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Frans H Van der Merwe
Waikato Institute of Technology

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Original Scientific Research Study

QUANTIFYING AND COMPARING THE PHYSICAL CHARACTERISTICS OF SUB-ELITE LEVEL UNIVERSITY AGE RUGBY PLAYERS FROM NEW ZEALAND AND JAPAN.

Marrin B.P. Haggie[1] , Norio Saga[2], and Frans H. van der Merwe[1]

[1]Waikato Institute of Technology, Hamilton, New Zealand.
[2]Teikyo University, Tokyo, Japan.

BLUF

Although the physical characteristics of New Zealand and Japanese sub-elite university-age rugby players are similar, Japanese athletes possess greater levels of strength and power, but New Zealand athletes elicit greater application and transfer of strength and power.

ABSTRACT

This study sought to quantify and compare the physical characteristics of sub-elite university-age, rugby players from New Zealand and Japan. Fifty-seven male athletes from New Zealand (n=28) and Japan (n=29) were assessed using standardised testing protocols to determine individual physical characteristics. Athletes were measured for height, weight, body composition, flexibility, muscular strength, muscular power, muscular endurance, speed, change of direction speed, aerobic capacity and repeated sprint ability. Differences between the two cohorts were minimal. However, the New Zealand athletes tested significantly better ($p < 0.05$) than the Japanese athletes for flexibility (27.81 ± 7.27cm vs 13.15 ± 6.65cm) and 10m sprint speed (1.76 ± 0.08s vs 1.81 ± 0.08s). Japanese athletes tested significantly better ($p < 0.05$) than their New Zealand counterparts for countermovement jump (72.91 ± 6.69cm vs 59.68 ± 7.77cm), bench-throw (1215.38 ± 218.14w vs 825.9 ± 209.45w), 60s push-up endurance (65.63 ± 16.68 vs 53.63 ± 12.87) and repeated sprint ability test difference (0.25 ± 0.07s vs 0.49 ± 0.3s). No significant differences were evident for all other measured variables. The physical characteristics of New Zealand and Japanese sub-elite university-age rugby players were similar (Height: 183.5 ± 7.77cm vs 178.89 ± 6.48cm, Mass: 96.55 ± 9.39kg vs 93.9 ± 13.52kg, and Σ8 Skinfold measures: 92.96 ± 35.73mm vs 99.13 ± 30.43mm). However, the New Zealand athletes showcased superior 10m sprint speed and hamstring and lower back flexibility. The Japanese athletes showcased superior lower body power, upper body power, muscular endurance and repeated sprint abilities. Rugby union practitioners should seek to further understand the transfer and application of measured physical characteristics to on-field rugby specific movements and performance.

Key Words - Rugby, sub-elite, physical characteristics.

INTRODUCTION

Rugby union is a competitive, intermittent high-intensity sport involving short periods of physical contact, static exertion and high-speed running, interspersed with periods of low-intensity activity (10, 23). The rugby-playing athlete is exposed to bouts of acceleration, sprinting, ball carrying, changes of direction and various levels of position-specific physical activity such as tackling, rucking and mauling over differing periods (16). Duthie et al. (16) stated that due to the physical demands of rugby union, athletes must possess well-developed levels of aerobic and anaerobic power, speed, strength, muscular power and muscular endurance. Higham et al. (23) and Gabbett et al. (19) add that athletes of the rugby codes should have well-developed repetitive sprint and change of direction speed abilities. Athletes' body composition (height, mass and body fat levels) has also been observed as a discriminating factor between athletes with superior rugby-playing abilities and those without (16,18). Therefore, optimal levels of the above qualities are required to ensure training and competition over a season and rugby union playing career are successful (15).

