EVALUATION OF FOOTBALL SHOULDER PADS

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INTRODUCTION

The evolution of protective equipment in all sports has been haphazard and mainly by trial and error. This is particularly true in football, a high-contact sport with an increasing number of participants. The very nature of football demands that attention be paid to shock attenuation and force distribution. A literature search revealed two very different types of articles relating to shoulder pads and their testing. The first type deals with evaluation of shock absorbing materials used in shoulder pads and the second type considers the efficacy of the entire shoulder pad unit. The American Society for Testing and Materials provided guidelines for testing these materials (1989). However, because the shock absorption effectiveness of materials is largely dependent on how the material is represented in the entire pad unit, these tests do not yield results that will allow valid and reliable product comparisons.

The second type of study deals with the description and evaluation of the entire shoulder pad unit. Watkins (1986) cited shock absorption as one of the most important characteristics of proper protective equipment. No studies identifying procedures for valid and reliable measurement of shock absorption were found.

The purpose of this study was to identify relevant criteria and procedures for comparison of the effectiveness of football shoulder pads using different materials (e.g., open-cell and closed-cell foam) and different representations of these materials (e.g., density and thickness). The study consisted of two phases: 1) phase I to develop and conduct a field test to provide player perceptions regarding overall effectiveness, and 2) phase II to develop instrumentation and procedures for a laboratory test to provide objective data regarding shock absorbancy.

FIELD TEST METHODOLOGY

Four subjects were recruited from the local high school football team to participate in the field test. Two of the subjects performed the drills while wearing four different pair of pads. The other two subjects assisted by performing the drills, simulating an actual practice situation. The two test subjects were elite middle linebackers of similar size, allowing usage of the same size shoulder pads. Four pairs of pads were used in the field test with three sets using open-cell foam in an air management system and the fourth using closed-cell foam. Great care was taken to ensure proper pad adjustment and fit using procedures suggested by Roberts (1984). Each subject performed four drills commonly used in practice using each of the four sets of shoulder pads. The drills were performed under the direct supervision of one of the high school coaches to ensure that they were performed correctly and in the same manner as during practice. Immediately following each drill the subjects were asked to respond to a questionnaire regarding force distribution - both the amount of force and the area over which it was dispersed. The first part of the force distribution section asked the subjects to rate the amount of pressure experienced on specific anatomical landmarks on a four-point scale from none to severe. The second part of the force distribution section called for the subject to mark with a colored pen the area(s) over which the greatest force was noted. This was an attempt to determine whether the force was at a particular point or over a general area. All hitting drills were videotaped for subsequent observation.

Questionnaire results indicated that greatest pressures were perceived on the acromion. The deltoid and clavicle were also perceived to receive a substantial amount of pressure. The sternum and ribs were perceived to receive the least amount of pressure.

LABORATORY TEST METHODOLOGY

Phase II of the study was designed to directly measure pressure on sites identified in phase I during a controlled blocking drill simulating field conditions. A pressure measuring system was developed consisting of twelve force-sensing resistors (Stone and Vaughan, 1990), signal conditioning circuitry, an analog to digital data acquisition and analysis unit, and a microcomputer (see Figure 1). The piezoresistive transducers, manufactured by Interlink Electronics, Santa Barabara, CA, consisted of a polymer thick film device 0.6 mm thick and 12.7 mm in diameter providing a change in resistance with applied force. While the transducer output is nonlinear, signal conditioning circuitry were developed to provide output for 16 elements that was largely linear within the range of observations (-9 to 6 V). Prior to transducer placement, a layer of cloth tape was applied to the top of the right shoulder and chest. Twelve transducers were then placed at selected sites and covered with cloth tape. Next, shoulder pads were put in place and covered with a football jersey. The following transducer sites were selected by considering data from the field study and the profile of the top of the shoulder and chest area: 1) midline of the deltoid 7.62 cm below the lateral border of the acromion; 2) 2.54 cm superior to site #1; 3) 2.54 cm superior to site #2, 4) acromion; 5) 2.54 cm medial to site #4 on superior portion of trapezius; 6) 2.54 cm medial to site #5; 7) 2.54 cm medial to site #6; 8) 2.54 cm medial to site #7; 9) 2.54 cm posterior to site #8; 10) 2.54 cm posterior to site #8; 11) middle and most prominent aspect of clavicle; and 12) distal end of clavicle.

