



LEEDS
BECKETT
UNIVERSITY

Citation:

Hendricks, S and Till, KA and Oliver, J and Johnston, R and Attwood, M and Brown, JC and Drake, D and Macleod, S and Mellalieu, S and Treu, P and Grant, R and Jones, B (2018) A technical skill training framework and skill load measurements for the Rugby Union tackle. *Strength and Conditioning Journal*, 40 (5). pp. 44-59. ISSN 1533-4295 DOI: <https://doi.org/10.1519/SSC.0000000000000400>

Link to Leeds Beckett Repository record:

<https://eprints.leedsbeckett.ac.uk/id/eprint/4882/>

Document Version:

Article (Accepted Version)

The aim of the Leeds Beckett Repository is to provide open access to our research, as required by funder policies and permitted by publishers and copyright law.

The Leeds Beckett repository holds a wide range of publications, each of which has been checked for copyright and the relevant embargo period has been applied by the Research Services team.

We operate on a standard take-down policy. If you are the author or publisher of an output and you would like it removed from the repository, please [contact us](#) and we will investigate on a case-by-case basis.

Each thesis in the repository has been cleared where necessary by the author for third party copyright. If you would like a thesis to be removed from the repository or believe there is an issue with copyright, please contact us on openaccess@leedsbeckett.ac.uk and we will investigate on a case-by-case basis.

A technical skill training framework and skill load measurements for the Rugby Union tackle

Sharief Hendricks^{1,2}, Kevin Till^{2,3}, Jon L Oliver^{4,5}, Rich D Johnston^{6,7}, Matthew Attwood^{4,8}, James Brown^{9,14, 1}, David Drake¹⁰, Simon MacLeod¹¹, Stephen D Mellalieu⁴, Paul Treu¹¹, Roddy Grant¹², Ben Jones^{2,3,13,15}

¹Division of Exercise Science and Sports Medicine, University of Cape Town, Cape Town, South Africa

²Institute for Sport, Physical Activity and Leisure, Leeds Beckett University, Leeds, United Kingdom

³Yorkshire Carnegie Rugby Union Football Club, Leeds, United Kingdom

⁴School of Sport and Health Sciences, Cardiff Metropolitan University, Cardiff, United Kingdom

⁵Sports Performance Research Institute New Zealand, Auckland University of Technology, Auckland, New Zealand

⁶School of Exercise Science, Australian Catholic University, Brisbane, Australia

⁷Norths Devils Rugby Football League, Queensland, Australia

⁸Cardiff Metropolitan University Rugby Union Football Club

⁹Institute for Sport and Exercise Medicine, Stellenbosch University, Stellenbosch, South Africa

¹⁰Ulster Rugby, Kingspan Stadium, Belfast, Northern Ireland

¹¹Western Province Rugby and Stormers, Cape Town, South Africa

¹²Scotland Rugby Union, United Kingdom

¹³The Rugby Football League, Leeds, United Kingdom

¹⁴The International Olympic Committee (IOC) Research Centre, Cape Town, South Africa

¹⁵Leeds Rhinos Rugby League Club, Leeds, United Kingdom

Correspondence to:

Sharief Hendricks, PhD

Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences, the University of Cape Town and the Sports Science Institute of South Africa, Cape Town, South Africa

PO Box 115

Newlands

7725

Tel: + 27-21-650-4572

Fax: +27-21-686-7530

sharief.hendricks01@gmail.com

Twitter: @Sharief_H

Abstract

Drawing from skill acquisition and development literature, we present a novel tackle skill training framework. The framework outlines the training purpose (technique proficiency, technique capacity, skill proficiency and skill capacity), skill workload measurements (available information, task difficulty, rating of perceived challenge, skill load), as well as the training conditions and coaching style for the tackle in rugby union. Using this framework and skill load measurements, we propose a pre-season tackle training plan. This tackle skill framework and skill load measurements serve as potential preventative measures for tackle injury risk while improving players' tackle performance.

Introduction

With an estimated 8.5 million players across 121 countries, rugby union is now considered amongst the most played and watched sports in the world(1). Participation in the sport requires players to perform a range of contact (e.g., tackling, ball-carrying) and non-contact (e.g., passing, catching) skills interspersed with bouts of high-intensity running(2-4). Success in the sport is dependent, in part, on a player's ability to repeatedly perform these skills efficiently and effectively across an 80 minute match and throughout the season(5-7). Performing these skills are also associated with injury, and concussion in particular(8-10), with the majority (>50%) of these injurious events occurring during tackling or being tackled(11). At the youth level, tackle-related injuries account for 60% of all injuries(12), and the inclusion of the tackle in youth rugby has recently become a topic of public debate and a high-priority research area for the sport's governing body, World Rugby(13, 14).

The tackle is a physical and technical contest where opposing players compete for territory and ball possession. This physical and technical contest is common to a number of tackle collision sports i.e. rugby union, rugby league and American football. Rugby union and rugby league in particular, share the same field dimensions and game objectives – to advance the ball towards the opposition try-line by passing it backwards and score as many points as possible within two 40 minutes periods (separated by a 10-15 minute break). Notable differences between the two rugby codes are the number of players per a team on the pitch (a rugby union team consists of 15 players, whereas a rugby league team consists of 13 players) and what happens to ball possession after a completed tackle. In rugby union, the contest for ball possession continues while the ball is on the ground (known as the ruck), and

thus the attacking team can maintain ball possession until the next stoppage in play. In rugby league on the other hand, the contest for ball possession discontinues after a completed tackle, with the attacking team maintaining ball possession for six tackles before handing over ball possession. For the purpose of this paper, we will focus on the tackle in rugby union, although the work can be extended to rugby league and American football, given the similarities of the tackle.

