

The efficacy of a movement control exercise programme to reduce injuries in youth rugby: a cluster randomised controlled trial

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ABSTRACT

Background: Injuries to youth rugby players have become an increasingly prominent health concern, highlighting the importance of developing and implementing appropriate preventive strategies. A growing body of evidence from other youth sports has demonstrated the efficacy of targeted exercise regimens to reduce injury risk. However, studies have yet to investigate the effect of such interventions in youth contact sport populations like rugby union.

Objective: To determine the efficacy of an evidence-based movement control exercise programme compared with a sham exercise programme to reduce injury risk in youth rugby players. Exercise programme compliance between trial arms and the effect of coach attitudes on compliance will also be evaluated.

Setting: School rugby coaches in England will be the target of the researcher intervention, with the effects of the injury prevention programmes being measured in male youth players aged 14–18 years in school rugby programmes over the 2015–2016 school winter term.

Methods: A cluster-randomised controlled trial with schools randomly allocated to either a movement control exercise programme or a sham exercise programme, both of which are coach-delivered. Injury measures will derive from field-based injury surveillance, with match and training exposure and compliance recorded. A questionnaire will be used to evaluate coach attitudes, knowledge, beliefs and behaviours both prior to and on the conclusion of the study period.

Outcome measures: Summary injury measures (incidence, severity and burden) will be compared between trial arms, as will the influence of coach attitudes on compliance and injury burden. Additionally, changes in these outcomes through using the exercise programmes will be evaluated.

Trial registration number: ISRCTN13422001.

BACKGROUND

The health and social benefits of participating in regular physical activity are widely established.^{1 2} Organised team sport has

What is already known on this subject?

- Injury risk in youth rugby has become a prominent public concern, leading to the prioritisation of developing and implementing appropriate preventive strategies.
- Preventive exercise programmes have been demonstrated to be a useful means of reducing injury risk in youth sport.

What this study adds?

- This protocol outlines the first study to assess the efficacy of a preventive exercise programme for reducing injury risk in a youth contact sport population.
- Similarly, this protocol also describes the first study to profile youth rugby coaches' beliefs and attitudes towards injury prevention and their influence on compliance to the exercise programmes.

been shown to be one way of improving health and fitness,^{3–8} with these findings underpinning the strategies used by sports governing bodies to recruit prospective players.^{9–11} Engaging youth populations is important because of the health improvements sports participation may confer during childhood and into adulthood if sustained.¹² However, the risk of acquiring an activity-related injury is an inherent consequence of participation.^{2 13} This has prompted public calls to devise and implement evidence-based, sport specific strategies that balance injury risk reduction with optimising benefit from sports participation.^{14–16}

Youth rugby injuries as a prominent public health topic

Rugby Union (hereafter referred to as 'rugby') is among the most popularly played

contact sports world-wide. The game has experienced substantial growth since the transition at senior levels to professionalism in 1995, and this is likely to continue with the inclusion of rugby sevens in the Olympic Games from 2016.¹⁷ Participation is particularly popular within the youth level (6–18 years old), with over 1.5 million youth players in England.¹⁸ From the ages of 14–18 years, each team comprises 15 players with match durations up to 70 min. Rugby matches are characterised by intermittent bouts of high-intensity activity mixing running and evasion with frequent player to player contact events.^{19–22}

Given the intensely physical nature of match play, match injury incidence is high in rugby.²³ There is also potential for catastrophic (permanent disability) injuries, although these are rare.^{24 25} Epidemiological studies in youth rugby have reported time-loss match injury incidence rates of 24–47/1000 player-hours, with lower limb joint and ligament injuries the most common injury diagnosis,^{26–28} injuries to the knee and shoulder region resulting in the greatest burden,²⁷ and contact situations such as the tackle presenting the greatest injury risk.^{29–31}

Sport-related injuries may lead to future reductions in health, an increase in disability and ultimately a reduced quality of life.^{32–34} A recent study demonstrated high financial costs for injured youth rugby players seeking further medical treatment following participation in a rugby tournament in South Africa.³⁵ The average cost of follow-up injury treatment in this study was estimated at US\$731 per injured player, which is higher than previously reported for high school male American Football players (US\$577) and wrestlers (US\$670).³⁶ The disruption caused by injuries on the physiological and morphological development experienced during growth and maturation also heightens the consequences of injury to youth athletes.³⁷ These findings have collectively contributed to increasing public concern about the risk of injury from youth rugby, leaving the possibility that perceptions of excessively high-injury risk might reduce further participation at the youth level.^{14 38} The formulation and implementation of appropriate preventive strategies to reduce injury incidence in youth rugby is therefore a priority.

