Can a cross training program improve rugby skills in adolescent male rugby players?

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"Rugby is a good occasion for keeping thirty bullies far from the centre of the city."

- Oscar Wilde (1854-1900) -

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed: ______________________ Michel Christian Marnewick

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Background

From a very young age sport has been an important part of my life. As a child I enjoyed taking part in a number of different sports including rugby, hockey, cricket, athletics, cross country and tennis. My parents stressed the importance of sport to me and it is their passion for sport which inculcated a love for sport and exercise in me. At the schools I attended, I was allowed to channel that passion into organised competitive sport at school, district, and even provincial level. I quickly learned that sport is not merely a way to pass the time, but is a combination of many things, such as exercise, relaxation, fun, and a way to maintain or improve physical and mental health as well as giving a general sense of well-being. Above all, it is a subject which needs to be approached on a scientific basis for its benefits to be fully enjoyed.

In 2002, while pondering what to study after finishing school I was injured playing rugby. The injury effectively ended my rugby career and subsequently thrust me into the awkward position of realisation and acceptance. At the age of 19 while studying sport and recreation I decided that if I couldn't play rugby, I would do everything I could to improve rugby, in all aspects of the sport, and entered AUT University as an under-graduate student with that ultimate aim in mind.

Rugby union has been my major focus since my under-graduate studies and the idea for this thesis was partly due to an "accidental" discussion with my father. The idea came about in 2006 whilst we were watching a rugby union match in South Africa. The movements of the players, the skills and the actions required for the game mirrored so many other sports: The spatial awareness and defensive patterns of soccer; the catching and passing skills of basketball; the use of teammates' body weight and the basic skills of wrestling for the ball at rucks, mauls and tackle areas; the skills taken for granted in other sports such as volleyball, rugby league, weightlifting and handball. The question arose: Could young rugby players benefit from the training regimes and techniques used in other sports to improve their rugby skills and performance?

With that discussion, the idea for this thesis was formed.

The disappointing performances by New Zealand and Australia at the 2007 Rugby World Cup only re-enforced my choice in research. Why did two such powerful rugby union nations perform so poorly? And at what level does one aim to start the process of improving the performance of an entire rugby playing nation? When I read that the Australian Rugby Union was actively searching for future Wallabies in other sports, it confirmed the initial view that other sports could be used to structure a cross-training program for rugby union. I also formed the view that if those other sports were not directly useful as cross-training regimes, they could at the very least perhaps serve to identify athletes with the potential and athletic talent required for rugby union.

Abstract

Rugby union has changed significantly since becoming a professional sport in 1995 (IRB, 2007). The sport is now played at a more intense level, with athletes requiring greater levels of conditioning and skill than ever before. The luxury of being paid to play rugby has also proved to be a major motivational factor in athletes choosing rugby as a career and in attracting young rugby players to the sport.

One only has to watch a high school first XV match to see that rugby union is now being taken more seriously and practiced at a higher level than before. Schoolboys are being identified as potential rugby stars at much younger ages and some schools actively engage in programs to identify and capture talented players from far outside their school districts. Provincial rugby unions do the same with regard to more mature players.

The Australian approach mentioned above also raises the question: Are there athletes with the potential to play rugby at provincial and even national level playing other sports right now, and not rugby union?

In coaching at school level I have witnessed many rugby players who possess the natural talent and have the physique to become very good rugby players, but unfortunately many such players lack the basic rugby skills which are needed to perform at elite level. Skills such as passing a ball equally well from either side, passing the ball accurately to a moving team member, kicking for accuracy, kicking for distance and basic decision-making skills such as when to pass, when to hold onto possession, when to kick, where to place the ball, and many other skills may be neglected by coaches when both the means and the opportunity to acquire or develop those skills are available in other sports.

Utilising other sports for rugby training could improve rugby playing performance and rugby skills.

The purpose of this study was to find whether cross training could improve male adolescent rugby skills. Three major sports (soccer, basketball and wrestling) were selected to form the base of the cross training intervention program. Pre- and post-tests were performed with the entire rugby squad (24 participants) prior to and at the conclusion of the intervention program. After pre-testing, the participants were grouped into either the intervention (12) or the control group (12). Supervised cross training sessions were performed twice a week for 10 weeks as well as traditional rugby training twice a week for 10 weeks with the intervention group. The control group performed supervised conventional rugby training twice a week for 10 weeks. All participants (24) played in a rugby match once a week during the 10 week period of the study.

The results are explained and examined in this study.

Introduction

Rugby is quickly becoming one of the most popular sports in the world. It is currently played in more than 100 countries worldwide and played from pre-primary school right through to masters level (IRB, 2007). The sport is enjoying tremendous growth in a number of developing countries such as China, Russia, Brazil and Kenya. Whilst most players play rugby simply for fun or for improvements in their physical fitness and motor skills, an ever growing number of participants set out to become elite rugby players.

Since becoming a professional sport on 25 August, 1995 (IRB, 2007) rugby has witnessed tremendous growth not only in participation numbers, but in the numbers of coaching and administrative staff required to service the sport. The resources available to the various rugby playing nations are significantly greater than before with advertising and broadcasting rights bringing in large amounts of cash. There are, however, great differences in the spread of those revenues with the top countries and competitions attracting the greatest amounts of money, as the Adidas sponsorship of the All Blacks and the multimillion dollar funding of the Tri-Nations and Six Nations competitions demonstrate.

There are obvious differences in wealth and resources between different countries, and this has an impact not only on the performance of individual players but also on the movement of players from one country to another. Thus, while certain anthropometric, physical, game-specific and motor control variables may have been the traditional or natural distinguishing features between players, the financial resources available to the rugby union player or the team now also play an important part. It isn’t too hard to imagine that in the future, countries such as Argentina and the USA, (where different football codes are more popular and have greater financial backing than rugby union), could become the rugby union world champions, but only through proper funding of the sport, and improved program development, training and coaching methods.

Rugby union and science are now also more closely linked than ever before, and like most other major sports (such as golf, soccer, tennis, athletics and swimming) the advantages of using sport and exercise science to improve performance, are often what separates the winners from the losers.

The question is, what forms of training could benefit rugby union players?

The following report will look at the use of soccer, basketball and wrestling as a means to improve rugby playing performance amongst adolescent males through the use of cross-training.

Aims

1. To determine whether a cross-training program consisting of soccer (association football), basketball and wrestling can significantly improve physical fitness parameters (more so than regular training) in adolescent male rugby players.

2. To determine whether a cross-training program consisting of soccer, basketball and wrestling can significantly improve (more so than regular training) adolescent male rugby players' perceptions of their rugby skills.

Hypotheses

1. It is predicted that a cross-training program consisting of soccer (association football), basketball and wrestling will significantly improve physical fitness parameters more so than regular training in adolescent male rugby players.

2. It is predicted that a cross-training program consisting of soccer, basketball and wrestling can significantly improve adolescent male rugby players' perceptions of their own rugby skills more so than regular training.

Applications

1. To analyse previous literature on rugby union and find the specific and non-specific determinants of rugby union success.

2. To find substantial evidence that rugby union is currently under-utilising different training methods and other sporting components as an alternative to traditional rugby training.

3. To find whether a self-efficacy questionnaire can prove beneficial in providing a guide for young athletes' perceptions of skill-specific tasks related to the game of rugby union.

4. To improve the coaching methods used by current rugby union coaches at all levels, so as to improve the quality of rugby training for players at all levels.

5. To produce research which may be taken further in the future and which may be useful to the International Rugby Board, national rugby unions, and/or provincial rugby unions.

Literature Review

> "An analysis of the demands that rugby makes on young players has revealed that the basic skills and abilities a player needs are handling (catching and passing), running, kicking, a good sprint time and endurance."
>
> Pienaar, Spamer and Steyn, (1998 p. 692)

Rugby union is made up of two 40 minute halves (at senior level) which are separated by a 5-10 minute interval. Two teams contest play, each with 15 players on the field at one time, with the exception of players being sent off for misconduct. Each player has a designated position and number outlined by the International Rugby Board (IRB, 2007). The positions and numbers are as follows: loose head prop (1); hooker (2); tight head prop (3); left lock (4); right lock (5); left flanker (6); right flanker (7); number eight (8); scrum half (9); fly half (10); left wing (11); inside centre (12); outside centre (13); right wing (14) and fullback (15), (Duthie, Pyne and Hooper, 2003; IRB, 2007).

These positions are grouped according to the demands placed on the players in each of the individual positions (Quarrie and Williams, 2002). The two major groups are players numbered 1 to 8, the "forwards" (ball winners/carriers), and the 9 to 15, the "backs" (ball carriers/distributors). Within these two groups, player 1 to 3 are referred to as the "front row", while numbers 1 to 5 are commonly called the "tight 5". Bulk and physical strength are the main attributes of the front row (Quarrie et al., 1996; Quarrie and Wilson, 2000; Duthie, Pyne and Hooper, 2003). The "second row" is formed by the locks (numbers 4 and 5), usually the tallest players in the team (Quarrie et al., 1996). The "loose forwards" are players 6 to 8 and are also referred to as the "back row" as they form the final row of players in a scrum. They are required to have both bulk and speed (Quarrie et al., 1996; Quarrie and Wilson, 2000). Within the backs, "half backs" are players 9 to 10, while the "midfield backs" are players 12 and 13. The half backs are required to have good handling skills in both catching and passing and in kicking, while the midfield backs are players with equal ability in defence and attack (Quarrie et al., 1996). The "outside backs" or "back three" (11, 14 and 15) are referred to as such because they play wider and from further back than the other players and their speed is an important factor (Quarrie et al., 1996; Quarrie and Williams, 2002).

The literature on the subject recognises these distinctions. Each of the positional groups' (forwards and backs) broad physical requirements, skills and tasks are specific to the role which they play within the team (Maud, 1983; Quarrie et al., 1996). The front row positions demand strength and power as the players are required to gain possession of the ball, lift other players (lineouts), are in continual close contact with the opposition, and have limited opportunities to run with the ball (Duthie, Pyne and Hooper, 2003). The main prerequisite for locks is that they are tall, with a generally large body mass and power an additional advantage (Quarrie et al., 1996; Duthie, Pyne and Hooper, 2003). The loose forwards require strength and power as it is a requirement of players in these positions to gain and retain possession of the ball. It is also a prerequisite for the loose forwards to be powerful and mobile in open play, have excellent speed (to reach rucks and mauls, and offer their support to other players), acceleration and endurance (Maud, 1983; Quarrie et al., 1996).

Aerobic endurance is required by the half backs as they control the possession of the ball obtained by the forwards and also need to arrange the backline at scrums, rucks and mauls. To be able to do this, they must be able to keep with play. Good speed is also an important attribute for the half backs, as they need to accelerate away from approaching defenders (Duthie, Pyne and Hooper, 2003). Vision, communication and overall ball skills are crucial in any half back pairing as these players offer the link between the forwards and the backs. Midfield backs require strength, speed and power as they have a high frequency of contact with the opposition. Larger body size can also be beneficial in these positions. Vision and communication in the midfield backs are also important in selecting the right options when on attack. Outside backs require considerable speed to out-manoeuvre their opponents. They perform a large amount of support running, chasing down kicks and covering in defence (Maud, 1983;

Quarrie et al., 1996; Quarrie and Williams, 2002; Duthie, Pyne and Hooper, 2003).

It is clear that there is a diverse range of physical attributes among rugby union players. A distinct physique will naturally orientate a player towards a particular position rather than others (Quarrie et al., 1996). According to Duthie, Pyne and Hooper (2003), "this makes rugby union an atypical sport when compared with a number of other team sports where homogeneity of physique and physical performance attributes are more common".

Determinants of rugby union success

Rugby union success is determined by two not entirely discrete sets of factors, namely those peculiar or unique to the individual athlete (intrinsic factors) and those contributed by external factors such as the availability of professional coaching and facilities (extrinsic factors). It would appear that internal and external factors combine to produce success at rugby union and that both factors are required for success at the higher levels of competition.

Intrinsic Factors

The trends in physique in rugby union are similar to physical changes in several other sports. The increase in size in athletes at a rate greater than international standards occurs selectively in sports where size dictates a competitive advantage, provided an appropriate proportion of fat-free mass is retained (Olds, 2001; Duthie, Pyne and Hooper, 2003). Height, is advantageous in sports involving jumping (basketball, volleyball, rugby union, AFL, rugby league), while body mass is advantageous in contact sports (such as rugby union, rugby league, wrestling and American football) and sports involving throwing and lifting (shot put, wrestling, American football and weightlifting). Interestingly, the rate of increase in body mass in American football players accelerated sharply at about the same time (1975) as in rugby union (Norton and Olds, 2000). This acceleration may have been due to increasing professionalism, the popularisation of resistance training or even the use of anabolic steroids.

Several factors which are peculiar or unique to the individual rugby player and play a role in determining the degree of success with which a player can play the game are discussed below.

Body Mass

There have been major changes in the body mass of elite rugby players over the last 30 years (Olds, 2001). Consequently, literature older than ten years may have limited application to current-day rugby players (Duthie, Pyne and Hooper, 2003), especially with increased professionalism and the physical demand of top level rugby union constantly progressing. The body mass of rugby players is generally greater than international players of soccer (77.5kg ± 1.3kg) (Bangsbo et al., 1991), basketball (90.8kg ± 11.8kg) (Boyle, Mahoney and Wallace, 1994) and field hockey (75.0kg ±5.4kg) (Boyle, Mahoney and Wallace, 1994). In rugby union, a larger body size correlates significantly with scrummaging force (Quarrie and Wilson, 2000) and competitive success (Olds, 2001). Where extra mass consists of fat rather than lean tissue, the power-to-weight ratio is reduced, energy expenditure is increased, and horizontal and vertical acceleration are diminished (Withers, Craig and Norton, 1986).

Differences in body mass have been observed within the forwards and backs as discrete groups (Bell, 1973; Bell, 1980; Nicholas and Baker, 1995; Quarrie et al., 1996). For example, body mass was significantly lower (89.7 ± 8.1kg) in senior A hookers compared with props of the same level (102.8 ± 8.1kg) (Quarrie et al., 1996). Within the backs, inside backs had a substantially lower body mass (75.0 ± 6.9kg) compared with midfield (85.9 ± 6.9kg) and outside backs (83.4 ± 6.9kg) (Quarrie et al., 1996). These differences are particularly evident when the large range of player roles within each of the groups is considered (Duthie, Pyne and Hooper, 2003).

In recent years the greater mobility of the forwards has been associated with lower body fat levels and higher lean body mass (Olds, 2001). Apart from physical qualities, elite players must possess excellent technical and motor abilities (Duthie, Pyne and Hooper, 2003). One example of improving stability, especially in contact situations, is by lowering the centre of gravity and widening the base of support, thus giving greater lower body mass (McKenzie, Holmyard and Docherty, 1989). Given that mass influences stability (Hay, 1993), a large lean body mass will assist playing technique.

Height

Differences in stature (standing height) among the various positional groups in rugby union are unclear (Duthie, Pyne and Hooper, 2003). Recent literature has demonstrated that county and international forwards and backs have similar stature (Olds, 2001). Conversely, others have shown that both first- and second-class forwards are markedly taller than backs of the same level (Nicholas and Baker, 1995; Quarrie et al., 1996; Nicholas, 1997). It would be fair to assume that elite level rugby players have greater stature than non-elite rugby players, since stature is a pre-requisite at higher levels of performance, especially in the forwards.

The higher the level of competition, generally the taller the players are. For example, senior A forwards (1.86 ± 0.06m) were taller than their senior B counterparts (1.81 ± 0.06m) (Quarrie et al., 1995). Within the forward pack, there are significant differences in height between front row, second row and back row players, (Nicholas and Baker, 1995; Quarrie et al., 1996; Nicholas, 1997), with hookers (1.79 ± 0.03m) being significantly shorter than locks (1.92 ± 0.03m) (Quarrie et al., 1996). Such variation in stature is also present in the backs with the inside backs (1.73 ± 0.05m) markedly shorter than the midfield (1.80 ± 0.05m) and outside backs (1.79 ± 0.05m) (Quarrie et al., 1996). These differences in stature are all based on the positional roles and requirements of the players.

At higher playing levels, there is a clearer distinction in stature between the forwards and backs. The positional demands of rugby union require certain characteristics and this is particularly evident for the lock position in which the overall jump height achieved during the lineout is crucial to success (Duthie, Pyne and Hooper, 2003). Locks have similar relative vertical jump performance to other forwards and are inferior when compared with the backs (Maud, 1983), however, this is probably due to their greater body mass and body fat levels. Their greater height allows locks to achieve a superior absolute jumping height in the lineout, where relative jumping height serves no real purpose, especially since locks achieve their reaching height through the assistance of other forwards lifting them during the jump phase. Locks (1.92 ± 0.03m) (Quarrie et al., 1996) appear to be the only position that has superior stature to other team field sports such as soccer (1.83 ± 0.01m) (Bangsbo, Norregaard and Thorso, 1991) and field hockey (1.77 ± 0.03m) (Boyle, Mahoney and Wallace, 1994), while being similar to basketball players (1.91 ± 0.10m) (McInnes et al., 1995).

Percentage Body Fat

The majority of anthropometric assessments of rugby players have involved quantifying the body fat levels of players (Duthie, Pyne and Hooper, 2003). The calculation of percentage body fat can be somewhat problematic due to limitations in establishing percentage body fat from estimates of body density and skinfold measurement (Martin et al., 1985).

Despite some conflicting results, the general consensus is that body fat levels decrease with higher levels of play (Duthie, Pyne and Hooper, 2003). This may reflect the different training and dietary requirements of higher level rugby teams (Burke, Gollan and Reid, 1986). In a study by Mayes and Nuttall (1995), it was found that there were no substantial differences in the estimation of body fat between senior (15.1 ± 3.5%) and under 21 (15.6 ± 4.0%) players. Alternatively, earlier data on first-class players demonstrated that forwards (11.1 ± 1.2%) had a lower percentage body fat than their second-class equivalents (13.3 ± 1.0%), (Rigg and Reilly, 1988). The differences in percentage body fat may reflect the higher training levels and more favourable dietary practices of elite players. The lower body fat of the backs (10.0 ± 2.3%) (Carlson et al., 1994) may also reflect the higher speed requirements of these players. Body fat values for backs are similar to other sports such as soccer (9.1 ± 1.1%) (Toriola, Salokum and Mathur, 1985), field hockey (12.4 ± 2.4%) (Boyle, Mahoney and Wallace, 1994) and track sprinters (9.7 ± 1.7%), (Toriola, Salokum and Mathur, 1985). While additional body fat may serve as a protective buffer in contact situations, (Bell, 1973) it is a disadvantage in sprinting and running activities. Given the different demands for forwards and backs, it is not surprising that body fat differs between these positions (Duthie, Pyne and Hooper, 2003).

Muscle Strength and Power

Strength is the maximal force produced by a muscle or muscles at a given speed (Hamill and Knutzen, 2003). Power is the product of force (strength) and velocity (speed) (Hamill and Knutzen, 2003). Rugby performance requires high levels of muscular strength and power for success, particularly for the forwards in scrums, rucks and mauls, and for backs in sprinting and tackle situations (Carlson et al., 1994; Mayes and Nuttall, 1995).

