Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players

Joel Marshall

MSpEx

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ABSTRACT

Rugby union is a game that requires athletes to have well-developed anaerobic and aerobic capacity. However, it is unclear whether specific physical qualities can be used to distinguish between athletes of higher or lower competition levels. Therefore, the aim of this dissertation was to determine differences in anthropometry, strength, power, speed, and aerobic capacity between male rugby union athletes across professional, semi-professional, and amateur levels of competition. Chapter 2 presents a narrative review of the current physical characteristics of rugby union players across different competition levels and provides practical recommendations to help strengthen methodological approaches within the sport. The review presented findings which proposed a holistic approach to physical development at the lowest level of competition. The review also provided a greater understanding of the different physical characteristics between each level of competition. However, the literature highlights the need for future research to be grown to help continue to distinguish between the ranges of competition and the physical characteristics which could be required to reach the next level of competition. Consequently, chapter 3 compared a variety of physical characteristics between competition levels. Specifically, it was found that the larger differences were between the highest competition level (professionals) and either of the lower competition counterparts (semi-professional and amateur). Professionals produced significantly higher outputs in sections of strength, power, speed, and aerobic capacity markers when compared to the lowest competition amateur athlete. These results suggest that lower-level competition players should look to improve the wide variety of physical characteristics because of the nature of the sport. Furthermore, as players look to move through competition levels, speed characteristics should be monitored and trained closely as they differentiate between all levels of competition. Finally, training application should look to change towards power focused criteria when trying to reach the highest competition level. The information gathered is of value to researchers and strength and conditioning practitioners as it helps to distinguish physical characteristics required to reach a professional level.

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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.

Chapters 2 and 3 represent two individual manuscripts that have either been submitted or in preparation to be submitted to peer-reviewed journals for publication. My contribution to these works as well as the various co-author's contributions are outlined on the following pages. All co-authors have approved the inclusion of joint work within this master's dissertation.

Signed:

Date: 20 December 2021

Candidate Contributions to Co-authored Publications

The student was the main contributor of the research in this dissertation to the minimum requirement of 80%. The student was also the main contributor to the writing of ethics applications and necessary progress reports for the completion of the dissertation.

Chapter 2.

Marshall, J., Brughelli, M., Uthoff, A. Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players: A narrative review.

Marshall, J. (80%)

Brughelli, M. (10%)

Uthoff, A. (10%)

Chapter 3.

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Aaron Uthoff

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Ethical Approval

Ethical approval to undertake this research was granted by the Auckland University of Technology Ethics Committee (AUTEC; #21/109) on 16 July 2021 (Appendix 1.).

Because this dissertation was to include participants contracted to New Zealand Rugby (NZ Rugby), ethical approval was granted by Medicine and Science Advisory Panel (MSAP) on 11 August 2021 allowing research using NZ Rugby athletes to be published (Appendix 2.).

Chapter 1

INTRODUCTION AND RATIONALE

BACKGROUND:

Rugby union has always been viewed as physiologically complex, as players engage in intermittent high intensity activity throughout a 80min game split over two 40min halves (Duthie et al., 2003). Since the professional era of rugby union, the speed and intensity of the game has increased as a result of rule changes and advanced resourcing capabilities (Duthie et al., 2003; Duthie, 2006a). This evolution necessitates the understanding of specific qualities, so we are able to simplify the development pathway of players. Physical characteristics such as aerobic capacity, strength, power, and speed have been noted as critical determinants towards performance in rugby union (Argus et al., 2012; Jones et al., 2018). To be specific, tasks such as tackling, accelerating into contact, scrummaging and mauling success rely heavily on muscular strength and power (Baker & Newton, 2008; Crewther et al., 2009). Therefore, the role of physical profiling is an integral part as information collected seeks to provide high performance environments with an in-depth physical analysis around players capacity and development opportunities (Duthie, 2006b). High performance practitioners have continued to grow the way anecdotal performance data is being used; some of which is likely playing a pivotal role in differentiating between athletic potential and the level of competition achieved (Fullagar et al., 2019). Current research agrees that improvement in certain physical characteristics may enhance an athlete’s chances of progressing to higher levels of competition within rugby union (Hansen et al., 2011).

Current research has suggested that anthropometric, speed, strength and power characteristics provided detail to differences between top competition level professionals compared to both lower competition counterparts. Specifically, vertical power production using tests such as countermovement jumps, and horizontal power production via weighted sled pulls seem to be useful when differentiating professionals and lower competition levels (Hansen et al., 2011; Watkins et al., 2021). Therefore, the use of similar profiling opportunities should be accepted as fundamental in the development process. In agreeance, speed characteristics such as acceleration and max velocity outputs were also prominent in the dissection of competition levels. Watkins et al. (2021) found that sprint performance across all distances was significantly greater for international and professional players compared with club players, most prominently across the first 10 m (1.71 and 1.74 seconds vs. 1.79 seconds, respectively). Suggesting once again the use of specific profiling tools should be fundamental within any development process. In relation to rugby union and recent research, the physical characteristics that are being collected have the opportunity to be expanded. This increase in knowledge will help continue to grow the sport of rugby union as it provides high performance environments with an in-depth physical analysis and understanding around player profiling and development (Duthie, 2006b). Physical profiling has now become an integral part of growth within rugby union is the rationale for why we have done this dissertation.

SIGNIFICANCE & PURPOSE:

This dissertation collated and reviewed the current literature around the differences in physical characteristics between levels of competition in rugby union. For better implementation within high performance environments, growing the research of physical differences within rugby union is paramount. To this, a wide variety of physical characteristics were examined to grow the current literature of physical outputs and the differences between competition levels of male rugby union players.

DISSERTATION AIM:

The specific aims of this dissertation were to:

1) Evaluate the current literature of the differences of physical characteristics between varying competition levels within rugby union.

2) To grow, compare and understand further differences in physical characteristics between male rugby union players across amateur, semi-professional, and professional levels of competition.

DISSERTATION STRUCTURE & FORMAT:

The dissertation follows the pathway two format (manuscript structure) where the dissertation is comprised of a series of stand-alone chapters that are prepared for peer-reviewed publication. This includes a narrative review (chapter 2), and one research study (chapter 3) to be submitted for publication. A conclusions chapter (chapter 4) is provided to give an overview of the study and practical application from the results found.

Chapter 2: A narrative review that focused specifically on the differences of physical characteristics between different levels of competition within male rugby union. This review dissected a variety of different physical outputs that have been previously collected to help develop understanding into the importance of physical profiling, player development and differences of player outputs within rugby union.

Chapter 3: This study investigated the differences of physical characteristics between levels of competition of male rugby union players. It was decided to collect anthropometric, strength, speed, power, and aerobic capacity outputs to continue to broaden the literature. This research was conducted to provide greater insights into the most important outputs across competitive levels to help in the development of rugby union players as they climb the competitive ladder to be a professional.

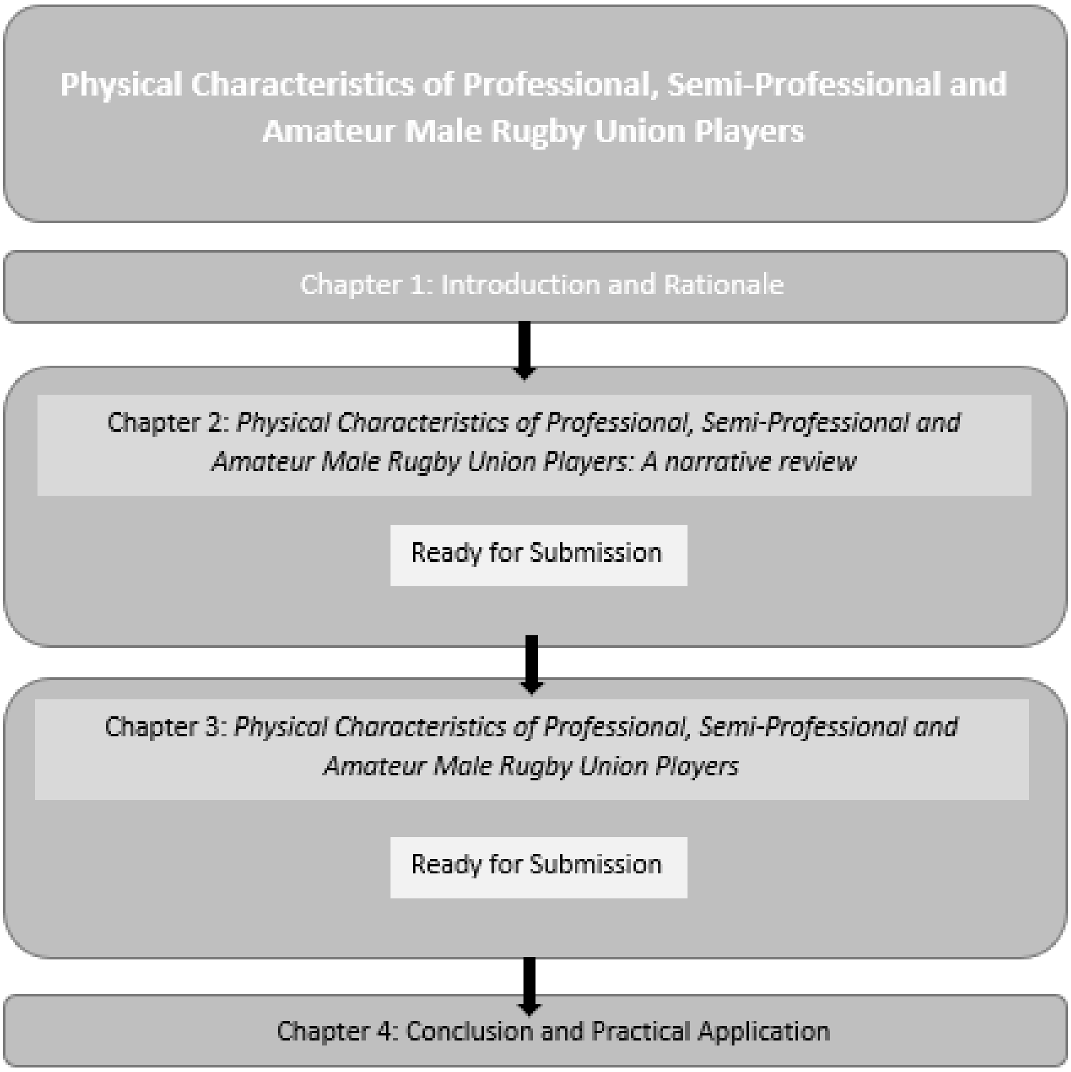

Figure 1. Dissertation Structure Outline

Chapter 2

Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players: A Narrative Review

Prelude:

Physical performance assessments are commonly used to give the practitioner, coach, and athlete insight into athletic performance. Basic physical qualities have also been used effectively to discriminate between levels of competition within rugby union. The purpose of this review was to summarise the current literature surrounding commonly assessed physical characteristics of rugby union players, with a focus on the differences between levels of competition. The physical characteristics include (1) anthropometry, (2) strength, (3) speed, (4) power, and (5) aerobic capacity. Quantifying athletic activity through accurate assessment is an essential piece of preparation of any athlete working towards a desired level of competition, and such information could be used to aid practice and prescription of strength and conditioning within rugby union. This chapter was purposeful in identifying current gaps and areas of improvement for future research and application in chapter 3.