Rugby union research has sought to provide information regarding the physical capacities of athletes who compete at the elite level. Argus et al. (2) reported height and body mass values of 184.7cm and 103.4kg for professional athletes and 187.2cm and 100.7kg for semi-professional athletes. Durandt (13) reported mean sit and reach test scores of 6.6-11.2cm across all positional groups (i.e., props, locks, hookers, loose forwards, inside backs and outside backs). In addition, Durandt (13) reported body fat percentages of 12.3-20.0% across all positions. One repetition maximal strength values for bench press and squat measurements of 140.6kg and 191.4kg, respectively, highlight the well-developed strength capacities of professional athletes (9). In addition to the well-developed strength capacities, Argus et al. (2) perpetuated the notion that professional rugby union athletes have well-developed physical capacities when they reported lower body power outputs of 8880w. To supplement the high power output of the lower body, Argus et al. (3)

reported upper body power outputs using the bench throw of 1298w. The times for 10m sprint efforts have been reported as 1.85s and 1.78s for forward positional athletes and 1.73s and 1.69s for backs positional athletes (9, 31). The same studies reported 20m sprint times for forwards as 3.16s and 3.07s, respectively, and Smart et al. (31) reported 30m sprint times of 4.04s for backs. Durandt (13) reported mean 10m and 40m sprint times of 1.7-1.9s and 5.1-5.7s, respectively, across all positional groups. Gabbett et al. (18) reported 10m and 40m sprint times of other professional rugby code athletes of 1.73s and 5.25s, respectively. Gabbett et al. (18) reported that the same athletes elicited test scores of 2.26s for the 505 change of direction test. Durandt (13) reported muscular endurance measures of 50.2-63.3 and 10.2-18.7 for the 60-second push-up and pull-up tests, respectively, for elite rugby union athletes. Durandt (13) also reported multi-stage shuttle run scores of 1602-2102m, which equated to predicted maximal aerobic capacity (VO^2_{max}) values of 48.4-55.6 ml.kg.min across all positional groups.

Most rugby union research has included athletes from the developed rugby playing nations (Tier 1) such as New Zealand, Australia, South Africa and the unions of the United Kingdom (5,14,23,30,34,35). Little has been published on rugby union athletes of the developing nations (Tier 2 and Tier 3). However, Vaz et al. (36), Suarez-Arrones et al. (32) and Adnan (1) have made attempts to illustrate the physical and physiological profiles of athletes from developing nations. It should be noted that physical and physiological profiling articles of rugby union athletes from developed nations are also limited. However, it was reported by Adnan et al. (1) that the athletes they studied from a developing rugby nation elicited mean height and weight measures of 175cm and 81.28kg, respectively, and bench press strength was reported as 77.7kg for forwards and 86.12kg for backs. Vaz et al. (36) also reported some measures of athletes from another developing rugby union playing nation and reported mean weight measures of 100.7kg and 88.0kg, height measurements of 184.4cm and 180.6cm, 1RM back squat measurements of 233.3kg and 202.3kg and 1RM bench press measurements of 109.5 and 98.3kg for forwards and backs, respectively. The reports of both of these studies illustrate the differences in values reported for two developing nations that, leads to the conclusion that at the developing levels, there are no clear similarities in the physical measures between countries and further research is required to understand the physical characteristics of rugby union athletes from the developing nations (Tiers 2 and 3) to make comparison with those from developed nations (Tier 1).

The elite-level success of any rugby-playing nation has been reported to reflect the junior development pathways of athletes. Such pathways and programmes require athletes to progress from age-group based teams, and systems to senior and sub-elite levels of play and then to the elite levels (15). In addition, it has been observed that due to the increase in teams of the elite southern hemisphere professional rugby competition, there has been an increase in the demands for competitive athletes and the in-competition demands placed on each athlete, suggesting that more players from sub-elite and development programmes are needed to populate the professional teams (2). Studies investigating the physical capacities of sub-elite level athletes have illustrated the often inferior statistics of sub-elite level athletes (31). That being said, sub-elite level athletes have elicited superior levels to professional athletes in some measures (2,31). Therefore, physical and physiological profiling of athletes has been utilised to ascertain whether athletes are physically ready and prepared to withstand the demands of high-intensity, heavy-contact professional rugby union play (28).