Given that muscle strength is required during the contact situations in rugby, (Reilly, 1997) forwards should possess greater absolute strength than backs. When evaluated on a range of strength tests, collegiate forwards and backs performed essentially the same, (Tong and Wood, 1997) possibly attributable to the young training age of the athletes. The notion that forwards require more strength and backs require speed was supported by Miller et al., (1996), who found that international forwards produced greater force at low isokinetic speeds compared with backs. In contrast, the backs produced greater force at higher speeds and their results were similar to those of international track sprinters (Miller et al., 1996).

Speed

Running speed and acceleration are essential requirements in any playing position, as players are often required to accelerate to take a position nearby or sprint over an extended distance. Backs achieve similar sprint times to track sprinters over distances of 15 and 35 metres (Dowson et al., 1998). Rugby players typically sprint between 10-20 metres (Docherty, Wenger and Neary, 1988; Deutsch et al., 1998) and have been tested over distances of up to 100 metres (Rigg and Reilly, 1988; Carlson et al., 1994; Quarrie et al., 1995; Quarrie et al., 1996).

It has been shown that first-class rugby players are marginally faster than their second-class counterparts (Rigg and Reilly, 1988). It is no surprise that backs have also been shown to be faster over 20 and 50 metres, 30 metres, and 40 (36.6 metres) and 100 (91.4 metres) yards, (Maud, 1983; Quarrie et al., 1996; Dowson et al., 1998) than forwards, especially since forwards have greater body mass and higher body fat levels.

These results indicate that speed is a discriminating factor between forwards and backs, highlighting the need for specialised sprint training programmes for the different playing positions (Duthie, Pyne and Hooper, 2003).

Muscle Fibre Type

It is well established that athletes requiring either high speed or very good endurance have a different proportion of fibre type in the muscle (Jardine et al., 1988). For rugby players, similar distributions of fast twitch fibres in the vastus lateralis (lateral quadriceps) have been found between forwards (53 ± 5%) and backs (56 ± 4%) (Jardine et al., 1988). In comparison, the vastus medialis (medial quadriceps) and gastrocnemius (upper calf) muscles of ice hockey players and track sprinters were 55-60% fast twitch fibres (Jardine et al., 1988). Soccer players have percentages of fast twitch fibres ranging from 40-51% (Bangsbo, Norregaard and Thorso, 1991). The limited information available on the distribution of muscle fibre types of rugby players suggests similar characteristics to other team sports, with a trend to greater proportion of fast twitch fibres than the running-based sport of soccer (Duthie, Pyne and Hooper, 2003).

Self-Efficacy

> "Self-efficacy theory is a social-cognitive approach to behaviour that takes into account behavioural, physiological, and cognitive factors, as well as environmental influences."
>
> Weigand and Stockham, (2000 p. 62)

Determinants of rugby union success are not limited to physical factors. Specific and non-specific factors can all lead to the development of skill in young athletes. According to Roberts (1992), "the theory of self-efficacy has been the most extensively used theory for investigating motivational issues in sport and exercise". Self-efficacy is essentially a person's belief in their ability to succeed in specific situations. The theory developed within Albert Bandura's social cognitive theory framework, poses self-efficacy as a common cognitive mechanism for mediating people's motivation and behaviour (Smith and Bar-Eli, 2007). A person's sense of self-efficacy can play a major role in how he/she would approach tasks, challenges and goals. Self-efficacy stresses the role of observational learning and social experience in the development of personality. According to this theory, people with higher self-efficacy are more likely to view difficult tasks as something to be mastered, rather than something to be avoided. For example, an experienced rugby goal kicker will have greater self-efficacy levels than an inexperienced rugby goal kicker as the experienced kickers will have performed the skill more frequently, and thus become more confident in their own ability to handle the task and the pressure associated with the task.

In strength and conditioning research it is difficult to find studies that have incorporated a psychological aspect into the measures as well (Cox, 2002). Using a self-efficacy tool during data collection in any physical measure could prove useful in determining when the most suitable time would be to perform testing with participants. According to Bandura's theory, expectations of personal efficacy are derived from four principal sources of information, they are; performance accomplishments, vicarious experiences, verbal persuasion, and physiological arousal (Smith and Bar-Eli, 2007).

In the sport literature, self-efficacy researchers have typically correlated aggregate self-efficacy scores with aggregate performance scores rather than examining the similarity between self-efficacy and performance at the level of individual tasks (Wurtele, 1986; Smith and Bar-Eli, 2007). This could in part be due to the nature of the tasks used in sport. In most sports studies, subjects' efficacy expectations and performance have not been assessed in terms of the approach/avoidance to a series of tasks that increase in difficulty. Rather, subjects have been asked about their confidence beliefs concerning a single task in terms of how long or at what height they can perform and then are asked to attempt that task in two or more trials (Smith and Bar-Eli, 2007). There is growing support, however, for position-specific and task-specific self-efficacy measures. Several studies (McAuley and Gill, 1983; Gayton et al., 1986) have shown that particularised measures of self-efficacy have greater explanatory and predictive power than global measures. Thus, the use of position and task-specific self-efficacy measures/questionnaires could prove to be far more beneficial in the analysis and quantifying of self-efficacy levels in athletes.

In a study by Weigand and Stockham (2000), the measurement of self-efficacy was tested among 110 British female field hockey players in either a first, second or third division team. Based on responses from the participants during the pilot study, self-efficacy was assessed by having players record the level to which they thought they were capable of performing eight tasks considered to be major components of the game and task-specific to forward (three items), defensive (three items) and midfield (two items) positions. The results showed significant differences between positions and divisions when position-specific self-efficacy was assessed. These results showed support for Bandura's belief (Weigand and Stockham, 2000) that the measurement of self-efficacy should be carried out in a micro-analytical manner by assessing task-specificity. Instead of measuring cross-skill efficacy expectations, it would be more beneficial to take into account the potential ability differences between individuals at different positions and assess skill-specific self-efficacy.

The assessment of task-specific self-efficacy measures has typically been performed via questionnaire (Weigand and Stockham, 2000; Hepler and Chase, 2008), but there appears to be limited research in this area with young athletes. Specifically, using a self-efficacy questionnaire in a young sports team could prove difficult, since young adolescent males are often influenced by their teammates, peers and the results of their rugby matches. The potential for a useful, current and position-specific self-efficacy template in rugby union could prove beneficial in the future and may improve the level of accuracy currently used in self-efficacy.

Extrinsic Factors

There are also several extrinsic factors which may have an impact on the performance and degree of success of an individual player. In the context of this thesis, these factors are considered extrinsic because they are controlled or contributed by persons other than the player and they relate mainly to the quality of coaching, training and other support facilities available to the player.

These factors are not entirely separable from the intrinsic factors discussed above and often work hand in hand with the physical attributes of the individual player to improve his or her rugby union performance. Nevertheless, it is in these external factors that the quality of the coaching and other support staff and facilities available to a player may make a significant contribution to the players' success.

Fitness Training

It has been shown that first-class rugby union players have superior muscular strength, power and endurance to second-class players (Gabbett, 2000). Significant differences have also been reported between elite and non-elite Gaelic football players for speed, aerobic power and muscular power (Gabbett, 2000; Gabbett 2002a). These results suggest that fitness requirements differ according to the level of competition. These findings however, may also be attributed to the poorly developed training habits of non-elite football players (Gabbett, 2000). Specialist fitness training may therefore be used to break the pattern of poor training habits to enhance the performance of sub-elite level players.

Athletes may not have the ability to increase their height or segment length, but crucial changes in muscle mass can be noted in a number of cross-training intervention studies (Hennessy and Watson, 1994; Gamble, 2004; Doan et al., 2006; Gabbett, 2006). Physical factors that can be improved include: speed, power, strength, endurance and agility (Hennessy and Watson, 1994; Gamble, 2004; Doan et al., 2006; Gabbett, 2006). Additionally, the ability to increase lean muscle mass and muscle cross section are factors which may improve a rugby player's performance and prevent injury. These factors are all important in rugby union, regardless of the level of performance or the position which the athlete plays.

Training loads and methods

The fundamental physiological skills required for rugby union include strength, speed, anaerobic power and aerobic capacity. Recent changes to the professional game have increased the amount of time spent with the "ball in hand", thus creating longer periods of open or running play (International Rugby Board, 2007). What this means for rugby players is that they may now find themselves performing up to 5% greater aerobic work during a rugby match than before. Even though the new rule changes to rugby union have caused greater workloads on the players, the fundamental physiological skills required are still very similar. The only additional increase may have to be made to players' aerobic endurance, as the ball is in play more, but this idea is only relevant at provincial (Air New Zealand Cup and Super 14) and international level (Tri-Nations only) where the new Experimental Law Variations (ELV's) have been used (IRB, 2007). This highlights the fact that rugby players at elite levels should now have to increase their training loads and vary the training methods, specifically in aerobic endurance.

Diet

Different dietary and training strategies within a season elicit variable changes in body composition of athletes (Burke, Gollan and Reid, 1986). In rugby, desirable changes in body composition (increases in lean mass and/or decreases in skinfolds) occur primarily during preparation for competition when training volume is high (Burke, Gollan and Reid, 1986). Longitudinally, the annual increase in body mass for rugby players from 1905 to 1996 was well above secular increases (Olds, 2001). The greater increase is attributed to improved selection procedures, specialised training, new techniques, better equipment and facilities, and greater attention to athlete support (Olds, 2001).

Resistance Training

At amateur level the role of resistance training can play an important part in an athlete's development. However, there are some limitations to gym based training, including: expense, time limits and the age of the athlete. All these factors need to be considered when aiming to develop the strength and power of young athletes.

At club and school level it is often the fittest rugby team that wins the match. Coaches are constantly looking for new training methods which will give their teams a physiological advantage over the opposition. For this reason, a cross-training program that improves physiological skills may be beneficial for the sport and could be modified according to the different levels of performance and the ages of the rugby players.

Skill-based Conditioning

Skill-based conditioning refers to training which simulates not only the sport for which a team or athlete is training, but also simulates games and fitness from other sports. Traditional conditioning refers more to the systematic training of skills through drills and repetition. The skill-based conditioning games approach emphasises movement specificity to a greater extent than do traditional conditioning methods (Gamble, 2004). This is significant, as the more specific an activity is to the training mode in which endurance gains are made, the greater the degree to which those gains are expressed (Durstine and Davis, 2001; Wilmore and Costill, 2004). For example, a simple game such as "tag" can teach players to move away from a defender and move into space, both skills which are crucial in rugby union. The games format requires players to react to the movement of both teammates and opponents as well as to the movement of the ball (Gamble, 2004). By doing so, the conditioning games mode of training incorporates the changes in direction and velocity and the "utility" movements (lateral and backwards movements) that are features of any rugby union match or other team sport (Gamble, 2004). Not only are the benefits of such games related to skill, but they are also more fun than repetitive drills. Basketball, cricket, soccer and netball sessions have all been used by rugby union and rugby league teams to improve overall ball skills and hand-eye coordination (Mercer, 2001).

In young rugby players it is often the physically larger players who are selected for rugby teams. The idea of selecting smaller multi-skilled adolescent rugby players, rather than bigger less-skilled adolescent rugby players is an idea which is still new to many coaches. By improving a young rugby player's skill level one could provide that athlete with the skills needed to become a professional rugby player. Some current international rugby players, specifically backline players and a few forwards, are examples of rugby players who possess tremendous rugby skills, but not a great deal of stature or mass. It raises the question of why there is such a lack of quality cross-training programs for adolescent rugby players. A cross-training program which develops and improves young rugby players' rugby skills could provide greater developments than just strength and conditioning programs or weight training programs. The answer may be that most coaches are concerned that changing a style of their coaching or incorporating something new into trainings, could affect playing performance.

Age specific analysis and coaching

A 2005 study by van Gent and Spamer identified the anthropometric, rugby-specific skill, and physical and motor component changes between under 13, under 16, under 18 and under 19 elite rugby players. The data provides substantial evidence that the majority of anthropometric, physical and motor skill changes occur between the under 16 and under 19 groups. What this means is that in the three years between these age groups, players are most susceptible to change physically and mentally. Subsequently, this age frame could be the most fragile time in the development of a potential elite rugby player.

In the under 13 group, players were predominantly of similar anthropometric build whilst the major differences were in the motor skill differences between forwards and backs. Backline players showed greater skill in terms of rugby-specific skill components than the forwards.

In the under 16 groups, forward and backline players were found to have few differences of anthropometric components. It also proved that at this age the coach can still change a forward to a backline player and vice versa. At this age group the results showed there were not many differences between the tight and loose forwards in terms of physical and motor components. The backline and halves (inside backs) showed significant differences in more components, which suggests that these groups need specific physical and motor component training.

There is a significant role for coaches to play in this regard. Rugby coaching between the ages of 13 and 18 needs to focus more on skill development, rather than repetition of drills and set pieces. Improving young rugby players skills may prove beneficial, especially while they will be going through puberty and large physiological and anthropometrical changes.

Profiling

With growing analysis in rugby union, the ability to develop position-specific performance indicators has created better profiling for different playing positions. Performance indicators can include; successful tackling, unsuccessful tackling, successful passing, unsuccessful passing, handling errors, tries scored, successful kicks, unsuccessful kicks and penalties (James, Mellalieu and Jones, 2005). Within these factors the ability to specify more performance indicators is also possible, for example, successful kicks can be related to penalty kicks, kick restarts and kicks in play. Performance indicators have improved the specificity of a rugby player’s role within the team, but at the same time have increased the expectation of any player, at most levels of performance.

Limitation in data collection and research

While there is no shortage of rugby union studies regarding physical, anthropometric and physiological data, there are some gaps in the literature regarding young rugby players and cross-training programs for rugby union players. While many studies elicit results in under 19 and collegiate age rugby union players, very few have analysed data from school age rugby players or age groups below under 19 level. The findings of the studies which did analyse young rugby players proved to be insufficient and none have presented the idea of cross-training programs for adolescent aged rugby players.

Spamer and de la Port (2006) showed the various anthropometric and physiological changes in under 18 and under 16 rugby players, but their work did not include any data with younger rugby players of similar ability or standard. The study by Spamer and de la Port (2006) was also concerned with elite schoolboy rugby players only and provided no comparison with sub-elite schoolboy rugby union players.

The work of Pienaar, Spamer and Steyn (1998) specifically analysed the rugby performance of 10 year old boys. While this study did work with younger rugby players than the norm, it provided no follow-up studies to show changes in performance.

As well as the work of Pienaar, Spamer and Steyn (1998), Van Gent and Spamer (2005) is one of the few studies that has focussed on younger age groups (≤ 18 years) in rugby union, although the study was more concerned with anthropometry and physical changes, rather than physiological or motor-skill development.

Regular training practices in rugby union

The differences between training methods in rugby union can be classified into two major groups; elite and amateur level. Within these two factors are a multitude of variances in regards to training intensity, training frequency, training specificity and training mode.

Elite level

Training intensity

The training intensity of elite rugby union players is dictated largely by the duration of the season, timing of the season and positional requirements of different players (Gabbett, 2005b).

Training frequency

The training frequency at elite levels of rugby union may not be as high during the competitive season as it is at amateur levels. A major reason for this is the off-season and pre-season training which elite level rugby players take part in (Gabbett, 2005b), whereas at amateur level the majority of training is done throughout the competitive phase of the season (Deutsch et al., 1998). During the competitive phase at elite levels the majority of rugby union training focuses on maintaining strength, power and endurance while improving rugby playing skills such as passing, tackling, evasive running and communication (Duthie, Pyne and Hooper, 2003; Gabbett, 2003b). At amateur levels the competitive phase is used for increases in strength, power and aerobic endurance, rather than maintaining fitness standards alone (Duthie, Pyne and Hooper, 2003).

Training specificity

Exposure to the elite level in any sport provides athletes with greater training knowledge. Professional rugby unions have systems and staff in place which give rugby players access to educated trainers who can provide information and position-specific rugby conditioning. The experience which can be gained merely from training with a representative rugby team is something which would enable an athlete to train more smartly and more efficiently unsupervised. Strength and power training at elite level will only focus on around three sessions per week, focussing on multi-joint and free weight exercises (squats, deadlifts, lunges, box jumps, bench press, pull-ups) rather than single joint, machine based exercises (dumbbell curls, quadriceps extensions, hamstring curls), (Gabbett, 2003b).

Training mode

At elite level rugby union, the variety of training methods available to rugby union players is vastly different to that of amateur rugby players. Elite rugby players are trained by strength and conditioning professionals who are aware of periodisation and peaking. The access to such professionals also enables elite level rugby players to incorporate the latest training methods into their own or unsupervised training sessions. While resistance and cardiovascular training make up the bulk of pre-season training (Gabbett, 2003b), there are the additional benefits of skill-based games which add the element of fitness and fun to any training.

Amateur level

Training intensity

Amateur rugby players often make the mistake of over-training (Gabbett, 2003b). This is largely because of the belief that "more is better" when it comes to strength and conditioning, a theory which is not always true. Adequate rest periods are crucial in gaining optimum results from strength and conditioning (Adams et al., 1992; Baker and Nance, 1999a; Olds, 2001; Wilmore and Costill, 2004) and this fact is largely unknown amongst amateur rugby players (Gabbett, 2000; Gabbett, 2003b) or athletes with limited exposure to elite level training methods. This difference could inhibit actual increases in strength and conditioning, and affect the goals and performance of the athlete.

Training frequency

At amateur level in rugby union, the frequency of training is entirely in the hands of the individual, unless there are systems available to the players which allow them to train with a group or with a trainer. The major factor that this brings into consideration is a player's motivation to train, whether it be intrinsic or extrinsic (Cox, 2002). As previously highlighted (Mayes and Nuttall, 1995; Duthie, Pyne and Hooper, 2003), there are major differences in body fat levels between elite and amateur rugby players and this could be largely due to the motivation to train, the availability to train and having the finances required to join a fitness centre or gym, especially amongst lower socio-economic individuals (Cox, 2002).

Training specificity

The specificity of amateur rugby players' training is often the major difference between elite and sub-elite performers (Gabbett, 2003b). Amateur rugby players only have limited access to strength and conditioning professionals and this may sometimes come at a financial cost, another limiting factor in itself (Cox, 2002; Gabbett, 2003b). Most amateur rugby players are aware of the training requirements for rugby union, but it is seldom that there are dedicated programs in place for young amateur rugby players to make the most of their strength and conditioning training sessions, if they have any. Additionally, amateur rugby players may not be aware of the specific strength and conditioning training required for their playing position.

Training mode

Skill-based conditioning is a relatively new idea by amateur standards and this form of training is not yet well known by most rugby coaches. The majority of amateur rugby conditioning centres on resistance training in a fitness centre and some cardiovascular conditioning through running, cycling or swimming (Duthie, Pyne and Hooper, 2003).

Cross-training

Cross-training is defined by Moran and McGlynn (1997) as "using another sport, activity or training technique to help improve performance in the primary sport or activity".