Introduction

Rugby union is a collision-based field sport which requires a variety of physical characteristics (Appleby et al., 2012; Argus et al., 2012; Duthie, 2006b). Due to the nature of the game, physical characteristics such as endurance, strength, power, agility, and speed have been noted to be critical components towards performance in rugby union (Argus et al., 2012; Jones et al., 2018). Since the professional era, game speed has improved drastically with players covering a relative distance of approximately 70-80m.min^{-1} per game (Quarrie et al., 2013; Ross et al., 2015). As a result, the physical capabilities of the athletes have also increased (Smart, 2011; Smart et al., 2013). It has been revealed that these physical characteristics have been used effectively to discriminate between players, positional groups, and levels of competition (Appleby et al., 2012; Argus et al., 2012; Barr et al., 2014; Duthie, 2006b; Hansen et al., 2011; Jones et al., 2018).

Such research has spurred national rugby unions to provide opportunities to a range of athletes through resourcing high performance environments, and of which physical preparation is a major component (Duthie, 2006b). Therefore, physical profiling has now become an integral part within high performance environments. The information collected seeks to provide management and players with an in-depth physical analysis and understanding around player profiling and development (Duthie, 2006b). Current research of collision-based sports has largely focused on the physical characteristics of anthropometric measures, maximal strength, and speed markers, with some leading into basic determinants of power output, such as sprint momentum (Barr et al., 2014; Hansen et al., 2011). Barr et al. (2014) suggested sprint momentum as a more successful measure within professional rugby union because of the relationship between body mass and speed when relating to the collision nature of the sport. High performance practitioners have continued to grow the way such anecdotal performance data is being used; some of which is providing greater input into decision making around players, playing level and competition play (Fullagar et al., 2019). Continued investigation has provided support and development around the use and collection of power outputs, suggesting that they are among the most important factors for sports performance (Haff et al., 2001; McKeown, 2013) and likely play a pivotal role in differentiating between athletic potential and level of competition.

Therefore, the purpose of this review is to compare commonly tested physical characteristics between competition levels targeted at rugby union players. The variables included (1) anthropometry, (2) strength, (3) speed, (4) power, and (5) aerobic capacity. This review provides objective markers to support practitioners and coaches around talent identification, while also giving athletes a greater sense of physical targets to aim for as they strive towards higher levels of competition.

Literature Review

After conducting a literature search of five databases (i.e., Google Scholar, SPORTDiscus, PubMed, ScienceDirect, and OVID journals), a total of 15 studies were used in the comparison of physical characteristics between competition levels targeted at rugby union athletes. These 15 studies presented observational data across various qualities, making comparisons between age, position, and competition level. A total of seven studies included physical characteristics between rugby union professionals to amateurs (Argus et al., 2012; Barr et al., 2014; Hamlin et al., 2021; Smart et al., 2013; Watkins et al., 2021), while another two studies compared semi-professional and amateur rugby union players (Hansen et al., 2011; Jones et al., 2018).

Anthropometry

The importance of height and body mass of a rugby union player is something not largely contended upon (Duthie, 2006b; Sedeaud et al., 2012). The physical stature or profile of a rugby union player may be advantageous within professional rugby union (Duthie, 2006b; Duthie, Pyne, Hopkins, et al., 2006; Till et al., 2020). A study by Hamlin et al. (2021), investigated the difference between players whom reached the professional level compared to those players who did not. It was shown that height and body mass of the higher competition level players appeared to be greater than those of their lower-level counterparts (1.16% and 4.93%, respectively). Smart et al. (2013), indicated that professional level rugby union athletes were, on average, 10kg heavier compared to semi-professional or amateur level athletes. This very large difference highlights how physiques are continuing to change within rugby union (Smart, 2011; Smart et al., 2013). Interestingly, these differences were also largely tracked in conjunction with aerobic capacity data. Therefore, players carrying more mass may be negatively affected during sprint and fitness testing.

Duthie, Pyne, Hopkins, et al. (2006) explains that excess body fat has detrimental effects on acceleration and metabolic energy cost. Findings suggested that forwards carry greater skinfolds compared to backs (Hamlin et al., 2021; Smart et al., 2013) and could be assumed that forwards would have reduced sprinting and fitness capabilities compared to backs. High body mass in forwards has been indicated as an important characteristic due to the higher contact demands of the positional unit and could be a reason why forwards would have higher body composition than backs.

The findings acknowledge that taller, heavier and leaner athletes tend to make it to higher competition levels is consistent across a variety of rugby codes such as rugby league (Gabbett, 2002; Gabbett et al., 2009) and rugby union 7s (Ross et al., 2015). Therefore, given the importance of anthropometric characteristics towards performance within collision-based sports its suggested that anthropometric data should be tracked longitudinally along with the other physical capabilities. The findings that are presented can be found in Table 1.

Table 1. Anthropometric characteristics of rugby union players between different levels of competition.

Study	Participants (Number, Sex & Sport)	Competition Levels	Methodology	Measurements	Results
Hamlin et al. (2021)	N= 83 Male Rugby Union	Professional (n= 24) Amateur (n= 59)	Body mass, Height, and sum of 8 were reported on.	Body Mass (kg) Height (cm) Skinfolds (Sum of 8)	Professional vs Amateur ↑ 5.03% ↑ 1.16% ↑ 5.3%
Smart et al. (2103)	N= 1161 Male Rugby Union	*Not Reported*	Anthropometric measurements taken included body mass and sum of 8.	Body Mass (kg) Skinfolds (Sum of 8) Body Mass (kg) Skinfolds (Sum of 8)	Professional vs Provincial ↑3.25% ↑9.5% Provincial vs Amateur ↑ 2.3% ↑ 6.2%
Gabbett, T. (2002)	N= 159 Male Rugby League	Senior/Semi-Professional (n= 71) Junior/Amateur (n= 88)	Participants underwent Body mass measurements.	Body Mass (kg)	Semi-Professional vs Amateur ↑33.35%
Gabbett et al. (2009)	N= 64 Male Rugby League	Semi Professional (n= 28) Amateur (n= 36)	Participants underwent measurements of height, body mass, and sum of seven skinfolds.	Height (cm) Body Mass (kg) Skinfolds (Sum of 7)	Semi-Professional vs Amateur ↑1.1% ↑4.2% ↓11.2%
Ross et al. (2015)	N= 65 Male Rugby 7's	Professional = 22 Amateur = 43	Participants were assessed for height, mass, body composition.	Height (cm) Body Mass (Kg) Body Composition (Sum of 8)	Professional vs Semi-Professional ↑ 2.3% ↑ 9% ↓16%

N.B. ES = effect size, cm = centimetre, Kg = Kilogram

Strength

It is understood that greater muscular strength underpins many physical and performance attributes and can be extremely important in an individual's improvement in performance (Suchomel et al., 2018; Suchomel et al., 2016). The outputs of fundamental skills such as sprinting, jumping and change of direction (COD) are basic determinants of strength. The rate at which force can be produced (RFD) is often related to success in a large variety of sporting events (Haff & Nimphius, 2012; Stone et al., 2002).

In rugby union, muscular strength is a key contributor to on field performance due to the intermittent style of play intertwined with maximal-effort collision-based activity (Duthie, 2006b). Three studies have presented strength data between different competition levels of rugby union athletes via popular compound movements such as the bench press, back squat, deadlift, and chin ups (Argus et al., 2012; Hamlin et al., 2021; Smart et al., 2013). All three studies showed that on average higher-level athletes were able to produce greater absolute and relative strength over a variety of lifts, including the deadlift (7%), back squat (8.3%), box squat (17.9%), bench press (12.9%) and chin up (6.5%). Hamlin et al. (2021) showed that those athletes who are able to move to higher competition levels generally had greater strength development than those who remained amateur; forwards 8.8% and backs 2.1%. Argus et al. (2012) also supported this notion by comparing 112 rugby union players of different levels (43 professional, 19 semi-professional, 32 academy and 18 high school). Within the study, it is suggested that higher-level athletes produced greater absolute strength, and relative strength than lower-level athletes throughout all tests, confirming on average an upper body strength difference between professional and semi-professional of 4.9% and 18.4% from professional to amateur. Lower body strength followed the same trend, with an average of 1.08% separating professional and semi-professional but with a larger 17.9% difference between professional and amateur level rugby union player. Thus, strength could be considered a main determining characteristic when comparing between higher and lower levels of competition, such as professional compared to amateur level athletes. Supporting these findings, studies within rugby union 7s (Ross et al., 2015), and rugby league (Baker, 2002; Baker & Newton, 2008; Fernandes et al., 2019) also produced similar findings of higher strength outputs as the competition levels increase. Interestingly, the differences between semi-professional to professional were smaller compared to amateur to semi-professional or professional players. These results imply that other characteristics, such as maturation (Naughton et al., 2000) and training age/experience (Kanehisa et al., 2003; Weakley et al., 2017) could play as a potential facilitator in strength differences between playing standards. It also implies that absolute strength may not be a good measure to identify difference between higher levels of competition, (e.g., semi-professional versus professional). Therefore, other performance characteristics may be better indicators between the higher levels of competition within rugby union. The findings that are presented can be found in Table 2.

Table 2. Strength characteristics of rugby union players between different levels of competition.

Study	Participants (Number, Sex & Sport)	Competition Levels	Methodology (Measurements & Duration)	Exercise Selection	Results
Argus et al. (2012)	N= 112 Male Rugby Union	Professional (n= 43) Semi Professional (n= 19) Amateur (Academy) (n= 32) Amateur (High School) (n= 18)	1RM estimated using a 1-4 RM testing protocol. 1RM = (100*weight)/(101.3-(2.67123*reps))	Bench Press Box Squat Bench Press Box Squat	Professional vs Semi Professional ↑4.9% ↑1.08% Professional vs Amateur ↑18.4% ↑17.9%
Hamlin et al. (2021)	N= 83 Male Rugby Union	Professional (n= 24) Amateur (n= 59)	1RM estimated using a 5-10 RM testing protocol. 1RM = Weight ÷ (1.0278 - (0.0278 × Number of repetitions))	Deadlift Back Squat Bench Press Chin-up Prone Row	Professional vs Amateur ↑7.06% ↑3.8% ↑8.2% ↑4.8% ↑11.6%
Jones et al. (2018)	N= 184 Male Rugby Union	Professional Regional Academy (n= 55) Amateur (n= 129)	3 RM testing determined by maximal weight lifted.	 Bench Press Neutral Grip Pull-Ups	Professional vs Amateur ↑30.5% ↑6.6%
Smart et al. (2013)	N= 1161 Male Rugby Union	*Not reported*	1RM estimated using a 2–6 RM testing protocol. 1RM = w1.013−(0.0267123·r)	Bench Press Box Squat Back Squat Chin Up Bench Press Box Squat Back Squat Chin Up	Super Rugby vs Provincial ↑0.5% ↑8.0% ↑5.9% ↑1.3% International vs Super Rugby ↑1.0% ↑8.3% ↑-2.7% ↑3.3%
Baker (2002).	N= 95 Male Rugby League	Professional (n= 20) Semi Professional (n= 36) Amateur (n= 15) Amateur Junior (n= 13) Amateur untrained Junior (n= 11)	1 RM testing determined by maximal weight lifted.	Bench Press	1RM Bench Press was a potential descriptor of playing achievement levels (R=0.8).
Baker & Newton (2008)	N= 40 Male Rugby League	Professional (n= 20) Semi-Professional (n= 20)	1 RM testing determined by maximal weight lifted.	 Back Squat	Professional vs Semi-Professional ↑17.0%.
Fernandes et al. (2019)	N = 65 Male Rugby League	Professional (n= 26) Semi-Professional (n= 23) Amateur (n= 16)	Lower body 1 RM was estimated using an estimated 3 RM testing protocol. ((3RM load/93) *100) Upper body 1 RM testing determined by maximal weight lifted.	 Back Squat Bench Press Back Squat Bench Press	Professional vs Semi-Professional ES = −0.43 ± 0.53 ES = −1.42 ± 0.44 Professional vs Amateur ES = −2.04 ± 0.56 ES = −3.18 ± 0.46