Preventing injuries in rugby

Interventions to reduce injury risk in rugby to date have largely targeted catastrophic injuries to the head and spinal cord, which carry the most profound adverse consequences to both the subsequent quality of life of injured players and the public profile of the sport.^{39–41} This has been addressed by improving coaching standards and ensuring that the laws of the game are appropriate and consistently enforced. National initiatives such as the New Zealand Rugby Football Union's RugbySmart,^{42 43} and South Africa Rugby Union's BokSmart programmes,^{44–46} have demonstrated effectiveness in reducing catastrophic injury incidence (Relative Risk (RR): 0.6).^{47 48}

In addition to improving coaching standards, law amendments have sought to reduce the risk posed by events that carry the greatest propensity for severe injury, with a focus on game events where players engage in physical confrontation such as the scrum and tackle. Recently revised scrum engagement protocols, defined in the laws of the game, have reduced and standardised the pre-engagement distance between opposing front rows and introduced a prebind requirement, thereby reducing the high forces generated by the initial impact at engagement.⁴⁹

Interventions to reduce the incidence of tackle-related injuries in rugby have focused on the coaching of safe and effective tackle technique,⁵⁰ and consistent enforcement of safe tackle technique through employing more severe sanctions in cases of unsafe or illegal tackles. However, there is only anecdotal evidence at present to support a consequent reduction in the instances of dangerous tackling and a reduction in overall tackle-related injury risk.⁵¹

Improving the physical condition of players remains a consistent theme in the majority of recommended strategies to reduce injury risk in sport, with inadequate physical fitness cited as a common risk factor for injury.^{52 53} Preventive exercise-based intervention in youth soccer has been associated with a reduction in lower limb injury risk (RR: 0.68),⁵⁴ and knee ligament injury risk (RR: 0.59).⁵⁵ However, the efficacy of preventive exercise programmes have yet to be investigated in youth rugby. It is common for injury prevention (prehabilitation) programmes to be implemented at elite levels of rugby.⁵⁶ However, these are primarily implemented at a local level by practitioners and such programmes may only be adopted practice in a small minority of teams at youth/school level. Before such exercise programmes may be rolled out and evaluated for effectiveness in real-world contexts, their efficacy must first be demonstrated in a more tightly-regulated environment.⁵⁷

Components and features of an efficacious preventive exercise programme

From a biomechanical perspective, injury may be viewed as the result of a tissue being acutely exposed to a force in excess of its normal tolerance or a repetitive exposure to forces that may result in submaximal load becoming injurious.⁵⁸ Load tolerance is tissue-specific and dependent on the nature, magnitude and velocity of loading patterns in addition to other intrinsic player characteristics such as physical fitness and previous injury history. Preventive training strategies may reduce harmful tissue loading patterns through reducing the external forces acting through a tissue, altering posture and kinematics and enhancing a specific tissue's ability to withstand load. Exercise training interventions have been proposed as the most appropriate means to effect these biomechanical and neuromuscular changes and a consequent reduction in injury risk.^{58 59}

A recent review article by Herman *et al*⁶⁰ highlighted that efficacious preventive exercise programmes share similar characteristics such as including varied training methods, progressing exercise difficulty or volume at regular intervals, including sport-specific content, being completed at least three times per week by players and being implemented for a minimum trial period of 12 weeks. It has been indicated that adopting such comprehensive multifaceted exercise programmes may reduce injury risk, although which combinations of exercise training methods offer optimal efficiency and efficacy in reducing injury incidence is unknown.⁶¹ For instance, a recent meta-analysis of the existing literature demonstrated that programmes that were multifaceted (OR: 0.32) or focused on strengthening (OR: 0.32) or core stability (OR: 0.33) were shown to be particularly efficacious in reducing knee ligament injury risk.⁶²

Change of direction and landing are common events in rugby which place substantial external forces through lower limb joints and have previously been implicated in non-contact lower limb soft tissue injury occurrence in other field-based sports.^{63–66} In addition, injuries to lower limb structures such as the anterior cruciate ligament have previously been reported among the injury categories associated with the greatest burden in senior professional (108–186 days lost/1000 h athlete-exposure) and academy rugby players (241 days lost/1000 h athlete-exposure).^{27 67 68} Therefore, training methods that serve to improve absorption of external forces while enhancing lower limb joint position sense and muscle strength have been proposed to reduce the incidence of such injuries.⁵⁸ Lower limb proprioception and plyometric training (ie, jumping, bounding and dynamic stabilisation to enhance power and speed) have been shown to improve handling of external loads on the knee and improve joint angles during landing.^{69–72} Furthermore, these forms of training may also result in beneficial voluntary and reflexive muscle activation patterns that reduce harmful joint loading through enhanced proprioceptive feedback mechanisms.⁷³ However, the evidence associating these potentially favourable changes with injury risk reduction remains equivocal.^{74 75}

Movement feedback training for manoeuvres such as cutting and landing may also alter movement patterns and reduce potentially harmful joint forces. Feedback training involves providing qualitative feedback to an athlete according to a description of techniques that minimise their risk of sustaining an injury.⁷⁶ Previous studies have demonstrated that feedback training designed to alter torso movement and foot placement relative to the body's centre of mass and increase co-contraction of the hamstring and quadriceps may reduce knee varus/valgus loading during cutting and landing manoeuvres.^{77–82} Additional considerations for training include differences between anticipated and unanticipated actions, with the latter being associated with increases in external loading and inhibited muscle activation patterns that stabilise joints.^{83 84} Rehearsal of

cutting and landing techniques should therefore include activities that ensure players are familiar with making unanticipated manoeuvres.