Whether as a ball-carrier or tackler, proficient tackle contact skills in matches have been associated with a reduced risk of injury(12, 15-17), and a higher likelihood of tackle success(6, 18-20). As the tackle is the most frequently occurring contact event, maintaining a high-level of tackle contact skill across the duration of a match also requires a degree of physical fitness to resist technical fatigue(7, 21, 22). Indeed, in rugby league, the players involved in the most tackle contests actually exhibit the lowest contact injury incidence, suggesting technique and exposure to tackles is important(23). Like any skill, to develop contact skills, coaching correct technique and building technical capacity through training is conceivably the best strategy for reducing the risk of injury and improving performance in matches(7, 24). Whilst current coaching resources to train contact skills provide technical guidelines and training drill examples, they offer limited information for coaches, strength and conditioning coaches, trainers and players on how to develop contact skills and build technical capacity using a training plan(25).

Recent studies on tackle training have highlighted a mismatch between tackle contact training preparation and tackle contact match demands(26-28). Also, coaches at the adolescent level have been reported to rely mainly on informal, anecdotal resources (playing experience,

watching rugby matches and colleagues who are coaches) to inform their tackle training(27, 28). Even though coaches reported knowing the high risk of injury in the tackle and the importance of proper technical preparation, they recognised that they may not fully understand the technical components of contact skill training, and this influences their ability to coach proper contact technique for safety and performance(27). National rugby injury prevention programmes such as BokSmart and RugbySmart aim to provide educational material on the risk of injury during tackle and information on safe and effective tackle contact technique(29, 30). However, this knowledge alone is not enough to modify tackle training behaviour(27, 31, 32). To increase the likelihood of a desired behaviour, a specific action plan is required(33, 34). Therefore, to improve tackle training behaviour, a detailed training plan for coaches, strength and conditioning coaches and trainers to implement, outlining specific technical components of contact skill training and activities is needed.

The Translating Research into Injury Prevention Practice (TRIPP) model is a sport injury prevention model that outlines a series of six stages that need to be completed to ensure the uptake and sustainability of preventative measures in the 'real world'(35, 36). The first stage of the TRIPP model aims to establish the extent of the injury problem in the sport through injury surveillance studies. For example, based on rugby union injury surveillance studies, it is known that the tackle causes more than 50% of all match injuries(11). The second stage aims to understand why and how injuries occur i.e. identifying injury risk factors. For the tackle, poor contact technique in the tackle has been identified as a major risk factor for injury(12, 15-17). The third stage of the TRIPP model seeks to develop a potential preventative measure. In this case, a framework and training plan for the tackle. In stage 4, the preventative measure is tested in ideal or controlled conditions. Stage 5 of the injury

prevention model aims to understand the intervention implementation context including personal, environmental, societal and sports delivery factors that may act as facilitators or barriers to the uptake of the preventative measure. The final stage (stage 6), monitors the effectiveness of the preventative measure in the real world. In this instance, the extent to which the tackle plan can improve tackle training and reduce the number of tackle injuries, while improving tackle performance. To date, the majority of tackle-related research in rugby union has fulfilled the first and second stage of the TRIPP model(12, 15-17). We use the TRIPP model to argue that to go beyond stage 2 and to obtain an effective implementation solution for the tackle in rugby union, a potential injury prevention measure needs to be developed first.

Engaging in a tackle is fundamentally a highly technical and physical movement skill(24, 37). Accordingly, current skill training frameworks and physical training principles can be used to design a tackle contact skill training plan. Therefore, the purpose of this paper is to apply current skill training frameworks and physical training principles to outline a tackle contact skill training plan to prepare players for match tackle contact demands with the goal of reducing players' risk of injury while improving their tackle performance.

Skill training frameworks

Three skill training frameworks will be used to model the tackle contact skill training plan – i) the constraints-based framework for skilled performance(38); ii) the challenge point framework(39) and iii) the skill acquisition periodisation (SAP) framework(40). These skill training frameworks can also be used to model other fundamental contact (e.g. rucking) and

non-contact skills (e.g. passing) in rugby union. The constraints-based framework for skilled performance explains how coordination patterns emerge during goal-oriented behaviour and views movement as a functionality of the player (physical and psychological characteristics), the task and the environment. The challenge point framework describes the interaction between the difficulty of the task (dependent on the skill level of the player) and potential available information to the player (i.e. too much or too little information). By understanding this relationship, the framework describes how the optimal challenge point can be achieved to ensure successful skill learning and transfer. The SAP framework re-conceptualized the principles of physical training, and focuses on specificity, progression, overload, reversibility and tedium, in order to describe how sport skill training can be periodized.