N.B. RM = repetition maximum; ES = effect size

Speed

The speed in which an athlete moves within match-play is fundamental to success (Lockie et al., 2015). Maximal velocity and acceleration qualities are seen as essential attributes one should aim to possess when trying to achieve maximal performance (Duthie, Pyne, Marsh, et al., 2006). Linear speed is no different and is considered an important physical quality for rugby union which has been associated with line breaks, beating defenders and metres advanced in senior players (Smart et al., 2014). Six studies have investigated velocity characteristics of rugby union athletes through different competition levels, with a majority of those also comparing the outputs between playing positions (Barr et al., 2014; Hamlin et al., 2021; Hansen et al., 2011; Jones et al., 2018; Smart et al., 2013; Watkins et al., 2021). Sprinting performance was assessed over 5-40m, including initial sprint velocity, or acceleration qualities (i.e., 5-10m), and maximal velocity (i.e., 20, 30 & 40m). Several more recent studies found considerable differences between amateur and professional levels of competition, which ranged from 3.7, 2.8, 2.8% over 10, 20 and 30-m, respectively (Hamlin et al., 2021). Moreover, sprint performance across all distances was significantly greater for international and professional players compared with club players, most prominently across the first 10 m (1.71 and 1.74 seconds vs. 1.79 seconds, respectively) (Watkins et al., 2021). These findings are similar to, but not as large, as those observed between 40 m sprint times between professional and amateur rugby 7's athletes (4.4%) (Ross et al., 2015) Sprinting speed has also been found to discriminate between playing positions in rugby union. Backs have been found to be faster than forwards across both the acceleration phase (5-20m) and maximal velocity sprint phase (30-40m), 6.5% and 7.1%, respectively (Hamlin et al., 2021; Till et al., 2020), while Watkins et al. (2021) observed a significant difference of 3.69% in maximal velocity (m.s-1) between the unit groups. Initial and maximal sprint momentum results also suggested significant differences exist (d= 0.96 vs. 0.54 & d= 1.15 vs. 0.50, respectively) between forwards and backs (Baker & Newton, 2008; Barr et al., 2014; Jones et al., 2018). The common use of momentum utilizes the body mass of the athlete together with the velocity captured; usually over 5, 10, and 20 meter distances (Baker & Newton, 2008; Barr et al., 2014). Both Barr et al. (2014) and Baker and Newton (2008) concluded that the significantly heavier professional athletes were not actually recording significantly greater velocities, but rather a better power to weight ratio because of the added mass. These findings suggest that a better power to weight ratio should provide the opportunity to create greater momentum; something which has been discussed as central for success within collision-based sports (Barr et al., 2014; Gabbett, 2002; Gabbett et al., 2009; Jones et al., 2018). Unlike strength characteristics, speed is easily distinguished between higher levels of competition and playing position. It can be argued that scouting, coaching, and monitoring of speed characteristics could be placed above strength outputs within the gym. While also considering the importance of tracking anthropometric data alongside speed outputs throughout all competition levels. The findings that are presented can be found in Table 3.

Table 3. Speed Characteristics of Rugby Union Players between different levels of Competition.

Study	Participants (Number, Sex & Sport)	Competition Levels	Methodology (Measurements & Duration)	Metrics Selection	Results
Barr, M. J et al. (2014)	N = 69 Male Rugby Union	Professional (n= 38) Semi-Professional (n= 31)	4x40-m sprints on an artificial field at 10, 30, and 40m.	ISV MSV ISM MSM	Professional vs Semi-Professional ES = 0.17 ES = 0.09 ES = 0.81 ES = 0.95
Hamlin et al. (2021)	N= 83 Male Rugby Union	Professional (n= 24) Amateur (n= 59)	2-3 repetitions on an artificial turf at 10, 20, and 30m.	10m Time (sec) 20m Time (sec) 30m Time (sec)	Professional vs Amateur ↓ 1.1% ↓ 0.65% ↓ 0.47%
Hansen et al. (2011)	N= 40 Male Rugby Union	Professionals (n= 25) Semi Professional (n= 15)	Players performed 3 maximal sprints over 5, 10, and 30m on an indoor rubber based artificial training surface.	5m Time (sec) 10m Time (sec) 30m Time (sec)	Professional vs Semi-Professional ↓ 2.6% ↓ 2.1% ↓ 0.23%
Jones et al. (2018)	N= 184 Male Rugby Union	Semi-Professional/ Academy (n= 55) Amateur (n= 129)	Speed was assessed by participants performing 3 maximally sprints over 5, 20, and 40m.	5m Time (sec) 20m Time (sec) 40m Time (sec)	Semi-Professional vs Amateur ↓ 0.9% ↓ 1.5% ↓ 2.7%
Smart et al. (2013)	N= 1161 Male Rugby Union	*Did not Identify*	Forwards and Halfbacks performed 2 repetitions over 10 and 20 m. Backs performed 10, 20 and 30 m. All sprints were performed on grass.	10m Time (sec) 20m Time (sec) 30m Time (sec) 10m Time (sec) 20m Time (sec) 30m Time (sec)	Super Rugby vs Provincial ↓ 2.2% ↓ 2.2% ↓ 1.9% Provincial vs non-Selected ↓ 0.71% ↓ 0.67% ↓ 2.1%
Watkins et al. (2021)	N= 176 Male Rugby Union	Professional/Int (n= 53) Professional/SR (n= 47) Amateur (n= 76)	2x Maximal sprints across 10 and 20m (Tight Forwards) and 10, 20, and 30 m (Loose Forwards and Backs).	Vmax (m·s-1)	Professional vs Amateur ↑ 3.02%
Baker et al. (2008)	N= 40 Males Rugby League	Professional (n= 20) Semi-Professional (n= 20)	Participants performed a minimum of two trials over 10 and 40m. Performed on turf.	10m Time (sec) 40m Time (sec)	Professional vs Semi-professional ↓ 0.62% ↓ 0.39%
Gabbett, T. (2002).	N= 159 Male Rugby League	Semi-Professional (n= 71) Amateur (n= 88)	Participants were assessed by performing two maximally sprints over 40m.	10m Time (sec) 20m Time (sec) 40m Time (sec)	Semi-professional vs Amateur ↑ 9.9% ↑10.5% ↑2.7%
Gabbett et al. (2009)	N= 64 Male Rugby League	Semi Professional/ Junior Elite (n= 28) Amateur/ Junior (n= 36)	3x 10, 20 and 40m speed at the beginning of the competitive season.	10m Time (sec) 20m Time (sec) 40m Time (sec)	Semi-Professional vs Amateur ↑ 1.35% ↑ 1.11% ↑ 0.92%

Ross et al. (2015)	N= 65 Males Rugby 7's	Professional (n= 22) Amateur (n= 43)	Players performed a 2x maximal effort sprints over 40m. 5m, 10m and 40m distances. Speed was assessed indoors on an artificial track.	40m Time (sec)	Professional vs Amateur ↑ 4.4%

N.B. ES = effect size, ISV = Initial Sprint Velocity, MSV = Maximal Sprint Velocity, ISM = Initial Sprint Momentum, MSM = Maximal Sprint Momentum, SR= Super Rugby, Int = International, F0 = theoretical maximum force, Vmax = Maximum achieved velocity in trial

Power

Power production can be enhanced by either increasing an athlete's ability to generate high magnitudes of force at low velocities or, expressing low magnitudes of force at high velocities (Cormie et al., 2010a, 2010b, 2011). The mechanical qualities underlying explosive lower-limb activities are of interest to those involved in rugby sporting codes. As we know, force plays an important role in rugby union because of the variety and frequency of contact situations (Argus et al., 2012). Twist and Worsfold (2014) also address that when developing athletic qualities for power athletes, such as rugby union players, the manipulation to either force or velocity characteristics, while keeping the other variable constant, will enhance power production and should always be viewed as playing a pivotal role in power development. It is largely believed that a force-dominant athlete has a greater chance of being able to produce a greater power output at high force and low velocities, while a velocity dominant athlete has the ability to produce a greater power output using submaximal weights moved at higher velocities (Argus et al., 2009; Baker & Newton, 2008; Cormie et al., 2011). Therefore, it should be noted then when discussing power production, strength qualities such as maximal, dynamic, and ballistic strength should also be addressed when profiling rugby union athletes.

Two studies have reported that professional players, on average, produce greater power outputs than non-professional players (Hansen et al., 2011; Watkins et al., 2021). Interestingly, the greater power characteristics for professional players were produced both in absolute and relative outputs and through different planes of motion, vertically (peak power: 12.6%; rate of power development: 21.2%) through weighted countermovement jumps (Hansen et al., 2011) and horizontally (average maximal power production: 27.7%) through weighted sled pulls (Watkins et al., 2021).

These findings align with those of other contact team sports, such as rugby league (21.3% vertically) (Gabbett, 2002), (9.5% vertically) (Gabbett et al., 2009) and rugby union 7's in both the vertical (absolute peak power: 28.5%; relative peak power 19.5%) and horizontal planes (5.8% distance jumped) (Ross et al., 2015), indicating athletes playing at higher competition levels have greater capacities to produce physical power outputs across the force velocity spectrum than their lower competition counterparts. Therefore, accurate in-depth power profiles should be used to provide insight into rugby union athletes' characteristics and can provide valuable guidance for training prescription (Samozino et al., 2015), through quantifying force-velocity qualities, picking up deficiencies in muscular function, while also aiding in identification of individual talent (Hansen et al., 2011). The findings that are presented can be found in Table 4.

Table 4. Power characteristics of rugby union players between different levels of competition.