Cross-training has been used in one form or another throughout the history of sport (Moran and McGlynn, 1997). In ancient Greece, strength training was used to enhance athletic performance in the predominant sports of the day; discus, javelin, sprinting, and wrestling – all sports requiring speed, strength and power. Today, athletes in a number of sports, from volleyball to wrestling, condition themselves with activities such as running, lifting weights, swimming and rope jumping (Moran and McGlynn, 1997). Athletes in almost all modern sports use weight or resistance training to improve their performance.

During the past 20 years, sport scientists have agreed that the most effective mode of training for preparing athletes for competition is that which most closely replicates competitive performance conditions, (Gamble, 2004), which is the central idea of “training specificity” (Durstine and Davis, 2001; Wilmore and Costill, 2004). This has led to growing interest in sport-specific methods to condition athletes for team sports. Conditioning drills that incorporate skills and movements specific to the sport are increasingly implemented, with the aim of simulating the movement patterns and metabolic conditions encountered during competition (Lawson, 2001; Meir, Colla and Milligan, 2001).

Traditional conditioning activities refer to continuous and intermittent running activities, power activities and agility activities, all of which are aimed at improving speed, aerobic fitness, lactate tolerance, muscular stretch-shorten cycle (plyometrics), and developing mobility and agility (Gabbett, 2006).

In team sports, skill-based conditioning games refer to continuous games played with two or more teams, with equal or unequal numbers, on a modified field, with modified rules and involving defence, passing, catching, multiple repeated sprints, and rapid changes in direction. These factors aim to improve ball control, defensive skills, decision making and strategic thinking, speed, agility, aerobic fitness and lactate tolerance (Gabbett, 2006).

As the cross-training methods of athletes improve conditioning and physique, the physical ability of athletes is also becoming greater and more apparent than ever. Physique however, is not the only factor that determines sporting success. In sports such as soccer, the size and shape of players are very similar to those of the general population (Norton and Olds, 1996). Apart from goalkeepers, no particular height or body mass confers an advantage in soccer (Norton and Olds, 1996). Other characteristics, such as motor skill and cognitive factors, are presumably more important. These factors are typically less obvious and less measurable than body size and shape (Olds, 2001).

Evidence has shown some form of benefit from cross-training in most major professional sports and even recreational fitness activities worldwide such as running and swimming (Hennessy, 1994; Johnston et al., 1997; Moran and McGlynn; 1997, Doan et al., 2006). These improvements have also been recorded across various levels of athletic performance and different skill levels of participants (Hickson et al., 1988; Haennel et al., 1989; Paavolainen et al., 1991; McCarthy et al., 1995; Johnston et al., 1997; Bishop et al., 1999).

Cross-training has been used in long distance running performance for many decades with even recreational athletes knowing that different forms of training such as swimming, trail running and sprinting could benefit long distance running performance. Research by Jung (2003) has highlighted the benefits of cross-training techniques on distance running performance. It was assumed that if some benefit could occur as a result of resistance training, running economy, lactate threshold, or anaerobic characteristics would likely be affected. The evidence seems to suggest that resistance training may improve VO_2 max and lactate threshold in aerobically unfit individuals, but these factors are unlikely to occur in endurance runners who already have a high VO_2 max.

A number of studies have found different duration periods for various cross-training programs in different sports. These periods range anywhere from six weeks (Hickson et al., 1988; McCarthy et al., 1995; Johnston et al., 1997; Hoff et al., 1999) to 20 weeks (Gettman et al., 1978), depending on the type of sport, the length of the competitive season and the effectiveness of the cross-training program. The criteria of a number of cross-training studies are highlighted in Table 1.

Table 1: Cross-training studies; subjects, frequency, duration and volume of training

STUDY	SUBJECTS	FREQUENCY & DURATION	VOLUME	TYPE OF TRAINING
Hickson et al., (1988)	8 trained males & females	3d/wk for 10 wks	3-5 sets of 5 RM	Power training
Haennel et al., (1989)	32 untrained males	3d/wk for 9 wks	3 sets of 15-20 reps; circuit training	Circuit training, strength endurance
Paavolainen et al., (1991)	15 elite male cross-country skiers	6 wks	15-90min/session	Cross-country ski training
Hennessy et al., (1994)	56 club rugby players	3d/wk for 8 wks	2-6 sets of 5-10 reps	Power, strength training
McCarthy et al., (1995)	30 untrained males	3d/wk for 10 wks	2 sets of 6 RM	Power & endurance training (cycling)
Bishop et al., (1996)	16 active, untrained males	3-4d/wk for 6 wks	3-6 sets of 1-15 reps	Power, strength and endurance training (cycling)
Johnston et al., (1997)	12 untrained female distance runners	3d/wk for 10 wks	2-3 sets of 6-20 RM	Strength endurance and running
Bishop et al., (1999)	21 trained female cyclists	2d/wk for 12 wks	3-5 sets of 2-8 RM	Power, strength & endurance training
Hoff et al., (1999)	15 trained female cross-country skiers	3d/wk for 9 wks	3 sets of 6 RM	Power training and cross-country ski training
Paavolainen et al., (1999)	22 elite male cross-country runners	9 wks	15-90min/session	Endurance training (running)
Doan et al., (2006)	16 sub-elite male & female golfers	3d/wk for 11 wks	2-3 sets of 7-35 reps	Strength, power & flexibility training

Adapted from Jung (2003)

In adults, significant knowledge is present about factors that determine muscle strength and skill adaptation and its change with training (Hansen et al., 1999; Spamer and De la Port, 2006), but less information is available about muscle development in children. Muscular strength increases more or less linearly with age from early childhood in boys (Hansen et al., 1999). Strength is known to be related to the physiological cross-sectional area of the muscle and hence, according to dimensional analysis, related to the second power of body height (Hansen et al., 1999). Strength is one of the major components of any sport (athletics, rugby union, rugby league, American football, cycling, boxing, swimming, martial arts, wrestling, basketball, soccer) and thus an important factor when selecting athletes for specific positions and teams. In adolescents, cross-training may prove useful in increasing strength, agility, speed, anaerobic power and aerobic capacity, attributes which are all beneficial to most sport. Young athletes who are above average height should therefore focus more on increasing muscular strength, muscular size and motor skill components to enhance potential performance in a number of sports.

One of the major aims of the proposed research is to determine whether a cross-training program can improve young rugby players' rugby skills and their perceptions' of these skills. Schmidt and Lee (1999) define skills as "movements that are dependent on practice and experience for their execution, as opposed to being genetically defined." The learning of skilled movement patterns, such as in team sports, is also dependent on the many factors including the amount and quality of practice or experience, which result in relatively permanent changes in a skilled behaviour (Pearson et al., 2006). The extent to which practice improves skilled performance also relies on a multitude of factors, including the attention and memory capabilities of the learner and the physical ability to perform the required task (Pearson et al., 2006). With adequate teaching and practice, refinement of motor skills can continue in males through adolescents (Anshel 1990; Pearson et al., 2006). Additionally, if progressive improvement occurs in motor skills, performance in complex motor tasks associated with team sports, may be less complicated because of previous practice and experience (Pearson et al., 2006).

The anthropometric factors contributing to performance in a range of sports have also been the subject of review (Norton and Olds, 2000; Olds, 2001). For example, in throwing events, body mass is one determinant of performance, along with the acceleration of the implement prior to its release. Body mass is also relevant in events such as rowing, where propulsion of the boat is a function of the absolute power that the rower generates. Individual characteristics besides body mass may include other anthropometric dimensions (e.g. body size, body composition, and relative segmental lengths), physiological factors (e.g. muscle strength and power, anaerobic capacity, aerobic capacity, maximal oxygen uptake) and biomechanical variables (e.g. mechanical efficiency) and psychological variables (Keogh, Weber and Dalton, 2003). In sports in which complex skills and intricate team-work are required, the link between individual characteristics and performance capability is not a straightforward relationship (Reilly, 2001). In sports like basketball and volleyball and in jumping in the line-out in rugby union, stature provides an advantage, but is less apparent in sports such as field hockey and soccer, where there can be a great degree of variability in height between individuals within one team (Toriola, Salokum and Mathur, 1985; Reilly, 2001).

Soccer

Soccer (also known as association football) is the most popular sport in the world, with over 40 million registered players and many more hundreds of millions of people purported to play the game (Ekstrand, 1994; Lees and Nolan, 1998). Soccer is a team game in which 11 players on each side try to score as many times as possible within the 90 minutes (senior level) by forcing the ball into the opponent’s goal. The game is made up of two 45 minute halves separated by a 15 minute interval (Lees and Nolan, 1998). The duration of soccer matches differs at different levels of play. Like rugby union, there are certain restrictions on how the game must be played; the main one being that a player may use any part of the body to propel the ball except by the arms or hands. Thus a large variety of skills and strategies have evolved to enable the scoring of goals (Lees and Nolan, 1998).

In soccer as in rugby union, the role of playing position is important in maintaining possession and being successful in defensive structure. While there are only 11 players in a soccer team the attacking and defensive structure of teams can differ. The positions in soccer are classed into three major groups; forwards, midfielders and defenders, which include the goalkeeper. However, these positions are not required or defined by the laws of the game (Lees and Nolan, 1998).

The inability to use one's hands or arms to move or direct the ball in soccer means that the feet and legs are the most used part of the body. A wide range of skills form the foundation of soccer performance but only one has been the subject of detailed biomechanical analysis (Lees and Nolan, 1998), namely kicking. Kicking is the most widely studied skill in soccer (Lees and Nolan, 1998).

According to Lees and Nolan (1998, p. 212) the description of the kicking skill is as follows:

> "It is characterised by an approach to the ball of one or more strides, with placement of the supporting foot at the side, and slightly behind, the stationary ball. The kicking leg is first taken backwards and the leg flexes at the knee. Forward motion is initiated by rotating the pelvis around the supporting leg and by bringing the thigh of the kicking leg forwards while the knee continues to flex. Once this initial action has taken place, the thigh begins to decelerate until it is essentially motionless at ball contact. During this deceleration, the shank vigorously extends about the knee to almost full extension at ball contact. The leg remains straight through ball contact and begins to flex during the long follow-through. The foot often reaches above the level of the hip during the follow-through".

Kicking skill, like most of the skills in soccer, has been shown to develop from an early age (Bloomfield, Elliot and Davies, 1979; Lees and Nolan, 1998). A study by Bloomfield et al. (1979) analysed the kicking action of young boys aged between 2-12 years. They characterised six levels of development by looking at various performance indicators. These ranged from level one (mean age 3.9 years), at which the children often hit the ball with their knee or leg, to level six (mean age 11.2 years), at which the mature kicking pattern (as previously described), had been achieved by 80% of the children. Although chronological age was not found to be a good predictor of skill development, the age ranges suggest that the skill develops rapidly between the ages of four and six years.

Based on the literature it would appear that kicking is a well-practised skill that develops from an early age. It is an asymmetrical skill, and while it can be rapidly adapted, it begins to show signs of breaking down under the requirements of speed and skill (Bloomfield, Elliot and Davies 1975; Lees and Nolan, 1998; Williams and Reilly, 2000).

The skill of kicking is one that has many relatable factors between soccer and rugby union. Both require some form of approach or run up, both require the supporting foot to be planted on ball contact and they both require contact with the medial side and top of the foot. There is however also one major difference between these sports; in soccer, kicking skills are seen as a prerequisite for every player and is a determinant in selection and team success. In rugby union though, it is only a few players in the team who need to possess the skill of kicking above the basic or average standard and advanced kicking skills are a prerequisite only for a few positions, particularly players number 9, 10, 12 and 15, and to a lesser extent, numbers 11 and 14 where the game is played according to the Experimental Law Variations (the ELV's).

The other major difference in kicking skill between soccer and rugby union is the early development of the kicking skill in soccer (Bloomfield, Elliot and Davies, 1979; Lees and Nolan, 1998). In rugby union, the skill of kicking is not stressed as a major pre-requisite for team selection or seen as a necessary skill in junior rugby. At professional level rugby union however, the importance of having skilled kickers in certain playing positions is crucial and the skill of kicking is taught by professional kicking coaches. A number of rugby union teams including the All Blacks, employ kicking coaches to teach players the skill, tactics and advantages of kicking. Interestingly, the All Blacks current kicking coach Mick Byrne has played representative level AFL for Melbourne and was previously employed by the Australian Rugby Union as the Wallabies kicking coach in 1999, the same year they won the rugby world cup (tvnz.com, 2005).

It appears that the transition from soccer to rugby union has been successfully achieved by some high-profile (elite) rugby players. All Black lock Ali Williams is renowned for not having played rugby union until the age of 17. Until then, Williams had played only soccer and was a rather successful goalkeeper. In 1998 he began playing lock for the King's College first XV and again played for them in 1999. In 2002 he made his debut for the Blues Super 14 franchise and the All Blacks (New Zealand Rugby Union, 2008). Williams has represented Auckland in soccer, tennis and cricket as well (New Zealand Rugby Union, 2008).

Liam Messam whom has represented New Zealand rugby at all age grade levels is another example of an extraordinary talent. Messam also played representative level soccer at junior school before focussing solely on rugby union. Messam has been a part of the New Zealand Maori and Sevens teams more recently, captaining the sevens team in 2005 and becoming an All Black in 2008 (New Zealand Rugby Union, 2008).

Basketball

Basketball was invented by a Canadian, Dr. James Naismith, at Springfield College (Massachusetts) in 1891 (Krause, 2002). The sport was invented to solve the problem of bored, restless physical education students in the winter and through the need for a new indoor game that "would be interesting, easy to learn, easy to play in the winter and by artificial light", (Krause, 2002). Until then, football had been played in the autumn and baseball in the spring and summer, but no proper sport or game had been introduced for winter. Thus, by creating a sport that could be played indoors in a confined space, was easy to learn, garnered plenty of exercise and had limited contact, the sport of basketball was created.

Basketball matches consist of four quarters which can vary in length depending on the level of performance. These quarters can range from eight minutes (high school level) to 12 minutes (NBA), with most international quarters lasting ten minutes (Krause, 2002). The only essential equipment in basketball is the basketball and the court, which needs to have two baskets at opposite ends. At more competitive levels the use as scoreboards, timing devices and referees are required (Krause, 2002). The size of the basketball court in international matches is 28 metres by 15 metres and the size of the basketball may change depending on the level of performance and whether it is men or women playing (Krause, 2002).

In basketball there are five players per team, each with a designated position, like rugby union. The positions include:

- Point guard – usually the fastest player on the team, who organises the team's offence by controlling the ball and making sure that the ball gets to the right players at the right times (Krause, 2002).
- Off/shooting guard – who creates a high volume of shots on offence and guards the opponent's best perimeter player on defence (Krause, 2002).
- Small/shooting forward – often primarily responsible for scoring points via cuts to the basket and dribble penetration, on defence seeks rebounds and steals, but sometimes plays more actively (Krause, 2002).
- Power forward – plays offensively often with his back to the basket, on defence plays under the basket (in a zone defence) or against the opposing power forward (in man-to-man defence) (Krause, 2002).
- Centre – uses his/her size to score on offence, on defence they protect the basket closely, or to rebound the ball (Hoare, 2000; Krause, 2002).

As in rugby union and soccer it is important to note that each team member in basketball plays a large role in attack as well as on defence. In basketball, like soccer, there are a few playing positions who place themselves in an automatic position of defence, should the opposition obtain possession of the ball. In rugby union however, this is one of the major differences between the three sports. In rugby union the entire team attacks while in possession of the ball and the entire team defends while trying to regain possession or tries to prevent a score.

In the United States, many elite basketball players developed their skills by playing an alternative to indoor basketball. Effectively known as "street basketball" or "streetball", the game is played in urban or rural areas on an outside court or area. The popularity of this sub-sport has generated large support in American countries where a large collection of the current professional talent began playing this version of the sport. In the United States large competitions are now held annually in major cities to motivate young players to play basketball and to scout for potential talent. Television rights to such competitions generate large amounts of money and equally large viewer audiences.

Basketball, like few other sports, also does not require an opposing team or player to be able to be enjoyed and many people enjoy the physical benefits that "solitaire" basketball training and play produce. An increasing number of fitness facilities nowadays have basketball courts and areas so that people may add basketball to their normal training regimes. This is an idea which is growing in popularity since people are always looking for different training methods and variety in health and fitness. The physical and physiological skills developed by basketball include speed, agility, anaerobic and aerobic endurance (Bogdanis et al., 2007).

In a large number of team sports, such as soccer and basketball, the competitive season is followed by a prolonged period of low physical activity or complete inactivity (Bogdanis et al., 2007). As a result, many athletes follow off-season training programs aimed at maintaining fitness parameters and limiting the harmful effects of detraining. The improvement of the physical and technical abilities of young basketball players during the off-season period is based more on the empirical knowledge, intuition and personal preferences of the coaches than on research data (Bogdanis et al., 2007). There appears to be a tendency for many basketball and other team sport coaches to perform more sport-specific training during the pre-season (Bogdanis et al., 2007), however, there is no experimental evidence to show that this practice is as effective as generic training in basketball.

A basketball study was designed by Bogdanis et al., (2007), to compare the effect of two short-term (four week) sport-specific and mixed program basketball training programs for changes in physical and technical abilities, in adolescent basketball players during the off-season. The results showed a significant increase in technical abilities of the sport-specific and mixed program groups compared to the control group, especially in shooting accuracy and, passing and dribbling ability. The sport-specific group however, showed greater improvement in these skills than the mixed program group (Bogdanis et al., 2007).

These results indicate the importance of developing technical abilities in young basketball players such as dribbling, shooting and passing; technical skills which are crucial in almost every team ball sport, especially rugby union. Dribbling improves eye to hand co-ordination (Crawcour, 2004) and shooting may also increase the skill of depth perception, a skill which could be crucial to hookers, locks, scrumhalves and flyhalves in rugby union (Meir, 2005). Passing accuracy and passing accurately while moving with the ball into an area of open space are skills required in basketball and have become important skills in rugby union (Meir, 2005).

Wrestling

> "There are similarities between wrestling and rugby and it is obvious how one can help the other. They're both about controlling your own body weight and using your opponent's body weight to your advantage."

James Haskell – England Rugby Player (Bech, 2008)

Wrestling is a sport in which one contestant competes with another using various holds and techniques in an attempt to force the shoulders of the opponent against a mat, thus scoring a fall and winning the match. If a wrestler cannot score a fall within the time limit, a winner is determined based on a point-scoring system. All wrestling matches are supervised by officials, who impartially enforce the rules of the sport. The two basic styles of amateur wrestling are generally employed around the world are; freestyle and Greco-Roman (Martell, 1993).

Freestyle wrestling is a style of amateur wrestling that is practiced throughout the world. Along with Greco-Roman, it is one of the two styles of wrestling contested in the Olympic Games. It is, along with track and field, one of the oldest sports in history and has been contested since the ancient Olympic Games (Martell, 1993).

Freestyle wrestling, like its American counterpart, collegiate (also known as scholastic or folk style) wrestling, has its greatest origins in “catch-as-catch-can” wrestling and the prime victory condition in both styles involves the wrestler winning by pinning his opponent’s shoulders down on the wrestling mat (Martell, 1993). Freestyle and collegiate wrestling, unlike Greco-Roman, also both allow the use of the wrestler's or his opponent's legs in offense and defence. According to the International Federation of Associated Wrestling Styles (FILA), freestyle wrestling is one of the four main forms of amateur competitive wrestling that is practiced internationally today (Martell, 1993).