Such physical and physiological profiling studies have reported the physical capacities of athletes who compete at the sub-elite level, with most studies utilising athletes from Tier 1 nations. Hansen et al. (21) reported height and body mass values of 180cm and 93.8kg for elite junior (age: 19.3 years) athletes. Durandt (13) reported mean sit and reach test scores of 5.9cm as measures of hamstring and lumbopelvic flexibility. Body fat percentages of 12.7-20.7% across all positions were reported by Durandt (13). One repetition maximal strength values for bench press of 135kg reported by Lombard et al. (28) and 1RM squat measures of 112.3 by Jensen et al. (25) indicate that the absolute strength of the sub-elite athletes and elite junior athletes are inferior to those of the professional athletes. Durandt (13) reported vertical jump measures of 48.8-61.5cm, equating to lower body power outputs of between 8,487.3w and 8,809.9w. 10m and 40m sprint times have been reported as 1.73 and 5.23s, respectively (28). Although these values were indicative of both forwards and backs, it was mentioned that the backs were consistently faster than the forwards for both sprint measures. Durandt (13) reported muscular endurance measures of 49.2-60.2 and 10.5-14.9 for the 60-second push-up and pull-up tests, respectively, for development-level rugby union athletes. Durandt (13) also reported multi-stage shuttle run scores of 1720-2040m, which equated to predicted maximal aerobic capacity (VO^2_{max}) values of 49.0-53.1 ml.kg.min across all positional groups, which was similar to those elicited by the professional athletes.

Tier 1 nations have shared World Cup success since the first Rugby World Cup of 1987; however, the developing nations are improving their on-field performances. This was evident at the 2015 Rugby World Cup when Japan beat South Africa, which was considered an upset but was evidence of a growing nation within international rugby. In recent years, the Japanese rugby union has experienced a period of growth not seen before in the country since the introduction of the sport. National team performances at the last rugby World Cup have spiked national interest in the sport, especially after beating world rugby's Tier One nation, South Africa. To achieve further success on the international stage, the development of the next generation of players is critical to ensure successful performances. In recent times the national university rugby competition has increased both the quality of the competition and the calibre of graduates entering the Japanese professional rugby competition; however, little is known of the physiological profiles of university level Japanese players compared to athletes of a similar age and playing level of other more developed rugby playing nations.

New Zealand's dominance of the sport of the past two World Cup tournaments suggests that the calibre of a player entering the professional system from the sub-elite and development systems is well established. This is evidenced by the successes of the New Zealand under-20 teams at the annual World Rugby Under-20 World Cup tournaments. However, to date, limited studies are available investigating the physical capacities of athletes of this level and age group. Such studies have addressed the anthropometrical and physical profiles of a range of sub-elite level rugby union athletes (11,28) and injury patterns reported throughout a full rugby union season (5). The current study aimed to measure the physical profiles of a cohort of university level Japanese rugby players and compare them with the physical profiles of New Zealand players of a similar age and competition playing level. It should be noted that during the year of testing and measurement, each cohort won its respective national competition.

METHODS

Approach to the problem

This cross-sectional observational study was designed to quantify and compare the physical characteristics of sub-elite-level university-age rugby players from New Zealand and Japan. Anthropometrics, flexibility, upper- and lower-body strength and power, muscular endurance, speed, acceleration, change of direction speed, aerobic capacity and repeated sprint ability were assessed and analysed and compared across positions and the different nationalities. Participants' data were excluded for tests they could not complete due to injury.

Subjects

Fifty-seven male, sub-elite, Rugby union athletes from New Zealand (n=28 Age: Height: 183.5 ± 7.8cm, Weight: 96.5 ± 9.4kg) and Japan (n=29 Age: Height: 178.9 ± 6.5cm, Weight: 93.9 ± 13.5kg) volunteered to participate in this study. The study was given institutional consent from the Waikato Institute of Technology Human Ethics in Research Committee. Testing was completed before the commencement of each team's respective competition, with all athletes grouped into their general playing positions (i.e., forwards and backs). Individual athletes who were incapable of completing all measures were still granted permission to complete the measures they were physically capable of completing.