Resistance training is a commonly adopted part of training programmes for many competitive and recreational athletes.⁸⁵ Previous research has demonstrated strength training alone may not alter biomechanical or neuromuscular risk factors for joint injuries,^{72 86} but may potentiate the effects of concurrent methods such as feedback training.⁸⁷

Eccentric resistance training of the posterior thigh has been associated with reductions in the incidence of hamstring muscle strain injuries in soccer (RR: 0.30 to 0.43),^{88–90} on account of correcting hamstring to quadriceps strength imbalance and altering the length–tension relationship of the hamstrings.⁹¹ Findings in professional rugby also support the use of eccentric strengthening of the posterior thigh as part of a comprehensive training programme in reducing match-related hamstring muscle injuries (RR: 0.56).⁹²

Acute traumatic shoulder injuries, such as dislocation or instability, sustained during match-related contact events have previously been associated with a high injury burden in professional (105 days lost/1000 h athlete exposure) and youth rugby players (259 days lost/1000 h athlete exposure),^{27 68} leading to calls for training programmes to be employed that serve to 'prehabilitate' the shoulder to the contact-related demands of match play.⁹³ In support of this, previous research has highlighted the use of resistance training of the upper limb to correct rotator cuff imbalances around the glenohumeral joint,⁹⁴ which has been highlighted as a risk factor for shoulder injury in rugby players.⁹⁵

The inclusion of resistance training exercises designed to address neck strength also appears warranted. Recent evidence proposes that neck strength is a modifiable risk factor for concussion,⁹⁶ with Collins *et al*⁹⁷ demonstrating that an inverse relationship may exist between concussion risk and neck strength. However, the efficacy of a neck strengthening intervention for reducing concussion risk has not yet been demonstrated.⁹⁸ Furthermore, recent evidence in youth rugby players suggests that neck strength profiles are subject to wide intra-age group variation,⁹⁹ with under-18 front-row players being shown to possess significantly lower neck strength profiles than adult front-row players despite having a similar peripheral strength profile.¹⁰⁰ Given that the under-18 age group is the last recognised youth playing age group before players may play in the front row in the adult game, this highlights the potential risk of injury to players, particularly those playing in the front row, who are transitioning into the adult game without the necessary physical capabilities. These findings collectively highlight the need for training strategies designed to strengthen the neck musculature for the dual purposes of reducing both neck injury and concussion risk.¹⁰¹

This paper outlines the research aims, study design and methodology for a cluster-randomised controlled

trial designed to evaluate the efficacy of an exercise programme in reducing injury risk in youth rugby. The study design has been devised in accordance with the CONSORT statement.¹⁰²

RESEARCH AIMS AND HYPOTHESIS

The intended aims of this study are to assess the efficacy of a preactivity movement control exercise intervention to reduce the incidence and severity of rugby-related injuries in a youth population, as well as to assess the influence of coach attitudes on compliance to the exercise programmes and the interaction of age and effect of intervention.

The primary hypothesis of this study is:

1. The incidence rate (ie, number of recorded injuries per 1000 h of player exposure), average severity (ie, number of days elapsed between injury occurrence and full return to play) and burden (ie, product of incidence and average severity) of rugby-related injuries will be reduced following 14 weeks of using the intervention exercise programme when compared with a sham exercise programme.

In addition, secondary hypotheses of this study include:

2. Coach attitudes towards injury prevention, as defined by coach responses to questionnaires given at both start and conclusion of the study period, will improve as a function of using the intervention exercise programme when compared with the sham exercise programme.
3. Coach attitudes towards injury prevention, as defined by coach responses to a questionnaire given at start of the study period, will influence compliance to the exercise programmes.
4. There will be no interaction between age and effect of intervention.

THE RANDOMISED CONTROLLED TRIAL METHODOLOGY

The study is a cluster-randomised controlled trial to assess the efficacy of a preventive exercise programme over one school playing season. The standardised field-based monitoring of injury, exposure and compliance data used in this trial will be similar to those that have been used previously in comparable study designs for other community-level football codes,^{54 103 104} and conform to the current consensus statement on definitions and data collection procedures in rugby union.¹⁰⁵ The study will also include an investigation into the attitudes, knowledge and beliefs of coaches involved in leading the exercise programmes both before and after the intervention period. This is similar to previous work undertaken for similar purposes in youth female soccer.¹⁰⁶

Each school is regarded as a cluster and there will be a number of teams within each school across several age groups that will be administered the allocated exercise programme. This has been designed in order to minimise the number of schools required to provide the

necessary statistical power for the study and to reduce the risk of contamination between the trial arms. An advantage to conducting this study across three age groups is that it will enable an initial assessment, as a secondary outcome, of the potential interaction effect between movement control training and age.

