Total Impact Method: A Variation on Engagement Technique in the Rugby Scrum

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Introduction

The rugby scrum is a formalised technique used to begin play after a minor infringement. The two forward packs meet, the ball is placed between the two front rows, and 'hooked' for distribution by the halfback. While this appears to be a simple technique for restarting the game it has become a major platform of both attack and defence and in the modern game involves a number of techniques used to gain an advantage - for both teams.

Figure 1 - 'crouch and hold '

While there has been considerable discussion (Milburn, 1997: Quarrie, 2001: Scher, 1982) regarding the frequency of and potential for cervical injury, and the development of laws to reduce those injuries, the two packs prepare for contact with every intention of meeting the other team with maximal impact forces. The command 'crouch and hold' (see fig 1) provides a stationary position of both packs prior to contact, with the intention of reducing speed, and corresponding impact forces at engagement. The pack sets up square (or with the tighthead prop slightly forward to negate screwing of the scrum) to the other team, and 'holds' until the referee calls 'engage', at which stage the two come together very quickly. Despite the best intentions of the "Laws of the Game", each pack drives forward with the intention of beating the other across the designated centre line of the scrum, and applying maximum impact forces on the opposition. The advantage of meeting the opposition on their side of the centre line may be gained by anticipating the referee's call, or moving faster than the opposition.

Accurate anticipation is difficult, and may cost a penalty. The Total Impact Method (T.I.M.) utilises basic principles of biomechanics to drive the pack into engagement more quickly and forcefully than the opposition, and so gains that advantage legally, and with a number of further benefits.

Before discussing the detailed techniques of T.I.M. however, it is necessary to revisit the biomechanical principles involved in scrummaging.

Speed/Force Application

The magnitude of force applied by one pack upon the other is proportional to the mass of the pack, and the rate of change of velocity (acceleration) at impact. In this case the assumption is made that both packs are of similar mass and that both have similarly efficient binding techniques. The principle of conservation of momentum ensures that the pack that is moving faster at impact will apply a greater force, and that pack will tend to maintain its position rather than being moved back.

Direction of Force

The direction in which each player applies forces is determined by the body posture of the player in relation to the point of application (Bartlett, 1999) and in relation to others. (Quarrie & Wilson, 2000). Body position is influenced by the placement of the feet, and the efficiency of the binding techniques. For the purposes of this discussion it is assumed that binding techniques are satisfactory.

Body Posture: The importance of vertebral column alignment in the transfer of force from one player to another is well recognised. The phrase "spine in line" (ACC Rugby Smart, 2001) is commonly used to describe the optimum body position of players; shoulders and hips at the same height, and head up to transmit forces through the shoulders at an angle as nearly horizontal as possible. An essential component of body posture too must be the angles at the hip, knee and ankle joints, both prior to and during force application. This is a significant factor in force application technique and will be dealt with in greater detail in the section on torque-angle relationships.

Foot Position: Track and field athletes, and some international swimmers, choose to apply forces at the start of their races from an offset foot position, with one foot in front of the other. While it is obvious that a single leg extension will not generate as much force as two legs doing the same job, there is ample evidence (Enoka, 1994) that the extension torque developed in a single leg vertical jump is greater than the expected 50% of a two legged extension. In theory then in our scrum there is an advantage in applying forces through one foot, immediately followed by the other. Certainly from the impulse momentum point of view the application of force added to the already moving body will increase the total time of force application, resulting in a greater change in momentum.

Foot placement however is personal; players may be more comfortable with offset feet or with feet parallel. It also depends on the particular objective for that scrum, whether the team is trying to defend an attack or wheel/screw the scrum to create an advantage. Martin Toomey (personal communication, 2001), fitness advisor to the All Blacks 1997-1999 says, "In general it is recognised that having the feet offset allows greater variation when it comes to creating options as it is difficult to react going backwards with your feet together. Coaching generally centres around being offset to absorb the impact and then taking small steps (in unison) to try and promote your scrum".