Tackle contact training outcomes

Before applying the above frameworks, two factors should be determined: the skill level of the player(s) and the purpose (or outcome) of the training session and training plan. The technical skill level of the player could be assessed during a one-on-one drill using the tackler and ball-carrier contact technique criteria listed in Table 1. The tackle is split into three phases - precontact, contact and post-contact, where players are awarded 1 point when the execution of a technical criterion is observed, and 0 if the criterion is not observed(37). The total score (arbitrary units) and percentage for the number of technical criterion satisfied is subsequently calculated to determine the technical skill level of the player. For the purpose of this paper, we consider *technique* as the execution of a set of coordinated movement patterns, and *skill* as the proficiency of execution of the correct actions determined by the

demand of the situation, therefore technique proficiency and capacity acts as a pre-requisite for skill proficiency.

Insert Table 1 here

Table 1: Criteria to assess tackler and ball-carrier technical skills (15, 17, 37).

Accordingly, the purpose of the training session within the training plan may be to either: i) learn a proper tackle contact technique (s); ii) develop and refine technical proficiency and iii) build technical capacity (the ability to maintain quality technique under a fatigued state); thereafter; iv) develop and refine tackle contact skill proficiency (quality); and v) build skill capacity (quantity i.e. the ability to maintain quality skill under a fatigued state, Table 2).

Insert Table 2 here

Table 2: Summary table of tackle contact skill training variables.

Tackle contact skill training variables

Once the purpose of the training session has been determined, the difficulty of the task(s) can be established to meet the specific training objectives. Similarly, the environment in which the task is performed should be designed with the necessary information and conditions for achieving the training objective(s). The environment could be highly structured, blocked and become progressively more representative of match-play. The relationship

between task difficulty and the availability of information can be used to determine the challenge point of the training session (Figure 1). Knowing the aim of the training session will also guide how the coach instructs the players (Table 2).

Insert Figure 1 Here

Figure 1: Tackle contact skill training framework. Modified from Guadagnoli and Lee (39).

Permission to modify granted by Guadagnoli

Physical training load comprises of external load and internal load(41-43). External load quantifies the work external to the player(41-43), for example, number of tackles. Internal load quantifies the players' perceived physical experience of the external work. This perceived physical experience is typically captured on a 0-10 rating scale known as the Rating of Perceived Exertion (RPE)(41-43). From a technical skill perspective, the challenge point can be used as a quantification of skill load(39, 40). The task difficulty and the availability of information is usually set by the coach/trainer and serves as an external quantification of skill load. For practical purposes, coaches, strength and conditioning coaches and trainers could use a visual analogue scale from 1 to 10 (Figure 1) to rate the difficulty of the task (1=technique proficiency; 10=skill capacity) and the level of information available to the players (1=highly structured, low representativeness; 10=practice match). The resulting values from these two ratings would indicate the challenge point set out by the coach/trainer. To determine whether the player experiences this challenge and works around the optimal challenge point, the player could be asked to rate how challenging they perceive the skill session to be (Rating of Perceived Challenge, RPC, 1=not challenging,

10=highly challenging). The players' RPC of the skill session would represent a measure of internal skill load. A further measurement of internal skill load would be to multiply the RPC by the amount of tackles a player performs within a given time is important (i.e. tackle rate).

The performance-learning paradox during contact skill training

It is also important to consider the performance-learning paradox when training tackle contact skills(38-40). A training session with a low challenge point (highly structured and blocked) will lead to high levels of skill performance in practice and low levels of skill learning (retention and transfer), whereas a session that is high in task difficulty and highly representative (e.g. match practice; high challenge point), will have lower levels of skill performance in practice and higher levels of skill learning. These relationships are dependent on the skill level of the player and the optimal challenge point is when the potential for skill retention and transfer is high and decrements in practice performance is kept to the minimum(40). For a progressive contact skill training plan, it is recommended to start the plan with a low challenge point (high levels of performance in practice) and build towards a high challenge point.

A preseason tackle contact training plan

To demonstrate as an example how these variables could be used to plan tackle contact skill training, we describe a 5-week pre-season training plan (leading to the first competitive match at the end of week 5) for the developing player (experienced junior or senior player),

for both the ball-carrier and the tackler (Table 3). The pre-season prepares players for the competitive season. Indeed, a well-designed pre-season is associated with better performance and reduced risk of injury during the in-season(44, 45). With that said, the proposed plan is adaptable and should be modified based on the team setting, the technical ability and skill level of each player and the phase of the season.

Insert Table 3 here

Table 3: Five-week tackle contact training programme for player development.

The 5-week tackle contact training plan

Table 3 outlines and describes the external and internal physical loads, as well as the external and internal skill loads of a 5-week tackle contact training plan. The table also includes a training description for clarity and a coaching style that can be implemented to facilitate the process.

The objective of week 1 is to develop the player's technical proficiency for the front-on and side-on tackle. Because the focus is technique, the first couple of days are highly structured using a 1 vs 1 static drill that is low impact and does not require the attacker and defender to accelerate toward each other. Furthermore, undertaking tackle training on consecutive days is possible, given the technical focus of the activity and low physical demand. Once the coach is satisfied with the player's technical proficiency in contact during the 1 vs 1 static drill, the challenge point of the 1 vs 1 drill can be increased to semi-structured with players moving

towards each other and the ball-carrier deciding whether to side-step right or left (Week 1, Day 4). The coaching style during this week is prescriptive i.e. emphasising the specific techniques for safe and effective contact. The second week builds on week 1, and aims to develop the players' technical capacity and refine or remediate techniques. Week 2 starts with another highly structured 1 v 1 drill; however, the ball-carrier and tackler move toward each other (no direction change from ball-carrier). For each shoulder (right and left) and type of tackle (front-on and side-on), the player engages in a set of 8 contact events (players engage in 10-15 contact events during a match (46-48). Before and between each set, players perform a physical conditioning block to induce fatigue. Week 2, Day 2, the skill load as well as the physical load of the skill session is reduced to correct and fine-tune the player's contact technique. On Week 2, Day 4, players engage in a close contact/wrestling type drill to further build technical capacity.