Study	Participants (Number, Sex & Sport)	Competition Levels	Methodology (Measurements and Duration)	Outputs	Exercise Selection	Results
Argus et al. (2012)	N= 112 Male Rugby Union	Professionals (n= 43) Semi Professional (n= 19) Academy Amateur (n= 32) High School Amateur (n= 18)	Players then completed two sets of four repetitions of bench throw at 50% and 60% of 1RM. Players then completed two sets of four repetitions of jump squat at 55% and 60% of 1RM.	Peak Power (PP)	Bench Throw Jump Squat Bench Throw Jump Squat	Professional vs Semi-Professional ↑ 25.7% ↑7.1% Professional vs Amateur ↑ 35% ↑16.8%
Hansen et al. (2011)	N= 40 Male Rugby Union	Professionals/Elite (n= 25) Semi Professional/Elite Jnr (n= 15)	Players performed 3 rebound jump squats with an external load of 40 kg.	PF (N-kg) EC RFD-MA (N-s) Rel EC RFD-MA (N-s-kg) Rel EC-FA30 ms (N-kg) EC-FA100 ms (N) EC-FA200 ms (N) Rel EC-FA200 ms (N-kg) EC-I200 ms (N-s)	CMJ Weighted	Professional vs Semi-Professional ↑ 10.9% ↑ 46% ↑ 41.8% ↓ 22.2% ↑ 13.2% ↑ 26.4% ↑ 21% ↑ 11.9%
Watkins et al. (2021)	N= 176 Male Rugby Union	Professional/Int (n = 53) Professional/SR (n= 47) Amateur/Club (n= 76)	Players completed 2x 20m (Tight Forwards) or 2x30 m (Loose Forwards and Backs) maximal sprints.	F_0 (N) V_0 (m·s^{-1}) P_0 (W) Vmax (m·s^{-1}) F_{rel} (N·kg^{-1}) P_{rel} (W·kg^{-1})	Weighted Sled Pull	Professional vs Amateur ↑ 26.8% ↑ 2.8% ↑ 29.2% ↑ 3% ↑ 23.8% ↑25.7%
Ross et al. (2015)	N= 65 Males Rugby 7's	Professional (n= 22) Amateur (n= 43)	Players completed 3x3 of bodyweight CMJ, weighted CMJ (50kg) and Horizontal CMJ (Broad Jump) to determine varying power outputs.	Peak Power (w) Relative Peak Power (w.kg^{-1}) Jump Length (cm)	CMJ (w) CMJ (w.kg^{-1}) CMJ(50kg) (w) CMJ(50kg) (w.kg^{-1}) Broad Jump	Professional vs Amateur ↑ 32% ↑ 23% ↑ 25% ↑ 16% ↑ 5.8%
Baker, D. (2002)	N= 95 Male Rugby League	Professional (n= 20) Semi Professional (n= 36) Amateur High School (n= 15) Amateur Junior High School (n= 13) Amateur Untrained Junior High School (n= 11)	Upper-body and lower-body power outputs were assessed bench press throws and jump squats, with a resistance of 20 kg.	Mean Power Output (W) Mean Power Output (W)	BP Throws Jump Squats BP Throws Jump Squats	Professional vs Semi - Professional ↑ 7.6% ↑ 17.9% Semi-Professional vs Amateur ↑ 11% ↑ 10.7%
Baker et al. (2008)	N= 40 Male Rugby League	Professional (n= 20) Semi-Professional (n= 20)	Participants were assessed for power by performing three repetitions with resistances of 40, 60, 80, and 100 kg.	Maximal Power (Pmax [W])	Jump Squat	Professional vs Semi-Professional ↑11.5%.
Gabbett, T. (2002).	N= 159 Male Rugby League	Senior/Semi-Pro (n= 71) Junior/Amateur (n= 88)	Participants performed two maximal vertical jumps for height.	Jump Height (cm)	Vertical Jump	Semi-Professional vs Amateur ↑21.3%

Gabbett et al. (2009)	N= 64 Male Rugby League	Semi Professional/Elite Junior (n= 28) Amateur/Sub Elite Junior (n= 36)	Participants performed vertical jumps to estimated lower body power.	Jump Height (cm)	Vertical Jump	Semi-Professional vs Amateur ↑ 9.5%
Fernandes et al. (2019)	N= 65 Male Rugby League	Professional (n= 26) Semi Professional (n= 23) Amateur (n= 16)	Participants completed 3 rep assessments of peak velocity and power at 20, 40, 60, and 80 kg.	Peak Power (W) Peak Velocity (ms^{-1})	Bench Press (PP) (PV) Squat (PP) (PV) Bench Press (PP) (PV) Squat (PP) (PV)	Professional vs Semi-Professional ES= 1.68 ES= 1.83 ES= 1.05 ES= 0.61 Semi-Professional vs Amateur ES= 2.15 ES= 3.37 ES= 2.12 ES= 1.62

N.B. ES = Effect Size, BP = Bench Press, PV = Peak Velocity, PP= Peak Power, PF = Peak Force,RelPP = Relative Peak Power, EC RFD-MA = Eccentric -Concentric Rate of Force Development at Moving Average, Rel EC RFD-MA = Relative Eccentric-Concentric Rate of Force Development moving average, RelEC-FA-30 = Relative Eccentric Force at 30milliseconds, EC-FA100 = Eccentric-Concentric Force at 100milliseconds, EC-FA200 = Eccentric-Concentric Force at 200milliseconds, RelEC-FA100 = Relative Eccentric-Concentric Force at 100milliseconds, EC-I200 = Eccentric-Concentric Impulse at 200milliseconds, F_0 =Maximal horizontal force production, P_0 = Theoretical maximum power, , V_0 = Maximal horizontal mechanical power production, Vmax = maximum achieved velocity in trial, F_{rel} = Relative maximal force production, P_{rel} = P_0 relative to body mass

Aerobic Capacity

Maximal aerobic capacity is an important physical characteristic for rugby union athletes to possess (Duthie, 2006b). The athlete's ability to 'recharge' energy stores and run at a speed adequate to the game is a determining factor in one's ability to perform (Duthie, 2006b). All available studies which investigated aerobic capacity qualities of players of different competition levels used the Yo-Yo intermittent recovery test level 1 (Gabbett et al., 2009; Hamlin et al., 2021; Jones et al., 2018; Ross et al., 2015). Within rugby union, Jones et al. (2018) found a 21.8% difference in aerobic capacity (distance covered during the Yo-yo level 1 recovery test) between semi-professionals and amateur rugby union players. Hamlin et al. (2021), indicated that body mass is a significant factor between competition levels of rugby union athletes; and potentially explain why aerobic capacity was not found to improve at the higher competitive levels. Like sprinting, aerobic capacity may be negatively affected by body mass. Therefore, aerobic capacity might not be an ideal athletic characteristic to distinguish between higher levels of competition. Instead, aerobic capacity could be used to make sure one is capable of the rigours of the positional demands and competition level involved. The findings that are presented can be found in Table 5.

Table 5. Aerobic capacity characteristics of rugby union players between different levels of competition.

Study	Participants (Number, Sex & Sport)	Competition Levels	Methodology	Test Selection (And Output)	Results
Hamlin et al. (2021)	N= 83 Male Rugby Union	Professional (n= 24) Amateur (n= 59)	Aerobic Capacity was measured through Yo-Yo IRT L1.	Yo-Yo IRT L1 (Level Completed)	Professional vs Amateur ↑ 1.95%
Jones et al. (2018)	N= 184 Male Rugby Union	Professional Regional Academy (n= 55) Amateur (n= 129)	Aerobic fitness was collected using Yo-Yo Intermittent Recovery Test Level 1; IRTL1.	Yo-Yo IRT L1 (Distance Covered)	Semi-Professional vs Amateur ↑21.8%.
Gabbett et al. (2009)	N= 64 Male Rugby League	Semi-Professional/ Elite Junior (n= 28) Amateur/Sub Elite Junior (n= 36)	Participants underwent an estimated maximal aerobic power (multi-stage fitness test).	Yo-Yo IRT L1 (Level Completed) Total Distance Covered Estimated V02	Semi-Professional vs Amateur ES = 0.96 ES = 0.97 ES = 0.98
Ross et al. (2015)	N= 65 Rugby 7's	Professional (n= 22) Amateur (n= 43)	Aerobic endurance was measured using a multi-stage fitness test (MSFT).	Multi-Stage Fitness Test (Distance Covered)	Professional vs Amateur ↑19%

N.B. ES = effect size

Conclusion

Physical performance assessments are commonly used to give the practitioner, coach, and athlete insight into athletic performance. They can be used for both talent identification and performance monitoring, aiding in individual identification of ability for those preparing strategies to develop the next elite athlete (Hansen et al., 2011). This is particularly important for sports such as rugby union, where athletes need to develop physical attributes, due to an increase in game speed and intensity of the collision (Quarrie et al., 2013; Smart et al., 2014). This has contributed to the continued increase in prescription of strength and conditioning resources for these athletes (Duthie, 2006b). With an increased emphasis on physical development, accurate assessments enable better interpretation of the data, which can be used to improve exercise prescription. This may enhance an athlete's chances of progressing to higher levels of competition (Hansen et al., 2011).

Power characteristics provided basic detail to differences between top competition level professionals compared to both lower competition counterparts. It's indicated that both vertical power production using tests such as countermovement jumps, and horizontal power production via weighted sled pulls seem to be useful when also differentiating between both lower competition levels. Speed characteristics such as acceleration and max velocity were most applicable for discerning between higher competition levels, from professional to semi-professional players. While strength testing provides greater insight into the differences between the lower competition levels, from amateur to semi-professional. Aerobic capacity seems to be the least important performance characteristic to distinguish between the higher levels of competition (professional and semi-professional) but provided a great insight into lower-level athlete comparisons, semi-professional to amateur. A variety of studies have also produced similar results in other team-based sports with popular but narrow testing parameters (Appleby et al., 2012; Argus et al., 2012; Baker, 2002; Baker & Newton, 2008; Barr et al., 2014; Gabbett, 2002; Hansen et al., 2011; Jones et al., 2018). It suggests that aerobic capacity and general strength should be the focus early in training to get amateur athletes to the semi-professional level. Once achieved those athletes should maintain those capacities but begin to shift their focus to getting faster and increasing power output if they wish to progress into elite levels.

It is imperative that a range of physical characteristics be assessed to assist in both talent identification and athlete monitoring for rugby union. These characteristics can distinguish between levels of competition and provide sports scientists, strength and conditioning staff, coaches, and athletes with valuable metrics to guide training prescription. However, the assessment techniques used in the literature only scratch the surface of the available testing outputs and monitoring tools currently employed by rugby union physical development staff.

Chapter 3

Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players

Prelude:

This chapter focuses on a variety of physical differences between varying levels of competition. Specifically, it looks at anthropometry, strength, power, speed, and aerobic fitness outputs of male rugby union players who are playing professional, semi-professional and amateur in a variety of different competition levels. A primary goal for this chapter was to continue to grow, compare and understand further differences in physical characteristics between male rugby union players and the levels of competition.

Abstract:

Aim: The aim of this study was to determine the differences in physical characteristics between male rugby union athletes across different levels of competition. The physical characteristics included anthropometry, strength, power, speed, and aerobic fitness. **Methods:** 55 male rugby union athletes were split across different competition levels: professional (N=16), semi-professional (N=17), and amateur (N=22). The testing procedure was broken into two parts, initially the indoor testing assessments took place to collect anthropometric, strength, velocity, and power outputs. The second part was performed both inside on hardwood floor for speed assessments, and outside on a field to collect aerobic capacity. **Results:** Clear differences existed between professional and semi-professional in strength (IMPT: 13.2%, $p = 0.004$) and power (eccentric deceleration rate of force development: 59.9%, $p = 0.004$, CMJ concentric peak force: 18.4%, $p = 0.011$ and hop test contact time 12.8%, $p = 0.007$). An increase in differences were observed between professional and amateur players in strength (IMTP: 17.6%, $p = <0.001$), power (CMJ relative peak power: 10.2%, $p = 0.014$, CMJ relative eccentric deceleration rate of force development: 78.4%, $p = <0.001$, CMJ concentric peak force: 25.9%, $p = < 0.001$ and hop test contact time 12.4%, $p = 0.006$), speed (20-meter sprint time: 3.4%, $p = 0.015$, 30-meter sprint time: 3.7%, $p = 0.014$, 10–20-meter split time: 4.8%, $p = 0.002$ and 20–30-meter split time: 4.3%, $p = 0.023$) and aerobic capacity (18%, $p = 0.031$). **Practical Application:** Lower-level competition players should look to improve the wide variety of physical characteristics because of the nature of the sport. The holistic development of the lower-level athlete may allow them to have a greater capacity to train other characteristics as the competition level rises. As players look to move into higher competition, training should focus on specific capabilities such as sprinting

performance or power development. Further research is needed to determine more in depth understanding into positional groups between competition levels.