Sample size

The intervention (and sham) is to be completed at the start of both training sessions and match warm ups, with injury occurrence monitored during training sessions and matches. The Rugby Football Union regulations (the Governing Body in England) state that an under-15 fixture will last for a maximum of 60 min and under-16 to under-18 fixtures will last for a maximum of 70 min. In both cases, teams will comprise 15 players. It is anticipated that each team will contest between 12 and 18 fixtures during the winter term. In addition, each squad of approximately 20 players is anticipated to train for between 2 and 5 h per week. As a result, all included teams are likely to provide between 200 to 300 h of match exposure and 500 to 1200 h of training exposure.

This study is powered on the primary comparison of injury incidence rate between the trial arms. The sample size calculation was based on the formula proposed by Hayes and Bennett:¹⁰⁷

$$c = 1 + (Z_{\alpha/2} + Z_{\beta})^2 [(\lambda^0 + \lambda^1)/y + k^2(\lambda_0^2 + \lambda_1^2)] / (\lambda_0 - \lambda_1)^2 \quad (1)$$

Where, c=Number of clusters for intervention (the output); $Z_{\alpha/2}$ (95%)=1.96, Z_{β} (90%)=1.28, λ_0 (match injury rate in control arm)=0.035 (35 injuries/1000 h exposure), λ_1 (match injury rate in intervention arm)=0.0245 (based on 30% risk reduction); y=follow-up time per cluster (match exposure hours)=900; k (inter cluster coefficient of variation)=0.2*. *Based on the between-team coefficient of variation in injury incidence rates calculated from Palmer-Green *et al.*²⁷

λ_0 and k were calculated from the findings of a previous study investigating match injuries in a school rugby cohort consisting of 222 players, 134 injuries and an injury incidence of 35 injuries /1000 h exposure.²⁷ The required minimum sample size for the intervention trial arm is 13 clusters (schools). When matched by 13 schools in the control arm, and with an additional 7 schools in each trial arm to account for possible dropout, 40 schools will be recruited initially on randomisation with the aim of retaining 32 schools. Considering that included schools will contribute approximately 60 players each, we estimate that a total of 1920 players will participate in this study.

Recruitment

The trial will seek to retain 32 independent schools that offer rugby during the school winter term, having recruited sufficient schools to allow for an approximately

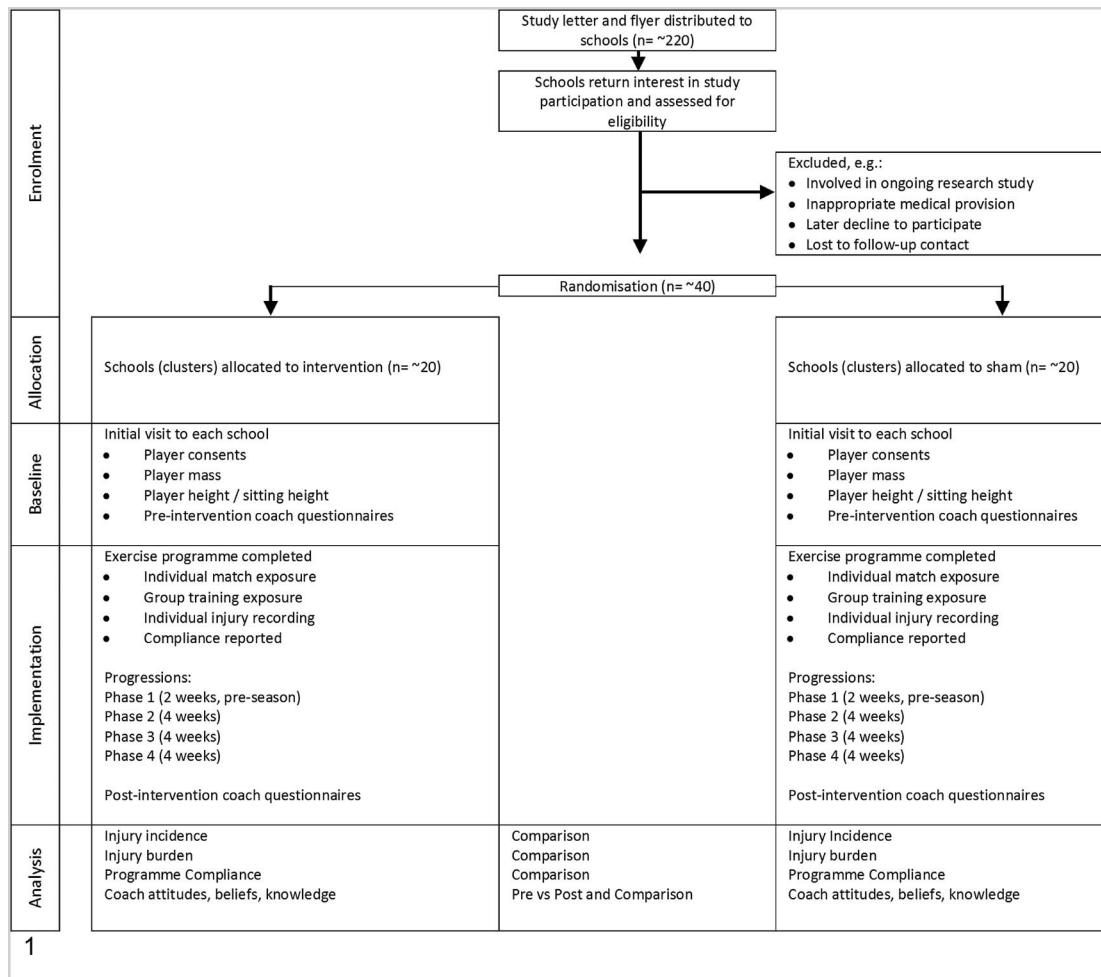


Figure 1 Timeline of the study.