PROCEDURES

Anthropometrics

Anthropometrical measurements consisted of height and body mass using a stadiometer and calibrated weight scales (Wedderburn, Melbourne, Australia) and sum of eight skinfolds using skinfold callipers (Harpenden, West Sussex, England). Height was measured to the nearest 0.1cm, body mass was measured to the nearest 0.1kg, and skinfolds were measured to the nearest mm and were taken from 8 sites (biceps, triceps, subscapular, iliac crest, abdominal, supraspinale, mid-thigh and medial calf). Anthropometrical measurements were completed by an International Society for the Advancement of Kinanthropometry (ISAK) accredited practitioner.

Flexibility

Hamstring and lumbopelvic flexibility were measured using the sit and reach test using the Figure Finder Flex-Tester (Rockton, Illinois, U.S.A). Athletes were required to sit at the Flex-Tester and displace the apparatus' finger plate as far as possible in a controlled manner, holding the final position for 3 seconds. Athletes completed three attempts, and the greatest value was selected for analysis. Measurements were recorded to the nearest cm.

Strength

Maximal strength testing was performed employing the bench press and the back squat measures using a weight calibrated 20kg bar and external weight plates ranging from 0.5 kg to 20 kg. Bench press and back squat strength protocols of the International Powerlifting Federation (26) movement standards were utilised to measure upper and lower body strength. For athletes unable to attain a one-repetition maximum lift (1RM) for either of the two lifts, the Brzycki (6) predictive equation was utilised to predict 1RM strength. Before the commencement of the testing session, each participant included a general preparatory warm-up of each exercise where they completed 2-3 sets of 5-8 repetitions at 60 - 70% of their predicted 1RM at a self-selected tempo and rest interval, following their last warm-up set. Athletes were afforded five minutes to rest before their first attempt. After each successful attempt, additional weight was added to the bar. An athlete was deemed to have reached their 1RM when they could successfully complete the necessary movement standards, as required by the IPF, but could not complete two repetitions. Athletes rested for 3 minutes between attempts.

Power

Lower and upper body power were assessed using the countermovement jump (CMJ) and the bench throw (BT) tests, respectively, following the Australian Institute of Sport's testing protocols (33).

CMJ was measured using a Swift Yardstick (Swift Performance Equipment, Lismore, Australia). Each athlete was required to stand next to the Yardstick with both feet flat on the ground and reach with their dominant hand as high as possible to determine their standing reach height. Athletes were then required to complete a double foot CMJ, with arm swing, to displace the highest vane on the Yardstick using their dominant hand. Athletes completed three attempts, interspersed by two-minute rest intervals. The difference between standing reach height and the highest vane displaced in the three attempts was considered as the measure to be used for analysis. Measurements were recorded in cm and converted to power (w) using the Harman formula (22).

BT was measured using the GymAware linear force transducer (Kinetic Performance, ACT, Australia) and a Smith machine rack. Athletes were required to complete the BT using a calibrated bar and plates with a total mass of 30kg. According to BT protocol, athletes lowered the weighted bar in a controlled manner to touch the chest before explosively pushing it away from the chest as fast and as high as possible. In all cases, athletes released the bar from their hands when the arms were at full extension, and the tracks of the Smith machine ensured the bar travelled vertically. Values were displayed in watts (w) and stored on the associated GymAware application on an Apple iPad (Cupertino, California, U.S.A) prior to being exported to a Microsoft Excel spreadsheet (Redmond, Washington, U.S.A) for further analysis.

Muscular Endurance

Local muscular endurance was assessed using the 60-second maximal push-up test and the 60-second maximal pull-up test. Athletes were required to complete as many repetitions of the required movement as they could in 60 seconds. The push-up and pull-up techniques were in accordance with standardised testing procedures (7,28). The total amount of full repetitions the athlete could complete for each movement was considered as their test score and was used for analysis.