Introduction

Highly demanding physically, tactically, and skill-based, the game of rugby union requires a variety of physical characteristics to perform at an elite level (Argus et al., 2012; Duthie, 2006a; Jones et al., 2018). Since the professional era of rugby union, the speed of the game (Quarrie et al., 2013), number of collisions and player size have all increased (Duthie et al., 2003; Tierney et al., 2021; Till et al., 2020; Twist & Worsfold, 2014). Due to these increased demands, players' physical attributes such as strength, speed and aerobic capacity have been noted as critical components towards an increase in player performance (Appleby et al., 2012; Argus et al., 2012; Barr et al., 2014; Duthie, 2006b; Hansen et al., 2011; Jones et al., 2018). These physical attributes are responsible for the frequency and intensity of numerous bouts of high intensity activity interspersed with lower intensity activities (Twist & Worsfold, 2014). The greater the players' ability to continually perform frequent bouts of high intensity activities such as tackling, line-breaks and set piece, will contribute to the success or failure of the team (Duthie et al., 2003; Duthie, 2006a). As competition levels increase, these physical characteristics look to amplify the intensity of game play which in turn increases the odds of success of the athlete and or team (Jones et al., 2008; Smart et al., 2014).

The holistic integration of coaches, performance staff, experience, and growing research ensure that the activity profile of the player has been well thought out to help maximise the transfer of physical qualities to the competitive environment (Twist & Worsfold, 2014). Providing a greater example of the connection between physical characteristics and match specific actions, Twist and Worsfold (2014) have dissected match specific actions into well-known physical capabilities; force (e.g., scrumming, rucking, mauling), velocity (e.g., sprinting, line-breaking, kick chase), and power (e.g., tackling, fending and change of direction). Quantifying these physical capacities is fundamental to any practitioner wanting to develop a deeper understanding, examine differences, create standards, or outline accurate conclusions to inform programming (Twist & Worsfold, 2014). Within this space, physical profiling has now become an integral part of athlete development, allowing practitioners to create accurate profiles and track changes over time (Comfort et al., 2011; Duthie, 2006a). Although, single performance measures cannot be used to determine the quality of a player (Duthie et al., 2003; Duthie, 2006a) or their potential impact, an understanding of a variety of physical characteristics, their importance, and their differences can provide an insight into individual players' potential for long-term success.

Research in collision-based sports such as rugby has largely focused on the physical characteristics of anthropometric measures, maximal strength, and speed markers, with some leading into basic determinants of power output (Barr et al., 2014; Hansen et al., 2011). It is understood that aerobic capacity (Hamlin et al., 2021; Jones et al., 2018; Ross et al., 2015) and general strength (Argus et al., 2012; Hamlin et al., 2021; Smart et al., 2013) should be the focus early in training to get amateur athletes to the semi-professional level. Once achieved, athletes should maintain these capacities as they have been known to provide a greater capacity to train (Jones et al., 2013). Instead, allowing them to pursue other capacities, such as speed or power, which had been shown to be significantly greater between increasing competition levels (Hamlin et al., 2021; Watkins et al., 2021). Unfortunately, the combination of physical characteristics across multiple competition levels is scarce and one reason why this research was undertaken. Therefore, the aim of the study was to determine the differences in physical characteristics between male rugby union athletes across professional, semi-professional, and amateur levels of competition. We hypothesized that anthropometry, aerobic capacity, and strength qualities will distinguish between the lower levels of competition, while speed and power will be the differentiating factor between the higher grades of competition.

Methods

Experimental Approach to the Problem

A cross sectional study was implemented to examine the differences in physical characteristics between levels of competition within rugby union. To understand whether certain physical traits were linked to playing level, anthropometrics, maximal lower-body strength and power, linear sprinting performance, and aerobic fitness were compared between rugby union athletes participating at either the club, provincial, or professional levels. All procedures were aligned with elite rugby testing protocols and collected as part of an athletic profile of the subject.

Participants

Fifty-five male rugby union athletes, comprising of 16 professional, 17 semi-professional, and 22 amateur players, all provided consent to be included in this study. See Table 1 for age, height, and body mass for each group. The participants playing positions were broken down into 29 forwards and 26 backs. Their specific positional groups were comprised of 10 props, 7 hookers, 5 locks, 7 loose forwards, 6 halfbacks, 5 first fives, 6 midfields, and 9 outside backs. Participants were selected if they were over 18, injury free, and currently competing in either New Zealand amateur club, Bunnings National Provincial Competition [NPC] (semi-professional), or Super Rugby (professional) competitions. In some cases, participants competed across two different levels (e.g., Super Rugby and Bunnings NPC). In those cases, the participants were categorized as their highest level of achievement. For example, a subject who was contracted to both a Super Rugby franchise and Bunnings NPC team would be viewed as a fulltime professional as their rugby season spans across a whole calendar year. This would be the same as a Bunnings NPC player who also played amateur club rugby would be viewed as a semi-professional as they were part of professional environment for part of a year. All amateur players were involved in some capacity with the provincial union but without any contractual obligations. All participants were informed of the risks and benefits before given written formal consent. The Auckland University of Technology Ethics Committee approved this project.

Table 6. Anthropometric characteristics of professional, semi-professional and amateur rugby union Players (n=55)

	Professional (n=16)	Semi-Professional (n=17)	Amateur (n=22)
Age	25.4 ± 2.59	22.1 ± 3.12	22.3 ± 3.26
Height (cm)	182.69 ± 5.95	183.94 ± 6.44	182.38 ± 6.71
Body mass (kg)	102.64 ± 11.51	100.20 ± 13.26	100.56 ± 14.55

ǂ Significantly ($p<0.05$) different from amateur players.
Values are mean ± SD.

Procedure

Twenty-four hours prior to testing, athletes were asked to refrain from rigorous training. Standard training gear was consistently worn throughout testing. All athletes were accustomed to all tests being collected within this study and therefore familiar with the procedures.

Prior to the performance testing session, athletes' bodyweight and height were assessed to determine basic anthropometric body measures followed by a verbal explanation of the performance testing procedures. The participants then completed a standardised 10 min whole body dynamic warm up lead by a qualified strength and conditioning specialist, including submaximal movements of the testing procedures. The first testing session took place inside and involved the athletes performing a maximal isometric pull (isometric mid-thigh pull) and maximal jumps from various positions (counter movement jump, repeated hop test, and broad jump). Isometric pulls and all vertical jumps were instantaneously assessed via AMTI Force Plates using a sampling frequency of 1000 Hz. Each participant performed 3 trials per physical effort.

The athletes then performed the second testing session, which started with a 10-min standardised warm up consisting of jogging, dynamic stretching, and submaximal stride-outs (70-90% of maximum sprint velocity) lead by a qualified strength and conditioning specialist. The testing procedures involved athletes performing a maximal sprint (5m, 10m, 20m, 30m), devoid of any deceleration. Each participant performed 2 trials at the selected distance, interspersed with 3-min passive rest. Once rested the final test of 1200m maximal aerobic effort 'Bronco' took place outside on a firm grass rugby field.

Anthropometry Collection

Body mass and height were measured to the nearest 0.1kg and 0.1cm using calibrated scales (Wedderburn Professional Weight Scale, New Zealand) and Stadiometer (Wall mounted height meter growth ruler, Mediapress. Hong Kong) respectively.

Strength

Strength was measured through the athlete performing a maximal isometric mid-thigh pull (IMTP) sampled via AMTI Force Plates processed by ForceDecks Software (Vald Performance, Brisbane, Australia). Players completed a standardised 10 min whole body dynamic warm-up, including submaximal movements of the testing procedures. The IMTP was chosen as strength derivative because of its ease of use when testing compared to traditional counterpart 1-Rep Max (1RM) testing because of its ability to be potential less fatiguing, potentially safer, while also allowing for the quantification of peak force (Fpeak) (Comfort et al., 2019).

The IMTP procedure has been described by Comfort et al. (2019); Comfort et al. (2020). This was an iterative process in which the athlete started with a bar height that allowed for a body position that replicated the start of the second pull position during the clean (optimal knee [125-145°] and hip [140-150°] angles): upright torso, slight flexion in the knee resulting in some dorsiflexion, shoulder girdle retracted and depressed, shoulders above or slightly behind the vertical plane of the bar, feet roughly centred under the bar approximately hip width apart, knees underneath and in front of the bar, and thighs in contact with the bar (close to the inguinal crease dependent on limb lengths. When making joint measurements, athletes were asked to apply no tension to the bar but that all "slack" (e.g., elbow flexion, shoulder girdle elevation/protraction) was removed from the body, as this would result in a change in joint angles during the maximal effort which is undesirable.

Submaximal trials of the IMTP were completed prior to maximal effort trials (e.g., 3-4 seconds each of: 50% maximal effort, 75% maximal effort, 90% maximal effort, separated by 60-120 seconds rest). For each of the maximal effort trials, standardized instructions were given of some iteration of "push your feet into the ground as fast and as hard as possible" to ensure that both maximal RFD and PF were obtained. It is essential that athletes understood that the focus was to drive the feet directly into the force platform and not attempt to pull the bar with the arms or to rise up on to their toes.

A countdown of "3, 2, 1, PULL" gave the athlete sufficient warning to be ready to give a maximum effort and provided at least one second of quiet standing to enable the identification of the onset of the pull. Verbal encouragement was provided to ensure that the athlete gave a maximum effort. A minimum of two trials were collected with the highest being used for analysis.

Importantly, the IMTP has been shown to be highly reliable (ICC > 0.91; CV < 4.5%) both within and between sessions, with low variability and low measurement error in rugby players. (Comfort et al., 2019; McGuigan & Winchester, 2008).

Power

Vertical Jump

Average vertical power was obtained during the collection of two separate jumps sampled on AMTI Force Plates processed by ForceDecks Software (Vald Performance, Brisbane, Australia).

Counter Movement Jump. Following the dynamic warm-up, athletes performed one CMJ at 50% effort, one CMJ at 75% effort, and two maximal effort CMJs with no arm swing. Athletes performed each jump by starting in the standing tall position with hands grasping a wooden dowel placed across their shoulders and feet placed hip width apart with one on each of the ForceDecks AMTI Force Plates (Vald Performance, Brisbane, Queensland, Australia). The force plates were zeroed prior to the athlete stepping onto the plates, and the athletes were instructed to stand as still as possible prior to performing any jumps to determine body mass. The force–time curve was visually inspected to ensure limited movement occurred in the weighting phase, and a signal was provided by the software when an accurate bodyweight measure was taken. The subject was then instructed to start with equal weight distribution on both force cells. Following a verbal cue of 'Start'', athletes were instructed to drop into a self-selected countermovement depth, perform a maximal effort vertical jump "as quickly and explosively as possible," and land back onto the force plates. For each jump, verbal encouragement was provided to ensure that maximal effort was given during each attempt.

