Mechanics of a Rugby League Scrum

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INTRODUCTION

The original purpose of the scrum in rugby league was as a means of restarting play but this has been lost in the scramble for a competitive edge over one's opponents. Successful scrummaging has become a powerful offensive skill in affording a base for attacking back play and in wearing down the opposition. In addition, scrummaging is used as a defensive manoeuvre where the object is to deny the opposition their chance for clean possession.

The role of the scrum has been identified by Bell and Hooper (1979) as "...the single facet of play which provided most ball to the winning teams." This observation was based on analysis of patterns of play in five rugby union matches. Although no comparable analysis has been reported for rugby league the importance of possession gained through scrums is implicit.

A consequence of this competitiveness has been the adoption of techniques that are contrary to the spirit of the game and in some cases potentially hazardous to players. Specific examples of this include the increased "looseness" in binding to afford the hooker a greater advantage in striking for the ball, and the second row forwards packing with their head and neck against the buttocks of their prop and not "...placing their heads in the space between the hooker and front row forwards." (RFL International Laws of the Game, 1984, p. 29). Other ploys expose players to the mechanisms responsible for serious cervical spinal injury and include charging together of the front rows at engagement and collapsing the scrum either through a deliberate act or from one prop bearing down on his opposite.

The scrummage technique considered most effective is equivocal and almost exclusively based on anecdotal evidence. This knowledge, based on hundreds of hours of practice and refinement can be considered as valuable as that obtained from the most controlled of systematic investigations. What is needed however, is the understanding or reasoning behind the recommendation of adoption of a given technique or why a particular action is more favourable.

The purpose of this paper is to examine the forces transmitted by front row players in a rugby league scrurn and to determine the most efficient scrummaging technique. Parallel aims were to make recommendations on injury prevention and to provide a systematic basis for possible modifications in scrummaging laws.

An examination of forces in scrummaging has been undertaken for rugby union (Cohen and Siff, 1979; Hodge, 1983; Milburn, 1988, 1989; Stubbs, 1985; and Sumner, 1980) and some of these data can be related to the rugby union scrurn. Hodge reported a reduction in rugby union scrurn numbers to five produced a total forward force of 679.9 kg (6670 N). Cohen and Siff measured the forward force exerted by the front rowonly. The maximum static force exerted was 2500 N. From this figure they conservatively estimated the static force exerted by the whole scrurn to be 7000 N. In comparison, Stubbs reported the combined force exerted by the whole scrum totalled 900 lbs (4000 N.). The front row and second row units provided 650 lbs (2893 N, with 400 lbs (1780 N) provided by the front row only.

All force data presented above have been limited to the forward direction without reference to vertical or shear forces experienced by the front row players. It is considered the vertical and lateral shear forces to be of importance in the degeneration of discs, vertebrae, ligaments, and joints (Scher, 1983). The repeated stress which the cervical spine is subjected to, particularly among front row players, has been identified by Scher as a causative mechanism in the premature development of degenerative changes in the cervical spine.

The vertical and lateral shear forces acting on front row forwards in two rugby union scrurns were examined under different scrummaging formations (Milburn, 1989) and binding techniques (Milburn, 1988). Increased lateral shear forces were indicative of lack of tightness in the binding. Also, greater maturity and experience of the players examined enabled them to transmit force and maintain the integrity of the scrurn. Vertical forces tending to collapse the scrum were observed at engagement, illustrating the need for care to be taken in "setting" the front row and "sighting" the opposition before the scrurns engage.

PROCEDURES

A First Grade team from the New South Wales Rugby League was examined scrummaging against an instrumented scrum machine. Data on body alignment and body motion were obtained from high speed 16 mm film taken from an overhead perspective using a Bolex model H16 camera operating at 48 frames per second, and from a left-hand side perspective using a Locam model 5001 camera operating at 100 frames per second. Alignment of body segments were obtained directly from the projected image.

Data on the forces exerted were obtained using a Kistler model 9281B force platform incorporated into an extended scrum machine. The scrurn machine was constructed of 32 mm x 32 mm RHS steel and mounted on a reinforced concrete retaining wall. Players pushed against 200 mm x 30 mm x 750mm hardwood pads covered with high density foam for cushioning.

Kinetic data represented the three orthogonal components of force (forward, lateral shear and vertical) recorded by the front row player located over the instrumented section of the scrurn machine. The test section of the scrurn machine was mounted directly onto the force platform and was structurally independent of the remaining scrurn machine. A convention was adopted to allow interpretation of the forces transmitted by each front row forward. The three components of force were lateral shear force (X-force), of which the force directed to the left was considered positive (Figure 1), vertical shear force (Y-force), of which upward was considered positive, and horizontal force (Z-force), of which forward was considered positive.