25% attrition rate (figure 1). Inclusion criteria for this study stipulates that eligible schools must offer appropriate on-site medical provision for players in school years 10–13 (aged 14–18 years), while not employing training practices specifically for injury prevention purposes (other than the allocated exercise programme) during the study period. Appropriate medical provision in this case relates to the availability of on-site physiotherapists, nurses or doctors who will assess all rugby injuries occurring in the school to ensure comprehensive injury data capture. Schools that do not meet the inclusion criteria for the study will not be eligible to participate.

An initial internet search of independent schools in England yielded approximately 220 potentially eligible schools with listed contact details for at least 1 of the following members of staff: Head teacher/Principal; Director of sport, and/or Director of rugby. The list of schools will be randomised, independently of the research team, into blocks of 60 for recruitment. Initial awareness of the study will be raised through distributing electronic and paper flyers promoting the study to all schools. The research team will then follow-up initial contact by sending letters to the Head Teacher (copied to Director of Sport), subsequent email to Director of Sport and lastly phone calls to the Director of Sport/

Rugby within the first randomised block of schools. Follow-up will assess the eligibility of each school to participate as well as to explain the study more thoroughly. Each eligible school will be asked to confirm their agreement to participate in the study if satisfied with the participation agreement. If the target is not reached from the first block of 60 schools, the research team will move onto the next block of schools and repeat the process. This will continue until the target of 40 schools is reached. Once a cohort of 40 eligible schools has been recruited, the schools will be randomised (independently of the research team) into either the intervention or control trial arms on a 1:1 ratio.

Following a school confirming their participation in the study, any player who attends rugby training or matches for the year 10 (aged 14–15 years), year 11 (aged 15–16 years) and years 12 and 13 (aged 16–18 years) age groups for that school during the winter term will be eligible to participate. Rugby coach consent (in loco parentis), player assent and an opportunity for parental opt-out (not sent via the player but via school mailing lists) will be sought as part of the consent procedures. Players will also be asked to complete a short baseline questionnaire around their playing and injury history.

Trial study arms

Most rugby players will undertake a number of weekly coach-led training sessions within the school rugby environment in order to prepare appropriately for fixtures. These training sessions are predominantly composed of rugby-related games and drills with some supplementary strength and conditioning sessions, while a focus on specific preventive exercise activities is rare.¹⁰⁸ These characteristics are expected to be consistent in schools across both trial arms as the exclusion criteria for this study will preclude the recruitment of any schools that currently engage in specific preventive training practices outside of normal strength and conditioning sessions.

The intervention being trialled

The intervention exercise programme under investigation in this study will incorporate four progressive training modalities: balance/perturbation training, resistance training and a combination of plyometric training with controlled rehearsal of sport-specific landing and cutting movements with accompanying verbal feedback of technique. Phase progression will occur through a combination of increasing exercise complexity or the required volume of repetitions of certain exercises. In addition, the complexity of the programme phases will be offset by age group (ie, phase 3 of the under-15 programme will be similar in difficulty to phases 2 and 1 of the under-16 and 18 programmes, respectively) to ensure that phases are sufficiently stimulating for players. Balance/perturbation training will incorporate both static (eg, single leg balance) and dynamic (eg, hopping) components, and will progress through to balancing on a single leg with partner perturbation. Resistance training targeting the anterior and posterior thigh, trunk, upper limb and neck will follow a general pattern of beginning with isometric exercises and will progress through to concentric or eccentric exercises. Upper and lower limb plyometric training will begin with exercises designed to improve handling of eccentric loads (ie, force acceptance) before progressing to include subsequent concentric actions. The controlled rehearsal of cutting and landing manoeuvres will begin by targeting the isolated cutting and landing movements before progressing to more sport-specific and unanticipated actions. Similar coaching cues relating to maintaining lower limb and torso alignment along with co-contraction of lower limb musculature will apply to all movement actions. The intervention exercise programme was formulated in accordance with prior research that has reviewed and established the key features and underlying reasons for the efficacy of similar exercise programmes, such as regular progression or variation in programme contents and the use of sport-specific exercises.^{60 109} Where previous literature was not available, international best practice programmes were sought. This approach was complemented by consulting the evidence base of the injury profile in youth rugby in order to identify specific body

locations susceptible to injury and injury types that were felt likely to benefit from intervention. The intervention exercise programme design was approved following several virtual and one face-to-face meeting of a Technical Project Group, consisting of five injury prevention researchers, two graduate research students, one National Age-group physiotherapist, two Heads of Sport Medicine in Elite Sports Clubs and one University rugby coach. Both intervention and the sham programmes were piloted in four schools during the 2014/2015 winter term in order to inform this trial in terms of programme structure, content and delivery along with the data collection procedures. Changes to the exercise programmes and data collection practices were made following feedback provided by coaches in both trial arms on what they believed could be delivered and what they suggested should be modified for the full study.