The greatest force however can be applied with both legs driving in unison, and in a well-bound scrum, with good coordination, the greatest combined force will be applied with all players utilising optimal leg forces. At the setting of the scrum, and in resisting forces, the foot placement from which maximum forces may be applied might make the difference between moving the opposition and not moving them. After that first impulse the scrum is almost always in a fluid situation with the ability to be able to shift feet to alter the direction of, and absorb impact forces, paramount. However, at the 'set ', in order to drive forward with maximum force, feet should be close to parallel, at shoulder width, and turned out slightly to afford a better grip. (see fig 2)

Figure 2 - feet position in preparation for 'engage'

Force Production

The magnitude of the force produced by each player in the pack is determined by the characteristics of the task itself (Zatsiorsky, 1995). Good coaches and trainers will have practices and drills that very closely resemble the required specific scrum activity. The ability of the player to generate maximum forces in the scrum will be a product not only of their general conditioning and strength programmes, but of individual anthropometry (Quarrie & Wilson, 2000) and a specific power development programme designed around the constraints of the scrum. Our discussion of T.I.M. centres about the mechanical factors that may influence force production.

Length Tension Relationship: There is a relationship between the length of a muscle and the force it can produce. The length of single joint muscle is related to the joint angle, with a muscle at its shortest when the joint is fully flexed and longest when the joint is fully extended. Tension within the muscle is at maximum with the muscle at mid-length (Bartlett, 1999) and active tension is reduced when the muscle is both shortened and lengthened. The relationship is such that for muscles that cross a single joint the maximum force is produced near the middle of the range of motion, with lesser forces produced when the muscle is lengthened or shortened (Zatsiorsky, 1995). The implication for force production is that it is difficult to generate large forces with these single joint prime movers, either on your body or an external object, when the joints are nearing full flexion, or full extension. In our rugby scrum situation the angles at knee and ankle, and especially the hip, become an important factor when the application of maximum forces is required.

Force Velocity Relationship: An important aspect of muscle mechanics relates to the speed with which muscle shortens while active. We refer to the three general phases of muscle activity as:

Isometric	The muscle length does not change
Concentric	The muscle shortens
Eccentric	The muscle is trying to shorten ,but is being forced to lengthen. Eccentric muscle activity is common - it occurs whenever we stop a back swing prior to throwing a ball, when we walk down stairs or in general, whenever we decelerate a body segment.

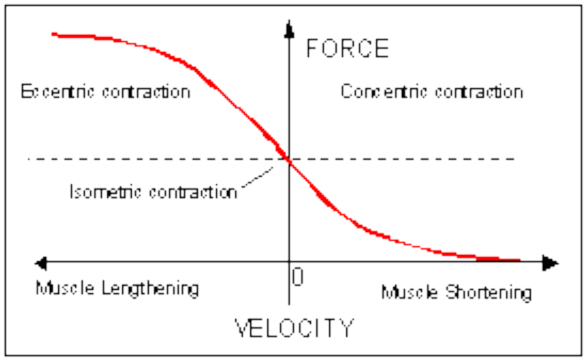

Figure 3 .-..force-velocity relationship

A muscle can produce a certain amount of force in an isometric situation. If this muscle then acts concentrically - shortens - the maximum force it can produce depends on the speed at which it shortens. The faster it is required to shorten the less force it will develop. The opposite is true for eccentric muscle action. The faster a muscle is stretched while attempting to shorten, the larger the forces it can produce. This relationship is referred to as the force-velocity relationship of muscle and in practice this means that large forces are not generated when our muscles are shortening at high speeds. (see fig 3) It is possible, however, to use this relationship to our advantage within T.I.M. by utilising the eccentric work characteristic. (see Stretch-Shorten Cycle)

Torque-Angle Relationship/Mechanical Advantage: The most efficient angle of the joint for the generation of torque varies according to the anatomical structure of the joint and the point of attachment of the muscles that move that joint. While individual muscles across a joint may have differing structure and points of attachment (Enoka 1994), and peak muscle force may not always occur at peak moment arm (Lieber, 1992), it is safe to say that generally muscle fibres are at an intermediate length when the joint is approximately mid range. The joint moment arm is usually maximised at mid range also. Research in both laboratory and rugby environments (Mills & Robinson, 2000) indicate that maximum forces may be generated through a mid range of the joint.

It is expected that maximum extensor torque at the hip joint might be generated through a range 130o to 160o. (Enoka, 1994, Zatsiorsky, 1995). It is interesting to note that Rodano and Pedotti (1987) report hip angles as acute as 110o amongst athletes in a scrum. Our flanker in Figure 4 demonstrates an angle of 107o. (In reality he is just about to shift that foot forward.) Quarrie & Wilson (2000) report that none of the body position variables correlate highly with individual scrum strength.

