EFFECT OF FOOT POSITION ON THE COMPRESSION AND LATERAL FORCE PRODUCTION OF A PLAYER IN A RUGBY SCRUM

Helen Bayne[1,2] and Cor-Jacques Kat[3]

High Performance Centre, University of Pretoria, South Africa[1]
Institute for Sport, Exercise Medicine and Lifestyle Research, Section Sports Medicine, Faculty of Health Sciences, University of Pretoria, South Africa[2]
Department of Mechanical and Aeronautical Engineering, University of Pretoria, South Africa[3]

Knowledge of the force production of an individual player with different foot positions, and ultimately of the full pack, will provide coaches and trainers with valuable information in order to improve their team's ability to manipulate the scrum forces and moments as well as making the scrum more stable thereby improving safety. This study aimed to examine the differences in the scrum compression force and lateral force generated by an individual player during the sustained pushing phase of the scrum with parallel and nonparallel foot positions. Nineteen front row rugby players scrummed against an instrumented scrum machine with three different foot positions. The results showed that the parallel foot position produces a higher pushing force than either of the other two nonparallel conditions. It was also shown that the nonparallel conditions produces a greater lateral force than the parallel foot condition with the lateral force being directed towards the side of the front foot..

KEY WORDS: rugby scrum; foot position; compression force; lateral force

INTRODUCTION: Scrummaging in rugby union involves a coordinated effort of eight players, arranged in three rows, working against the opposition scrum. In live scrummaging, the way that the two packs form against each other tends to create a force couple that produces a clockwise wheel of the scrum. The positioning and technique of the players is therefore important to either (i) negate this natural wheel to produce a stable "square" scrum, (ii) overcome the natural wheel in order to produce an anti-clockwise rotation, or (iii) utilize the natural wheel to produce a clockwise rotation. Coaches perceive that altering the relative position of the feet, so that one foot is slightly ahead of the other, will influence the direction of the resultant force and therefore the rotational moment on the scrum. Only one published study has investigated the effect on varying foot position on the magnitude of scrum compression force. Wu and colleagues found no difference in peak compression force between scrumming with the feet parallel or with one foot placed forward of the other, in individual players (Wu, Chang, Wu, & Guo, 2007). However, they did not measure the lateral forces, which may act to destabilise the scrum and is proposed to introduce a moment of force that induces undesirable rotation of the spine, which is a likely cause of premature degeneration of the cervical spine (Trewartha, Preatoni, England, & Stokes, 2014).
The engagement procedure rules for the scrum have recently changed from "crouch, touch, pause, engage" to "crouch, bind, set", with packs only allowed to actively begin scrummaging once the ball is introduced following the "set" call. This has resulted in a decreased importance of the initial peak force after impact for gaining dominance over the opponent, and a shift of focus to the sustained pushing phase (Preatoni, Cazzola, Stokes, England, & Trewartha, 2015).
Knowledge of the force production of an individual player with different foot positions, and ultimately of the full pack, will provide coaches and trainers with valuable information in order to improve their team's ability to manipulate the scrum forces and moments as well as making the scrum more stable thereby improving safety. In view of acquiring this information this study examined the differences in the scrum compression force and lateral force generated by an individual player during the sustained pushing phase of the scrum with parallel and nonparallel foot positions. The hypothesis is that the parallel foot position should

produce a higher pushing force than either of the other two nonparallel conditions. Furthermore, the nonparallel conditions should produce a greater lateral force than the parallel foot condition with the lateral force produced by the two nonparallel foot conditions being in opposite directions.

METHODS: A cross-sectional experimental design was used to assess changes in dependent variables (scrum compression force and lateral force) under three different conditions (three different foot positions).

Nineteen front row rugby players from seven amateur-level rugby teams volunteered to participate in the study. Ethical approval was obtained from the Research Ethics Committee, Faculty of Health Sciences at the University of Pretoria and each player provided written informed consent.

An instrumented scrum machine was used to measure the compression and lateral forces imposed onto it by a player. The scrum machine uses six calibrated S-Type load cells to record the measured tension/compression force in each of the six S-Type load cells. Data was recorded at 1.2kHz. The measured forces in the six S-Type load cells are used to calculate the compression and lateral forces imposed onto the scrum machine. Testing took place outdoors on a rugby field. The instrumented scrum machine was anchored to the playing surface. In order to reduce the variables the player's feet were supported by a sprinter-block-type support (referred to hereafter as the foot support). The foot support was also anchored to the playing surface. The use of the foot supports eliminated the effect of the playing surface on force production. This allowed for the focus to be on the biomechanics of the force production and excluded effects from the terramechanics between the player's boots and playing surface.