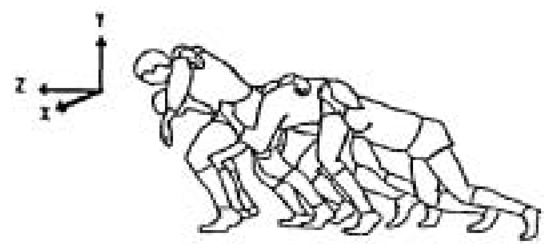

Figure 1: Convention adopted for direction of forces applied to scrum machine

By systematically moving the front row along the scrum machine with each trial, data on each front row player could be obtained under each test condition. Data were obtained under the following scrummaging combinations: front row only, front row plus second row, and full scrum.

Data presented in this investigation will compare forces recorded on each front row player and the contribution to the total scrum by individual units within the scrum. The three components of force at engagement will be presented along with a representative force (sustained force) derived from the average of forces during the time interval from one second until three seconds after engagement. This time interval was selected as it was considered the ball would normally be fed into the scrum within this period.

Total forward (Z) force was determined by summing the forces experienced by each front row forward. In addition, a resultant value of lateral (X) and vertical (Y) shear forces was determined by summing the force vectors across the front row forwards. Data were represented from impact until either the players terminated the scrurn or the time limit for recording (Five seconds) was exceeded.

LIMITATIONS

The absence of opposing players to provide motion, additional binding opportunities and forces opposing the player's motion were recognised as limitations in this study. Also, the orientation of the scrum machine did not allow for individual differences in body alignment, particularly in the lateral and forward directions. Data obtained were limited to only one set of forwards using binding techniques commonly used at the time of the study.

RESULTS AND DISCUSSION

Kinematics

The lack of symmetry in the scrurn during its formation and pushing did not resemble the formation advocated in the Skills Manual (Corcoran, 1979). Alignments of the trunk for both props was noticeably outwards; the tight head prop directed to the right whereas the loose head was directed to the left. The loose head second row was similarly aligned to the left. Movement from the "set" position to engagement was achieved with a forward and upward movement, with the hips of both props moving inwards on the second row "...discomforting his second row forward by squeezing the second rower's head with his hip." (Corcoran, 1979). Vertical motion consisted of the hips of the second row and lock being raised higher than the shoulders. The loose head prop compressed his position by lowering his hips (a move that most likely exacerbated the downward rotation of the second row forward).

When applying force against the scrum machine, motion was characterised by compression, particularly in the front row and by a shift towards the tight head (right) side. This compression was achieved almost exclusively by the "rounding" of the props' back and a lowering of the hooker towards the incoming ball.

The extreme flexion of the loose head second row forward's neck, in conjunction with lateral deviation and rotation under the buttocks of the prop was apparent in Figure 1. It is this combination of flexion and rotation that has been identified as the mechanism for cervical spinal injury in football player (Yeo, 1983).

Kinetics

Typical force-time histories (Figure 2) of each scrum showed a large engagement force on contacting the scrurn machine and in stopping the players' motion. This peak was followed by a considerable drop during the first second of the scrum. It is likely this drop in force was due to the observed "compression" and realignment of the scrum following engagement. Within the first second of the scrum being formed, the motion of players and the forces exerted became stabilised and a representative value of applied force could be obtained from the succeeding data.

The components of force recorded on each front row player are presented in Table 1. In an attempt to isolate the contribution of scrum sub units to the total scrum, each sub unit (front row only, front row plus second row, and full scrum) was tested separately. An estimation of subunit contribution could be made by subtracting the total forward force on all three front row players from the total for the complete scrum.