Speed and Acceleration

Athletes' speed and acceleration were assessed using a 40m maximal sprint with split distances of 10m and 20m with a rest period of 5 minutes between each repetition. All sprint and split times were recorded to the nearest 0.01s utilising the Speedlight system (Swift Performance, Lismore, Australia) and the associated application on an Apple iPad (Cupertino, California, U.S.A). To avoid breaking the timing beam, athletes started each repetition with the forefoot 30cm behind the line of the starting gate in a two-point crouched position. The athlete started each repetition at a time they felt comfortable starting and were instructed to complete each repetition as fast as possible. Athletes completed three repetitions, and the fastest 40m sprint time and its split times were considered for analysis.

Change of Direction Speed (CODS)

CODS was measured employing the 505 test (12). The test required athletes to begin 10m behind a timing gate (Swift Performance, Lismore, Australia) and sprint as fast as possible through the gate until they reached a line 5m past the gate. When they reached the 5m line, they were required to turn and sprint back through the timing gate as fast as possible. The athletes' times were measured to the nearest 0.01 seconds, and the fastest time achieved in three attempts was used for data analysis. Athletes were afforded three minutes of rest between repetitions.

Aerobic Capacity

Aerobic capacity was predicted using the Multi-Stage Shuttle Run Test (MSSRT; 27). The MSSRT requires the athlete to run laps between two cones positioned 20m apart, determined by a recording that emitted sounds or beeps to initiate the beginning of the next shuttle. As the levels increased, the time between the recorded sounds became shorter. The athlete was required to maintain the required running speeds as determined by the beeps and complete as many shuttles as possible until they failed to maintain the required running speeds for two consecutive laps. The athlete was also allowed to withdraw from the test if they felt they could not maintain the required running speeds. The athletes' level and shuttle scores were then converted into metres to determine the athletes' test scores. The test score was then used to predict the athletes' VO^2_{max} (27).

Repeated Sprint Ability Test (RSAT)

The RSAT requires the athlete to complete a maximal sprint of 20m every 20 seconds. The rest period afforded to the athlete is 20 seconds, minus the time it took to complete the previous sprint effort. The RSAT is deemed complete when the athlete has performed twelve repetitions. Electronic timing lights (Swift Performance) were used to measure and record each sprint effort. The difference between the fastest repetition and the slowest repetition was used for statistical analysis and to determine the athlete's fatigue index (33).

Statistical Analysis

Data were presented as mean (± standard deviation), and analysed using a Microsoft Excel spreadsheet (Redmond, Washington, U.S.A). An analysis of variance (ANOVA) was implemented to assess the differences between the different cohorts with a significance level of $p < 0.05$ implemented for all tests. Cohen's d effect size was interpreted using the Hopkin's scale to determine the magnitude of effect size (17) (Table 1).

Table 1 - Scale for determining the magnitude of the effect size.

Effect Size (d)	Magnitude
0-0.2	Trivial
0.2-0.6	Small
0.6-1.2	Moderate
1.2-2.0	Large
>2.0	Very large

RESULTS

The results of a variety of anthropometric, physical, and performance test measures found that the differences between the New Zealand and Japanese athletes were minimal (Table 2). Japanese athletes tested significantly better ($p < 0.05$) than their New Zealand counterparts for repeated sprint ability test difference (0.25 ± 0.07s vs 0.49 ± 0.3s) (Figure 1), countermovement jump (72.91 ± 6.69cm vs 59.68 ± 7.77cm; 6056.91 ± 1599.14w vs 5596.52 ± 1037.34w) (Figure2), bench-throw (1215.38 ± 218.14w vs 825.9 ± 209.45w) (Figure 2) and 60s push-up endurance (65.63 ± 16.68 vs 53.63 ± 12.87). The New Zealand athletes, however, tested significantly better ($p < 0.05$) than the Japanese athletes for flexibility of the hamstring and lumbar pelvic region (27.81 ± 7.27cm vs 13.15 ± 6.65cm) and 10m sprint speed (1.76 ± 0.08s vs 1.81 ± 0.08s) (Figure 3). No significant differences were evident for all other measured variables.