Intervention arm: normal training+intervention exercise programme

Schools in the intervention arm will receive the intervention exercise programme in addition to continuing with usual training practices. The intervention exercise programme is designed to be completed as the initial 15 min of every training session and prior to every match, though certain exercises will be withdrawn when the programme is performed prior to matches. The coach or associated member of staff will act as a delivery agent following 'train the trainers' sessions delivered by the research team, including a demonstration of a phase 1 session by the researcher to a group of players with coaches observing. The programme is progressive with a new main phase being introduced every 4 weeks.

Control arm: normal training+'sham' exercise programme

In addition to adhering to normal training regimens, schools in the control group will be given a structured 'sham' programme that was derived from what is currently regarded as best practice in schools rugby. As a result, the programme will incorporate features of an active running-based warm-up, dynamic stretching, wrestling, mobility, with additional speed and agility-related exercises (without specific feedback instructions included in the intervention programme). The programme is structurally indistinct from the intervention programme, with each session occurring at the beginning of each training session or match preparation lasting approximately 15 min and with exercises being varied at the same integer (4 weeks for main phases). However, the exercises chosen are intended to be different from those included in the intervention programme, having been compiled from internet media searches of current warm-up practices employed by youth rugby teams. Each session will be led (again, following 'train the trainer' sessions by the research team) by the coach or associated member of staff, acting as a delivery agent.

Blinding

To minimise the risk of subversion bias in selecting schools to contact, the list of schools will be randomised and ordered by an individual external to the research team before approach and follow-up is started.

The schools will be blinded as to the allocation of trial arms, but will be briefed by the research team that they will be receiving an exercise programme to be completed prior to training sessions and matches in their under 15 to under 18 age group teams throughout the winter term. As the study is being conducted over several intracluster age groups, clustering at the level of the school should serve to preclude the risk of contamination between teams from the same school. The school-based data collectors and coaches will be unaware of the study design as a two-arm trial and should operate independently under the impression that the study is investigating the relationship between their allocated exercise programme and injury profile. Thus, the recording of injury, exposure and compliance should be blinded to the other trial arm or expectancy of outcome.

Standardisation procedures

Prior to start of the playing season and data collection, staff in schools allocated to each trial arm will be trained in the required exercise programme that they are to use. The research team will be responsible for training the school staff on their allocated exercise programme and for distributing the data collection and exercise programme materials. This will be undertaken through face-to-face practical demonstrations organised as part of centralised teacher training events, whereby the intervention or sham exercise programmes (phase 1) will be practically demonstrated to coaches. The format and layout of materials will be indistinct, with only the content of materials differing between the trial arms. Staff will also receive a filmed demonstration (available as a DVD), cue cards (snapshot images and key coaching points for each exercise) and booklets that detail the correct execution of specific exercises (with coaching points/instruction cues) for supplementary reference during the playing season. The instructions provided to the trainers in each experimental arm will be structurally indistinct.

Data collection materials will also be indistinct between the trial arms. Coaches of all individual teams will be provided with both paper and electronic copies (based on their preference) of an exposure and compliance report form to be completed on a weekly basis, detailing team-level training and individual match exposure, along with a compliance record in relation to the exercise programme. The member of staff responsible for logging and treating all reportable injuries will be provided with hard and electronic copies (depending on preference) of the injury report forms to be completed when a player visits for treatment.

In addition to completing a playing and injury history questionnaire, all consenting players will be subjected to baseline anthropometric testing (standing height, seated height, body mass and body composition) prior to start the study in order to characterise participants in the two study arms.

Data collection procedures

All data collection procedures will be tightly standardised, with the day-to-day running of the trial being coordinated by the research team, a nominated project manager at each school (typically the Director of Rugby or a graduate sports assistant), and the school medical staff.

The research team will oversee and monitor the progress of the study and coordinate the activities of the nominated project managers and the medical centres within each school. The nominated school project manager, in turn, will be responsible for coordinating the data collection of all coaches involved in the study on each site. Each coach will be responsible for collecting exposure and compliance data for their individual team. All coaches will have to attend compulsory training for the exercise programme and data collection. Detailed procedural instructions will be provided with both exercise programme and data collection materials. The use of primary data collectors in community-level sport has been demonstrated to be a reliable and valid means of collecting both exposure,^{110 111} and injury information.^{112 113}

All data will be prospectively collected by the coaching and medical staff and collated by the nominated project manager at each school. A member of the research team will visit each school on a bi-weekly basis in order to collect and collate completed exposure and injury report forms from the school project manager. In addition, the research team will visit each school on four equally spaced occasions during the winter term to meet with the school project manager, director of sport and a medical centre staff member to discuss study progress and to highlight any issues surrounding the study.