Once players are technically proficient and able to maintain good technique under fatigue, players can start developing their skill proficiency – i.e. execute the correct actions based on the demands of the situations. This occurs during week 3 by increasing the task difficulty and the available information to players during drills. For skill proficiency, drills are semi-structured with more space and players work in mini-units of 2 or more attackers vs. 2 or more defenders. Increasing the space and player numbers improves the representativeness of the drill situation, and players need to start making decisions and working within a team context. To increase the skill load, coaches can also introduce tactical awareness components (on attack and defence) and instruct players to perform post-contact actions (tackler competing for the ball after the tackle (jackal), ball placement for ball-carrier, or ruck activity for supporting players. Similar to building technique capacity in week 2, but now to build skill

capacity, the skill 'drills' performed earlier in week 3 can be combined with a physical conditioning block or a high intensity non-contact skill block.

The purpose of week 4 is to build skill capacity, with a skill refinement session between the two capacity building sessions. Skill capacity in week 4 is achieved primarily through small sided contact – Week 4, Day 1, small-sided contact game using a small field (quarter of the field, playing touch line to touch line) and Week 4, Day 4, small-sided contact game with a larger field (half the field, playing try-line to half-way line). To build skill capacity further, week 5 starts with a practice match, which can be played in 20 minute blocks. This is followed by an easy skill refinement session on Week 5, Day 4, before the first match on Week 5, Day 6.

Rate of progression

Increasing the skill loads and progression through the training plan will vary based on the age and skill level of the player. For example, the rate of progression for a younger, less experienced player will be more gradual than the rate of progression described in the 5-week pre-season training plan. The younger, less experienced player may require extra or repeat sessions under lighter skill loads before progressing to more challenging sessions. The training plan can therefore be adapted to include these extra or repeat sessions and extend beyond 5-weeks. It is also important to note that that fatigue and recovery status (measured via player wellbeing and muscle soreness) of the player is considered prior to undertaking subsequent contact training sessions. Ideally, progression through the plan should be determined on an individual basis; however, this may not always be possible in a team or squad setting. The best method to determine the rate of progression of players is through

observation, assessment and the players response to the session. The session can be video recorded and assessed by a coach/trainer that is knowledgeable about the technical and skill requirements for safe and effective tackle contact. Through this observation and assessment, the coach and/or trainer can determine whether the player has reached their optimal challenge point or whether the player should progress to more technically and physically demanding conditions. How challenging players perceive the skill session to be (the RPC) will also assist in the monitoring and optimizing of the training plan.

Phase of the season

During the pre-season, the main goal of the training plan is to prepare players for the forthcoming competitive season; therefore, progress through the plan is important. However, during the in-season, a team may have multiple training goals, which may change weekly based on the match fixtures and outcomes from previous matches. As such, the purpose of the tackle contact training session can be adapted accordingly. For example, during the in-season, coaches can use as a low skill load and physical load session as a warm-up drill and train both skill proficiency and skill capacity in the same session. The 5-week pre-season tackle contact training plan includes sufficient rest and recovery between sessions and considers the tedium factor (state of being bored due to monotony, which may negatively impact training) over the period(40). The tackle contact training plan also assumes players are concurrently training other technical and tactical aspects of rugby union. With that said, the tackle contact training plan can be combined with other physical, technical and tactical aspects of rugby training. For instance, performing passing drills between sets of tackle contact bouts. Also, the tackle contact training plan takes into consideration that players are concurrently

undergoing a physical conditioning training plan. Therefore, the optimal contact skill load should be managed in conjunction with other player loads(14).

Conclusion

Drawing from skill acquisition and skill development literature, we present a novel tackle skill training framework and skill load measurements that can be used to design and monitor tackle training, with the goal of reducing players' risk of injury while improving their tackle performance in matches. The tackle skill training framework starts by outlining the objectives a contact skill training session or plan might be to: i) learn a proper tackle contact technique(s); ii) develop and refine technical proficiency; iii) build technical capacity; iv) develop and refine tackle contact skill proficiency; and v) build skill capacity, or a combination of the aforementioned outcomes depending on the training goals. Once the purpose of the training session is known, the difficulty of the task(s) and the available information in the training environment can be set to meet the training outcome(s). The task difficulty and the availability of information can be used as an external quantification of skill load. The perceived challenge of this skill load can be measured using a 1-10 rating scale, with 1=not challenging and 10=highly challenging.

Using the skill training variables, we have described a 5-week pre-season tackle contact training plan (leading to the first competitive match at the end of week 5 for the developing player, for both the ball-carrier and the tackler). Progression through the pre-season training may vary based on the age and skill level of the player. Younger, lesser skilled players may require extra or repeat sessions before progressing to higher skill loads. During the in-season,

training goals may change weekly based on the fixtures. To adapt to these changing training goals, the tackle contact skill training variables and outcomes can be manipulated accordingly.