Greco-Roman wrestling is especially popular in Europe, but it is practiced throughout the world. The distinctive feature of Greco-Roman wrestling is that contestants must apply all holds above the waist, and the use of the legs in scoring or defending is prohibited (Martell, 1993). Tripping, tackling, and using the legs to secure a hold are not permitted. Greco-Roman wrestlers begin their bout in a standing position, and attempt to either throw their opponent to the mat or to use holds to drop them to the mat (Martell, 1993).

Since the use of the legs is not permitted in Greco-Roman wrestling it has more direct comparability and relevance to rugby union. Using one’s legs to make a rugby tackle is not only illegal but could be quite dangerous, especially to the opponent, and is something which could cause a rugby player to be suspended from participation in the sport (IRB, 2007).

In 1998, a participation survey in the United States found that the sport of wrestling was ranked sixth in the number of male participants (229 176) and eighth in the number of schools participating (8 900) (Pasque and Hewett, 2000). These numbers highlight the fact that wrestling is considered a major sport in certain countries, whilst rugby union is largely unheard of, especially at school and college level in the United States.

Anecdotal evidence to support wrestling has been dominant in rugby league and more recently in rugby union. Rugby league has been using wrestling training and techniques for a number of years to simulate the tackle (Mercer, 2001). In rugby league, the tackle is far more important than in rugby union, since the game revolves around a set of six bouts of possession. This means that going forward in rugby league is crucial and defensively the tackle is very important in stopping the opposition from gaining too much territory. By using man on man wrestling techniques (Mercer, 2001) rugby league teams such as the West (Sydney) Tigers and Manly Sea Eagles were some of the first teams to learn the basic skills of wrestling, and the applicability of wrestling in the tackle and forcing the opposition to use up their set of six with as little territorial advantage as possible. Today, it is common practice to see all 16 National Rugby League (NRL) Premiership clubs and many Super 14 rugby teams having pre-season wrestling training as well as some wrestling training for conditioning during the season.

At elite rugby union level the All Blacks, Springboks and England all frequently use wrestling games during their rugby training. England rugby union flanker James Haskell is renowned for his regular personal use of wrestling in the off season, as well as other martial arts forms such as boxing, Muay Thai and freestyle wrestling to improve physical conditioning for rugby (Bech, 2008).

Haskell has been touted as a future England rugby captain and he is one of the few rugby players who stood out on their autumn tour of New Zealand in 2008. Haskell has said that the different types of physical training has improved his rugby skills by making him stronger in the tackle and teaching him how to use his opponents' body weight to make a tackle and fight for ball possession (Bech, 2008).

There are few other sports or activities which replicate the movements and body positions of a typical tackle situation in rugby union as much as wrestling. The benefits of increased upper body strength, core strength, strength endurance and grip strength are all physical factors which could improve a rugby player's ability to make a tackle successfully and avoid being tackled. Not only are the individual gains important, but the effect that wrestling could have on rucking and mauling skills is clear. A number of well known rugby union and rugby league representatives have wrestled competitively at some stage of their careers (see Appendix I) and the idea to increase wrestling strength (especially amongst forwards) is one that needs further development.

Rationale for selecting soccer, basketball and wrestling

Soccer

It has been stated that top soccer players do not necessarily have an extraordinary capacity in any areas of physical performance, but rather the skill of soccer training and adaptation is based on playing the sport (Hoff and Helgerud, 2004). Soccer, like rugby union, is becoming more competitive at all levels of the sport and is played at a higher "tempo" (Williams and Reilly, 2000; Hoff and Helgerud, 2004) today, than it was ten years ago. Rugby union and soccer share a number of physiological predictors of success including sprint ability, jumping ability and VO_2 max capacity (Williams and Reilly, 2000; Duthie, Pyne and Hooper, 2003). The importance of increasing these physiological factors however, may improve an athlete's ability to reach the top tier of the sport or reach representative selection.

Time motion analysis between soccer and rugby union have shown that soccer players on average cover greater distances than rugby players (Hoff and Helgerud, 2004) in a single professional level match, but the work done by specific positions in soccer is also less than certain positions in rugby union (Duthie, Pyne and Hooper, 2003; Hoff and Helgerud, 2004). It is important to note that at senior level a soccer match is 90 minutes without extra time and a rugby match at the same level only 80 minutes without extra time. In rugby union the entire team is constantly moving in either a forward/backward or lateral direction as teams need to commit larger groups of players to areas such as rucks, mauls, scrums and lineouts, while also aiming to maintain defensive structures which aren't exploited by the opposition. For these reasons both these sports require different aerobic training and variations are not limited to sport, playing position and level of performance. Therefore, a training program for either of these sports would need to be specifically developed on these factors.

Since both soccer and rugby union are team ball sports and no two matches can ever be replicated, the ability to prepare for the unexpected or unforeseen has become important in gaining a competitive edge over opposition. The ability to anticipate game situations in either of the sports can be the difference between scoring points or not. The capability in training aspects which could improve athletes' ability to act and react in certain situations has become more apparent and the work of people such as Dr. Sherylle Calder (Crawcour, 2004) who has specialised in improving eye-hand co-ordination has shown that by improving an athlete's peripheral skills one can improve that athlete's ability to handle game-specific situations. An eye-hand or eye-foot co-ordination game may significantly improve visual skills in young athletes and the idea of incorporating such games in future research is very relevant. In particular, this could teach young athletes when to pass the ball and when not to pass the ball, resulting in greater field territory and possession, and in turn improve athletes' task-specific self-efficacy.

Kicking skill is a hugely important skill in soccer and is in itself the large predictor of soccer/team selection (Bangsbo, Norregaard and Thorso, 1991; Williams and Reilly, 2000). In rugby union the skill of kicking is developed according to a person's ability to kick any ball and since kicking skill is developed at such a young age (Bloomfield, Elliot and Davies, 1979; Lees and Nolan, 1998) one can assume that a child learns to kick a soccer ball before they do a rugby ball. The shape of the different balls also creates differences in the adaptation to kicking each of the balls. A soccer ball can be struck from a stationary position on the ground, while a rugby ball may have to be turned or picked up and dropped onto the foot or the ground before being struck. The development of rugby kicking skill is therefore more complex and may need to be taught from a younger age and greater emphasis placed on the importance and value that rugby kicking skill can contribute to rugby union performance.

In terms of defence, a number of different sports all share similar defensive patterns and goals. Sports such as soccer, basketball, NFL, rugby league and AFL all have very similar defensive patterns as rugby union. All these sports require a large portion of one-on-one defence and the ability to "mark" an opponent or opposite number. Soccer and rugby union share similar size playing areas and participant numbers, and as a result may seem more closely linked. Defensively, both soccer and basketball have a number of relatable factors to rugby union and each of these sports has different defensive aspects that can be related to rugby union. For example, the one-on-one defence in basketball is more closely related to rugby union in terms of positional one-on-one defence than is soccer, but soccer requires greater periods of sprinting during defensive play (Bangsbo, Norregaard and Thorso, 1991).

In soccer, there are more participants (11 per side) than in basketball (five per side), but also a far greater playing area (Bangsbo, Norregaard and Thorso, 1991). While one-on-one defence is not crucial because of the higher number of participants, it is important in terms of losing field territory as the defensive team. In basketball, there is a smaller playing area, so one-on-one defence is crucial in terms of not conceding points.

In both soccer and basketball it is legal to pass the ball forward to another player (within the laws of the game) and also legal to slow the game down by use of other players. In soccer and basketball participants can slow the game down by passing the ball back to the goalkeeper (soccer) or merely keeping possession of the ball for long periods of time (soccer and basketball). In rugby union however, it is illegal to pass the ball forward or to deliberately slow the game down (IRB, 2007). In rugby union a player can be tackled as soon as they have the ball (within the laws of the game) and do not have the luxury of a goalkeeper who can assist in slowing the game down.

Basketball

The basic fundamentals of running, passing and catching are the most interchangeable between rugby and basketball. The only difference is that in rugby union a pass is not allowed to go forward. If one were to describe basic attacking plays in either of these sports it would be very easy to assume that the one was the other. In basketball for example, players are required to catch and pass the ball to teammates while running. Additionally, this is happening in a fast changing scenario requiring directional control and communication, allowing the catcher to advance the attacking team's position while making tactical decisions to improve the team's chance of scoring. These phases of attack are required while being obstructed within the rules of basketball by opposing players.

As in rugby union, the most important aspect of any attacking team comes down to one thing, maintaining possession of the ball, for as long as is required to score points and prevent the opposition from scoring points.

In basketball, as in rugby union there are three major factors which are evident in defence. They are:

1. Reading the opposition play
2. Preventing the opposing players from advancing
3. Aiming to regain possession of the ball

Wrestling

Gaining territory in rugby union is crucial, as is maintaining possession of the ball. Using momentum and specificity of training to achieve both these factors is something that only a few contact sports can address, wrestling being one of these. When going into the tackle in rugby union it is crucial that a player aim to stay on his feet and keep moving forward to gain territory while retaining possession of the ball. The ruck and maul area has showed that only through proper body positioning and use of momentum can a player become successful at both gaining territory and maintaining possession (Duthie, Pyne and Hooper, 2003).

Besides for the obvious benefits at contact area, wrestling also improves core strength, shoulder stability and grip strength (Martell, 1993; Roemich and Sinning, 1997). Not only could this improve the ability of rugby players in contact situations such as the ruck and maul, but it could possibly reduce the risk of potential rugby injuries through the strengthening of crucial body parts and joints in such as the shoulders, knees, ankles, wrists and neck.

As previously mentioned, there is no other sport in which the rugby tackle is as closely replicated as in certain wrestling movements. In terms of defence, wrestling offers possibly the most apparent skill cross-over and the use of upper body strength and gripping onto opposition is crucial in the success of both these sports.

Other sports which may improve rugby performance

In 2007 the Australian Rugby Union (ARU) launched an initiative to recruit young rugby players from other sports. This idea was mainly the result of Australia's poor performance at the 2007 Rugby World Cup in France, where they failed to reach the semi-finals. The ARU views track and field, volleyball, basketball, wrestling and power lifting as possible sources of rugby players (Guinness, 2007). The recruitment drive among these sports is in search of elite athletes with the size, skill and inclination to make the switch to rugby union. The underlying idea is that if an athlete is able to perform at an elite level at another sport they should have the basic skills to learn the fundamentals of rugby union and through proper analysis a playing position could be identified for almost any elite athlete (Guinness, 2007).

Australian Rules Football

Similar sporting codes such as rugby league and Australian Rules Football (AFL) may have more in common with rugby union than other sports, since the basic objectives are very similar. As in rugby union, the training emphasis for AFL has centred on strength, power and speed development, even in the off-season and preseason (Woodman and Pyke, 1991; Keogh, 1999). In a study by Keogh, (1999) it was suggested that height, body mass, strength and vertical jump were the most important qualities assessed in predicting selection into an elite under 18 AFL team. Since these factors can all be improved considerably through resistance training, it has been suggested that a training program consisting of both weight training and plyometric training could lead to significant increases in strength and muscular power (Adams et al., 1992; Keogh, 1999).

A sport such as AFL may provide talented individuals who could excel in rugby union, especially in the AFL positions where relative vertical jump is important, such as in the fullbacks and wings in rugby union. In AFL the number of competitors per team (18), the size of the playing area and the basic rules are very similar to rugby union and thus the potential skill cross-over is very high.

Rugby League

Rugby league offers perhaps the closest simulation to rugby union, since the contact phases are more similar than that of rugby union and AFL, and the training methods for both these sports have been interchanged for some time (Gabbett, 2003a). The ability of rugby players to easily "switch codes" has also been illustrated by the large number of international rugby league players who have played rugby union at some representative level, and vice versa (see Appendix II).

A typical senior rugby league match is 80 minutes in duration, with frequent intense bouts of running and tackling, interspaced with short bouts of recovery, (Gabbett, 2006). For this reason, rugby league is physically demanding, requiring players to draw upon a variety of fitness qualities including muscular strength and power (Baker & Nance, 1999a; Gabbett, 2000), speed (Baker & Nance, 1999b; Gabbett, 2005), agility (O'Connor, 1996; Gabbett, 2005a), endurance (O'Connor, 1996; Meir et al., 2001; Gabbett, 2005a) and ball skills (Meir, 1994).

In a study of rugby league players, Gabbett (2003a) found similar heart rates (152 bpm vs. 155 bpm) and blood lactate concentrations (5.2 mmol/L vs. 5.2 mmol/L) during competition and training consisting entirely of skill-based conditioning games. Gamble (2004) also reported significant improvements in aerobic fitness following a nine week pre-season training period of skill-based conditioning games in elite rugby union players.

In rugby league, Gabbett (2006) also found increases in the number of points scored per match and the points-differential of a rugby league team over a nine week period using pre- and in-season skill-based conditioning games compared to traditional conditioning. Additionally, greater physiological changes were seen in speed and muscular power while using skill-based conditioning games than traditional conditioning over the same period. What this study found is that the greater improvements in speed and muscular power in athletes participating in skill-based conditioning games is a result of the greater training specificity provided by those activities (Gabbett, 2006).

Volleyball

Volleyball may prove to be beneficial in improving rugby playing ability since there are many physiological and skill related factors between the two sports. A volleyball match can last up to 90 minutes depending on the level of competition (Gabbett, Georgieff and Domrow, 2007), coupled with frequent short bouts of high intensity exercise and periods of low intensity activity requiring players to have well developed aerobic and anaerobic energy systems (Gabbett, Georgieff and Domrow, 2007). Large demands are also placed on the neuromuscular system during the various jumps, sprints and high intensity court movements that occur repeatedly during competition. Because of these factors, volleyball players require well developed speed, agility, upper and lower body muscular power, and maximal aerobic power (Gabbett, Georgieff and Domrow, 2007).

Aside from the physiological and physical factors, the skill related factors such as jumping, passing, spiking, blocking and overall ball control all play an important developmental role that can be used in rugby union. In New Zealand, a large number of Polynesian rugby players also play volleyball, and the improvements in ball handling, power and speed is evident in their style of rugby union, especially as these skills are often referred to in rugby union as the "Polynesian flair".

Volleyball may prove to be more beneficial to certain rugby union positions than others, especially for locks and outside backs, where running, jumping and catching (often at the same time) are all important pre-requisites for performance (Duthie, Pyne and Hooper, 2003).

Rationale for analysis of other sports in rugby cross-training

Australian Rules Football

In AFL, the emphasis in training for most positions in AFL has tended to focus on strength, power and speed development, even in the off-season (Woodman and Pyke, 1991; Keogh, 1999). Aerobic endurance and training is another aspect of AFL which is crucial for team success and a requirement for greater performance (Woodman and Pyke, 1991). While the results of this research have not shown significant increases in aerobic capacity between the control and intervention groups, this may be due to the lack of aerobic conditioning incorporated into the cross-training program for the intervention group and perhaps the lack of aerobic conditioning during rugby training for the control group.

Research by Keogh (1999) in AFL team selection with elite under 18 groups has shown that height, strength, vertical jump and body mass were the most important physical qualities assessed in the study for predicting selection into this team. Since body mass, strength and vertical jump can all be considerably improved through resistance training; greater emphasis on this type of training may enhance performance in some players (Keogh, 1999). The findings by Keogh (1999) also support the results reported for players at different levels in rugby union (Rigg and Reilly, 1988) and volleyball (Thissen-Milder and Mayhew, 1991).

Rugby League

In rugby league, the final play of possession requires the attacking team to kick (Gabbett, 2006). This set play on the final phase of possession has become an important aspect in rugby league as many of the tries are scored off cross-field aerial kicks. Anecdotal evidence (Mercer, 2001; Gabbett, 2006) has shown an increased number of tries scored from cross-field aerial kicks and this, combined with the ability of the players to catch the ball under pressure from opposition is evidence of the increased ball skills required and possessed by current professional rugby league players.

Basketball and rugby league have become the preferred sports of Polynesian male athletes during the winter months in New Zealand. The cross-over of skill from basketball to rugby league is immense and one only has to see the aerial ball skills that some of the Polynesian rugby league players possess to know that other ball sports have played a major part in their development.

The cross-field aerial kick is also becoming more effective and more utilised in rugby union. Teams will often resort to the cross-field aerial kick when opposition has been scattered and the opportunity to get the ball across the field quickly can result in tries. New Zealand, Australia and England have become successful in the cross-field aerial kick, with players like Carlos Spencer, Stephen Larkham, Jonny Wilkinson, Daniel Carter, Stephen Donald and Matt Giteau all adept at this kick at test match level. Interestingly, it is the countries where rugby league is played at professional level that the rugby union teams from these countries (Australia, New Zealand and England) are more confident and successful in attempting these cross-field aerial kicks.

Volleyball

In a volleyball study by Gabbett, Georgieff and Domrow (2007), the results showed strong support for the importance of developing passing and serving technique in junior volleyball players. The study highlighted major differences in skill between groups of talented and less talented junior volleyball players for spiking, serving and passing technique. The physiological and anthropometric characteristics of players were similar between groups, and none of these parameters contributed strongly to discriminant analysis (Gabbett, Georgieff and Domrow, 2007). These results support the idea that a greater emphasis on skill development at junior level volleyball is required, just as greater skill development at junior level rugby union is required (Pienaar, Spamer and Steyn, 1998; Spamer and de la Port, 2006).

Conclusion

Cross-training is not limited to sport-specific training. In recent times, the improvement of visual skills has been highlighted by scientific studies (Meir, 2005) and the employment of visual skills coaches, especially in rugby union (Crawcour, 2004). More and more professional unions are using cross-training as resources for improved rugby performance. The English and South African rugby teams have each employed a visual skills coach who works closely with the players to improve their visual and proprioceptive systems. The evidence of their success at the 2003 and 2007 Rugby World Cups respectively highlights the value that such a form of visual skills coaching can have for rugby.

A cross-training program that incorporates strength, speed, anaerobic power, aerobic capacity as well as developing rugby playing skills could be beneficial to a rugby players' overall skill development. Thus, the proposed research seeks to:

1) Develop a cross-training program that can be used by coaches and rugby unions in future.

2) Determine whether cross-training components can be used to improve the anthropometry, physiological capacities and skills of adolescent male rugby players more so than regular training.

3) Determine whether a cross-training program could improve adolescent male rugby players' perception of their own rugby skills.

The increase in anecdotal evidence showing elite rugby union players representation in other sports is supportive of the hypotheses for this research. With greater access to media and information, the evidence supporting cross-training may increase the known number of elite athletes, not just rugby union players, who have excelled in other major sports.

Methodology

Study Design

The design for this study was a randomised controlled trial. Due to the nature of the study the participants and researcher were unblinded as the subjects were aware of the type of training that they participated in. The study used a ten week intervention between pre- and post-tests.

The data collected from participants included pre- and post-tests for anthropometry (body mass, height and reaching height), physiological (strength/muscular endurance, anaerobic power, speed, aerobic power, and rugby-specific (passing accuracy and distance, and kicking accuracy and distance) measures. A pre- and post-test self-efficacy questionnaire was also completed by each participant to assess individual perception of task ability within a team.