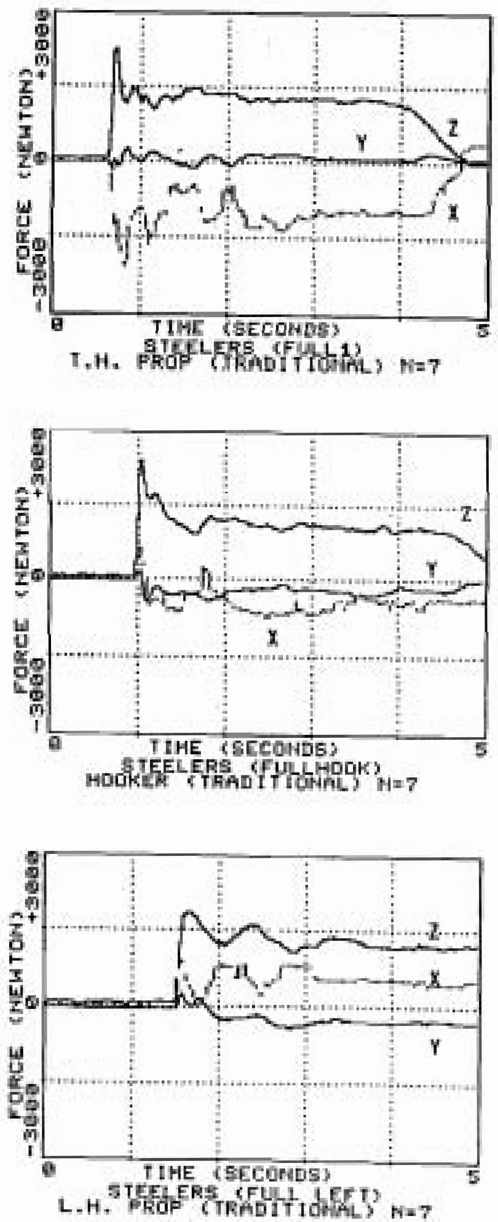

Figure 2: Forces recorded in a full rugby league scrum

TABLE 1. Scrum sub-unit contributions to forces experienced in a rugby league scrum.(N).

	Engagement			Sustained		
	X	Y	Z	X	Y	Z
Front row only						
Tight head	644	-464	2345	236	-93	533
Hooker	-196	382	1601	291	-96	624
Loose head	224	235	1375	178	-20	736
Total	- 672	153	5411	705	-209	1893
Full row plus second row						
Tight head	-1405	-195	1757	-1094	-103	1196
Hooker	-621	254	1648	-607	-122	1504
Loose head	919	-70	2054	-565	-144	1430
Total	-1107	-11	5459	-2266	-369	4130
Full Scrum						
Tight head	-2089	268	2250	-833	-286	1200
Hooker	1216	-454	2410	-451	-226	1102
Loose head	1151	0	1897	573	-282	1327
Total	278	-186	6557	-711	-794	3742

The full scrum utilising their usual binding and scrummaging technique produced a total Z (forward) force of 6557 N at engagement. This force represents approximately two-thirds of a tonne (6700 N), with the tight head prop (1897 N). When packing against an opposing scrurn, these engagement forces would most likely be substantially greater due to the increased speed of engagement of the two front rows coming together.

These data are less than the peak forward force reported by Hodge (1983) for a rugby union scrurn. They are consistent with the hypothetical maximum of 7523 N reported by Sumner (1980) determined by geometrically summing the forces exerted by a single front row player. Loads carried by a six-player (full scrum less side row forwards) rugby union scrum of 6611 N at engagement (Milburn, 1989) were similar to those recorded for the full rugby league scrurn. The combined effect of two opposing forward packs on engagement would therefore be close to the estimated load of "one and a half tons" (14955 N) of force often reported as the loads placed on the front row players (Burry, 1979; Schner, 1977).

The forces recorded at engagement represented an impulsive force that would be larger to halt the motion of scrum with a larger mass, or if there was a large change in speed over a short period of time, as would occur on impacting the rigid scrum machine. The force recorded at engagement was therefore as much indicative of the speed at which the scrum contacted the scrum machine as it was of the ability of the scrum to apply forward force through coordinated muscular action. Interpretation of these kinetic data should take into account whether the scrum came together fast, or whether the front row was set already in the scrum machine. The sustained force (average value for a pushing scrum) would be more representative of the players' ability to exert force.

Also implicated as an injury mechanism are the shear forces acting on the front row players. The X (lateral shear) force on the tight head prop was -2089 N, which represents a substantial right-directed force consistent with the player's observed alignment and motion. Alignment of the trunk for the tight head prop was noticeable towards the right, whereas for the loose head prop it was to the left. The loose head second row player was similarly aligned to the left, with the remaining players perpendicular to the scrum. Consistent forces recorded for the hooker (1216 N) and the loose head prop (1151 N).

Vertical force at impact was directed downwards on the tight head prop (-268 N), upwards on the hooker (454 N) and negligible on the loose head prop. These forces were consistent with the role of the props outlined in the Skills Manual (Corcoran, 1979); namely the tight head prop "getting low" to reduce the opposition hooker's view of the incoming ball and the loose head direction his force upwards to enhance his hooker's view of the ball.