The tackle contact skill framework and training plan serves as potential preventative measures for tackle injury risk while improving players' tackle performance. This satisfies the third step of the TRIPP model. The next steps would be to determine the efficacy of the tackle contact skill training plan (step 4, for example, randomized-controlled design model in controlled settings), describe the implementation context for such a plan to work (step 5, for example, individual, environmental, societal, cultural factors that may act as facilitators or barriers to the delivery of the training plan), and the effectiveness of the training plan on injury risk and performance after it has been implemented in the "real world"(35, 36). This research will require a long-term outlook with considerable amount of human and financial resources, and the current tackle contact skill training plan serves as an essential starting point to achieve this. Lastly, tackle contact skill is required by most tackle collision based sports such as rugby league and American football. The tackle skill training framework and skill load measurements can therefore be applied to these sports as well.

Training Recommendations

- Test the skill level of the player(s) using the standardized tackler and ball-carrier criteria. Award a player 1 point when the execution of a technical criterion is observed, and 0 if the criterion is not observed. The total score (arbitrary units) and percentage for the number of technical criterion satisfied is subsequently calculated to determine the technical skill level of the player.

- Determine the purpose of each training session within the training plan i.e. i) learn a proper tackle contact technique(s); ii) develop and refine technical proficiency; iii) build technical capacity; iv) develop and refine tackle contact skill proficiency (quality); and v) build skill capacity.
- Apply the tackle contact skill training framework to plan and design tackle training sessions.
- Use the internal (rate of perceived challenge) and external skill (task difficulty and available information) workload measurements, along with the physical workload measurements for tackle skill to monitor and optimize the training the session and training plan.

References

1. World Rugby. Global Participation. *Year in Review 2016*:44-45.
2. Quarrie KL, Hopkins WG, Anthony MJ, et al. Positional demands of international rugby union: Evaluation of player actions and movements. *J Sci Med Sport* 2013;16(4):353-59.
3. Read D, Weaving D, Phibbs P, et al. Movement and physical demands of school and university rugby union match-play in England. *BMJ Open Sport Exerc Med* 2017;2(1):e000147.
4. Ziv G, Lidor R. On-field performances of rugby union players—a review. *J Strength Cond Res* 2016;30(3):881-92.
5. den Hollander S, Brown J, Lambert M, et al. Skills associated with line breaks in elite rugby union. *J Sci Med Sport* 2016;15:501-08.
6. Hendricks S, Matthews B, Roode B, et al. Tackler characteristics associated with tackle performance in rugby union. *Eur J Sport Sci* 2014;14(8):753-62.
7. Hendricks S, Lambert MI. Theoretical model describing the relationship between the number of tackles in which a player engages, tackle injury risk and tackle performance. *J Sports Sci Med* 2014;13(3):715.
8. Burger N, Lambert MI, Viljoen W, et al. Tackle-related injury rates and nature of injuries in South African youth week tournament rugby union players (under-13 to under-18): an observational cohort study. *BMJ open* 2014;4(8):e005556.
9. Mc Fie S, Brown J, Hendricks S, et al. Incidence and factors associated with concussion injuries at the 2011 to 2014 South African rugby union youth week tournaments. *Clin J Sport Med* 2016;26(5):398-404.

10. Tucker R, Raftery M, Kemp S, et al. Risk factors for head injury events in professional rugby union: a video analysis of 464 head injury events to inform proposed injury prevention strategies. *Br J Sports Med* 2017;51(15):1152-57.
11. Roberts SP, Trewartha G, England M, et al. Collapsed scrums and collision tackles: what is the injury risk? *Br J Sports Med* 2015;49(8):536-40.
12. Burger N, Lambert MI, Viljoen W, et al. Mechanisms and factors associated with tackle-related injuries in South African youth rugby union players. *Am J Sports Med* 2016:0363546516677548.
13. Tucker R, Raftery M, Verhagen E. Injury risk and a tackle ban in youth rugby union: reviewing the evidence and searching for targeted, effective interventions. A critical review. *Br J Sports Med* 2016;50(15):921-25.
14. Quarrie KL, Raftery M, Blackie J, et al. Managing player load in professional rugby union: a review of current knowledge and practices. *Br J Sports Med* 2016:bjsports-2016-096191.
15. Burger N, Lambert MI, Viljoen W, et al. Tackle technique and tackle-related injuries in high-level South African Rugby Union under-18 players: real-match video analysis. *Br J Sports Med* 2016:bjsports-2015-095295.
16. Hendricks S, O'Connor S, Lambert M, et al. Video analysis of concussion injury mechanism in under-18 rugby. *BMJ Open Sport Exerc Med* 2016;2(1):e000053.
17. Hendricks S, O'Connor S, Lambert M, et al. Contact technique and concussions in the South African under-18 Coca-Cola Craven Week rugby tournament. *Eur J Sport Sci* 2015;15(6):557-64.