All tests were supervised and administered by the researcher.

Participants

Participants (n = 24) were randomly assigned to either a control (n = 12) or intervention (n = 12) group. This number allowed the researcher to recruit a full rugby squad and divide the participants into the two even groups. The sample size was based on Hopkins (2000).

According to Hopkins (2000):

$N = 64\ s^2 / d^2$

Most outcome measures have a reported CV (s) < 6%

The difference to which we wish to detect (d) = 10% between group difference.

$N = 64 * 0.06^2 / 0.1^2$

= 23 subjects in total.

The proposed sample size for this study was based on the average number of rugby players in a high school graded rugby team, which is approximately 22-25. Other cross-training intervention studies with similar sports, subjects and training durations to that proposed have reported significant between-group differences in the outcome measures (McCarthy et al., 1995; Johnston et al., 1997, Hoff, Helgerud and Wisloff, 1999).

All participants were current male students at King's College playing in the under 14 Auckland secondary schools division. Selection criterion included age, playing history, lack of injury and consent to participation by parent/guardian.

The details of the intervention group (n = 12) were: age, 13.8 ± 0.3 years; height, 1.69 ± 0.88m; body mass, 65.7 ± 18.8kg; and playing history, 5 ± 1.5 years.

The details of the control group (n = 12) were: age, 13.9 ± 0.3 years; height, 1.71 ± 0.83m; body mass, 65.9 ± 8.6kg; and playing history, 5 ± 1.9 years.

Measures

For this project there were 14 physical variables (three anthropometric, six physiological and five rugby-specific skill-based) which the researcher measured and analysed as well as a self-efficacy questionnaire. Certain physical variables had more than one component to measure, such as speed (10 and 20 metre sprint time) and strength/muscular endurance which had two separate variables (pull ups and twisting sit ups). Each of these measures proved valid in obtaining an overall measure of the participants' strength.

The following physical variables were measured and analysed for anthropometry during the project were; body mass (1), height (2) and reaching height (3).

The physiological measures recorded were; anaerobic power (4), speed (5 & 6), aerobic power (7) and strength/muscular endurance (8 & 9).

The rugby-specific measures recorded were; passing accuracy (10), passing distance (11 & 12), kicking accuracy (13) and kicking distance (14).

Additionally, a self-efficacy questionnaire was utilised pre- and post-testing to prove the hypothesis that a cross-training program consisting of soccer, basketball and wrestling could significantly improve adolescent male rugby players' perceptions of their own rugby skills.

All measures were taken at King's College under the researcher's supervision and control.

Anthropometry

Body mass was measured to the nearest 0.1kg, using calibrated electronic scales (Seca, Hamburg, Germany). Standing height was measured with participants being barefoot using a standard wall-mounted stadiometer to the nearest 0.1cm (Pienaar, Spamer and Steyn, 1998; Gabbett, 2002a; Keogh, Weber and Dalton, 2003). Standing height was measured by having participants standing 10cm from the wall in a side-on position with the arm closest to the wall raised directly above their head. Participants would make a chalk mark on the wall by pressing the longest finger onto the wall. This standing height was then measured (Ellis et al., 2000).

Physiological tests

Aerobic capacity was measured using the Multistage Fitness Test Shuttle Run (Tomkinson et al., 2003, Pearson et al., 2006). The Multistage Fitness Test Shuttle Run is a valid (Grant et al., 1995) and reliable indicator of VO^2 max (Sproule et al., 1993; Keogh, Weber and Dalton, 2003) and is often used to assess aerobic capacity in team sport athletes. This test has been well described by the Australian Coaching Council (1988). It involves a series of 20 metre shuttle runs which become progressively faster. Participants were required to maintain the given speed until reaching volitional fatigue. The number of shuttles completed was recorded and an equivalent VO^2 max estimated (Australian Coaching Council, 1988). Measures of intra-class correlation coefficient (ICC) for test-retest reliability and typical error of measurement for the multistage fitness test have been shown to be between 0.90 - 0.92, and 3.1% - 4.62%, respectively (Gabbett, 2002a; Keogh, Weber and Dalton, 2003; Gabbett, 2005).

Sprinting speed was recorded with a precision of 0.01 seconds over 10 and 20 metres using a Speed Trap infrared timer (Brower Timing Systems, Draper, Utah, USA). From a stationary position 50cm behind a clear white line (Maulder and Cronin, 2005) of the first timing lights, participants began the sprint with both feet shoulder-width apart and fell forward to break the beam of the timing lights (Maulder and Cronin, 2005). Once the beam was broken the test was started and participants had to sprint 20m as fast as they could. Three 20 metre trials were performed and all split times (10m and 20m) were recorded. The time of participants fastest 20m trial (and that trials' 10m split time) were used for data analysis. Participants were given 3 minutes rest between each sprint trial (Keogh, Weber and Dalton, 2003; Maulder and Cronin, 2005). In junior rugby league tests the ICC for test-retest reliability and typical error of measurement for the 20 metre sprint test have been shown to be between 0.89 - 0.97, and 1.3% - 1.52%, respectively (Gabbett, 2002a; Keogh, Weber and Dalton, 2003; Gabbett, 2005; Gabbett, Kelly and Sheppard, 2008).

Lower body muscular power was estimated using the standing vertical jump (Greene et al., 1998; Ellis et al., 2000; Gabbett, 2002a). During the jumping action, participants were required to keep their outstretched arm above their head while keeping the other arm relaxed at their side. From a stationary starting position and crouching to whatever depth is preferred, the participant took-off from two feet with no preliminary steps or shuffling. At the top of the jump, participants marked the wall with chalk on the inner hand and the height they reached was recorded using a wall-mounted stadiometer. Vertical jump height was measured as the difference between the outstretched arm in the starting position and that obtained during the jump. Each participant performed three trials of the vertical jump, with each trial separated by three minutes rest (Keogh, Weber and Dalton, 2003). The best of the three trials was recorded as the vertical jump height. Measures of ICC for test-retest reliability and typical error of measurement for the vertical jump test have been shown to range between 0.93 and 0.96, and 3.3% and 4.54%, respectively (Gabbett, 2002a; Keogh, Weber and Dalton, 2003; Gabbett, 2005).

Strength/muscular endurance were measured in two tests and they included, supinated pull ups and twisting sit ups (Ellis et al., 2000). All of these tests were performed within a 30 second time limit (Pienaar, Spamer and Steyn, 1998; Spamer and de la Port, 2006). The tests were designed to see how many repetitions a subject could perform within 30 seconds. Due to muscular fatigue and lactic acid build-up participants were only give one trial for each of these tests with at least two minutes rest between tests. For the pull up test, participants were made to perform supinated pull ups from a pull up bar. One repetition was counted as the participants' ability to pull themselves up so that their noses were in line with the bar (i.e. could see over the bar), on lowering themselves the participants had to ensure maximum elbow extension (Ellis et al., 2000), before continuing the pull up for another repetition. The test was started in the lowered position (elbows at maximum extension).

In the twisting sit ups test, participants were made to lie on their backs with the heels of their feet on a bench 30cm off the ground. Participants were told to keep their knees bent at a 90° angle and keep the fingers on their temples, rather than behind the head. From a flat position, the participants were told that a repetition would be counted as the ability to come up and have the elbow touch the opposite leg (i.e. left elbow to right leg and right elbow to left leg) if the elbow did not touch the leg, a repetition would not be counted (Ellis et al., 2000). A repetition was discounted if; the participant lifted any foot off the floor during the test, threw the head or arms forward in a jerky manner, moved the arms from the nominated position, lifted the hips off the floor, failed to maintain a 90º angle at the knees and was unable to complete a full sit up (Ellis et al., 2000). Participants did not need to return right down to the starting position (head on the floor), but needed to go down within 10cm of the ground. The test was started with participants flat on the ground with their hands on their temples. This test was modified from the variations explained by Ellis et al. (2000) while still maintaining the standardising procedures.

Proper technique of both these tests was sufficiently explained before performing them and participants had the opportunity to ask questions regarding technique and recording of data.

Rugby-specific skill tests

Passing accuracy was measured by a lateral pass to a mounted target (Pienaar, Spamer & Steyn 1998). In this test, a participant had to run (approximately $5m/s^{1}$) with a rugby ball in his hands for three metres up to a mark in line with the target (a circle with a diameter of 40cm, mounted on a stand one metre high). This target was three metres away, and the player had to throw the ball through the target with a lateral spinning pass. The test was performed five times from the left side and five times from the right side, so as to cater for both dominant and non-dominant sides. For each correct throw (through the circle) a score of one is given (maximum = ten points), if the ball hit any part of the target but did not go through, half a point was given. A rest period of one minute was given between every second trial from the same side (Pienaar, Spamer and Steyn, 1998).

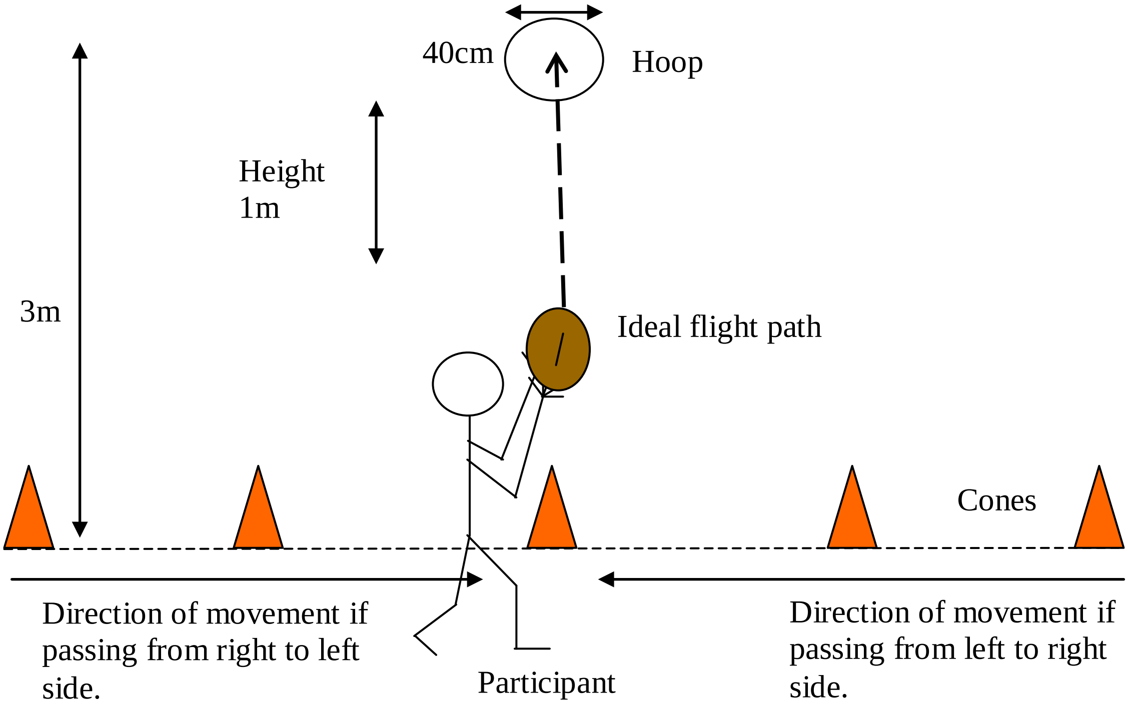

Figure 1: Passing accuracy skill test

Passing distance was measured by participants attempting to throw a lateral pass as far as they can, from both the left side and the right side. The participants were in a stationary position behind a clear white line and threw three lateral passes from their left to right side and then three lateral passes from their right to left side. This test highlights strengths in participant's dominant side and weaknesses in participant's non-dominant side (Pienaar, Spamer & Steyn, 1998). Each passing distance was recorded with the furthest pass from either side recorded for data analysis. The distance of the pass was recorded to the nearest metre. A rest period of one minute was given between each trial (Pienaar, Spamer and Steyn, 1998; Spamer and de la Port, 2006).

Kicking accuracy was measured by participants attempting to hit (punt kick) a box ($1m^3$ in size) from a distance of 20 metres. The aim was to have the ball hit the box directly and participants were advised not to let the ball bounce, i.e. the ball must hit the box directly from the air. Each participant was allowed five kicks at the box. The participants were scored on their ability to hit the top of the box (five points), the side/s (three points) or within two metres of the box (1 point); no points were given if the ball bounced before hitting the target. This test was only performed with the participant's dominant foot (Pienaar, Spamer and Steyn, 1998). The maximum score which could be obtained for this test was 25 points. The rest period for this test was one minute between each trial (Pienaar, Spamer and Steyn, 1998).

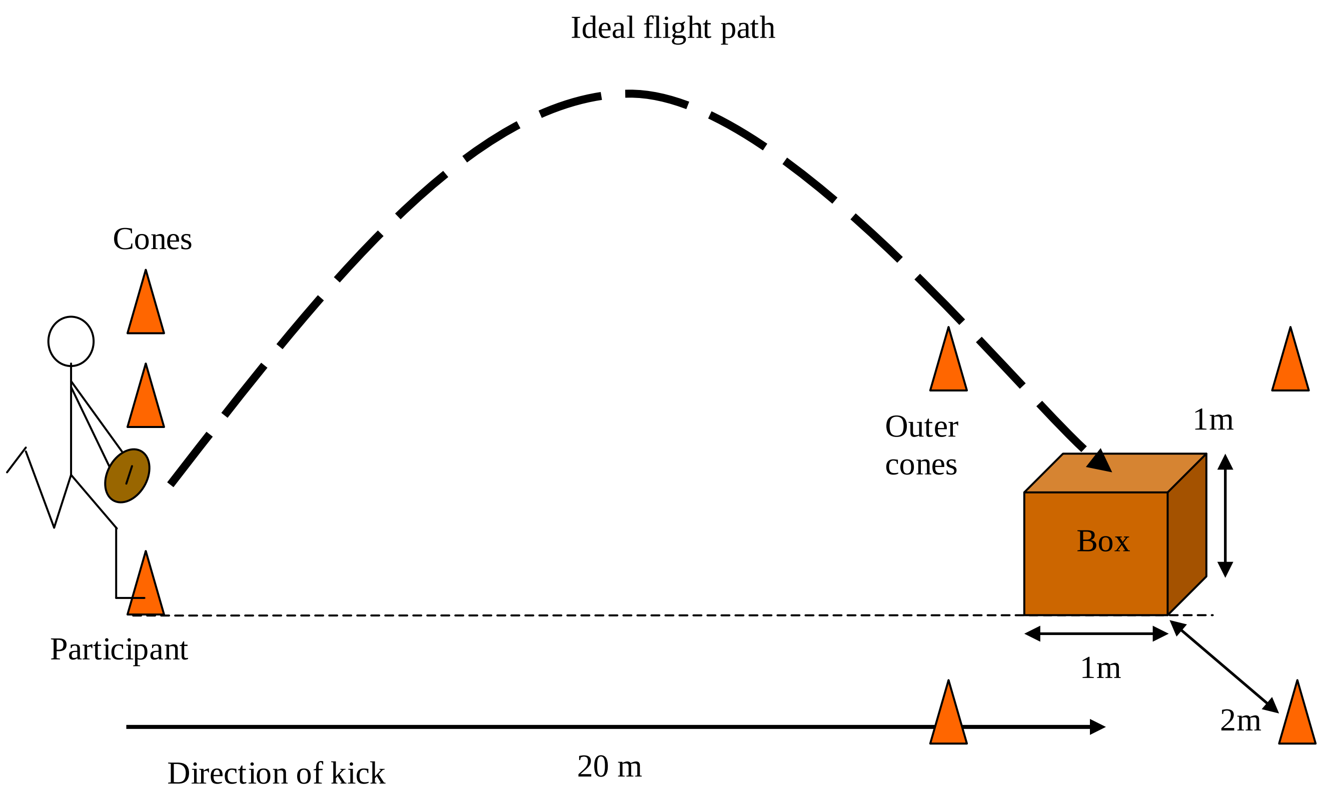

Figure 2: Kicking accuracy skill test

The kicking for distance test consisted of participants attempting to punt-kick a rugby ball as far as they could. Participants had the choice as to how to hold and kick the ball, as long as it was a punt-kick. A punt-kick is one where the ball is dropped and kicked straight from a person's hand, i.e. there is no touching of the ball on the ground before contact is made with the ball, such as in a drop kick or a place kick (IRB, 2007). This test was performed on the sports grounds at King's College, as the sports hall was not large enough for most participants' kicks. Participants only used their dominant foot and performed three trials; all trials were recorded with the furthest punt used for data analysis purposes. The kick was measured with a 50m tape measure running down the length of the 15m line, (15m parallel to the touchline). The 15m line was used to provide participants with a guide to kick as straight as possible, however, all kicks were measured to where the ball landed, and as a result all kicks were measured from the same point. Inter- and intra-reliability testing was performed with research assistants prior to data collection. A rest period of two minutes was given between each trial (Pienaar, Spamer and Steyn, 1998).

All rugby-specific skill tests involved the use of the same type of rugby ball (Gilbert A-XV rugby balls; Gilbert Rugby, London, England), inflated to the same pressure (80psi). These measures were taken to create standardised factors for all tests and all participants. During testing, the rugby balls were inflated to the same pressure twice a day and measured using a rugby ball pressure gauge (Gilbert Rugby, London, England).

Self-Efficacy questionnaire

The questionnaire sought to examine whether a cross-training program consisting of soccer, basketball and wrestling could significantly improve adolescent male rugby players' perceptions of their own rugby skills more so than regular training.

The questionnaire was based on the work of Weigand and Stockham (2000), who analysed position-specific self-efficacy amongst female field hockey players. Similar to Weigand and Stockham (2000), all participants in the present study were required to indicate (in Column A) whether or not they felt capable (yes or no) of executing each skill at four ascending levels of difficulty (e.g. I can hit the ball 16, 25, 50 or 75 yards), then were required (in Column B) to rate their certainty or confidence of performing each level from 0 (Extremely Uncertain) to 10 (Absolutely Certain).

Each question had a maximum score of 40 (four levels of ability x 10 points of confidence). For example, an answer of Yes (capability), Level 3(ability) and seven (confidence), would give a score of 21.

This questionnaire was adapted by the researcher and the participants' rugby coach to fit the specific skills of rugby union, also taking into consideration the level of under 14 rugby players and adequately standardising it. Questions were designed specifically to fit different positional roles in a rugby union team. The questionnaire consisted of 14 questions in total and was divided into nine specific variables of rugby union. They were: the scrum (three questions), the lineout (three questions), rucking/mauling, passing (two questions), kicking, communication, evading a tackle, making a tackle and kick/return. These questions were selected on their specificity to playing positions in rugby union (Duthie, Pyne and Hooper, 2003). The scrum, lineout and passing variables had multiple questions, so as to fit with the specific area that a participant may play during this set piece and their ability to pass in two directions.

As a result, there are questions which are more specific to some participants than others. A fullback (15) for example, would be less confident in performing the skills (questions) required by a prop forward (1 & 3) and vice versa. Since every position in a rugby union team requires different skills and has a different set of tasks, this questionnaire could prove useful in providing a variable which takes into account participants own perceptions of their task and skill performance. As well as relating it to the team's overall strengths and weaknesses.