The software identified the initiation of movement as a 30 N deviation from the initial bodyweight calculation, eccentric to concentric phase moment as the lowest centre of mass displacement, and take-off as the moment the vertical forces fell 30 N below body mass. A series of metrics from the ForceDecks software's default output were analysed to provide the end user with reliability of a multitude of metrics of interest. These metrics can be defined in ForceDecks user guide (Merrigan et al., 2021).

Repeated Hop Test [Bilateral] (RHT). Before the participant stood onto the above-mentioned force platform, it was zeroed. For the RHT, 11 jumps were completed in total, but the first was excluded because it was a CMJ that initiated the 'bounce' technique for the remaining 10 repeated jumps. Out of the remaining 10 jumps the software selected and analysed the best 5 jumps to use for the output. Each subject placed their hands on their hips to isolate the contribution from the lower limbs. Athletes were given the verbal instruction to 'to jump as high as possible and minimize time in contact with the ground'. From the 10 jumps recorded, the five that displayed the highest jump height whilst maintaining a ground contact time of 250ms was used in calculating reactive strength index (RSI). This test was administered 3 times with 90 seconds' rest between trials (Stratford et al., 2020).

Horizontal Jump

Broad Jump. Each participant stands behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The participant attempts to jump as far as possible, landing on both feet without falling backwards. For each effort the measurement was attained from the start distance from the toes to the hindmost point of the feet when landed. Participants were required to "stick" the landing for the jump to be recorded for analysis. The coefficient of variation of the horizontal countermovement jump or broad jump has been shown to be 2.4% in rugby players (Markovic et al., 2004).

Speed

Sprints were measured at 5, 10, 20 and 30 m using single beam with error correction processing (ECP) timing gates (Smart Speed, Fusion Sport, Queensland, Australia). Players completed two maximal sprints with 3-minutes passive recovery between bouts. Participants started each sprint 0.5 m behind the starting timing gate from a crouched split stance start with no countermovement. Timings during each split (5m, 10, 20 or 30 m) were set at an approximate hip height of 1.00 m and recorded to the nearest 0.01 s. Each subject's fasted sprint was used for analysis. The intraclass correlation coefficient (ICC) and coefficient of variation (CV) for similar protocols have previously been reported to be r = 0.94 and CV = 1.4%, r = 0.90 and CV = 1.7% and r = 0.96 and CV = 1.2% respectively within academy adolescent RU players (Darrall-Jones, Jones, et al., 2015).

Aerobic Capacity (Bronco)

The Bronco test is widely used in the rugby environment and consists of running 1200 m in a shuttle-type fashion (~5 min in duration). Cones were placed at the 0, 20, 40, and 60 m lines. Athletes were required to run from 0 to 20 m, return to the 0 m line, run to the 40 m line, and return to the 0 m line, and run to the 60 m line and return to the 0 m line. Completion of the 20-40-60 m shuttles was considered one repetition, with athletes completing 5 repetitions as quickly as possible to finish the test. Hand-held stop watches were used to record the bronco test finishing times. A 5-min field test was performed as it is easy to apply and practical for intermittent sport athletes as it measures both aerobic capacity and performance (Brew & Kelly, 2014). The test-retest reliability for the Bronco test has been shown with a CV of 2.1% (Hamlin et al., 2019).

Statistical Analysis

All performance data is reported as mean ± standard deviation. Collected data was statistically analysed through IBM Statistical Package for the Social Science 27.0.1 (SPSS) computer software. A One-way ANOVA was performed to determine the differences in physical characteristics between competition levels. For significant relationships, Fisher's least significant difference (LSD) post hoc analysis was conducted to determine specific difference between competition levels. Significant significance levels were set at $p \leq 0.05$.

Results

Anthropometry

No clear differences in anthropometry were found between all competition levels (Table 1).

Strength

In Table 3 there was a significant difference between the professional and semi-professional groups in isometric mid-thigh pull peak force (13.2%, $p = 0.004$), and a significant difference between professional and amateur players in isometric mid-thigh pull peak force (17.6%, $p = <0.001$).

Table 7. Strength and power characteristics of professional, semi-professional and amateur rugby union Players (n=55)

	Professional (n=16)	Semi-Professional (n=17)	Amateur (n=22)
IMTP PF (N)	4757.44 ± 740.83ǂ¥	4167.65 ± 506.44	3986.18 ± 435.65
IMTP timePF (sec)	3.52 ± 1.13	3.71 ± 1.03	3.16 ± 1.30
IMTP PF150 (N)	2872.03 ± 588.56	2724.12 ± 549.98	2730.05 ± 584.09
IMTP relPF150 (N-kg)	27.77 ± 3.54	27.84 ± 6.36	27.65 ± 7.62
IMTP AI150 (N)	342.28 ± 70.23	338.50 ± 78.71	332.74 ± 76.50
CMJ Height (cm)	38.21 ± 5.46	40.40 ± 5.34	39.13 ± 7.62
CMJ relPP (W-kg)	66.59 ± 8.94ǂ	61.96 ± 7.15	60.13 ± 7.27
CMJ relEccDecRFD (N-s-kg)	439.81 ± 301.75ǂ¥	237 ± 184.74	192.18 ± 51.92
CMJ conPF (N)	3931.75 ± 927.26ǂ¥	3270 ± 768.05	3028.45 ± 472.39
Hop Test (RSI)	2.82 ± 0.49ǂ	2.51 ± 0.40	2.45 ± 0.47
Hop Test CT (sec)	168.38 ± 13.89ǂ¥	191.41 ± 27.67	190.68 ± 26.03
Broad Jump (cm)	258.69 ± 14.88	254.29 ± 26.03	252.27 ± 17.96

IMTP = Isometric mid-thigh pull, PF = Peak force, timePF = Time to peak force, PV150 = Peak force at 150milli-seconds, rel = Relative to body mass, AI = Absolute Impulse, CMJ = Counter movement jump, PP = Peak power, EccDecRFD = Eccentric Deceleration rate of force development, con = Concentric, RSI = Reactive strength index, CT = Contact time.
ǂ Significantly ($p<0.05$) different from amateur players.
¥ Significantly ($p<0.05$) different from semi-professional players.
Values are mean ± SD

Power

Reported power derivatives varied between the competition levels. Specifically, the CMJ relative eccentric deceleration rate of force development (59.9%, p =0.004), CMJ concentric peak force (18.4%, p = 0.011) and hop test contact time (12.8%, p = 0.007) between the higher competition levels (Professional versus semi-professional) were significantly different. These differences were generally larger when comparing the professional counterparts to the lowest competition level (Amateur); CMJ relative peak power (10.2%, p = 0.014), CMJ relative eccentric deceleration rate of force development (78.4%, p = <0.001), CMJ concentric peak force (25.9%, p = < 0.001) and hop test contact time (12.4%, p = 0.006).

Speed

The findings in Table 8 indicate that there were some main effects across competition levels for average sprint times and splits (5-10-20 & 30m). Specifically, there were significant differences between professional players' horizontal speed characteristics in 20-meter sprint time (3.4%, p = 0.015), 30-meter sprint time (3.7%, p = 0.014), 10–20-meter split time (4.8%, p = 0.002) and 20–30-meter split time (4.3%, p = 0.023) when compared to the amateur playing group.

Aerobic Capacity

Table 2 noted aerobic capacity was significantly different between the highest competition level professional and the lowest competition amateur (18%, p = 0.031).

Table 8. Aerobic capacity and horizontal speed characteristics of professional, semi-professional and amateur rugby union Players (n=55)

	Professional	Semi-Professional	Amateur
Bronco (min:sec)	4:59 ± 0:16ǂ	5:03 ± 0:23	5:18 ± 0:31
5m (secs)	0.95 ± 0.03	0.96 ± 0.04	0.98 ± 0.05
10m (sec)	1.67 ± 0.06	1.68 ± 0.07	1.71 ± 0.09
20m (sec)	2.88 ± 0.11ǂ	2.93 ± 0.12	2.98 ± 0.14
30m (sec)	4.03 ± 0.17ǂ	4.10 ± 0.17	4.18 ± 0.21
5-10m Split (sec)	0.72 ± 0.04	0.73 ± 0.04	0.73 ± 0.05
10-20m Split (sec)	1.21 ± 0.05ǂ	1.25 ± 0.06	1.27 ± 0.06
20-30m Split (sec)	1.15 ± 0.07ǂ	1.17 ± 0.06	1.20 ± 0.07

ǂ Significantly ($p<0.05$) different from amateur players.
Values are mean ± SD.

Discussion

The aim of the study was to determine the differences in physical characteristics between various competition levels of rugby union through a range of physical characteristics. Considerable differences of physical outputs were found between the levels of competition; professional, semi-professional and amateur level players. The results imply that the professional athlete is fitter, and stronger as well as having the ability to generate greater velocity and power outputs. Practically, the results suggest that as players move through the ranks of competition levels, physical characteristics will need to improve to deal with the increased intensity of game play. Physical capabilities are therefore critical components to the success of the rugby union athlete (Argus et al., 2012; Jones et al., 2018). The results found align well with the researcher's initial hypothesis of the higher competition levels being able to produce greater results in a variety of physical characteristics. This was expressed through a larger number of significant differences between the highest and lowest competition levels, compared with the middle to lowest counterparts. Interestingly, the largest differences between professionals and both semi-professional and amateur counterparts was the eccentric deceleration rate of force development, 59.9% and 78.4% respectively. This difference in numbers suggest that the athlete's deceleration capabilities could have a lot to say about the differences between competition levels and should be looked to be discussed further.

We understand that the increasing physical stature of a rugby union player has been viewed as advantageous; especially for certain styles of game-play (Duthie et al., 2003; Till et al., 2020). Previous authors have stated that body mass of higher competition level players is in agreeance with the data gathered within this study, showing a 2% increase between the top and bottom competition levels (Hamlin et al., 2021). However, differences are likely due to higher level athletes having lower fat mass, aligning with the previous research which acknowledges that excess body fat has detrimental effects on acceleration and metabolic energy cost (Duthie, Pyne, Hopkins, et al., 2006). More research should be conducted to substantiate both previous findings and the above statement. Therefore, for an athlete to reach the next competition level it is suggested that the weight they carry is that of lean muscle mass compared to fat mass, especially at the elite level. The playing position may also have an influence on anthropometrics, due to the unique demands. Therefore, each positional group should be considered independently. However, averaged anthropometric data may be used to provide general comparisons between playing levels, so long as there is an equal distribution of positions in each cohort. Therefore, we must treat players comparatively to their positional and game play roles and responsibilities, which in turn, should be designed through discussion with the player, coaches, and management.