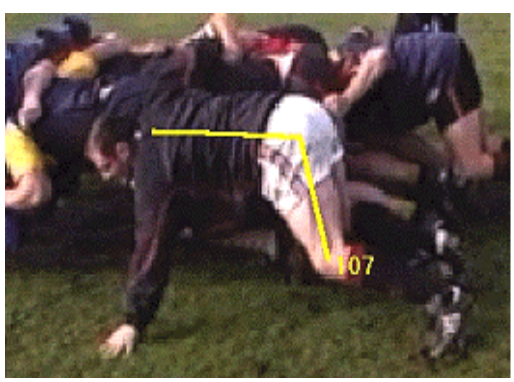

Figure 4 .-. hip angle

The development of maximum knee extension torque occurs through a range 114o-157o (Eloranta & Komi 1980; Enoka, 1994: Zatsiorsky, 1995) and this range is supported by Mills and Robinson (2000) who in a rugby specific environment report an optimum knee angle of 120o. (Our prop in Figure 5 demonstrates 110o, with a strong vertical surface to the lock to push against, and perhaps in preparation for some movement forward against a live scrum.) In the scrum the ankle joint will only plantar flex through about 10o (Rodano & Pedotti, 1987), with maximal force application at 103o (Rodano & Tosoni, 1992).

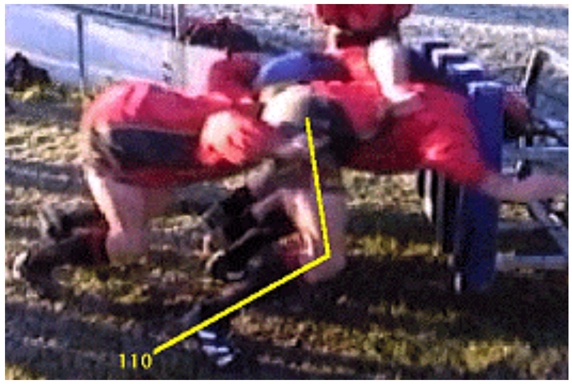

Figure 5 .-. knee angle

The optimal direction of force application in the rugby scrum may vary with the requirements of the specific situation but in simply applying force to the opposition, Rodano and Tosoni (1992) suggest there is some evidence that in both applying an impulsive force, and maintaining force application, that an angle of 120o is appropriate. In teaching T.I.M. we have found that, despite the research, in practice our players tend to adopt a position similar to the back three in Figure 6. They have settled for something nearer 135o for the lock, and the No.8 145o.

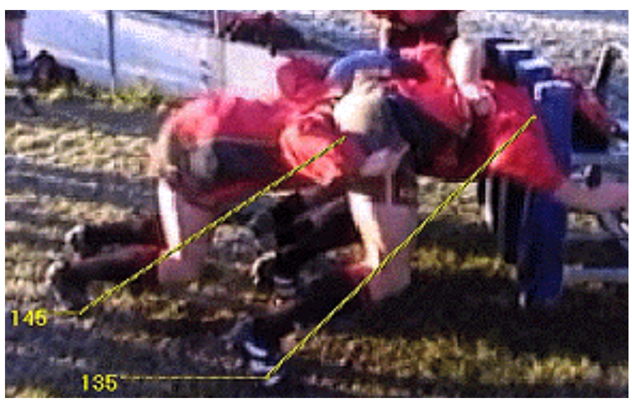

Figure 6 .-. direction of force/impulse angles

In summary, we can say that while there is research evidence (Rodano & Pedotti, 1987; Mills & Robinson, 2000) to support the adoption of specific joint angles in the scrum, there is also a contradictory view (Quarrie & Wilson, 2000) that suggests that there is a range of joint angles at each of the joints in the leg through which maximal torque may be generated. These angles are determined by the implications of the torque-angle and length-tension relationships within muscle, as well as individual preference and the requirements of the specific activity.

Bi-articular Muscles: Single joint muscles may be regarded as the prime movers of the body. They cross a single joint and contraction of the muscle fibres causes rotation at the joint. However, muscles that pass over two joints, the "bi-articular" muscles, are just as important as they support an energy transfer system that in the scrum facilitates the application of force at the ground delivered from the very powerful single joint extensors of the hip, knee and ankle.

For all athletes the important bi-articular muscles that support leg extension are rectus femorus in the quadriceps, biceps femoris in the hamstrings, and gastrocnemius in the plantar flexors. When the rugby player applies maximum forces in the scrum, the major activity is leg extension. In crossing two joints, the origins of each of the three bi-articular muscles move in the same direction and at the same time as the insertion of the muscle, keeping the muscle fibres in an almost isometric contraction. This principle of transmissibility in leg extension transfers work from the single joint hip extensors - gluteus maximus - all the way through the system to the ground reaction forces at the ball of the foot.

