.1	3	10.7	4	10.2	1	5.0	5	9.8	6	8.5
ACL	2	22.2	5	21.7	7	21.8	2	18.2	7	25.0	9	23.1	4	20.0	12	23.6	16	22.5
PCL	0	0.0	2	8.7	2	6.3	0	0.0	1	3.6	1	2.6	0	0.0	3	5.9	3	4.2
MMX	0	0.0	1	4.4	1	3.1	1	9.1	1	3.6	2	5.1	1	5.0	2	3.9	3	4.2
LMX	1	11.1	2	8.7	3	9.4	1	9.1	2	7.1	3	7.7	2	10.0	4	7.8	6	8.5
Total	9	100	23	100	32	100	11	100	28	100	39	100	20	100	51	100	71	100

MCL = Medial Collateral Ligament
MMX = Medial Meniscus
LCL = Lateral Collateral Ligament
PKB = Prophylactic Knee Brace Wearer
N = Number of Injuries
PCL = Posterior Cruciate Ligament
LMX = Lateral Meniscus
ACL = Anterior Cruciate Ligament
C = Control, Non-Brace Wearer
% = Column Percent

Appendix D

1986 and 1987 PKB Expenditures

Item	Cost
KT-1000	5,800.00
PKBs	25,472.00
Athletic Shoes	27,676.00
Consultant	300.00
Panel of Experts	223.42
TDY	3,420.62
Athletic Tape	2,928.80
Pre Tape	281.50
Memory Chip	21.60
PKB Replacement	13,855.80
Assistant Salary	4,534.21
Computer	5,287.00
Federal Express	69.00
Tape Adherent	226.80
Total	$90,096.75

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