The contributions of muscular strength and power towards success in collision based sports like rugby union are fundamental (Baker & Newton, 2008; Crewther et al., 2009). The importance of such physical capabilities becomes apparent during game actions which require high physical contact such as tackling, mauling, and scrummaging (Hendricks et al., 2014). Strength characteristics provide a foundation to the power component of the athlete, meaning the greater the strength the greater ability to produce higher power levels, if trained adequately. Therefore, differences between competition levels should be apparent when viewing these markers. Similarly, Baker and Newton (2008); Folland and Williams (2007); Rhea and Alderman (2004) have indicated that strength adaptations are dependent on training age and experience, suggesting that the more experienced players should have higher strength and power capacity because of the longevity of training compared to those that haven't been exposed to adequate strength or power training. Collectively, findings from this research support that professionals produce significantly higher physical outputs compared to semi-professionals in IMTP peak force (13.2%), and again between the professional and amateur level athletes (17.6%). This is in agreement with the previous studies by Argus et al. (2009); Hamlin et al. (2021); Smart et al. (2013), who highlighted that higher competition level athletes could produce greater absolute and relative outputs over a variety of compound lifts. Because of the fundamental nature of strength and its relationship with power, its importance has been identified as a key contributor to success in a large variety of sporting events (Haff et al., 2020; Stone et al., 2007).

When it comes to lower-body power capabilities, our findings that higher level athletes tend to perform better than lower-level athletes align with previous research (Argus et al., 2012; Barr et al., 2014; Hansen et al., 2011; Jones et al., 2018). Specifically, CMJ relative eccentric deceleration rate of force development (59.9%), CMJ concentric peak force (18.4%) and hop test contact time (12.8%) were all significantly different from professional to semi-professional players. Comparing professional to amateur level athletes, the significant characteristics were CMJ relative peak power (10.2%), CMJ relative eccentric deceleration rate of force development (78.4%), CMJ concentric peak force (25.9%) and hop test contact time (12.4%). These results relate well to previous studies by Hansen et al. (2011); Watkins et al. (2021), who also concluded that higher competition level athletes produced significant greater differences in power production. Interestingly, they both showed that these can be shown in both the vertical and horizontal plan of motion. We suggest that athletes playing at higher competition levels have greater capacities to produce physical power outputs across the force-velocity spectrum, regardless of direction, than their lower competition counterparts. The mechanical properties which underpin explosive activities play an important role in the physical development of players, enabling them to perform at a level needed. Existing research in the field has also indicated that when developing athletic qualities for power athletes, such as rugby union players, the manipulation of either force or velocity characteristics, will enhance power production and should be viewed as playing a pivotal role in power development (Cormie et al., 2010a; Cronin & Sleivert, 2005; McMaster et al., 2013; Suchomel et al., 2018; Suchomel et al., 2016; Till et al., 2020). Understanding the differences between levels of competition is paramount to the development of specific qualities. However, there is probably a point of diminishing returns in relation to peak force output. Therefore, once achieved, the focus should turn to developing other physical characteristics related to on field performances, such as producing power.

The athlete's ability to withstand the rigours of the game is fundamental to performance (Duthie, 2006a). Historically and anecdotally, aerobic capacity has been seen to be important and correlates well with endurance type sports (Lorenz et al., 2013). However, within intermittent sports and long-term athletic development programs, once aerobic capacity of player can withstand the demands of their game, other energy systems should be set to be reached. A prime example is that of the repeated explosive action seen throughout the game of rugby union and the importance those have on the final result. Decisions such as the above also fall within the conundrum every strength and conditioning coach has dealt with when working within the confines of a week-to-week schedule. Time on feet, game play, scheduling, and match performance all play a role on the decisions being made around players fitness levels and their ability to withstand the game. Not surprisingly, the results shown in this investigation demonstrated competition level differences between all groups within aerobic capacity, but to the extent of a significant difference between professional and amateur level players of 12%. The aerobic measures among this study were similar to those previously reported within rugby union and rugby union 7s (Jones et al., 2018; Ross et al., 2015). As a result, aerobic work should be a priority for moving from lower to middle levels, but additional aerobic work is not a determinant for going from sub-elite to elite. The question now stems that if the player is deemed aerobically adequate for the positional outputs, the shifts should be made to increase the performance in other ways, such as anaerobic system development.

Maximal acceleration and velocity qualities are seen as essential when understanding how the game of rugby union has evolved over the years. The collection of acceleration, deceleration and relative high-speed running work of forwards and backs through the use of global positioning systems (GPS) have quantified the amount of work being done and at what speed in the modern game of rugby union (Jones et al., 2015; Quarrie et al., 2013; Watkins et al., 2021). It's easy to validate the critical role of such qualities given that line breaks, tackle busts and meters advanced correlate with more successful performances (Smart et al., 2014), and linear sprinting ability is related to the number of line breaks (Duthie, Pyne, Marsh, et al., 2006; Smart et al., 2014). Additionally, as competition levels rise, so do the speed and contact intensity of the game (Duthie, 2006a). The findings of this study suggest that as playing level increases, so does linear sprinting ability. Professional players within this study demonstrated greater sprinting performance compared to their lower counterparts. This was especially apparent in the later stages of speed testing with significant differences coming from 20m (3.4%) and 30m (3.7%) times as well as 10-20m (4.8%) and 20-30m (4.3%) split times. The findings of professionals having greater speed markers across all distances than their lower counterparts align well with previous research (Hamlin et al., 2021; Watkins et al., 2021). Therefore, speed seems to be a primary physical capability which determines selection into higher competition levels. It also could be suggested that there might be relative fat mass differences between the levels of competition, as anthropometrics collected did not significantly differ in either height or body mass. Initial profiling and training the capacity of linear speed should be a key physical quality identified for both talent identification and talent development purposes.

Practical Applications

The physical characteristics collected can help aid strength and conditioning personnel with profiling at a variety of competition levels. However, the strength of the study was to elucidate the differences, and thus the importance, of certain outputs which can help with the physical progression towards the next level of competition. A holistic approach to developing physical capacities is initially very important in talent identification and talent development. Within high performance sport, it is largely a consensus that quality selection of young players is paramount as they move through the levels of competition. The information gathered has allowed us to suggest that aerobic capacity and base level strength is important to develop initially. Once adequate to deal with the rigours of the level of competition, the focus shifts to expressing force at greater velocities. Finally, the importance of the development of linear sprinting ability throughout all competition levels seems paramount as the increase in these capacities has a substantial effect on the performance of the game and as the players progress throughout levels of competition.

Chapter 4

Discussion, Conclusion, and Practical Applications

Prelude:

Given that previous chapters included their own separate discussion and conclusion paragraphs, this chapter focuses on summarising all major findings and current literature with an emphasis on real world application. Limitations and future research are also acknowledged to help advance the literature in differences between physical characteristics and competition levels within rugby union.

Discussion:

Assembling the insights within this dissertation has provided the understanding of physical traits which differentiate professional, semi-professional and amateur athletes. We were able to compile differences in physical characteristics previously investigated within rugby union and compare them to a wider range of physical outputs through varying competition levels. Providing such insights into the importance of physical profiling may help coaches and players determine specific areas of development for players to progress to higher competition levels.

We also understand that significant differences between most physical characteristics can provide an increase in success on the field (Appleby et al., 2012; Argus et al., 2012; Barr et al., 2014; Duthie, 2006b; Hansen et al., 2011; Jones et al., 2018). Within the reviewed literature, power production seems to be useful when differentiating between all competition levels. In agreeance with the dissertation hypothesis, aerobic and strength capacity seemed to provide the greatest insight when comparing semi-professional to amateur athletes. Interestingly, speed was a marker that was steadily improved throughout each competition level but essential to reach the top level of competition. From the research, it is imperative that a holistic approach towards profiling should take place to assist in both talent identification and athlete monitoring for rugby union.

Building on recent research, chapter 3 looked to develop a greater insight in physical capacities of the rugby union player at varying competition levels. The aim of the study was to determine considerable differences between the levels of competition to promote robust profiling tools within rugby union. Although similar in nature, previous studies did not have a wider range of physical characteristics to compare between varying competition levels. The results from this study (chapter 3) imply that the professional athlete is fitter, and stronger as well as having the ability to generate greater velocity and power outputs. Notably, professionals produce significantly greater physical outputs compared to semi-professionals in IMTP peak force (13.2%), CMJ relative eccentric deceleration rate of force development (59.9%), CMJ concentric peak force (18.4%) and hop test contact time (12.8%). While comparing professionals to amateurs, significant differences were IMTP peak force (17.6%), CMJ relative peak power (10.2%), CMJ relative eccentric deceleration rate of force development (78.4%), CMJ concentric peak force (25.9%) and hop test contact time (12.4%). Interestingly, no significant differences were found between semi-professional and amateur level athletes.

Practically, the results suggest that as players move through the ranks of competition levels, physical characteristics will need to improve to deal with the increased intensity of game play. It's implied that a holistic measure should be taking towards the building of capacities as a player moves up the competition pathway. We currently understand that younger athletes should seek to improve their aerobic and strength capacities first and foremost. Building a strong foundation to grow other capacities off is fundamental in developing athletic performance (Haff et al., 2001; Suchomel et al., 2016). Speed markers should be started early on in the developmental phase and continually grow in importance through the rise of competition levels. Finally, once adequate measures have been taken to build a robust foundation of physical qualities, the development of power characteristics can take a priority. The development of power qualities will be of great importance as these characteristics are understood by many as the most important factors in sports performance and a key contributor in differentiating between athletic potential and competition level (Haff et al., 2001; McKeown, 2013). Physical capabilities are therefore critical components to the success of the rugby union athlete (Argus et al., 2012; Jones et al., 2018). Further research should then look to identify specific physical differences between gender, lower competition levels, positional groups, unit groups, as well as the ability to understand even more in-depth physical capacities.

Limitations:

The dissertation presented does carry methodological limitations and constraints. These limitations should be taken into consideration when interpreting the results presented in the dissertation. Reasoning and justification of each limitation has been provided in the following:

1) One of the primary limitations was the lack of discussion around player positional groups. Within rugby union, players positional groups can have large discrepancies in game play and therefore physical characteristics. Thus, the results should be viewed with awareness.

2) Only height and mass were collected. Other anthropometric measures, such as lean muscle mass should be taken into consideration.

Conclusion:

The present dissertation adds to the current literature of physical differences between competition levels of rugby union. Its apparent that a holistic approach needs to be taken towards lower competition level players while the higher competition counterparts could place greater emphasis on the development of power and speed outputs. As competition levels rise, the ability to provide relative markers based of accurate profiling becomes paramount and recommended. However, practitioners need to take into consideration player positional groups as the sport of rugby union relies heavily on the discrepancies of game play between them.

Practical Application and Future Research:

1) A holistic approach should be taken early, with the emphasis being on general fitness and strength. Once adequate levels are achieved, athletes should focus on developing of power production.

2) Finally, in order to reach elite levels, athletes must ensure they have ample linear speed capabilities. Perhaps linear speed should be developed sooner, instead of the primary focus being on "fitness" and “strength”.

3) Future research should aim to compare physical qualities between players in the same position across different levels of competition to determine whether these traits hold consistent for all positional groups.

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Appendices:

Appendix 1:

Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

16 July 2021

Matt Brughelli
Faculty of Health and Environmental Sciences

Dear Matt

Re Ethics Application: **21/109 Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 15 July 2024.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.

AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
Auckland University of Technology Ethics Committee

Cc: joel.marshall@nzrfu.co.nz; aaron.uthoff@aut.ac.nz

Appendix 2:

NEW ZEALAND RUGBY

11th August 2021

Joel Marshall
By email: joel.marshall@wrfu.co.nz

Medicine and Science Advisory Panel Decision Letter

Re. Principal Researcher: Joel Marshall
Study Title: "Physical Characteristics of Provincial Union Professional, Semi-Professional Players and Club Level Amateur Players over a competitive season"

Dear Joel,

I am pleased to inform you that the Medicine and Science Advisory Panel (MSAP) for New Zealand Rugby (NZR) has reviewed your proposal and would like to provide its approval for the above proposed study.

This approval is conditional upon secure storage of the data being collected in

https://nzru.sharepoint.com/:f:/s/MedicalandScienceAdvisoryPanel/EpPA18qlliNJoid0ANqLB3sBgKkNbpyC_UX3hs_ePntVxw?email=joel.marshall%40wrfu.co.nz&e=H48j3E

At the conclusion of your study please provide MSAP with a report of your findings. This report will be passed along to relevant parties in NZR to ensure that this research is disseminated across the organisation.

If you require anything further or if we can be of assistance, please contact us via email msap@nzrugby.co.nz.

Kind regards,

Lauren Richardson
MSAP Coordinator

On behalf of the Medicine and Science Advisory Panel

New Zealand Rugby | PO Box 2172, Wellington 6140

Principal Partner of New Zealand Rugby

Appendix 3:

Participant Sheet

Date Information Sheet Produced:

21st June 2021

Project Title

Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players

An Invitation

Hi, my name is **Joel Marshall** - I am a Strength & Conditioning Coach of Wellington Rugby Football Union and master's student at Auckland University of Technology. I would like to personally invite you to participate in our master's project that aims to determine the Physical Characteristics of Professional, Semi-Professional Players and Amateur Players.

Your consent to participate in this research will be indicated by your signing and dating the consent form. Signing the consent form indicates that you have read and understood this information sheet, freely given your consent to participate, and that there has been no coercion or inducement to participate by the researchers from AUT.

What is the purpose of this research?

To develop a greater understanding of the differences in physical characteristics between Male Rugby Union athletes throughout different levels of competition. Therefore, the aim is to collect a wide variety of data to describe the physical make up of athletes at each level of competition via athletic testing protocols that you commonly perform as part of your rugby training.

This will allow greater examination of performance and mechanical properties between levels of competition and will help develop greater training resource and modalities to meet the needs of rugby athletes across differing levels of competition.

The findings of this research may be used for academic publications and presentations.

How was I identified and why am I being invited to participate in this research?

You were identified to participate in this research as you responded to the poster invitation in your training facility or locker room.

You were identified for this project because you are (1) a male between the ages of 18 and 35 years, (2) are free from disorder, or acute/chronic injury at the time of testing occasion (>3 months injury free, and (3) satisfy the minimum requirements for premier club rugby union player (Premier Rugby Player or higher in the 2020 or 2021 club competition or any athlete currently involved with the Wellington Hurricanes or Wellington High Performance Academy).

How do I agree to participate in this research?

If you choose to agree to participate in this research, you will contact Joel Marshall via email expressing your interest to be involved. You will then best be asked to report to the Rugby League Park training space and will be given written information about the testing procedure. Prior to collection, participants will be asked if they have any questions, following which they will be required to sign a consent form.

Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

What will happen in this research?

Once you have decided to participate in the study you will participate in a one-off physical data collection day. Participants will attend a single, two-hour testing session.

The study procedures are as follows:

Initially, height and body weight will be measured. Following this, a complete verbal explanation of the indoor testing procedures and equipment will occur, followed by a standardised whole-body dynamic warm-up for 10 minutes. The initial warm up will also include sub maximal jumps ranging from 80-95% next to the testing platform. The testing procedure will consist of up to 3 maximal isometric mid-thigh pulls with 2-3 minutes between trials and 3 maximal countermovement jumps, squat jumps, and repeated hops, with up to 1minute rest between trials. Due to the availability of the testing equipment, one participant will be tested at a time. During this period, the next participant will be starting their warmup.

During the outdoor testing procedure, which will follow the indoor testing, a verbal explanation of the testing procedure will take place followed by a set warm-up instructed by the identified researcher. This testing procedure will consist of two trials of maximal sprints performed over a set distance of 30 meters interspersed with 3-5 minutes rest. The final test will then take place with a maximal aerobic effort over 1220 meters.

The data collected in this research project will only be used for the purposes for which it has been collected.

What are the discomforts and risks?

There should be no significant discomforts or risks associated with this testing beyond those you typically experience during your normal sport testing and training. You will likely experience some shortness of breath and perhaps some lower body muscular soreness in the 48 hours after each testing session.

How will these discomforts and risks be alleviated?

Being an experienced athlete who regularly competes and is familiar with training at very high intensities, the exercise trials will be similar to what you have experienced within a typical week's training and competition. If excessive discomfort is felt at any stage during the testing, you are encouraged to inform the researcher with you at the time in order that they can best address the problem.

If you have any questions regarding and risk or comfort that you anticipate, please feel free to address these concerns to the researcher so that you feel comfortable at all times throughout the process.

AUT Student Counselling and Mental Health is able to offer three free sessions of confidential counselling support for adult participants in an AUT research project. These sessions are only available for issues that have arisen directly as a result of participation in the research and are not for other general counselling needs. To access these services, you will need to:

- drop into our centre at WB203 City Campus, email counselling@aut.ac.nz or call 921 9998.
- let the receptionist know that you are a research participant and provide the title of my research and my name and contact details as given in this Information Sheet.

You can find out more information about AUT counsellors and counselling on https://www.aut.ac.nz/student-life/student-support/counselling-and-mental-health

What are the benefits?

Each participant will receive a personalised comprehensive athletic assessment regarding their physical characteristics as well as overall research findings. This information can be used to provide further insight into your personalisized training recommendations. The researchers will benefit also, given that this is a novel, applied research study. New knowledge for researchers and practitioners will be gained looking into the differences between monitored and unmonitored athletes. The results from this study may have strong implications regarding exercise prescription for athletes in New Zealand.

The results of this research are intended for publication and will contribute to part of my masters dissertation and will also be submitted to peer-reviewed journals for publication.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?

Testing procedures and subsequent data collection may occur in small groups, therefore confidentiality during this period will be limited between those performing testing within the same session. No results will be imparted during the testing occasion; however, therefore your individual data will be protected and confidential from other participants in your testing group. Outside of the testing occasion, your privacy will be protected by data being de-identified (an athlete code instead of name, e.g. CMJ (N)_A1), and the researcher will not disclose anyone's participation in this study. All participant data will be averaged and represented as group means. No names or pictures will be used in reporting (unless the participant gives explicit additional written consent for media purposes following AUT protocols and organised via the AUT university relations team). During the project, only the applicant and named investigators will have access to the data collected. The results of the study may be used for further analysis and submission to peer-reviewed journals or submitted at conferences. To maintain confidentiality, in all publications resulting from this research participants' data will be averaged and represented as group means.

All data will be stored on password protected computers or in locked files. Following completion of data analysis your data will be stored by the AUT University SPRINZ research officer in the AUT University SPRINZ secure Ethics and Data facility at AUT Millennium campus. Given the progressive nature of research in this field, data will be kept indefinitely for the purposes of reanalysis (should future analysis methods arise) for purposes similar to that collected; however (as per above) all forms of data will be de-identified and kept secure for the entirety of the data's storage lifetime.

What are the costs of participating in this research?

Other than your time (2 hours) and effort, there will be no financial cost for you being involved with this study.

What opportunity do I have to consider this invitation?

We would appreciate it if you could let us know within two weeks whether you would be available to take part in the study or not. After consideration you may withdraw your participation at any time.

Will I receive feedback on the results of this research?

Yes, upon completion each participant will gain a personalised athletic assessment. It is your choice whether you share this information with your coach or other people.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Joel Marshall, joel.marshall@wrfu.co.nz, 0273273989.

Concerns regarding the conduct of the research should be notified to the Executive Secretary Dr Carina Meares of AUTEC, *ethics@aut.ac.nz* , (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Joel Marshall, joel.marshall@wrfu.co.nz, 0273273989.

Project Supervisor Contact Details:

Dr. Matt Brughelli, Sport Performance Research Institute New Zealand (SPRINZ), School of Sport and Recreation, Faculty of Health and Environmental Sciences, AUT University, Private Bag 92006, Auckland 1020, matt.brughelli@aut.ac.nz, 09 921 9999 x7025 or 027 221 7777

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *type the reference number.*

Appendix 4:

AUT

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Consent Form

For use when laboratory or field testing is involved.

Project title: **Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players.**

Project Supervisors: *Dr Matt Brughelli & Dr Aaron Uthoff*

Researcher: ***Joel Marshall***

By signing this form, you agree to the following statements:

○ I have read and understood the information provided about this research project in the Information Sheet dated June 2021.

○ I have had an opportunity to ask questions and to have them answered.

○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw myself or any information I have provided for this project at any time without being disadvantaged in any way.

○ I am not suffering from any current injury, illness, or disorder that may impair my ability to perform the required tasks nor am I outside the limits of the required age range of 18 to 35 years.

○ I agree to answer questions and provide physical effort to the best of my ability throughout testing.

○ I understand that there is no compensation for this research, and you are undertaking voluntarily. For research conducted in New Zealand; in the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations. All efforts have been made to ensure a safe testing environment and methodology. There are appropriate first aid equipment / facilities and trained staff to manage any adverse events during testing.

○ I agree to take part in this research.

○ I consent to the indefinite storage of my de-identified data for re-analysis, should future similar uses arise (please tick one): Yes○ No○

○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

○ I wish to have my performance information accessible to my coach (please tick one): Yes○ No○

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....

....

....

Date:

Approved by the Auckland University of Technology Ethics Committee on type the date on which the final approval was granted AUTEC Reference number type the AUTEC reference number

Note: The Participant should retain a copy of this form.

22 December 2021 page 1 of 1 This version was last edited in January 2020

Appendix 5:

AUCKLAND UNIVERSITY OF TECHNOLOGY RESEARCH PROPOSAL

AUT UNIVERSITY NEW ZEALAND

Physical Characteristics of Professional, Semi-Professional and Amateur Male Rugby Union Players.

WHAT IS IT?

The purpose of this research is to develop a greater understanding of the differences in physical characteristics between Male Rugby Union athletes across different levels of competition. Therefore, the aim is to collect a wide variety of data to describe the physical make up of athletes at each level of competition via assessment of strength, speed, fitness, and lower-body power.

WHAT IS INVOLVED

The potential participants will attend a single testing session that will last approximately 2 hours and perform common gym-based strength (isometric mid-thigh pull) and power (countermovement jumps, squat jumps, and a hopping test) testing, followed by a couple of 30 m sprints and aerobic fitness test to finish.

BENEFITS

Participants will be given the opportunity for a personal report analysing any and all of the movements and performance measures measured as well as a summary of the research at hand.

INCLUSION CRITERIA

To be considered, athletes will need to currently be playing at club premier male rugby union level or higher as well as be devoid of any lower limb injuries at time of testing (>3 months pre-testing).
or any athlete currently involved with Wellington Hurricanes or Wellington High Performance Academy.

If you are intertested to being included in this study please contact; Joel Marshall
0273273989 ; Joel.marshall06@gmail.com