There is a history of many hundreds of years of research (Galen, 1131-201 A.D; Fischer, 1927; Lombard, 1903) into the role of the bi-articular muscles in leg extension, some of it with particular reference to the changing direction of the forces (Andrews, 1987; Ingen Schenau 1989b). In the scrum situation, with the player in a spine horizontal position and hip, knee and ankle at an optimum angle, the reaction force will pass close to the knee, with a small moment arm (see fig 6) and in front of the hip with a considerably larger moment arm. This configuration requires activation of the single joint (mono-articular) muscles at hip and ankle, (gluteus maximus and soleus, and to a lesser extent, vastus at the knee), combined with a strong activation of the bi-articular hamstrings. The implication for the player in the scrum is that while general maximal strength and rate of force development is an essential part of their preparation, special interest should be taken in the strength characteristics of the hamstring group to maximise the contribution of the bi-articular system.

The Nervous System: While the central nervous system is of paramount importance in force production (Zatsiorsky, 1995), there is no evidence that motor unit activity may be influenced by anything other than specific training, and on occasions, psychological factors.

Rate of Force Development

It takes time to develop maximal force in a muscle. While the precise time might vary from person to person, on average, time to peak force will be in excess of 0.4 sec. (Zatsiorsky, 1995). In athletic activity in which speed is of importance, there is often less time than that available and so there is a trade off between the two. In the rugby scrum, while there is often little need for high speed, there will certainly be an advantage gained if peak force can be reached earlier at engagement. There are two avenues by which we might improve force production at speed. The first is based upon traditional specific power training methods (Zatsiorsky, 1995), which in this case would see athletes train with scrum specific resistance, in scrum posture, and at maximum velocities. The second avenue is use of the Stretch-Shorten Cycle. (see the following section)

Balance

Traditionally the scrum sets with the front row resisting the force of the locks as they get into position. To resist this passive force, props will, in most cases, place the outside foot forward and 'sit back' against the shoulders of the locks. Regardless of the position of the remainder of the scrum, upon 'engage' the front row must first change the point of balance - usually by shifting the forward foot back - then attend to the drive forward into the opposition. The T.I.M. position changes that balance, reducing the time taken to begin forward motion, and increasing the speed at which the pack moves toward the opposition.

Figure 7 .-. balancing prop using TIM.

Stretch-Shorten Cycle

The stretch-shorten cycle (SSC) describes a period in which a muscle undergoes eccentric work, is stretched, contracts isometrically to stop the counter movement, and follows immediately with maximal contraction with the intention of applying a maximal force. The cycle utilises the principles of stretch reflex, of the length-tension relationship of muscle, storage of elastic energy in the muscle-tendon complex, enhanced potentiation of muscle, and chemical energy from the preload effect. Jumpers and gymnasts utilise this concept to enhance jumping height and it is typified by the stretch involved in the ballistic back swing or pre-stretch in throwing or racquet games. Research into this phenomenon using vertical jumping as the vehicle (Komi, et al 1997: van Ingen Schenau, G.J., Bobbert, M.F., de Haan, 1997; Winter, 1997;) has indicated that while there is some disagreement on the actual processes involved, there is increased activation of muscle. If the major contraction involved takes place within 0.2 secs of the stretch onset, then the combination of all these factors will result in a higher jump, determined by the velocity at take-off. The same principal applies in all sporting situations. Increased activation of the muscle fibres by use of the principles of pre-stretch result in an increase in maximal force production. Specifically, and importantly for our scrum scenario, force enhancement occurs in dynamic concentric contractions after stretch, the force-velocity relationship shifts toward increasing forces at any given velocity (Bartlett 1999). If the time available for this stretch/shorten action is less than 0.3sec the rate of force development rather than maximal strength is the deciding factor (Zatsiorsky 1995).

While the stretch-shorten cycle helps deliver a greater maximal force and increases the rate of force development, there remains the problem of time. It seems we may choose between immediate contraction of muscle delivering less force, or utilisation of the SSC delivering greater force but with a time delay of up to 0.2sec. In the T.I.M. technique described below there is no deliberate attempt by players to consciously utilise the SSC. Rather, the set position by its very construction and the order of force application places players in a position where there will, in almost every case be a SSC effect.