Players undertook a self-selected warmup under the supervision of a coach to prepare for testing. Each player self-selected the distance of the foot supports from the scrum machine for the parallel condition, and a foot support was anchored to the ground at this location for each foot. The nonparallel positions were then established by moving one of the blocks forward by 26 cm. The individual players were asked to perform three scrums for each of the three conditions (feet parallel, right foot forward, left foot forward). The order of the foot position conditions was randomized. Following the "set" command that instructed players to engage, an audio signal that was synchronised to the data acquisition system signalled the start of the sustained pushing phase. Players were required to push maximally against the scrum machine for 10 seconds. At least one minute rest was allowed between repetitions.

The mean sustained compression force (forwards considered to be positive) and lateral force (directed to the right considered to be positive) was then calculated for each of the nine scrums (3 trials x 3 foot positions) the player performed. The sustained pushing period was selected such that it did not include any impact forces from the engagement or forces associated with the player stopping his maximal effort. This resulted in a sustained section of 9.5 seconds. Figure 1 shows the period associated with the sustained maximal scrum effort on the compression force. The same period is used for the lateral force. The mean compression and lateral force is calculated for this period for each of the trials. Each player's mean compression and lateral forces for the three conditions are obtained by calculating the mean of the three trials. Finally the mean compression and lateral forces for each condition are obtained by calculating the mean of the nineteen player's forces for the three conditions. The sustained compression and lateral forces are presented as the mean of the force ± one standard deviation (mean±1SD) (Figure 2).

A repeated measures analysis of variance was carried out to determine the significance ($p<0.05$) of the effect of scrum condition (three different foot positions). Bonferroni post hoc tests were applied to investigate the differences between each condition.

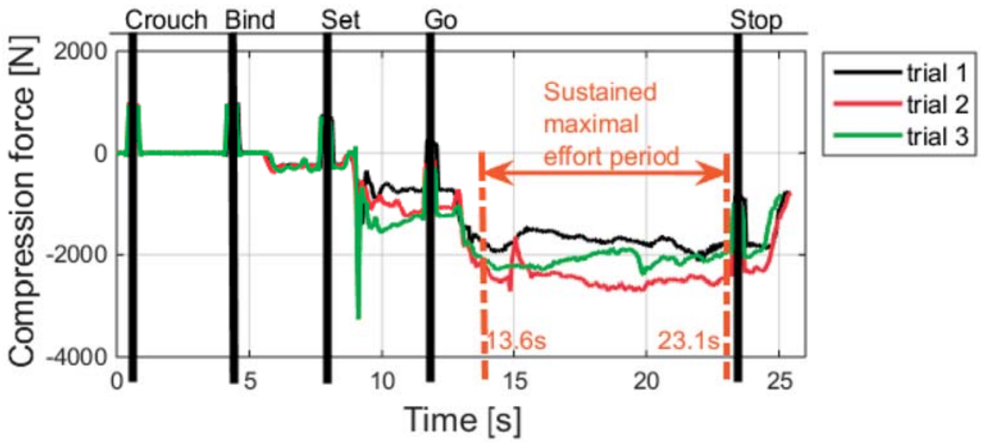

Figure 1. Compression forces of player measured during the three trials for parallel feet

RESULTS: There was a statistically significant effect of foot position on compression force and lateral force (F = 61.334, $p < 0.001$). Post hoc tests using the Bonferroni correction revealed that compression force was significantly greater in the parallel condition (2072.3 ± 375.3 N) than either of the nonparallel conditions (left foot forward: 1823.3 ± 356.4 N, right foot forward: 1762.8 ± 350.6 N) ($p < 0.001$), but there was no statistically significant difference between the two nonparallel conditions ($p = 0.062$).
Lateral forces were significantly different between each of the three conditions ($p < 0.001$). The smallest lateral force was generated in the parallel condition (-16.5 ± 75.3 N). There was a leftwards force generated during the left foot forward condition (-150.1 ± 69.3 N) and a rightwards force generated during the right foot forward condition (169.9 ± 103.0 N).