The self-efficacy questionnaire was completed both pre- and post-tests by all participants in a classroom at King's College. The researcher was present to answer any questions which participants may have had. A strict rule of no communication between participants was enforced during the questionnaire. A copy of the questionnaire is attached as Appendix III.

Training Programs

An intervention program consisting of two, 60 minute sessions per week (Monday and Wednesday) was conducted at King's College with the intervention group.

The intervention that was used in this study was a ten week training program consisting of body weight exercises (press ups, pull ups, sit ups and plyometric exercises), soccer components (dribbling, passing), basketball components (dribbling, shooting, and defence) and wrestling. As mentioned in the literature review, a number of studies (Hickson et al., 1988; McCarthy et al., 1995; Johnston et al., 1997; Hoff et al., 1999) have used different duration periods as intervention programs. The duration of this intervention program was based on this literature, the given timeframe with which to train participants and the fact that an Auckland graded high school rugby season will last approximately twelve weeks, regardless of the success of the team. The training program was not based on any previous rugby union literature since such literature has yet to be analysed.

The focus of the training was to specifically improve participants' (intervention group's) overall rugby skills and improve perceptions of their performance of these rugby skills.

The intervention group participated in two 60 minute rugby training sessions per week as well as the intervention program two days per week.

During this time, the control group participated in two 60 minute rugby training sessions per week only. Participants from both groups were involved in a rugby match once per week for the duration of the intervention. The two rugby training sessions per week were administered by the participants' rugby coach and the researcher had no involvement in these.

Once all data collection was completed the intervention program with the target group began. The intervention began on Monday 26th May, 2008. Post-test measures were taken at the conclusion of the intervention program. The intervention finished on Wednesday 30th July, 2008.

Data Analysis

SPSS version 14.0 was the statistical software package used during data analysis. Descriptive data were analysed and expressed as mean $\pm$ *SD* (Standard Deviation). Parametric methods were used since the data were normally distributed (Domholdt, 2000).

The dependent variables used for the statistical analyses of the anthropometry, physiological and rugby-specific skill tests were; height, mass, reaching height, aerobic capacity, speed (10m and 20m), anaerobic power, strength (pull ups and sit ups), passing accuracy, passing distance, kicking accuracy and kicking distance, with two levels each; pre- test and post-test. For the self-efficacy measure, the dependent variables were the scrum, lineout, ruck/maul, passing, kicking, communication, evading tackles, making tackles and kick/return. The scrum, lineout and passing questions had more than one variable, but during statistical analysis it was decided that these variables should be grouped as one question for that area only, so as to provide greater statistical significance.

Descriptive statistics were calculated for all kinematic variables. The analytical model used for the research was descriptive statistics method, using a general linear model for repeated measures. A general linear model for repeated measures identifies differences between paired data (Domholdt, 2000) for example: control vs. intervention or skilled vs. non-skilled. A one way analysis of variance (ANOVA) was used to determine whether there were significant differences between the kinematic variables in the control and intervention groups. Statistical significance was set at a confidence level of p equalling less than 0.005. Post hoc analysis between groups was done using the Bonferroni correction, Scheffe's method and Tukey's protected *t*-test (Domholdt, 2000).

Results

The pre-post anthropometric test scores for the control and intervention groups are presented in Table 2. As both groups tended to undergo increases in body mass, standing height and reaching height, no significant between-group differences were observed for these measures.

Table 2: Anthropometrical results for both groups (pre- and post-tests)

Measure	Control		Intervention		*p*
	Pre-Test	Post-Test	Pre-Test	Post-Test	
Anthropometry					
Height (cm)	171 ± 8	174 ± 8	170 ± 9	173 ± 10	0.827
Mass (kg)	65.6 ± 8.6	66.8 ± 8.2	65.6 ± 18.7	66.9 ± 18.8	0.548
Reach height (cm)	219 ± 10	223 ± 10	218 ± 10	221 ± 11	0.395

The pre-post physiological test scores for the control and intervention groups are presented in Table 3. Although the intervention group appeared to experience greater gains in vertical jump height (4% vs. -3.9%), pull up strength (43% vs. 14%) and aerobic power (7.2% vs. 3.2%) than the control group, no significant between-group differences were observed for any of the physiological measures.

Table 3: Physiological results for both groups (pre- and post-test)

Measure	Control		Intervention		*p*
	Pre-Test	Post-Test	Pre-Test	Post-Test	
Physiological					
Vertical Jump (cm)	43.3 ± 7.4	41.6 ± 8.3	40.3 ± 6.8	41.9 ± 7.0	0.499
Speed (10m) (s)	2.08 ± 0.16	2.12 ± 0.15	2.10 ± 0.13	2.13 ± 0.13	0.894
Speed (20m) (s)	3.54 ± 0.26	3.59 ± 0.28	3.58 ± 0.25	3.60 ± 0.24	0.958
Pull Ups	7 ± 5	8 ± 5	7 ± 5	10 ± 7	0.599
Sit Ups	21 ± 6	20 ± 6	23 ± 5	24 ± 6	0.600
Aerobic power (ml/kg/min)	43.2 ± 5.9	44.6 ± 5.3	41.6 ± 6.8	44.6 ± 7.0	0.486

The pre-post rugby-specific skill test scores for the control and intervention groups are presented in Table 4. The intervention group showed somewhat greater increases in passing distance from right to left (5.3% vs. -5.1%) and left to right (4.3% vs. -7.8%) side. Both groups recorded the same increase in kicking distance (7%), however no significant between-group differences were observed for any of the rugby-specific skill measures.

Table 4: Rugby skill test results for both groups (pre- and post-test)

Measure	**Control**		**Intervention**		***p***
	Pre-Test	Post-Test	Pre-Test	Post-Test	
Rugby Skill					
Passing accuracy	4.8 ± 1.4	4.0 ± 1.3	5.3 ± 1.8	3.7 ± 1.3	0.084
Passing distance (R to L*) (m)	13.7 ± 2.8	13.0 ± 1.5	13.1 ± 2.9	13.8 ± 2.1	0.119
Passing distance (L to R*) (m)	12.8 ± 2.8	11.8 ± 2.3	11.5 ± 1.9	12.0 ± 2.3	0.083
Kicking accuracy	3.8 ± 3.8	2.5 ± 2.9	3.7 ± 3.9	2.0 ± 2	0.257
Kicking distance (m)	32.6 ± 5.7	34.9 ± 5.2	31.3 ± 4.3	33.5 ± 3.8	0.143

*R to L = Right to left side
*L to R = Left to right side

The major finding for the self-efficacy tests is a general decrease in scores in both the control and intervention groups. Post-test results indicate a shared result of the 14 questions between the two groups (the control group scored higher in seven questions and the intervention group scored higher in the other seven questions), however, there are no significant between-group differences were observed for any of the questions. In the control group the average score during pre-testing was 16.6, out of a possible 40. This average decreased to 13.8 (20% decrease) at post-testing and may be due to a number of factors which are examined in the discussion section. In the intervention group the average score during pre-testing was 14.7, decreasing to 12.2 (20% decrease) at post-testing.

A full copy of the pre- and post-test efficacy results are shown below.

Table 5: Self-efficacy results between control and intervention group (pre- and post-test)

Question	**Control**		**Intervention**		***p***
	Pre-test	Post-test	Pre-test	Post-test	
Forwards Specific					
1a Scrum – Front Row	14.8 ± 9.7	15.1 ± 10.3	11.4 ± 10.5	9.3 ± 9.8	0.072
1b Scrum – Locks	16.3 ± 7.4	16.4 ± 8	12.2 ± 9.1	6.6 ± 6.4	0.072
1c Scrum – Loose Forwards	15.5 ± 10	16.5 ± 10.4	8.1 ± 8.8	6.8 ± 5.9	0.072
2a Lineout – Throwing	12.2 ± 7.6	14.3 ± 10.5	14.1 ± 12.2	16 ±.11.2	0.990
2b Lineout – Jumping	16.3 ± 9.5	15.3 ± 13.4	12.6 ± 10.3	10.6 ± 4.5	0.990
2c Lineout – Lifting	17 ± 9.3	13.7 ± 10.1	12.7 ± 10.9	10.5 ± 8.4	0.990
3 Ruck/Maul	23.6 ± 9	21.2 ± 8.9	15.4 ± 7.7	10.8 ± 8.5	0.581
Inside Backs Specific					
4a Pass – Left to Right	19.4 ± 11.7	11 ± 5.6	17.5 ± 10.9	16.7 ± 5.5	0.573
4b Pass – Right to Left	14.3 ± 14	10.7 ± 7.3	18.3 ± 11.9	12 ± 6.2	0.573
5 Kicking	12.9 ± 9	9.2 ± 6.7	13 ± 7.7	14.8 ± 8.2	0.173
6 Communication	17.2 ± 8.3	12.5 ± 7.9	16.1 ± 10	10.8 ± 8	0.895

Outside Backs Specific					
7 Evade tackle	17.3 ± 8.8	8.1 ± 5.3	15.8 ± 7.2	13 ± 7.9	0.305
8 Make tackle	20.8 ± 8.5	12.9 ± 12.1	18.6 ± 6.0	16.2 ± 13	0.147
9 Kick/Return	14.6 ± 6.5	15.9 ± 10	20.5 ± 9.3	16.3 ± 8.1	0.251

Discussion

The aim of this research was to determine whether a cross-training program consisting of soccer, basketball and wrestling components can significantly improve adolescent male rugby players' anthropometry, physiology or skills, and whether this cross-training program could significantly increase their perceptions of their rugby skills. The overall results show that there were no statistically significant between-group differences in the improvements in physical parameters or participants' perceptions of certain rugby skills between the intervention and control groups following the ten week intervention.

Previous research in this field has been concerned with either anthropometrical (Greene et al., 1998) or physiological (Gabbett, 2005b) changes during interventions, or has been concerned with skill-specific improvements (Pienaar, Spamer and Steyn, 1998; van Gent and Spamer, 2005) and efficacy in task-specific situations (Weigand and Stockham, 2000). The importance of this research is that it has incorporated all of these aspects amongst adolescent rugby players during a competitive rugby season.

While such a lack of statistical significance may reflect the ineffectiveness of the intervention program, there was a tendency for some of the improvements for the intervention group to be somewhat greater than the control group. Thus, it is possible that cross-training programs may offer some additional benefits compared to that provided by regular training. If this is the case, the lack of significance may reflect the relatively short training duration, the fact that the control group were still training and that based on their ages, subjects in both groups were undergoing puberty and hence experiencing natural physical maturation.. Thus, future research should investigate the potential benefits of cross-training for rugby players of varying ages and assess such changes over longer durations e.g. at least one season to gain a better insight into the benefits of such a training approach. A more detailed discussion of these results and the tendency for the intervention group to experience some additional benefits is presented in the following sections.

Anthropometry

The small increases in height, mass and reaching height for each of the two groups indicated similar trends in growth amongst both groups. Increases in these measures may be performance-enhancing as previous studies have shown that more elite rugby league and union players are taller and heavier than their less-skilled counterparts (Toriola, Salokum and Mathur, 1985; Rigg and Reilly, 1988; Gabbett, 2000; Gabbett, 2002a; Gabbett, 2005a; Spamer and de la Port, 2006). Such anthropometric factors are likely to be performance enhancing as they increase the players' ability to retain or gain possession and carry the ball over the advantage line as they allow greater momentum to be developed in contact situations and/or make catching kickoffs and lineout throws easier. Since the intervention was only ten weeks in duration and as the adolescent males were likely to be undergoing a pubertal-related growth spurt, the similar anthropometric changes for both groups were not unexpected. The increases in height and mass are similar to results previously found in studies using participants of similar age (van Gent and Spamer, 2005; Spamer and de la Port, 2006; Gabbett, Georgieff and Domrow, 2007).

Physiological tests

The results of the physiological tests highlight that there were no real significant changes between the control and intervention groups at post-testing. The increases in certain variables (e.g. strength and aerobic capacity) are not uncommon and other studies have shown similar changes amongst participants of this age group, albeit not all of these achieved statistical significance (Hoare, 2000; Gabbett, 2002a; Gabbett, 2005a; Spamer and de la Port, 2006).

Although not significant, there appeared to be a trend whereby the intervention group tended to experience greater increases in vertical jump, pull up strength and aerobic power than the control group. The improvements in the intervention group's vertical jump would prove useful in lineout jumping and in catching high kicks such as at kick offs and in general play. As the vertical jump test is commonly used as a general measure of leg power, this may also prove useful as leg power is a very important factor in all contact sports, particularly in the tackle situation (Reilly, 1997). The increases in pull up strength are directly related to the latissimus dorsi, biceps and forearm strength (Wilmore and Costill, 2004). This strength is important in tackling, scrummaging, mauling and passing. When making a tackle, arm and shoulder strength is important in holding onto an opponent and trying to get them to ground. The importance of this has also been highlighted in wrestling, where grip and arm strength is crucial (Martell, 1993). Increases in aerobic power have been shown to benefit almost every sport (Hickson et al., 1988; Grant, et al., 1995; Ellis et al., 2000; Duthie, Pyne and Hooper, 2003; Jung, 2003) and in rugby union is crucial in maintaining extended periods of cardiovascular endurance. This is very important in any rugby match and has been shown to be an ability that young rugby players need (Pienaar, Spamer and Steyn, 1998; Duthie, Pyne and Hooper, 2003).

The greater training loads which the intervention group were subjected to may have been the biggest reason why increases in vertical jump, pull up strength and anaerobic power were recorded. The intervention group took part in supervised cross-training which also aimed to improve overall strength and fitness. The ten week intervention may have had an effect on these factors and the results support the idea of increased strength, anaerobic and aerobic power amongst the intervention group.

Rugby-specific skill tests

The results of the rugby-specific skill tests showed no significant between-group differences in the changes over ten weeks. However, the intervention group tended to show more improvement than the control group in the passing distance to both sides. This tendency may be due to the large amount of basketball training incorporated into the intervention (Bogdanis et al., 2007) and due to the increased upper body strength that was likely to result from the wrestling. Passing distance is crucial off set phases, especially the scrum and lineout and when initiating counter-attacks from quick returns. The ability of young players (especially backs) to pass the ball quickly and accurately is a skill which becomes a major prerequisite for these positions at senior levels of rugby (Duthie, Pyne and Hooper, 2003). It is also important that a young rugby team be able to pass equally well from both sides and the increases in the intervention group have shown that cross-training with other ball sports may seem to improve this skill.

Interestingly, both groups showed decreases in passing accuracy and kicking accuracy over the course of the training program. This may indicate the importance of improving fine and gross motor skills in relation to these tasks, particularly with young rugby players who are undergoing a growth spurt (Crawcour, 2004). Including catching and kicking games into rugby trainings may improve these skills in young rugby players.

The specific changes between groups in the pre- and post-testing also raises the idea that position-specific training/intervention programs may yield greater changes in pre- and post-testing. It may raise the need for programs to be designed based on playing ability or skill level and that specific analysis of team sport athletes in this age group is necessary, since most athletes will not be of the same skill level (van Gent and Spamer, 2005).

Self-Efficacy

The argument for improving physical factors raises the issue of when young rugby players need to be taught the importance of increasing physical strength and the importance in relation to skill development. Some rugby coaches may argue that physical size is more important at a young age than rugby skill and thus the result is based on the type of coach, rather than the athlete. The argument for improving perceptions of rugby skills however, is one which every coach would appreciate and it is obvious that if you can improve a rugby player's task-specific self-efficacy you may yield greater results from the individual and team players (Weigand and Stockham, 2000; Krause, 2002; Smith and Bar-Eli, 2007). The importance of self-efficacy to individual performance is crucial in a sport like rugby union, where size and skill can have a major effect on playing ability. Smaller rugby players may find that greater self-efficacy will improve their confidence in performing against physically larger opposition.

Both these factors are important in team success and therefore neither one is more important than the other. Size and strength is very important in young rugby teams, but so too is self-confidence and self-efficacy. Therefore, an ideal young rugby team would be physically large, strong, fit, possess good all around rugby skills and have high levels of task-specific self-efficacy.

Overall, there were no significant between-group differences in any of the self-efficacy variables over the course of the 10 week study. However, the control group showed some small increases in their baseline scores for five of the 14 questions between pre- and post-testing. These were; scrum (front row), scrum (locks), scrum (loose forwards), lineout throwing and kick/return. The control group showed greater baseline scores in forward and backline specific questions in the post-testing compared with the intervention group. This is evident in the scores for questions regarding the scrum, lineout (except throwing), ruck/maul and communication. The only backline specific question in which the control group scored higher than the intervention group was the communication question.

In general, the intervention group increased baseline scores in two of the 14 questions between pre- and post-testing, they were; lineout throwing and kicking. The intervention group showed greater baseline scores than the control group in one forward specific question and some backline specific questions in the post-testing. This is evident in the scores for questions regarding lineout throwing, passing (from both sides), kicking, evading tackles, making tackles and kick/return. The exception is the result for lineout throwing, which could be largely due to the amount of basketball training performed during the intervention.

The increased perception of their rugby skills by the intervention group is specific to two major contact areas; evading a tackle and making a tackle. The results of the self-efficacy questionnaire indicate that while the average score for the intervention group in these two questions may have decreased, the decreases in their scores was far less than the changes recorded in the control group for the same two questions. This means that members in the intervention group may have felt that the wrestling component of the cross-training intervention helped in their ability to make and evade tackles in rugby union.

The lack of any significant between-group differences in the self-efficacy measures may have reflected the general decrease in self-efficacy scores for both groups across the 10 weeks (Weigand and Stockham, 2000; Hepler and Chase, 2008).

The lack of between-group differences and tendency for both groups to regress over time may have something to do with the timing of the questionnaire with respect to their rugby matches. The pre-testing questionnaire was completed the day before the team's first rugby match of the season. The team did not have a overly successful season and lost their first game by more than 40 points. While the team did improve throughout the season, they recorded losses for both the final two matches of the season. As post-test self-efficacy was measured a few days after the final match, these losses have the potential to result in a significant loss of sports-specific self-efficacy (Weigand and Stockham, 2000; Smith and Bar-Eli, 2007; Hepler and Chase, 2008).

It is also possible that the lack of between-group differences in the self-efficacy scores may have something to do with the lack of rugby-specific training in the intervention group. The aim was to limit rugby-specific skill training and pre- and post-test specific measures so as not to give the intervention group a direct advantage over the control group. As a result, participants in both groups may have answered the questionnaire based more on rugby results and scores than on personal skill-development and task-efficacy. The questionnaire which was used in this research was based on a previous study (Weigand and Stockham, 2000) for hockey players and was designed to be task-specific, position-specific and incorporated individual scores, group scores and team scores. However, it is acknowledged that the validity and reliability of the questionnaire used in this study is unknown.

Both groups have shown a general decrease in self-efficacy scores between pre- and post-testing and this may have something to do with the implementation of the pre-testing questionnaire. The pre-testing questionnaire was completed the day before the team's first rugby match of the season and the self-confidence levels within the team may have been high since they had not yet played against any opposition. The result of the first match would have had a definite effect on all participants' self-efficacy (Weigand and Stockham, 2000; Smith and Bar-Eli, 2007), since the team lost by more than 40 points. While the team did improve throughout the season certain results may have had effects on post-testing self-efficacy as well, the team recorded losses for both the final two matches of the season and post-test self-efficacy was measured a few days after these results.