The Total Impact Method (T.I.M.)

In terms of force application, at the setting of many scrums the Number 8 and the flankers have been passengers, with head up looking for any last minute changes by the opposition, and not applying any great force at all in the first instance. In the T.I.M. technique the Number 8 forward drives it and the major change the coach must make is to convince the Number 8 to take responsibility for the drive at engagement. The initial push must be immediate and maximal. In presenting T.I.M. for use by coaches the assumption is made that players are well versed and prepared in the techniques of reactive force production, the adoption of body positions conducive to maximal force production, and binding techniques adequate to support the activity.

Setting the Scrum

The front row sets in a balanced position bent forward together with spine in line, head up and slightly higher the hips. Feet are nearly square/parallel, slightly splayed, and wide enough for a solid base. Weight is on the balls of feet, and the player is almost falling forward. (see fig 7) The front row is held in position by the locks; they would fall forward if released.

Locks take their position in the pack with feet in position as for the props, slightly off-set, and slightly splayed. (see fig 2) From a crouched position, the head is placed between prop and hooker at hip level, without pushing. The lock binds with outside arm between the legs of the prop, and onto the shorts across his inside leg with elbow at approx 900. The inside arm binds across the back of the companion lock. The locks raise their backside until the back is horizontal and balance is such that the two are pushing back against the shoulders of the Number 8. The lock pulls the prop lightly into his shoulder, treating his backside as if it were eggshell !!

The Number 8 sets with head between the hips of the locks, feet offset as a sprinter in the blocks, and leaning into and applying some force to the locks. (see fig 6). The Number 8 binds around the hips rather than between the legs.

The flankers bind onto the lock between the shoulder blades, crouched with feet offset, and shoulder nestled against the buttocks of the appropriate prop. The outside foot is forward of the inside foot.

Engagement

Upon the command 'engage,' the Number 8 drives forward with both legs as does a track sprinter, with extension of the rear leg preceding the front leg momentarily. This rapid 1-2 action delivers a forward impulse against the buttocks of the locks, pushing them forward against the front row and initiating the Stretch-Shorten Cycle in their leg extensors. Simultaneously, the two flankers do the same, applying a force against the props. The greater this impulse from the Number 8 the greater will be the SSC effect, with accompanying increase in rate of force production.

The two locks in response to the forward force applied by the Number 8 are pushed forward and with a coordinated rapid extension of the legs provide a propulsive force into the already moving front row, adding to the momentum initiated by the flankers. If they choose to set with one foot slightly forward that foot will advance to with the forward movement. All players, but especially the locks must be practised in the techniques of reactive strength and respond immediately to the push from behind. The rate of force development in their extensors is increased by the pre-stretch or loading effect of the preparatory position, and their drive forward complements the forward motion of the continuing impulse from the Number 8.

The front row players, being in a slightly forward, off-balance position, respond immediately to the push from the flankers and with body in optimum position drive forward, as the force from the locks is added to the impulse.

Note: It is essential during this force application phase that all players must be aware of the effect of pushing too low on the buttocks of the player in front. Force applied far from the joint will cause the hip to flex which is contrary to the required extension.


Figure 8 .-. No 8 & flanker about to 'engage'

Contact

The impulse has begun with the Number 8 and as that first force is applied, the player has brought the back foot forward to place it square with the front foot. At contact of the two packs all players have both feet on the ground and in position to provide maximal forces through optimum joint angles. The pack has moved quickly, and players are in position to maintain that force application, and resist forces applied by the opposition.

Safety

The greatest fear of every rugby player, coach, administrator and parent is that of a player suffering a life threatening spinal injury. A player has a greater chance of suffering such an injury when diving in the recreational swimming pool or driving to practice (Dedrick, 1985) than when playing. However severe spinal injuries do occur in rugby amongst all players, and safety must be one of our considerations.

Coaches and players are competitive and quite consciously seek any available advantage at scrum time. This advantage is not always in the spirit of the game, and as demonstrated by the number of penalties, not always within the laws of the game either. Unfortunately, the traditional head to head construction of the scrum itself provides a fertile field for prospective neck injury, while also providing an opportunity for dominance. The desire to dominate and the chance of injury, do not sit well together. Perhaps the most effective illustration of this conflict can be found in three quotes below.

Peter Milburn (1993) says, "A majority of injuries are found to occur at engagement where the forces experienced by front-row playersÉ.can exceed the structural limits of the cervical spine. These forces are a consequence of the speed of engagement, and the weight (and number) of players involved in the scrum."