18. Hendricks S, van Niekerk T, Sin DW, et al. Technical determinants of tackle and ruck performance in International rugby union. *J Sports Sci* 2017:1-7. doi: 10.1080/02640414.2017.1322216
19. Tierney GJ, Denvir K, Farrell G, et al. The effect of technique on tackle gainline success outcomes in elite level rugby union. *Int J Sports Sci Coach* 2017:1747954117711866.
20. Wheeler KW, Askew CD, Sayers MG. Effective attacking strategies in rugby union. *Eur J Sport Sci* 2010;10(4):237-42.
21. Gabbett TJ. Influence of fatigue on tackling technique in rugby league players. *J Strength Cond Res* 2008;22(2):625-32.
22. Tierney GJ, Denvir K, Farrell G, et al. Does player time-in-game affect tackle technique in elite level rugby union? *J Sci Med Sport* 2017: doi.org/10.1016/j.jsams.2017.06.023
23. Gabbett TJ, Jenkins DG, Abernethy B. Physical collisions and injury in professional rugby league match-play. *J Sci Med Sport* 2011;14(3):210-15.
24. Hendricks S, Till K, Brown JC, et al. Rugby union needs a contact skill-training programme. *Br J Sports Med* 2017;51(10):829-30. doi: 10.1136/bjsports-2016-096347
25. Hendricks S, Lambert M. Tackling in rugby: Coaching strategies for effective technique and injury prevention. *Int J Sports Sci Coach* 2010;5(1):117-36.
26. Campbell PG, Peake JM, Minett GM. The specificity of rugby union training sessions in preparation for match demands. *Int J Sports Physiol Perform* 2017:1-23.
27. Hendricks S, Sarembock, M., Jones, B., Till, K., Lambert, M.I. The tackle in youth rugby union – gap between coaches' knowledge and training behaviour. *Int J Sports Sci Coach* 2017: doi.org/10.1177/1747954117738880.

28. Hendricks S, Sarembock M. Attitudes and behaviours of top-level junior rugby union coaches towards the coaching of proper contact technique in the tackle – a pilot study. *S Afr J Sport Med* 2013;25(1) doi: 10.7196/sajsm.459
29. Patricios J. BokSmart—South African Rugby’s national rugby safety and injury prevention program. *Curr Sports Med Rep* 2014;13(3):142-44.
30. Quarrie KL, Gianotti SM, Hopkins WG, et al. Effect of nationwide injury prevention programme on serious spinal injuries in New Zealand rugby union: ecological study. *BMJ* 2007;334(7604):1150.
31. Brown JC, Verhagen E, van Mechelen W, et al. Coaches’ and referees’ perceptions of the BokSmart injury prevention programme. *Int J Sports Sci Coach* 2016:1747954116667100.
32. Fraas MR, Burchiel J. A systematic review of education programmes to prevent concussion in rugby union. *Eur J Sport Sci* 2016;16(8):1212-18.
33. Leventhal H, Singer R, Jones S. Effects of fear and specificity of recommendation upon attitudes and behavior. *J Pers Soc Psychol* 1965;2(1):20.
34. Ross L, Nisbett RE. The person and the situation: Perspectives of social psychology: Pinter & Martin Publishers 2011.
35. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport* 2006;9(1-2):3-9; discussion 10. doi: 10.1016/j.jsams.2006.02.009
36. Finch CF, Donaldson A. A sports setting matrix for understanding the implementation context for community sport. *Br J Sports Med* 2010;44(13):973-78.
37. Hendricks S, Lambert M, Masimla H, et al. Measuring skill in rugby union and rugby league as part of the standard team testing battery. *Int J Sports Sci Coach* 2015;10(5):949-65.

38. Davids KW, Button C, Bennett SJ. Dynamics of skill acquisition: A constraints-led approach: Human Kinetics 2008.
39. Guadagnoli MA, Lee TD. Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. *J Mot Behav* 2004;36(2):212-24.
40. Farrow D, Robertson S. Development of a skill acquisition periodisation framework for high-performance sport. *Sport Med* 2017 :1-12.
41. Jones CM, Griffiths PC, Mellalieu SD. Training load and fatigue marker associations with injury and illness: A systematic review of longitudinal studies. *Sport Med* 2017;47(5):943-74.
42. Soligard T, Schwellnus M, Alonso J-M, Bahr R, Clarsen B, Dijkstra HP, et al. How much is too much?(Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *Br J Sports Med* 2016;50(17):1030-41.
43. Drew MK, Finch CF. The relationship between training load and injury, illness and soreness: a systematic and literature review. *Sport Med* 2016;46(6):861-83.
44. Hulin BT, Gabbett TJ, Lawson DW, Caputi P, Sampson JA. The acute: chronic workload ratio predicts injury: high chronic workload may decrease injury risk in elite rugby league players. *Br J Sports Med* 2015:bjsports-2015-094817.
45. Windt J, Gabbett TJ, Ferris D, Khan KM. Training load--injury paradox: is greater preseason participation associated with lower in-season injury risk in elite rugby league players? *Br J Sports Med* 2016:bjsports-2016-095973.
46. Duthie G, Pyne D, Hooper S. Time motion analysis of 2001 and 2002 super 12 rugby. *J Sports Sci* 2005;23(5):523-30.
47. Roberts SP, Trewartha G, Higgitt RJ, El-Abd J, Stokes KA. The physical demands of elite English rugby union. *J Sports Sci* 2008;26(8):825-33.

48. Smart D, Gill N, Beaven CM, Cook C, Blazeovich A. The relationship between changes in interstitial creatine kinase and game-related impacts in rugby union. *Br J Sports Med* 2008;42(3):198-201.