In terms of corresponding self-efficacy with increases in physical parameters there doesn't seem to be any support in this research that either of these measures influences the other. Research suggests that match result may have a far more significant influence on individual and team self-efficacy than playing performance alone, especially in athletes of similar age to this group (Smith and Bar-Eli, 2007).

This also raises an important question; is it more important to improve physical factors or the perception of improved skills in young rugby players?

Self-efficacy and self-confidence literature (Smith and Bar-Eli, 2007) has shown support for examining children's self-confidence more towards actual sport and physical activity situations. Additionally, other areas which have been highlighted in need of attention in Bandura's model (Smith and Bar-Eli, 2007) are the study of self-confidence across a number of situations (e.g. over the course of a season), and the study of team confidence in relation to self-confidence (Smith and Bar-Eli, 2007).

Variables such as previous performance, affective self-evaluation, goal setting and physiological states may exert a direct influence on sport performance (Smith and Bar-Eli, 2007) and it may prove useful to have athletes set goals related to the findings of a self-efficacy task sheet at the beginning of a season, before and after the first competition match. A self-efficacy task sheet could provide coaches with an outline of the players' perceived task-specific and position-specific strengths and weaknesses within a team. This could prove to be very useful during the pre-season and before tournaments in minimising team and individual weaknesses, and could make training more specific and beneficial to team success.

Overall, the results show that no significant changes were found between the control and intervention groups after a ten week intervention program with the aim of specifically improving physical fitness parameters and perception of playing ability. This is consistent with the results presented by Weigand and Stockham (2000) who found no significant main effects between playing position and playing division in female hockey players. The results from Weigand and Stockham (2000) have also highlighted similar findings in this research, where forwards scored higher in the forward-specific questions than backs, and the backs scored higher in the backs-specific questions than the forwards. The applicability of the tests used in this research may need to be more scrutinised and greater standardising procedures may need to be taken to show more significant between group differences in the future.

Limitations

While the research produced some interesting findings there were a number of limitations which may have affected the results. Some of these limitations include:

1. The duration of the cross-training study.

Due to the length of the competitive season for an under 14 school rugby team in the Auckland competition there was difficulty in obtaining access to participants for a longer period than 10-12 weeks. Pre-testing could have been done earlier in the year, but because of participants' other commitments to sport and extra-mural activities this would have prolonged the pre-testing period by a number of weeks.

2. Frequency of cross-training sessions.

Like the duration of the cross-training, the frequency of cross-training sessions could also have been adjusted. However, obtaining access to facilities at the school on more than two days per week (standard) proved far more difficult than initially planned. Also, the idea of having a cross-training session on a Friday afternoon did not prove ideal to either participants or coaching staff, especially since rugby matches were played on Saturday mornings.

3. Access to sports facilities during bad weather

As the cross-training program was performed during the winter months in Auckland it was anticipated that some of the training sessions would be affected by rain. This was the case, resulting in some of the training sessions for both groups needing to be conducted indoors. Ultimately, this resulted in a number of training sessions having to be modified to some extent.

4. Injury to participants

While there were no major injuries to any of the intervention group there were the standard knocks and bruises from rugby matches. Often participants were affected on the Monday cross-training session due to the Saturday rugby match and this limited the exposure or participation in the cross-training sessions.

5. Difficulty understanding questionnaire

While the result of the self-efficacy questionnaire supports the idea that the participants understood the questions and answer templates, there was some initial confusion amongst a number of participants. Some of the questions needed clarifying, especially those regarding the positions not played by that participant. It may be useful in the future to have participants read all questions first and have a question and answer session, before starting to answer the questionnaire. Further, quantifying the validity and reliability of this questionnaire in adolescent rugby players would have added to this study.

6. Lack of specific rugby playing positions in either groups

The self-efficacy results have highlighted the importance of creating a balance between the control and intervention groups. The intervention group only had one front row forward, which could be a reason why the control group scored much higher in the first three questions of the self-efficacy questionnaire. It may have been more useful to select two groups based on playing position rather than random selection.

7. Limited control over the control group during the intervention.

Since data was collected at a boarding school and only at certain times of the day, supervision of the control group was not always easy to manage. The control group may have been participating in other fitness activities and sports outside of their traditional rugby training, and this may have been the reason why physical changes were not significantly different between groups. It was also possible that as neither group was blinded to the allocation of the other group, that a number of the control group spoke to members of the intervention group and as a result added some of the cross-training components to their regular training program.

Future Research

The limitations have highlighted a number of ideas which could be successfully incorporated into future research related with this or similar rugby/cross-training studies:

1. The use of other sports for cross-training and during the intervention program.

As highlighted in the previous literature, there are a number of sports which could potentially improve an athlete's skill in rugby union. The sports that were selected for this study were selected on the basis of skill-crossover to rugby union, what cross-training activities elite rugby union and rugby league teams e.g. Super 14 and NRL, respectively are currently using and what could provide the most substantial results in adolescent males within the timeframe specified. Other sports such as AFL, rugby league, volleyball and martial arts all have the potential to be used in rugby union cross-training and many ball sports could be used to improve rugby union skills and development.

2. Creating position specific training programs for young rugby players.

The idea to administer position specific training programs rather than group training programs has some rationale. While using the same fitness training for a prop as for a wing, the positional requirements of these players do not condone the same training or skill development and thus, it would be far more beneficial to create position-specific training programs for rugby players over the age of 13. At junior age groups (13-16 years) this could mean forwards focus on bodyweight exercises while backs focus on sprint training and communication. At elite level, position-specific training programs already exist, but the need to improve this at senior club level is apparent. Either way, the idea of position-specific training programs is something which requires greater development at school, junior and amateur senior level.

3. A longer intervention period (12-24 weeks).

While the literature has shown some support of intervention programs of less than 10 weeks in length, these studies have often been compared to an inactive control group. These studies have also shown greater control of participants and variables such as, access to private facilities and better testing conditions. The 10-week intervention program was designed based on past literature and resource availability. The difference between the control and intervention groups would be far more apparent if the intervention program was lengthened and/or the duration and frequency of training sessions was increased. Ultimately in this study, these variables were largely based on external and uncontrollable factors, and as a result, the differences between groups were not that significant.

4. Administer self-efficacy questionnaire to all participants before and after the first competitive rugby match, and again post intervention.

The effect of match outcome on self-efficacy was not initially included in the hypotheses, but the results from pre- and post-testing shows some examples of decreased self-efficacy in certain participants. As the participants suffered a heavy loss in their first round rugby match during the season (and several other losses at the conclusion of the season), it was thought that the result could negatively affect self-efficacy measures. At pre-testing in the future it may prove beneficial to record self-efficacy before and after the first match of the season and compare self-efficacy results based on the outcome of this rugby match. The idea of collecting self-efficacy scores before and after every match also provides greater basis of support with regards to when self-efficacy questionnaires should be administered and standardisation of measures.

5. Follow up studies to predict validity and applicability in different aged rugby union players.

The possibility to perform cross-training rugby union studies with different aged participants may yield varying results from this research. The potential to use older participants (16-18 years) or elite rugby players (20-30 years) could provide coaches and rugby organisations with more applicable data and improved training techniques.

6. Implementing the cross-training program at different times of the competitive season.

The effect of training frequency and duration outside of the intervention program may in fact play a large role in determining the effects of training used in a study such as this. By comparing the effectiveness of the intervention at a number of different stages of the year (post-season vs. pre-season vs. in-season) one could produce data which is applicable to different stages of the competitive season and thus improve the training methods during these specific stages of competition.

7. The different physical and physiological requirements of rugby union players, pre- and post-introduction of the Experimental Law Variations.

While there are currently studies underway to highlight the differences in physical and physiological requirement in relation to the ELV's in rugby union, it is not clear yet specifically how rugby players need to adapt their training. Although the ELV's are currently only being trialled in some competitions they have proven to be a major talking point in world rugby during 2008. Too little is yet known about the full effects which these rule changes have had on rugby union and research is desperately needed to highlight what changes athletes would need to make to their own training programs, specifically at non-elite level, if these laws were to come into effect at all levels of rugby union.

Recommendations

The following is a list of recommendations which the researcher believes may be of some value to rugby coaches and sports scientists working in rugby union and in particular with young rugby players in the future. These ideas are the researcher's own and are based on his research and previous experience of coaching rugby union.

1. Between the ages of 16 and 19, rugby players' training should focus more on motor skill development, rather than repetitive attacking and defensive drills.

2. Wrestling drills and games should be included into rugby trainings. At a young age rugby players need to be taught the physicality of the tackle through proper understanding of technique and contact. Rugby coaches should consult a wrestling coach who can teach proper technique and the skills of wrestling and grappling. Wrestling games also add an element of fun and competition to "traditional" rugby training.

3. In wrestling games, make sure that players of different sizes wrestle each other. In a rugby match a player does not get to choose which player they want to tackle and teaching smaller players to use bigger opponents' body weight in a wrestling/tackle situation will boost their confidence and tackling skills, especially at junior age group level.

4. Encourage young athletes to play as many sports as possible. Rugby union is a team sport and therefore early specialisation is unnecessary. The skills that can be learnt from playing many sports will only improve a rugby player's overall skill.

5. When teaching a young rugby player the skill of kicking and ball strike, provide the athlete with a soccer ball as well. The effect of spin and curve can more easily be seen with a soccer ball than a rugby ball.

6. During pre-season training, combine rugby union training with AFL training. The majority of rugby union pre-season training is designed to improve aerobic capacity and endurance, and studies (Woodman and Pyke, 1991; Keogh, 1999) have shown that AFL players can cover up to 10 633m per game of which 58% of the total distance was jogging and 20% sprinting (Keogh, 1999).

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Appendices

Appendix I – Rugby Union and Rugby League wrestling representatives

Well-known New Zealand Rugby Union and New Zealand Rugby League players who have wrestled at a representative level:

Rugby Union:

- Gary Knight (All Black 1977-1986 & Commonwealth Games wrestling medallist)
- Inga Tuigamala (All Black 1989-1993)
- Mark "Bull" Allen (All Black 1993-1997)
- Mark Weedon (New Zealand XV 1995)
- Kees Meeuws (All Black 1998-2004)
- Sam Tuitupou (All Black 2004-2006)
- Ben Herring (Super 14 2004-2006)

Rugby League:

- Mark Horo (Kiwi 1995)
- Matt Rua (Kiwi 2000)

(New Zealand Wrestling History, 2005)

Appendix II – Multiple rugby and football code representatives

Australian Rules football (AFL) to rugby union:

In AFL the commonalities to rugby union only really apply to certain positions (particularly those that involve kicking and catching such as the backs and second row in rugby union; half forwards and rucks in Australian Rules). Also at amateur level, conversion between theses sports is quite common, as in the case of many start-up Australian Rules clubs in countries such as France and developing AFL countries such as New Zealand and Samoa.

Name	Country	Top Aussie rules level	Top rugby union level	Top representative level
Nick Evans	New Zealand	NZ Under 21	All Blacks	New Zealand (RU), New Zealand U21 (AR)
Mikaele Pesamino	Samoa	Bulldogs	Auckland, Manu Samoa	Samoa (AR), Samoa (RU)
Rambo Tavana	Samoa	Bulldogs	Manu Samoa	Samoa (AR), Samoa (RU)

Rugby union and rugby league:

These are two of the closest sporting codes and they share many similar skills. Until 1995 rugby union was "officially amateur" and rugby union players were offered money to switch codes. That trend has since reversed. Conversion from one code to another is more difficult for *forwards* rather than *backs* where the similarities are most adjacent. It is worth noting that several players, including Iestyn Harris, Mat Rogers, Rocky Elsom, Brad Thorn, Lesley Vainikolo, Wendell Sailor and Ryan Cross, have all converted between the two codes on more than one occasion (Australian Rugby Union, 2008; New Zealand Rugby Union, 2008).

<u>Rugby union to rugby league:</u>

Name	**Country**	**Rugby union level**	**Rugby league level**	**Representative level**
Frano Botica	New Zealand	All Blacks	Super League (Europe) NRL	New Zealand (RU/RL) Croatia (RU)
Michael Cleary	Australia	Wallabies	NSW RL	Australia (RU/RL)
Ryan Cross	Australia	Super 14	NRL	Australian Schools (RU)
Arthur Daniels	Wales	Club (Llanelli)	Rugby League Championship	Wales/Great Britain (RL)
Jonathan Davies	Wales	Welsh Premier Division	Super League (Europe)	Wales/Great Britain (RL) Wales (RU)
Marc Ellis	New Zealand	All Blacks	NRL	New Zealand (RU/RL)
Rocky Elsom	Australia	Wallabies	Junior	Australia (RU)
George Fairburn	Scotland	SRU national	Rugby League	Great Britain

		league/Kelso RFC	Championship	
Russell Fairfax	Australia	Wallabies	NSW RL	Australia (RU)
Ray French	England	England	Rugby League Championship	Great Britain
John Gallagher	New Zealand	All Blacks	Super League (Europe)	New Zealand (RU)
Scott Gibbs	Wales	Welsh Premier Division	Super League (Europe)	Wales/Great Britain (RL/RU)
Scott Gourley	Australia	Wallabies	NSW RL	Australia (RU/RL)
Daryl Halligan	New Zealand	NPC	NRL	New Zealand (RL)
Sam Harris	Australia	Super rugby	NRL	Australian Schools (RU) City v. Country (RL)
Nigel Heslop	England	International	Rugby League Championship	England
Craig Innes	New Zealand	All Blacks	NRL	New Zealand (RU/RL)
Ben Kennedy	Australia	Australian U21	NRL	Australia (RL)
John Kirwan	New Zealand	All Blacks	NRL	New Zealand (RU)
Tony Melrose	Australia	---	NSW RL	Australia (RU)
Dally Messenger	Australia	Wallabies	NSW RL	Australia (RL)
Garrick Morgan	Australia	Wallabies	NRL	Australia (RU)
Rex Mossop	Australia	Wallabies	NSW RL	Australia (RU/RL)

Michael O'Connor	Australia	Wallabies	NSW RL	Australia (RU/RL)
Brett Papworth	Australia	Wallabies	NSW RL	Australia (RU)
Ray Price	Australia	Wallabies	NSW RL	Australia (RU/RL)
Scott Quinnell	Wales	Wales	Super League (Europe)	Wales (RU/RL)
Jason Robinson	England	England	Super League	England (RU) Great Britain (RL)
Matthew Ridge	New Zealand	All Blacks	NRL	New Zealand (RU/RL)
Wendell Sailor	Australia	Wallabies	NRL	Australia (RU/RL)
Kevin Ryan	Australia	Wallabies	NSW RL	Australia (RU/RL)
Ricky Stuart	Australia	Wallabies	NRL	Australia (RU & RL)
George Smith	New Zealand	All Blacks	All Gold's	New Zealand (RU/RL)
Alan Tait	Scotland	Scotland/1997 Lions Tour	Rugby League Championship	Great Britain
Brad Thorn	New Zealand	All Blacks	NRL	Australia (RL) New Zealand (RU)
John Timu	New Zealand	All Blacks	NRL	New Zealand (RU/RL)
Va'aiga "Inga" Tuigamala	New Zealand	All Blacks	Super League (Europe)	New Zealand (RU) Western Samoa (RL)
Lesley Vainikolo	Tonga	England	Super League	England (RU) New Zealand (RL)

Craig Wing	Australia	Australian Schoolboys	NRL	Australia (RL) Australian Schools (RU)
William Topou	Australia	Australian A U19 Schoolboys	NRL	

<u>Rugby league to rugby union:</u>

Name	Country	Rugby league level	Rugby Union level	Representative level
Chris Ashton	England	Great Britain	Northampton Saints	Great Britain (RL)
Berrick Barnes	Australia	NRL	Super rugby, Wallabies	Australia (RU)
Nathan Blacklock	Australia	NRL/Super League	Super 12	Australia (RL)
Willie Carne	Australia	NRL	Super rugby	Australia (RL)
Brian Carney	Ireland	NRL	Celtic League	Great Britain (RL), Ireland (RU)
Ryan Cross	Australia	NRL, Kangaroos	Super rugby, Wallabies	Australian Schoolboys (RU)

Andy Farrell	England	Super League	English Premiership, England	Great Britain (RL), England (RU)
Iestyn Harris	Wales	Super League	Heineken Cup, Celtic League	Great Britain (RL), Wales(RU)
Sam Harris	Australia	NRL	Super rugby	Australian Schoolboys (RU), City v. Country (RL)
Wise Kativerata	Australia	NRL	Shute Shield	Australia Sevens (RU)
Tasesa Lavea	New Zealand	NRL	Super rugby	New Zealand (RL), New Zealand (RU)
Ben MacDougall	Australia	NRL	Celtic League	Scotland (RU)
Stephen Myler	England	Super League	English Premiership	
Henry Paul	New Zealand	NRL	English Premiership	New Zealand (RL), England (RU)
Jason Robinson	England	Super League	English Premiership, England	Great Britain(RL), England Captain and British Lions (RU)
Mat Rogers	Australia	NRL	Super rugby	Australia (RL/RU)
Wendell Sailor	Australia	NRL	Super rugby	Australia (RL/RU)
Clinton Schifcofske	Australia	NRL/Super League	Super rugby	State of Origin {RL}
Timana Tahu	Australia	NRL	Super rugby, Wallabies	Australia (RL)
Brad Thorn	Australia	NRL	Super rugby, All Blacks	Australia (RL), New Zealand (RU)
Lote Tuqiri	Australia	NRL	Super rugby, Wallabies	Australia (RL/RU), Fiji (RL)
Lesley Vainikolo	England	Super League	English Premiership,	New Zealand (RL), England (RU)

			England	
Andrew Walker	Australia	NRL	Super rugby, Wallabies	Australia (RL/RU)
Chev Walker	England	Super League	English Premiership	Great Britain (RL), England Saxons (RU)
Barrie Jon Mather	Great Britain	National team	England RU	National Team - first player to play for both national teams post RU professional era

Association football (soccer) to rugby union:

Luke McAlister – the New Zealand international rugby union footballer, grew up in the north-west of England and had a trial with Manchester United before converting to rugby union at an early age.

Loreto Cucchiarelli – the former player-coach of the Italian rugby union team, played football for Lazio at a young age.

Liam Messam – Waikato and All Black number 8/flanker represented Waikato in soccer at junior age group level.

Conrad Jantjes – the current Springbok fullback played for the youth national team of South Africa at soccer, rugby union and cricket.

Kevin O'Flanagan and Mick O'Flanagan (brothers) – both represented Ireland at soccer and rugby union.

Ali Williams – represented Auckland in soccer before starting to play rugby at secondary school in 1998.

(New Zealand Rugby Union, 2008)

Appendix III – Self-Efficacy Questionnaire

Read the statements carefully. Every player MUST ANSWER ALL QUESTIONS, even if you are a BACK, you must answer the FORWARDS questions. There are 13 questions in total.