Ken Quarrie, Injury Prevention Manager of the NZRU,(2001) says, "Players at higher grades may be at relatively higher risk of injury because of the increased size and power of players and the greater aggression with which the game is played."

On the other hand, Graham Henry, coach of the 2001 British and Irish Lions to Australia, said, "The scrum has become passive in the last two or three years and I don't think it's good for the game. It's becoming a non-playing part of the game and it's important we get it sorted before the test series." And, as reported in the popular press, "It's important that the scrum maintains the identity it has had over a long history and it doesn't become a part of the game which is a non entity and embarrassing."

The conflicting points of view demonstrate that coaches and administrators of the game feel that:

- it is important to do everything in our power to restrict the opportunity for cervical spine injuries in the rugby scrum
- any advantage gained is worth the risk.

The discussion that follows addresses those conflicting points of view.

Benefits

Without any doubt the, major attraction of T.I.M. is the advantage gained in getting to the centre line faster than the opposition, with the accompanying increased forces. However, the changed stance of players prior to engagement has also provided some benefits that may well have increased player safety. Coaches and players in teams using T.I.M. report a number of benefits:

1. Increased scrum forces at impact. During the development of T.I.M. amongst various teams within the Canterbury (NZ) region, tests were conducted on an instrumented scrum machine with a professional pack, and a school 1st XV. In both cases, forces applied at impact were significantly greater after T.I.M had been learned than before. In addition, coaches and players reported increased impact forces, with the ensuing advantage of dominance prior to ball entry.
2. Increased ability to beat the opponent to the line. There is agreement amongst coaches and players that a significant aspect of T.I.M. has been the ability to beat the opponent to the centre line.
3. A more comfortable front row prior to engagement, with the props set without having one foot forward to resist the pushing locks. Using T.I.M., the locks, rather than pushing forward, are pulling the front row back, which takes any pressure off those players and allows them to get well set in a balanced stance with head up and spine in line. At this stage, with no forward forces to be resisted, the front row may easily adjust hip height and prepare themselves for contact with minimal vertical/shear forces. In that 'pulled back' position, the heads of opposing forwards are slightly further away from each other, reducing the risk of a head clash. (see #7)
4. At engagement all feet are on the ground and able to apply/resist maximum forces. In practice, the Number 8 utilises a sequential movement with the back foot coming forward to be placed parallel the other at contact. Locks in some packs have preferred a similar configuration, but the final position at impact has been characterised by an increased ability to maintain forces application. The position has become known as 16 feet.
5. Scrum Unity. Front row players report that using T.I.M. there is a greater unity of the pack at contact. With the pack being driven from the back there is a bodily contact between players as they drive forward. Upon contact the complete mass of the pack is involved in the first contact, making better use of the total pack weight. Using previous systems with the front row leading the movement toward engagement, the front row makes contact first, followed a moment later by the locks coming

in from behind.

6. Scrum Binding. Using previous methods, it was essential that as the scrum set players were tightly bound before engagement. With T.I.M., players reported that they may set without the need for very tight binding. At the command 'engage', the pack moves forward, driven from number 8, and players activate their tight binding techniques as they move forward.
7. Time available for force development. In retrospect, reduced time was always a possibility. With any primary technique change, there must be other changes made as a consequence. With T.I.M., the changed posture of the front row has resulted in a noted decrease in the separation of the two front rows at 'crouch and hold'. As the technique developed it was noticed that front row players were setting up slightly closer to the scrum machine. With two packs using the method, the two front rows have tended to 'set' closer together than traditionally. This reduced distance of course has the effect of reducing time to contact and may in fact reduce impact forces. Of course, if impact forces are in fact reduced, then there may well be a decreased risk of cervical trauma at impact.

Conclusion

While the method was developed originally to obtain an advantage in getting over the centre line of the scrum, there have been benefits in terms of player control and comfort, with the possibility of increased protection from traumatic neck injury at engagement. Coaches and players are enthusiastic in their praise for T.I.M. Players are more comfortable in setting the scrum; there is a greater speed at engagement, and an increased unity of the pack at impact. Binding techniques have changed in response to the changed sequence of forces. The scrum itself seems better able to maintain a forceful position after impact, and the role of the Number 8 player has changed considerably. These benefits of course are anecdotal and based on player/coach opinions. We look forward with anticipation to further research and the practical test of national team success.

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