Average forces transmitted during the sustained scrum (from one until three seconds after engagement) showed fluctuations consistent with the undulations in body alignment. The magnitude of forces recorded were considerably less after engagement; for example, the total forward force was almost halved to 4742 N. Both the magnitude and direction of the lateral forces on the hooker changed. After engagement the hooker experienced a right-directed force (-459 N) which was not consistent with the recommended technique of aligning his body "...as close as possible to the point of entry of the ball into the scrum." (Skills Manual, p. 72). The vertical force on all players was slight (less than 300 N) and directed downwards, possibly reflecting the downward motion due to the compression and rounding of the props' backs.

Contribution of Scrum Units

In an attempt to isolate the contribution of each scrum unit, each unit was tested separately and the forces recorded are presented in Table 1. An estimate of each unit's contribution could be made by subtracting the sub-unit forces from the data for the full scrum.

As stated previously, the forward force at engagement was as much indicative of the speed of engagement as it was of size or muscular strength. The present results indicate the need for correct body alignment and strength to maintain body position while engaging the front rows. Forces on the tight head prop in the three-person scrum at engagement (2345 N) were larger than for the full scrum (2250 N). These large engagement forces were unnecessary and could be substantially reduced with the adoption of proper coaching techniques (for example, "sighting" the opposing front row before engaging) and firm refereeing decisions to avoid front rows charging together.

Comparison of average sustained forces indicated that the second row contributed more than half of the total forward force (2237 N) to the total scrum unit. In comparing the full scrum with the front row plus second row situation, it appeared the lock did not contribute significantly to the total forward force. This result is consistent with that obtained for the rugby union scrum (Milburn, 1989). The front row also appeared to contribute substantially to the forward force in the scrum. However, props have multiple roles in the full scrum of applying force as well as transmitting force from the second row and lock, while still maintaining the integrity of the scrum. An examination of body position of the loose head prop in the full scrum and front row only conditions confirmed a more inclined body position which would suggest these roles.

One force value that showed substantial differences between the three scrum units was the resultant value of average shear force (Table 1). During the sustained scrum, the inclusion of the second row unit decreased the scrum's stability (as represented by the sustained lateral shear force), adding to the forces carried by the hooker. Although the lock forward did not add to the average total forward force, his inclusion reduced the lateral shear force on the hooker and equalise the load distribution across both props.

The addition of more forwards to the scrum served generally to increase the magnitude of the sustained vertical shear forces. Unlike the rugby union scrum (Milburn, 1988, 1989), these forces were slight (less than 300 N) and were equally distributed across the front row.

CONCLUSIONS

Results of this investigation into the loads experienced by front row forwards in a rugby league scrum have implications for rule modification, interpretation and coaching. These are as follows:

The rugby league scrummaging technique as currently adopted by a New South Wales Rugby League first grade team differed substantially from that outlined in the skills manual and also from that defined in the International Laws of the Game. This technique was considered dangerous because of the potentially hazardous practice of the loose head second row forward binding under the buttocks of the prop with his neck flexed and rotated. This combination has been identified as the major mechanism for serious cervical spinal injury in the event of a scrum collapsing.

The impulsive engagement force experienced when the scrurn engaged the scrum machine was considerable greater than the forward force the scrum was capable of sustaining. The magnitude of this force was related directly to the mass of the scrum and the speed at engagement. This indicates the need for correct alignment and strength to maintain body position while the two front rows come together. All players should be made aware of the dangers of submitting to vertex impact injuries on forming a scrum. The deliberate clashing of heads constitutes as special danger in this respect. (Scher, 1983).

The loads experienced at engagement under some conditions exceeded the thresholds for injury to the cervical spine (2000 N in flexion, 562 N in extension); Mertz and Patrick, 1971 and between 750 and 1000 lbs. (1653 and 2204 N) for direct compressive loading; Bernstein, et al (1982). However, these data do not account for the additional contribution to the forces experienced at engagement from the speed of approach of the opposing scrum.

The lateral shear forces recorded were considerable. Informal discussion with retired rugby league hookers has indicated a reduction in mobility in the neck region, and although unsubstantiated by a retrospective survey or radiological data, this could be attributed to contemporary binding techniques. Results from rugby union scrums showed the higher binding reduced lateral shear forces (Milburn, 1989) and indicates need to "tighten" binding in rugby league scrurn.

The primary role of the second row forwards was to apply forward force. The second row contributed more than half the total forward force in the full scrurn. Instability was increased by their inclusion. The lock forward did not contribute any substantial additional forward force but acted to stabilise the scrum once it was formed.

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