For each statement below give yourself a rating between 1 and 10 for your confidence level at completing the different skills.
1 = Not confident at all 10 = Extremely confident

Criteria: **1 a) Scrum: Front Row**	**Capable:** **(Y/N)**	**Confidence:** **Out of 10**
L1: My spine does not buckle in scrums		
L2: My pushing in the scrum stops our scrum going backwards and allows our hooker to win the ball		
L3: My pushing in the scrum allows us to push the opposition scrum backwards		
L4: My pushing in the scrum allows us to push the opposition scrum backwards and win the ball from the opposition put in		

1 b) Scrum: Locks	**Capable:** **(Y/N)**	**Confidence:** **Out of 10**
L1: My spine does not buckle in scrums		
L2: My pushing in the scrum stops our scrum going backwards		
L3: My pushing in the scrum allows us to push the opposition scrum backwards		

L4: My pushing in the scrum allows us to push the opposition scrum backwards and I can get to the first breakdown after the scrum		

1 c) <u>Scrum</u>: Loosies	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: My pushing helps our scrum win the ball on our put in		
L2: My pushing helps our scrum win the ball on our put in and the opposition put in		
L3: I can wheel the scrum off our put in to improve our attacking options or decrease the opposition attacking options		
L4: I work with the other loosies to get the ball over the advantage line on our scrum wins and to keep the opposition from crossing the advantage line on their scrum wins		

2 a) <u>Lineout</u>: As the thrower	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I can throw it perfectly to the front of the lineout		
L2: I can throw it perfectly to the number 2 jumper		
L3: I can throw it perfectly to the number 4 jumper		
L4: I can throw it perfectly to the jumper at the back of the lineout		

2 b) <u>Lineout</u>: Jumping	**Capable:**	**Confidence:**

	(Y/N)	Out of 10
L1: I can catch a throw off our lineout with two hands		
L2: I can catch a throw off our lineout with two hands and pass it accurately off the top to the halfback		
L3: I can accurately tap the ball down to the halfback off the opposition's throw		
L4: I can win the opposition throw with two hands and pass it accurately off the top to the halfback		

2 c) Lineout: Lifting	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I can lift the jumper 30cm off the ground		
L2: I can lift the jumper 30cm off the ground at the right time to catch our throw		
L3: I can lift the jumper in a good enough position at the right time to win our throw		
L4: I can lift the jumper in a good enough position at the right time to win the opposition throw		

3: Ruck/Maul:	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: When a ruck or maul is formed, I get there to support my teammate if I am near by		
L2: When a ruck or maul is formed with our team in possession, I am **of assistance** in keeping our possession		

L3: When a ruck or maul is formed I **contribute strongly** to us keeping our possession		
L4: When a ruck or maul is formed with the other team in possession, I am primarily responsible for winning a turnover		

4: <u>Pass</u>: From the left and from the right. Please answer these for the left and right hand pass separately.	**Capable: (Y/N) Left**	**Right**	**Confidence: Out of 10 Left**	**Right**
L1: I can pass over 6 metres accurately and with enough power so that it won't be intercepted				
L2: I can pass over 8 metres accurately and with enough power so that it won't be intercepted				
L3: I can pass over 10 metres accurately and with enough power so that it won't be intercepted				
L4: I can pass over 15 metres accurately and with enough power so that it won't be intercepted				

5: <u>Kick</u>: With only your dominant foot	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I can kick the ball 20metres accurately		
L2: I can kick the ball 30metres accurately		
L3: I can kick the ball 40metres accurately		
L4: I can kick the ball 50metres accurately		

6: <u>Communication</u>:	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I listen carefully to and can understand each player either side of me		
L2: I listen carefully to and can understand 2-3 players either side of me		
L3: I direct and listen carefully to each player either side of me		
L4: I direct and listen carefully to 2-3 players either side of me and plan ahead the next two phases		

7: <u>Evade Tackle</u>: (One on one situation)	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I can make the advantage line		
L2: I can break the advantage line and maintain possession of the ball		
L3: I can break the advantage line and offload in the tackle to a support player		
L4: I can make a clean break		

8: <u>Make Tackle</u>: (One on one situation)	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I can tackle easy (small, slow moving) players		
L2: I can tackle easy (small, slow moving) players and get the ball off them		

L3: I can tackle difficult (bigger, fast moving) players		
L4: I can tackle difficult (bigger, fast moving) players and get the ball off them		

9: Kick/Return:	**Capable: (Y/N)**	**Confidence: Out of 10**
L1: I can catch any kick with all opposing team players over 10m away		
L2: I can catch any kick with all opposing team players over 10m away and get over the advantage line and stay on my feet until help arrives		
L3: I can catch a high kick under pressure (e.g. a bomb)		
L4: I can catch any kick under pressure (e.g. a bomb) and beat a defender		

Appendix IV – Self-Efficacy Questionnaire raw results (pre- and post-tests)

PRE-TEST:

QUESTION:	1a	1b	1c	2a	2b	2c	3	4		5	6	7	8	9
INTERVENTION														
Participant A	4	3	5	21	7	7	6	24	16	18	14	6	21	24
Participant B	21	18	14	14	36	14	21	21	0	7	24	14	21	24
Participant C	12	18	6	14	14	14	24	18	24	16	24	14	18	14
Participant D	0	21	8	18	7	15	16	36	40	24	32	24	14	27
Participant E	27	16	5	18	6	21	12	16	12	4	12	21	15	14
Participant F	21	15	8	27	8	15	16	9	14	5	3	14	24	24
Participant G	18	21	12	3	24	16	27	15	32	16	16	18	24	18
Participant H	0	0	0	14	5	5	10	36	24	16	16	21	28	28
Participant I	0	0	0	0	0	1	5	5	5	12	8	10	10	4
Participant J	10	10	7	0	12	3	18	12	8	14	0	8	9	14
Participant K	24	24	32	40	24	40	24	18	30	24	30	30	24	40
Participant L	0	0	0	0	8	1	6	0	15	0	14	10	15	15
MEAN:	**11.4**	**12.2**	**8.1**	**14.1**	**12.6**	**12.7**	**15.4**	**18**	**18.3**	**13**	**16.1**	**15.8**	**18.6**	**20.5**
± *SD:*	**10.4**	**9.1**	**8.8**	**12.2**	**10.3**	**10.9**	**7.7**	**11**	**11.9**	**7.7**	**10**	**7.2**	**6**	**9.3**

PRE-TEST:

QUESTION:	1a	1b	1c	2a	2b	2c	3	4		5	6	7	8	9
CONTROL:														
Participant A	18	21	20	12	20	5	14	6	0	0	0	5	20	12
Participant B	15	20	12	12	14	12	24	7	14	7	21	18	15	21
Participant C	14	14	14	16	14	16	36	27	12	8	27	14	27	16
Participant D	6	4	8	6	4	9	12	15	12	12	15	32	27	18
Participant E	5	18	7	0	14	5	21	30	0	24	15	12	15	7
Participant F	12	24	16	5	32	18	32	12	8	10	12	12	12	8
Participant G	0	10	18	0	12	12	21	21	21	16	21	16	21	14
Participant H	18	21	40	21	28	24	32	21	0	18	24	27	28	14
Participant I	16	6	4	18	2	15	8	10	4	0	5	3	8	4
Participant J	32	27	27	18	27	24	32	36	40	18	27	27	36	27
Participant K	10	10	10	20	20	32	30	40	40	30	18	20	28	20
Participant L	32	21	10	18	8	32	21	8	20	12	21	21	12	14
MEAN:	**14.8**	**16.3**	**15.**	**12.2**	**16.3**	**17**	**23.6**	**19.4**	**14.3**	**12.9**	**17.2**	**17.3**	**20.8**	**14.6**
± *SD:*	**9.7**	**7.4**	**10**	**7.6**	**9.5**	**9.3**	**9**	**11.7**	**14**	**8.9**	**8.3**	**8.8**	**8.5**	**6.5**

<u>POST-TEST:</u>

QUESTION:	1a	1b	1c	2a	2b	2c	3	4		5	6	7	8	9
INTERVENTION:														
Participant A	6	2	3	27	8	4	6	27	6	16	18	8	18	15
Participant B	16	12	12	18	16	4	27	12	3	8	6	15	8	27
Participant C	18	4	10	27	8	15	8	20	10	27	20	6	40	21
Participant D	5	18	10	12	16	15	6	18	20	9	12	4	30	30
Participant E	8	12	8	18	10	12	15	15	20	10	4	20	6	8
Participant F	10	6	20	8	3	6	18	14	15	12	2	6	4	6
Participant G	16	6	8	20	12	8	20	20	18	8	27	8	8	18
Participant H	0	0	0	3	16	6	4	24	8	16	6	24	32	8
Participant I	0	0	0	5	8	8	2	12	8	6	3	21	0	20
Participant J	0	3	4	8	6	16	6	12	8	27	4	16	27	15
Participant K	32	16	6	40	8	32	18	18	20	28	16	4	12	6
Participant L	0	0	0	6	16	0	0	8	8	10	12	24	9	21
MEAN:	**9.3**	**6.6**	**6.8**	**16**	**10.6**	**10.5**	**10.8**	**16.7**	**12**	**14.8**	**10.8**	**13**	**16.2**	**16.3**
± *SD:*	**9.8**	**6.4**	**6**	**11.2**	**4.5**	**8.4**	**8.5**	**5.5**	**6.2**	**8.2**	**8**	**7.9**	**13**	**9.6**

POST-TEST:

QUESTION:	1a	1b	1c	2a	2b	2c	3	4		5	6	7	8	9
CONTROL:														
Participant A	24	21	32	9	32	8	3	8	10	7	4	4	30	10
Participant B	12	27	6	6	4	8	30	9	8	4	16	8	16	12
Participant C	16	14	8	30	15	10	18	9	14	10	10	3	8	6
Participant D	4	12	10	2	0	0	18	12	3	14	8	9	0	30
Participant E	5	27	30	5	24	18	40	9	6	6	27	6	3	14
Participant F	18	24	20	16	40	12	20	12	9	10	3	0	3	12
Participant G	8	8	20	6	6	0	27	0	0	24	18	4	20	14
Participant H	12	24	32	16	30	16	20	21	15	18	8	8	15	27
Participant I	20	6	4	30	0	12	20	6	18	2	24	12	3	10
Participant J	40	18	18	30	16	24	24	12	12	2	6	18	40	32
Participant K	4	10	10	15	12	20	18	18	6	4	18	9	8	24
Participant L	18	6	8	6	5	36	16	16	27	9	8	16	9	0
MEAN:	**15.1**	**16.4**	**16.5**	**14.3**	**15.3**	**13.7**	**21.2**	**11**	**10.7**	**9.2**	**12.5**	**8.1**	**12.9**	**15.9**
± *SD:*	**10.3**	**8.1**	**10.4**	**10.5**	**13.4**	**10.1**	**8.9**	**5.6**	**7.3**	**6.7**	**7.9**	**5.3**	**12.1**	**10**

Appendix V – Newspaper Article (Southland Times, New Zealand)

College Sports: Wrestlers reap golden harvest on US tour

07.06.2000 - By JENNI RUTHERFORD

Kees Meeuws and Bull Allen are household rugby names (in New Zealand). Their muscle and strength have been admired by many fans during their careers. But few know that a lesser known sport - wrestling - contributed to their success.

Both dabbled in wrestling. All Black prop Meeuws wrestled for four years during his time at Kelston Boys High School, while Allen wrote in his book, Mark of the Bull, that wrestling had helped his propping.

New Zealand secondary schools coach Iain Adamson believes every rugby player should incorporate wrestling into their training sessions. "I've had 130kg props being thrown by an 80kg schoolboy," he said.

While wrestling was a sport on the side for Meeuws and Allen, some young New Zealanders are muscling their way to the forefront of the sport. Israel McMillan, from Rosehill College, has gone from strength to strength, winning the 54kg class at the New Zealand secondary schools championships.

McMillan also impressed on a recent tour to the United States. Another to catch the watchful eye of the Americans was Andrew Miller (King's College), who won the 58kg class. Miller, who captained the team in the United States, defeated a state placegetter while suffering from a shoulder injury, causing a major upset in a country where wrestling is a strong sport.

"It has more wrestlers than the number of rugby players in the entire world," said Adamson.

The New Zealand secondary school team toured southern California and at the two meetings picked up 28 medals, including 11 gold. The trip was an eye-opener for many of the boys, who had never been so far from home nor trained so hard. "We weren't used to the intensity. The Americans were amazed that we only trained twice a week," Adamson said. "Over there, they run in the morning and then have two training sessions a day."

Appendix VI – Internet Article I

Search for Wallabies in volleyball, wrestling.

Rupert Guinness in Marseilles | October 9, 2007

THE Australian Rugby Union hopes to find future Wallabies among the ranks of Australia's top Olympic sportsmen.

It plans to launch a recruitment drive among these sports in search of elite athletes with the size, skill and inclination to make the switch.

The ARU views track and field, volleyball, basketball, wrestling and power lifting as possible sources of rugby players.

However, the ARU is also willing to widen its search to many other sports. And it plans to use the coming trials for the Olympic Games in Beijing next year as an ideal opportunity to observe athletes at their peak.

"We have a well-driven pathway in terms of having skilful kids," ARU high performance general manager Pat Howard told the *Herald*. "There is also the unique aspect of athletic size. You can't coach kids that are six foot eight [203 centimetres]. You can't make them run [100 metres in 10.5 seconds].

"We have to look at these guys who are pretty naturally gifted athletes and see if we can also get them interested in rugby - or even if they have had a sense of rugby and played it at school."

The ARU's plan to cast the net wide was already in place before the Wallabies were eliminated from the World Cup in France by their 12-10 weekend loss to England in Marseilles.

But that loss highlighted the need for a greater depth of players who are naturally skilled, fast, strong and agile.

The ARU already has strong ties with the Australian Institute of Sport and plans to use this link to look at its sports and their parallels to rugby.

"Working with the AIS, there are sports like volleyball and basketball with the unique height advantages," Howard said. "Obviously, from their unique shapes, we will have a look at the wrestling shapes and see what are the bigger shapes there.

"And the speed is athletics. The power lifters … all sorts of sports. We can go and see what sort of athletes are out there and if they are interested in rugby. It won't be 100 per cent. Not everybody is going to be right for rugby or be interested … and maybe not suited for the physicality of the game. But you might just get lucky."

Howard said he would attend a number of Olympic sports events over the next months. He realised many of those events would be Olympic selection trials showcasing the potential recruits in their best condition and form. Potential converts to rugby could be athletes in sports who just miss the cut for the Olympics and were keen to switch immediately.

Or they could be those who are considering a change in sports after the Games in Beijing.

"Absolutely," said Howard, citing athletics and the crossover of former Fijian sprint champion Ricky Nalatu to union as an example. Like Howard, he played for the Queensland Reds.

"There are a lot of guys trying to get in the athletics team and guys who miss out," said Howard. "When Ricky Nalatu came across in the late '90s, he adapted very quickly to rugby, had a history [in rugby] and incredible pace. He came across to the sevens circuit, played for Queensland and increased our depth."

Howard is under no false illusion, however, about Australian rugby's problems, as highlighted by the Wallabies' exit from the 2007 World Cup.

"We did discuss before the game [that] the one massive threat is that Jonny Wilkinson knocks his kicks over, and that they could pressure us," he said. "It's a game they are very familiar with in Europe. And they played it particularly well. They [also] had chances to score tries, so we are not going to say we were unlucky. We lost and we have to accept that. But in terms of repercussions, that's not for today."

But even had Wallabies captain Stirling Mortlock's 78th-minute penalty kick gone over, Howard said a stringent review would still have been needed.

"Would we be patting ourselves on the back had 'Stirlo' put the kick over? Hopefully not. You don't put paint over the cracks. You have to have a good hard look at everything we are doing."

There is cause for much hope for the future with Australian backs Berrick Barnes, Adam Ashley-Cooper and Drew Mitchell all showing promise.

But Howard said much work was needed to be done if the Test pack was to be world class.

Appendix VII – Internet Article II

Boks get Martial Arts training

Thursday, October 30
http://www.sarugby.com/news/News/article/sid=10312.html

Springbok coach Peter de Villiers is leaving no stone unturned to ensure his team is literally fighting fit ahead of their three-Test tour starting against Six Nations champions Wales in Cardiff on Saturday, November 8.

Hennie Bosman, the reigning World Senior Karate Champion and kickboxing expert, was leading the charge when the Boks started off their training session at the University of Cape Town's Groote Schuur field on Wednesday afternoon.

There he was, with the help of another martial arts expert, teaching the Boks the art of handing off opponents in the tackle situation. He also drilled the players in exercises which were aimed at freeing themselves when held up in tackles.

Once the 7th Dan Black belt Bosman and his partner gave way, Springbok assistant coaches Dick Muir and Gary Gold put the players through their paces.

Muir kept the backs busy with basic handling exercises although players did not run in structured playing patterns.

As a result one could not gauge how new fly-half Ruan Pienaar and new cap Earl Rose would be fitting into the Boks' playing pattern, or what roles have been set out for them.

Jean de Villiers, the Boks' key backline decision maker, was absent at training. He has been laid low with a stomach bug and has been kept indoors at the team's Foreshore hotel in the Mother City.

Gold spent the afternoon working the forwards hard on the Australian-made scrummaging machine and there was lots of interest from the few thousand spectators in John Smit who was packing down at an unaccustomed tight head position, alongside hooker Bismarck du Plessis and loose head prop Tendai 'Beast' Mtawarira.

This front row was backed up by second rowers Victor Matfield and Bakkies Botha, flanked by Juan Smith and Pierre Spies, who usually plays at eighth-man. However, the opposing pack also packed down without a No 8.

Later on in the scrummaging session Gold, who was assisted by SARU referees expert Neville Heilbron, moved the permutations around which saw Smit locked with hooker Chilliboy Ralepelle and loose head strongman Gurthrö Steenkamp, at one stage.

However, the only position which remained constant as Gold moved the players around was that of the 'scrumhalf' who would-be spies might have mistaken as the

Boks' new secret weapon.

The 'scrumhalf' was none other Springbok flanker Schalk Burger who was sitting out at training because of a hamstring strain, which apparently is no cause for concern.

Weather conditions were fair in Cape Town on Wednesday afternoon and totally unlike what the Boks will encounter on their UK tour.

"It can be tough in the cold, rain and wind which we are bound to experience on tour," said Bok skipper Smit. "The really good teams adapt quicker to the local conditions. It's the same when teams tour here.

"There are other aspects like the mistiming of the seasons, but given there's not really an off-season any more, you can't blame the fact that we're at the end of our season." Smit also spoke about the importance of this tour in the light of the British and Irish Lions' campaign in South Africa next year.

"The bulk of the (British and Irish) Lions squad will come from the teams that we meet on this tour," said Smit. "Although the conditions will be different in South Africa than they will be on this trip, it is important that we win.

"Beating Wales, Scotland and England make it easier to set the tone for next year.

"Every player who goes on this tour will understand the magnitude of what is waiting for us next year.

"This is a great opportunity to suss out what they (the Lions) have in store for us and for us to score early psychological points."

"Any advantage we can gain against Wales, Scotland and England will be beneficial."