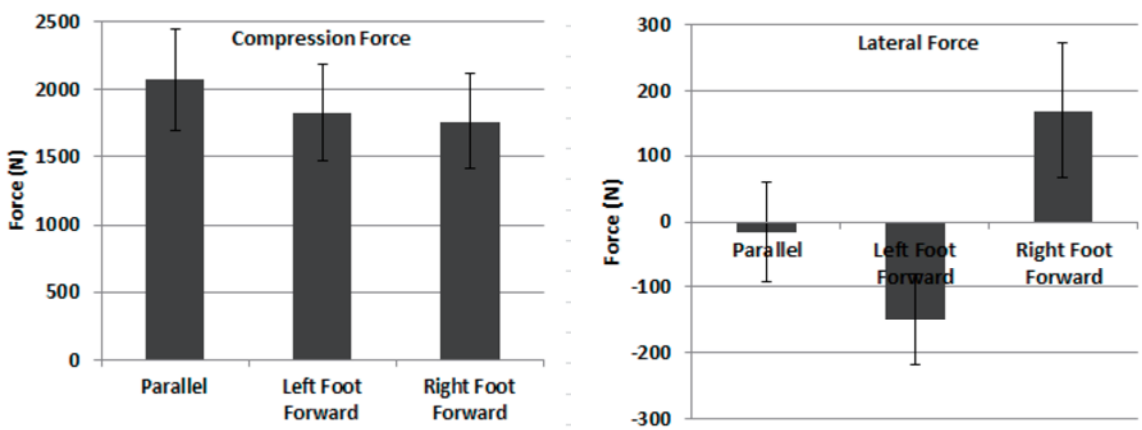

Figure 2. Sustained compression and lateral forces for the three conditions

DISCUSSION:
The results showed that the nonparallel foot positions produces a significantly lower ($p < 0.001$) compression force than the parallel foot position. In contrast, Wu et al (2007), reported no difference in compression force magnitude between parallel and nonparallel foot placement, The difference in results may be attributed to Wu et al (2007) reporting peak force and not sustained force. The magnitude of the difference in the compression forces between the parallel and nonparallel foot positions is in the range of 250-300N (~12-15%). This is not a large difference but will however cause the scrum to move in the direction of the resultant compression force, thereby giving the team moving in the direction of the resultant force the advantage. Research on the forces produced during scrummaging over the past 25

years has demonstrated a general trend for an increase in the magnitude of forces measured (Trewartha et al., 2014). The magnitude of compression force in the parallel foot condition in the current study (2072 N) is higher than reported in an earlier study on individual scrummaging by front row players (1340N – 1420N) (Milburn, 1990; Quarrie & Wilson, 2000). A more recent study reported slightly higher compression forces (2404 N) (Green, Kerr, Dafkin, & McKinon, 2015). However, these authors reported the peak force during a 6 s scrum while we have reported the mean force over a 10 s sustained maximal effort scrum, which may explain this difference.

The set-up of the nonparallel condition in the current study required the player to bring one foot forwards relative to the parallel condition, which would have resulted in increased hip flexion angle of the front leg. It has been suggested that a more extended hip angle is advantageous in the production of scrum compression forces (Milburn, 1990), and so the change in hip angle of the front foot in the nonparallel condition may contribute to the reduction in compression force production.

A significant ($p < 0.001$) difference in the lateral force was observed between each of the three conditions. For the two nonparallel conditions, the force was directed towards the side of the foot that was placed in front. It should be noted that the player's feet were equally spaced relative to the midline of the scrum machine and the player. It is expected that the lateral force magnitude and/or direction will change if the spacing of the feet is off-centre, relative to the player's midline and contact position on the scrum machine. The lateral force and the resulting moments produced by the player in the transverse plane will affect the lateral movement of the scrum as well as the wheel of the scrum. This will in turn affect the stability of the scrum. Further investigation is required into the lateral force production for different foot, and body, positions as well as how these relate to performance and stability of the scrum, especially during live scrummaging.

CONCLUSION:

It was shown that the parallel foot position produces a higher pushing force than either of the other two nonparallel conditions. It was also shown that the nonparallel condition produces a greater lateral force than the parallel foot condition and that the lateral force is directed towards the side of the front foot. Adopting a nonparallel foot position will therefore reduce the compression force that a player will produce, however the effect of the resulting lateral force and moment in the transverse plane on the stability of the scrum needs further investigation.

REFERENCES:

Green, A., Kerr, S., Dafkin, C., & McKinon, W. (2015). The calibration and application of an individual scrummaging ergometer. *Sports Eng*. doi:10.1007/s12283-015-0188-0

Milburn, P. D. (1990). The kinetics of rugby union scrummaging. *J Sports Sci, 8*(1), 47-60. doi:10.1080/02640419008732130

Preatoni, E., Cazzola, D., Stokes, K. A., England, M. E., & Trewartha, G. (2015). Pre-binding prior to full engagement improves loading conditions for front-row players in contested Rugby Union scrums. *Scand J Med Sci Sports*. doi:10.1111/sms.12592

Quarrie, K. L., & Wilson, B. D. (2000). Force production in the rugby union scrum. *J Sports Sci, 18*(4), 237-246. doi:10.1080/026404100364974

Trewartha, G., Preatoni, E., England, M. E., & Stokes, K. A. (2014). Injury and biomechanical perspectives on the rugby scrum: a review of the literature. *Br J Sports Med*. doi:10.1136/bjsports-2013-092972

Wu, W. L., Chang, J. J., Wu, J. H., & Guo, L. Y. (2007). An investigation of rugby scrimmaging posture and individual maximum pushing force. *J Strength Cond Res, 21*(1), 251-258. doi:10.1519/r-19235.1