Injury and exposure data

All injuries related to participation in school rugby that result in 24 hour or greater absence from subsequent school rugby training and matches for the 2015/2016 winter term will be recorded on a standardised form. In the event that a player sustains an injury, this will be noted on the weekly exposure form (for cross-referencing purposes) and they will visit the medical staff for recording and treating the injury. This will enable the collation of data related to the location, nature, mechanism and severity of each recorded injury. All injury forms will be completed by a member of the school medical staff or by a physiotherapist where the school has one. The medical centre will be required to record and code the medical diagnosis for each injury to three levels according to the Orchard Sports Injury

Coding System (OSICS) V.10.¹¹⁴ All players will be anonymised and given a unique 6-digit alphanumeric code for identification purposes. These codes will be used on correspondence, including injury report forms.

Programme compliance

The coaches responsible for recording the weekly match and training exposure will be responsible for recording whether or not the squad completed their allocated exercise programme elements. These data will be combined with exposure data in order to produce an index of compliance for all included teams (such as a percentage of exposures where the exercise programme was completed).

Behaviour, attitudes and knowledge

Running in conjunction with the field-based data capture, the attitudes, beliefs and knowledge of coaches surrounding injury and injury prevention are to be assessed both before and after the intervention has been implemented. This will be undertaken by two paper-based questionnaires of all coaches involved in the study, one prior to study start and one shortly before study conclusion using a standardised questionnaire designed by the authors based on previous work investigating similar features.^{106 115} The questionnaire was standardised by using both polychotomous and five-point Likert response alternatives. The questionnaires will assess whether coaches in the different trial arms have differing baseline views on injuries and injury prevention in youth rugby, the extent to which these views are associated with compliance to their allocated exercise programme and whether these views are altered as a result of implementing their allocated exercise programme.

Adjustment for potential confounders

As this study is being conducted across several age groups, a possible confounder in the relationship between the exercise programmes and injury occurrence may be the age or maturity status of the players. Anthropometric data collected at baseline will be used to calculate maturation offset non-invasively using the equation developed by Mirwald *et al*.¹¹⁶ in order to control for this during analysis.

Further baseline information will ascertain the playing position, playing experience and highest playing level attained by players. Although injury incidence rate for playing groups of forwards and backs is shown to be similar,^{28 117} injury patterns appear different. Forwards sustain a greater number of contact-related injuries, whereas backs tend to sustain a greater number of running and evasion-based injuries than forwards.^{118 119} Research in Australian Rules Football has highlighted that emerging players (less than 1 year of playing experience) were subject to a greater risk of injury than established players (more than 3 years playing experience).¹²⁰ Schools age rugby in England often offers the first opportunity for adolescents to experience playing rugby

in a structured environment, and it is highly likely that a wide range of previous experience and playing levels will be found within and between age groups. Furthermore, players will be likely to experience more advanced methods of training as they progress through increasing levels of participation in rugby. A recent study by Palmer-Green *et al*.¹⁰⁸ highlighted that 16–18 year old elite academy rugby union players spent almost four times as much time on weight training or conditioning compared with school players of the same age range over two playing seasons. Such discrepancies in training experience might be expected to influence the efficacy of the exercise programme in respect of providing a necessary training stimulus to players.

A history of previous injury is recognised as a significant risk factor for subsequent injury.^{121 122} All players will be asked to report their injury history for the previous year to control for this during analysis. Injury history recall up to one year beforehand has been shown to be accurate to the degree of recalling the presence of injury, but is inversely related with the depth of requested injury information.¹²³ Players that report any time-loss injury during the previous year will be asked to provide subsequent information around the injured body location, the date the injury occurred and an approximate length of absence in days.

Coaches will play a significant role in this study as the exercise programme delivery agents. As a result, their attitudes, beliefs and motives are likely to influence their squad's compliance to completing their allocated exercise programme, with this in turn likely to influence the efficacy of the exercise programme to reduce injury. Responses to the baseline questionnaire from coaches will therefore be captured to measure and adjust for the effect of coach attitudes on injury risk.

ANALYSIS

Injury, exposure and compliance data will be collected during the entirety of the school winter term. The outcomes of greatest interest will be the injury risk associated with both trial arms, alongside the overall compliance rates during the entire study. All analyses will be undertaken with SPSS (V.22 for Windows, IBM Corp, Armonk, New York, USA) and performed on an intention-to-treat basis with the control arm as the reference group. Baseline player-related variables (eg, maturation status, anthropometric profile, playing experience, injury history) and coach-related variables (eg, coach attitudes) will be compared across the trial arms using a generalised regression model with the variable of interest as the dependent variable (linear regression for continuous variables, logistic regression for categorical variables) and the trial arm (control or intervention) as the independent variable. Poisson regression, with adjustment for clustering by school, offset for player-hours of exposure and with adjustment for the aforementioned covariates (ie, maturation status, playing

position, playing experience, level of play, coaches' attitude and previous injury history) will be used to compare overall injury incidence and injury burden (injury incidence rate \times mean absence per injury) between the trial arms. The same approach will be used to compare injury incidence stratified by severity in accordance with proposed severity thresholds (ie, minimal (2–3 days absence), mild (4–7 days), moderate (8–28 days) and severe (>28 days)).¹⁰⁵ Separate analyses will be conducted for match and training injuries. Interaction effects (eg, maturation status \times trial arm) will be examined for evidence of intervention effect modification.