Table 1: Criteria to assess tackler and ball-carrier technical skills. (4, 20, 24)

Tackler	Ball-carrier
<i>Pre-contact</i>	<i>Pre-contact</i>
Identify ball-carrier onto shoulder	Focus on tackler
Body position - upright to low (dipping movement)	Shift ball away from contact to correct arm
Keep back straight, and centre of gravity ahead of base of support	Body position - upright to low (dipping movement)
Alignment square to ball-carrier	Keep back straight, and centre of gravity ahead of base of support
Assume 'boxer stance' - elbows low and close, hands up	Head up and face forward
Head up and face forward	Shuffle or evasive manoeuvre
Shortening steps	
Approach from front/oblique	
<i>Contact</i>	<i>Contact</i>
Explosiveness on contact	Fending into contact
Contact with shoulder	Side-on into contact
Contact in centre of gravity	Explosiveness on contact
Head placement on the correct side of ball-carrier	Body position - from low up into contact (airplane movement)
	Ball in correct arm and protected
<i>Post contact</i>	<i>Post contact</i>
Shoulder drive upon first contact	Leg drive upon contact
Leg drive upon contact	Arm usage - use arm and shoulder to push tackler
Arm usage - punch arms forward, wrap and pull (hit and stick)	Go to ground and present ball/break tackle/offload
Release ball-carrier and compete for possession	

Table 2: Summary table of tackle contact skill training variables.

	Variable	Description
Training Purpose	Technique Proficiency	Execution of proper contact techniques
	Technique Capacity	Maintain technique proficiency under a fatigued state
	Skill Proficiency	Execution of correct actions determined by the demand of the situation
	Skill Capacity	Maintain skill proficiency under a fatigued state
Skill Training Variables	External Skill Load	
	Available Information	Amount of potential information in the environment available to the player (1 – 10 rating scale)
	Task Difficulty	How hard the task is for the player to perform (player skill level dependent) (1 – 10 rating scale)
	Challenge Point	Sum of the available information and task difficulty divided by two
	Internal Skill Load	
	Rating of Perceived Challenge	Players rating of perceived challenge (RPC, rating scale, 1= Not challenging, 10=Highly challenging)
	Skill Load	Rate of contacts per session multiplied by RPC
Physical Training Variables	External Load	
	Number of Contact Repetitions	Number of contacts (ball-carrying and tackling) per session
	Duration	Length of the session (minutes)
	Rate	Number of contacts (ball-carrying and tackling) divided by session duration (contacts per minute)
	Internal Load	
	Intensity	Rating of perceived exertion (RPE, 0 – 10 rating scale)
	Physical Load	Duration of session multiplied by RPE
	Mental Effort	Rating of perceived mental effort (0 – 10 rating scale)
Training Conditions	Highly Structured, Blocked, Low Representativeness	1 vs. 1 drills, limited space, static, low impact
	Representativeness	2+ vs. 2+ drills, more space, dynamic, moderate-high impact
	Semi-structured, Moderate Representativeness	Small sided games

Coaching Style

Unstructured, High Representativeness

Practice Match

Prescriptive

Descriptive

Guided-discovery

Instructing the player to perform the required actions and movements

Informing the player that an error has been committed and that improvements can be made

Players self-learn unique solutions to movement challenges through exploration and discovery

Week 1	Day 1	Day 2	Day 3	Day 4	Day 5, 6 and 7	Week 1 Workloads
Variable						
Training Purpose	Technique Proficiency (Front-on)	Technique Proficiency (Side-on)	No Tackle Contact Training	Technique Proficiency (Front on and Side-on)	No Tackle Contact Training	
Skill Training Workload						
External Skill Load						
Task Difficulty	3	3		5		3.7
Available Information	1	1		3		1.7
Internal Skill Load						
Rating of Perceived Challenge (RPC)	2	2		4		2.7
Skill Load (Rate x RPC, AU)	1	1		3.2		5.2
Physical Workload						
External Load						
Number of Contact Repetitions	4 each shoulder	4 each shoulder		3 each shoulder x 2 types tackles		28
Duration (minutes)	15	15		15		45
Rate (contacts per minute)	0.5	0.5		0.8		0.6
Internal Workload						
Intensity (RPE)	2	2		5		3
Physical Load (RPE x duration, AU)	30	30		75		135
Mental Effort (rating 1-10)	2	2		5		3
Training Description	Highly structured, blocked, low impact, technique focus, 1v1 drill, static, no attacker-defender run up	Highly structured, blocked, low impact, technique focus, 1v1 drill, static, no attacker-defender run up		Semi-structured, moderate impact, 1v1 drill, dynamic, players run-up, attacker side-steps left or right		
Coaching Style Description	Prescriptive, focus on technical points	Prescriptive, focus on technical points		Prescriptive, focus on technical points		