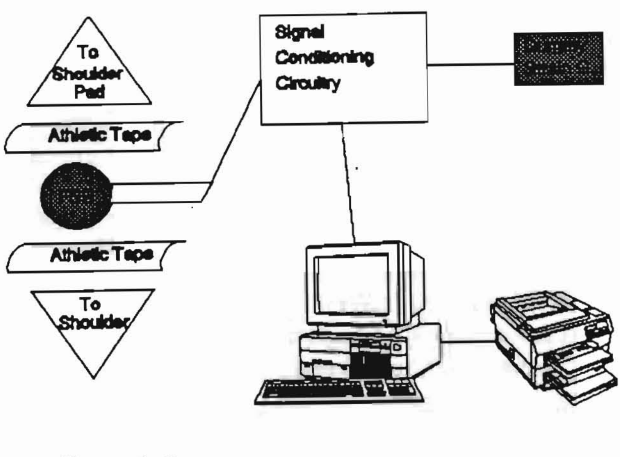

Figure 1. Pressure measurement system.

Four recent high school graduates who had played varsity football hit a wall-mounted spring-loaded blocking dummy while wearing each of six sets of football pads. The shoulder pads represented the use of both closed-cell foam and open-cell foam (one and three layers) with an air management system. Four experienced subjects used each set of pads to hit a blocking dummy several times. A strain gauge placed on the spring mounting of the blocking dummy provided output proportional to total impact force. Output from each pressure transducer and the strain gauge was acquired and stored in a digital computer while each subject hit the blocking dummy three times while using each set of pads. Also, subjects were given a questionnaire immediately following use of each pad asking them to estimate pressure on each site.

Table 1. Total impact force and peak site pressures for each set of pads*.

	Shoulder Pad #						
Variable	1	2	3	4	5	6	Mean
Site #2	18.6	15.5	8.2	6.2	6.6	10.0	18.8
Site #3	18.8	15.5	17.8	23.4	22.7	18.1	19.4
Site #4	41.5	27.1	38.9	26.0	35.3	34.2	33.8
Site #5	25.3	21.4	22.6	21.6	37.6	19.3	24.6
Site #6	20.0	21.3	12.6	17.6	25.0	21.6	19.7
Site #7	1.7	9.6	3.8	5.8	17.8	1.7	6.7
Site #8	8.6	12.5	5.9	4.9	7.5	2.7	7.0
Total Force*	2750.0	2700.0	2700.0	2690.0	2800.0	2760.0	

*Force units in N, pressure units in N/cm^2

RESULTS AND DISCUSSION

Questionnaire results indicated that, irrespective of the pad used, very little or no pressure was perceived on the sternum, scapula, trapezius, and ribs. In most cases, sites on which most pressure was perceived were the acromion, clavicle, neck, and deltoid. Table 1 provides summary total impact force and peak pressures for each set of pads. Pressures from sites 1, 9, 10, 11, and 12 were negligible and are not included. Means for total subjective pressure estimates (from the questionnaire) and the sums of pressures from all sites are also included. Data for 12 impacts (4 subjects X 3 impacts) are represented in this table. These data generally agreed with questionnaire results regarding sites receiving the greatest and least pressures. The greatest pressures were consistently received on the acromion (#4) and nearby portions of the trapezius (#5) for all subjects, and for all shoulder pads. While there was some variability associated with total impact force, there did not appear to be a pattern related to the shoulder pad used.

Effective shoulder pads should generally spread impact force over as large a period of time as possible. This can be accomplished through the use of thicker elastic padding; however, the thicker padding is likely to adversely affect performance by restricting movement and peripheral vision. High, painful pressures underneath the pads may also be diminished considerably by spreading the pressure over larger bodily areas. Pads should be shaped and contoured so as to allow prominences normal to the direction of impact force (e.g., acromion, trapezius) to absorb much of the impact force, yet prevent very high, injury-producing pressures on these prominences. Manufacturers are attempting to accomplish this feat through the use of open-cell foam and "air management systems" underneath a hard cover. These pads tend to be more effective than pads using closed-cell foam.

CONCLUSIONS

The evaluation of football shoulder pads should include an accurate assessment of pressures underneath the pads during usage approximating field conditions. Results of this study indicate that the superior portions of the shoulder and chest receive relatively large pressures during blocking drills. Specifically, the acromion and nearby portions of the trapezius receive the greatest impact pressures.

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