The influence of compliance on injury burden will also be analysed. Compliance will be computed into two entities: coach compliance (% of exposures where exercise programme was completed) and player compliance (% of total number of players that completed the exercise programme during each exposure). The product of these two proportions will be taken forward for analysis as the total compliance.¹¹⁵ Teams in both trial arms will be stratified into tertiles based on total compliance: low, intermediate and high. Poisson regression will be used to investigate the influence of compliance to the exercise programme on the risk of injury, with the low compliance tertile in the control arm serving as the reference group.

Behaviour, attitudes, beliefs and knowledge variables will be precoded and analysed in a number of different ways. Only coaches that complete the study and provide questionnaire responses for at least the preseason questionnaire will be included in this analysis. These variables will be compared at baseline between the two trial arms and at the end of the intervention to assess any changes using both categorical and continuous data analysis. To analyse the influence of coach beliefs on compliance, linear regression analysis will be used with team compliance (%) as the dependent variable and questionnaire responses serving as the predictor variables. To investigate the influence of coach attitudes on injury burden, Poisson regression, adjusted for clustering by school, will be used with injury burden (days/1000 player-hours) as the dependent variable and questionnaire responses serving as the predictor variables. The results will be presented as RR with 95% CIs and p values. Both sets of analyses will be adjusted for coaching experience (years) and coaching level, which will be recorded as part of the preseason questionnaire.

The summary measure of injury incidence (i) will be calculated according to the formula $i=n/e$ and expressed as injuries per 1000 player-hours, where n is the number of injuries sustained during the study period and e is the sum of total exposure recorded. Injury severity will be calculated as the number of days elapsed between the date of an injury occurring and the date of full return to play. Furthermore, injury burden will be calculated as a product of injury incidence and mean injury severity and will be expressed as number of

days lost/1000 h of athlete exposure. Two-tailed p values of 0.05 or less will be regarded as statistically significant.

STUDY TIME FRAME

The primary data collection is being conducted over a 4-month (late August to mid-December) period of 2015.

- ▶ January–April 2015: Preparation of data collection and exercise programme materials.
- ▶ April–May 2015: Recruitment of schools and teams; randomisation.
- ▶ May–June 2015: Confirmation of schools' participation; training of school staff; distribution of data collection and exercise programme materials to staff.
- ▶ August 2015: Start of study; baseline player questionnaire and anthropometric data collection; baseline coach questionnaire administered.
- ▶ August–December 2015: Implementation of exercise programme; field-based injury, exposure and compliance data collection; ongoing data entry.
- ▶ December 2015: Study conclusion; coach questionnaire.
- ▶ January–July 2016: Data analysis and publication writing.

OUTCOMES AND SIGNIFICANCE

The results of several studies and review articles have demonstrated that reducing injury risk in sport is a possible outcome via training interventions, but research to date within rugby has largely yet to move beyond describing the injury epidemiology and aetiology of injuries within specified rugby populations.²³ Training-based interventions have received notable attention in recent times on account of their ability to produce favourable neuromuscular and biomechanical changes in order to reduce injury incidence.^{54 55} However, only interventions that demonstrate efficacy within controlled environments should be considered for large-scale implementation in 'real-world' contexts. Thus, efficacy trials represent a crucial step in progressing strategies to improve safe practice and reduce injury risk across sport.

Sports governing bodies may only begin to devise and implement preventive strategies at the community-level once priority injury types and evidence-based strategies for their prevention have been identified.^{16 124} Governing bodies in rugby have previously identified catastrophic injuries as priorities for prevention and have been successful in implementing evidence-based strategies to reduce the incidence of these injuries. Though not as severe, the more common musculoskeletal injuries to youth players may still carry profound implications for future quality of life and sports participation and warrant intervention, with exercise-based interventions being best-placed to achieve this. This study represents the first attempt in youth rugby to investigate the efficacy of a multifaceted movement control exercise programme to reduce injury risk in youth rugby.

There are some notable strengths of this study design and the intervention exercise programmes which it evaluates. The creation of a standardised sham exercise programme as opposed to asking teams in the control arm to maintain usual practice should serve to maintain compliance levels but will also ensure that the risk to the degree of efficacy of the intervention exercise programme will not be diluted by control arm clusters adopting a variety of training practices as part of usual regimens. The intervention exercise programme structure and content has been developed in accordance with previously efficacious programmes and international best-practice. The intervention exercise programme has the potential to reduce injury risk (through a combination of reducing injury incidence and severity) through enhancing the ability of target body locations to resist external forces placed on them. Although this study is being conducted in schools rugby, it has the potential to inform the design and conduct of future studies within the broader school sports and rugby environment. Furthermore, the intervention exercise programme under investigation represents a possible first step in the development of a more generalisable injury prevention strategy for a variety of youth contact sports, should it be proved to be efficacious in the current setting.

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