Week 2	Day 1	Day 2	Day 3	Day 4	Day 5, 6 and 7	Week 2 Workloads
Variable						

Training Purpose	Technique Capacity	Technique Refinement/Remediate	No Tackle Contact Training	Technique Capacity	No Tackle Contact Training	
Skill Training Workload						
External Skill Load						
Task Difficulty	5	4		5		4.7
Available Information	3	3		3		3
Internal Skill Load						
Rating of Perceived Challenge (RPC)	4	3.5		4		3.8
Skill Load (Rate x RPC, AU)	6.4	2.8		8.4		17.6
Physical Workload						
External Load						
Number of Contact Repetitions	8 each shoulder X 2 types of tackles with physical conditioning block	4 each shoulder X 2 types tackles		8 each shoulder X 2 types of tackles (close contact, wrestling)		80
Duration (minutes)	20	15		15		50
Rate (contacts per minute)	1.6	0.8		2.1		1.5
Internal Workload						
Intensity (RPE)	6	3		6.5		5.2
Physical Load (RPE x duration, AU)	120	45		97.5		262.5
Mental Effort (rating 1-10)	3	4		4		3.7
Training Description	Highly structured, blocked, moderate impact, technique focus, 1v1 drill, attacker-defender run up, no direction change, physical conditioning block (e.g. running/repeated sprints between sets, high-intensity non-contact skill drill, A-frames etc.), before and between sets	Highly structured, blocked, low impact, technique focus, 1v1 drill, static, attacker-defender run up		Highly structured, moderate impact, 1v1 drill, dynamic, no run-up, attacker and defender wrestle in contact		
Coaching Style Description	Prescriptive and descriptive, focus on	Prescriptive, focus on technical points		Prescriptive and descriptive, focus on		

	maintaining technique			maintaining technique		
--	-----------------------	--	--	-----------------------	--	--

Week 3	Day 1	Day 2	Day 3	Day 4	Day 5, 6 and 7	Week 3 Workloads
Variable						
Training Purpose	Skill Proficiency	Skill Proficiency	No Tackle Contact Training	Skill Capacity	No Tackle Contact Training	
Skill Training Workload						
External Skill Load						
Task Difficulty	5	7		6		6
Available Information	7	8		7		7.3
Internal Skill Load						
Rating of Perceived Challenge (RPC)	6	7.5		6.5		6.7
Skill Load (Rate x RPC, AU)	6.6	8.3		13.7		28.6
Physical Workload						
External Load						
Number of Contact Repetitions	4 each shoulder X 2 types tackles	4 each shoulder X 2 types tackles		8 each shoulder X 2 types of tackles with physical conditioning block		64
Duration (minutes)	15	15		15		45
Rate (contacts per minute)	1.1	1.1		2.1		1.4
Internal Workload						
Intensity (RPE)	6	7.5		8		7.2
Physical Load (RPE x duration, AU)	90	112.5		120		322.5
Mental Effort (rating 1-10)	6	7		7		6.7
Training Description	Semi-structured, more space, mini-units, 2+ vs 2+ drills, attackers decide play, defender needs to identify ball-carrier, fast attacker-defender run up speed, high impact,	Semi-structured, more space, mini-units, 2+ vs 2+ drills, attackers decide play, defender needs to identify ball-carrier, fast attacker-defender run up speed, high impact, work within team		Semi-structured, mini-units, more space, 2+ vs 2+ drills, attackers decide play, defender needs to identify ball-carrier, fast attacker-defender run up speed, high impact, work within team context, tactical awareness, post-		

	work within team context	context, tactical awareness, double tackles, post-tackle actions (jackal for tackler, ball placement for ball-carrier)		tackle actions (jackal for tackler, ball placement for ball-carrier), physical conditioning block (e.g. running/repeated sprints between sets, high-intensity non-contact skill drill, A-frames etc.) before and between sets		
Coaching Style Description	Descriptive and guided-discovery	Descriptive and guided-discovery		Descriptive and guided-discovery		

Week 4	Day 1	Day 2	Day 3	Day 4	Day 5, 6 and 7	Week 4 Workloads
Variable						
Training Purpose	Skill Capacity	Skill Refinement/Remediate	Off	Skill Capacity	No Tackle Contact Training	
Skill Training Workload						
External Skill Load						
Task Difficulty	8	6		9		7.7
Available Information	8	6		9		7.7
Internal Skill Load						
Rating of Perceived Challenge (RPC)	8	6		9		7.7
Skill Load (Rate x RPC, AU)	6.4	4.8		4.5		15.7
Physical Workload						
External Load						
Number of Contact Repetitions	Small-sided contact (small-field size) Each player aims to make 8 contacts within 10 minutes	3 each shoulder X 2 types tackles		Small-sided contact (large field size) Each player aims to make 8 contacts within 15 minutes		68
Duration (minutes)	3 x 10 minutes	15		4 x 15 minutes		105
Rate (contacts per minute)	0.8	0.8		0.5		0.7
Internal Workload						
Intensity (RPE)	8	6		9		7.7

Number of Contact Repetitions	Practice Match (each player expected to make 10 contacts within 20 minutes)			2 each shoulder X 2 types tackles		Practice Match (each player expected to make 20 contacts within 40 minutes)		88
Duration (minutes)	4 x 20 minutes			10		2 x 40 minutes		170
Rate (contacts per minute)	0.5			0.8		0.5		0.6
Internal Workload								
Intensity (RPE)	9			6		10		8.3
Physical Load (RPE x duration, AU)	720			60		800		1580
Mental Effort (rating 1-10)	8			6				
Training Description	Practice Match			Semi-structured, mini-units, 1+ vs 1+ drills, moderate impact, dynamic, players run-up, attacker side-steps left or right		Match		
Coaching Style Description	Guided-discovery			Descriptive and Guided-discovery		Descriptive and Guided-discovery		