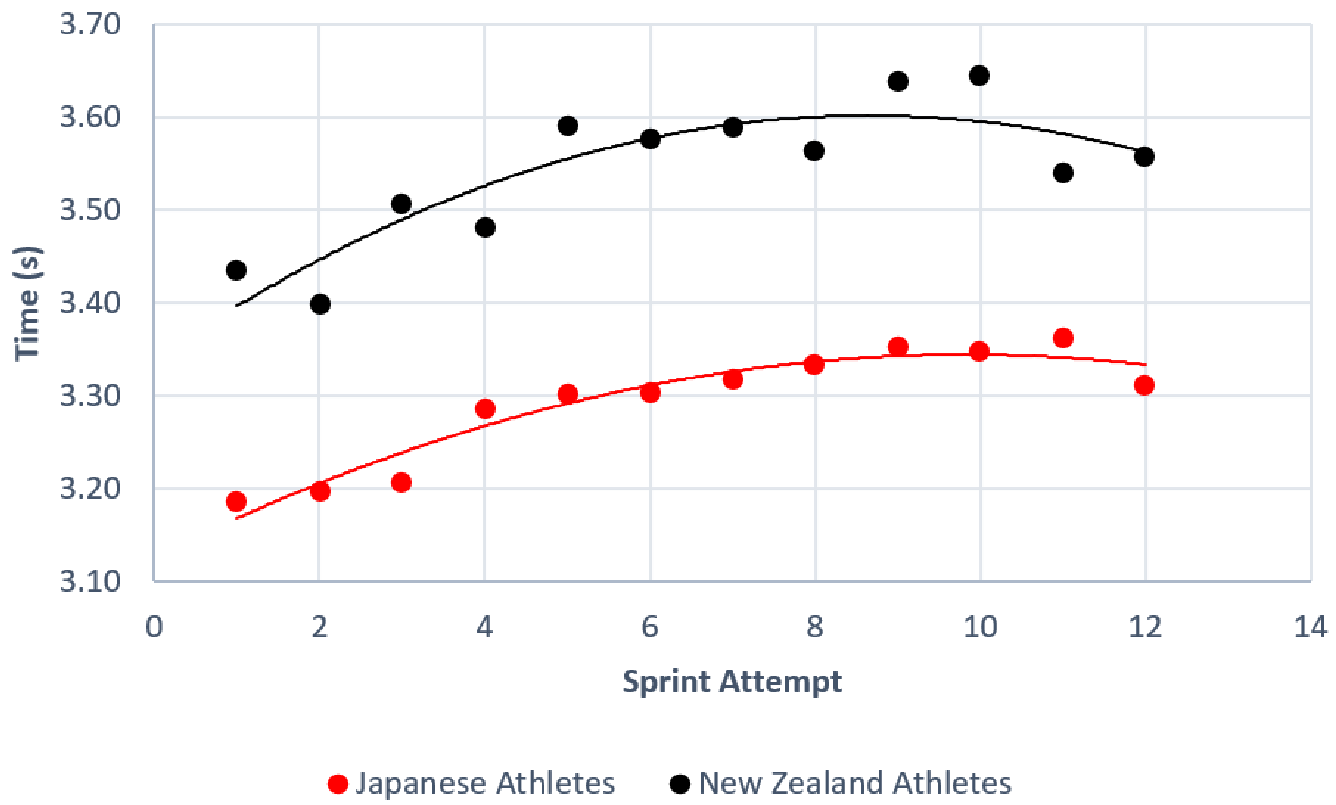

Figure 1 - Repeated sprint ability as a measure of sprint fatigue resistance.

Repeated sprint ability testing illustrated that the Japanese athletes showcased faster mean times for the twelve 20m sprint attempts (Figure 1). The Japanese athletes elicited a significantly smaller mean difference between the fastest and the slowest sprint attempts. Japanese athletes elicited significantly greater upper and lower body power (Figure 2) but the New Zealand athletes were significantly faster over the first 10m of a sprint (Figure 3). New Zealand athletes were faster over all distances measured during sprint testing.

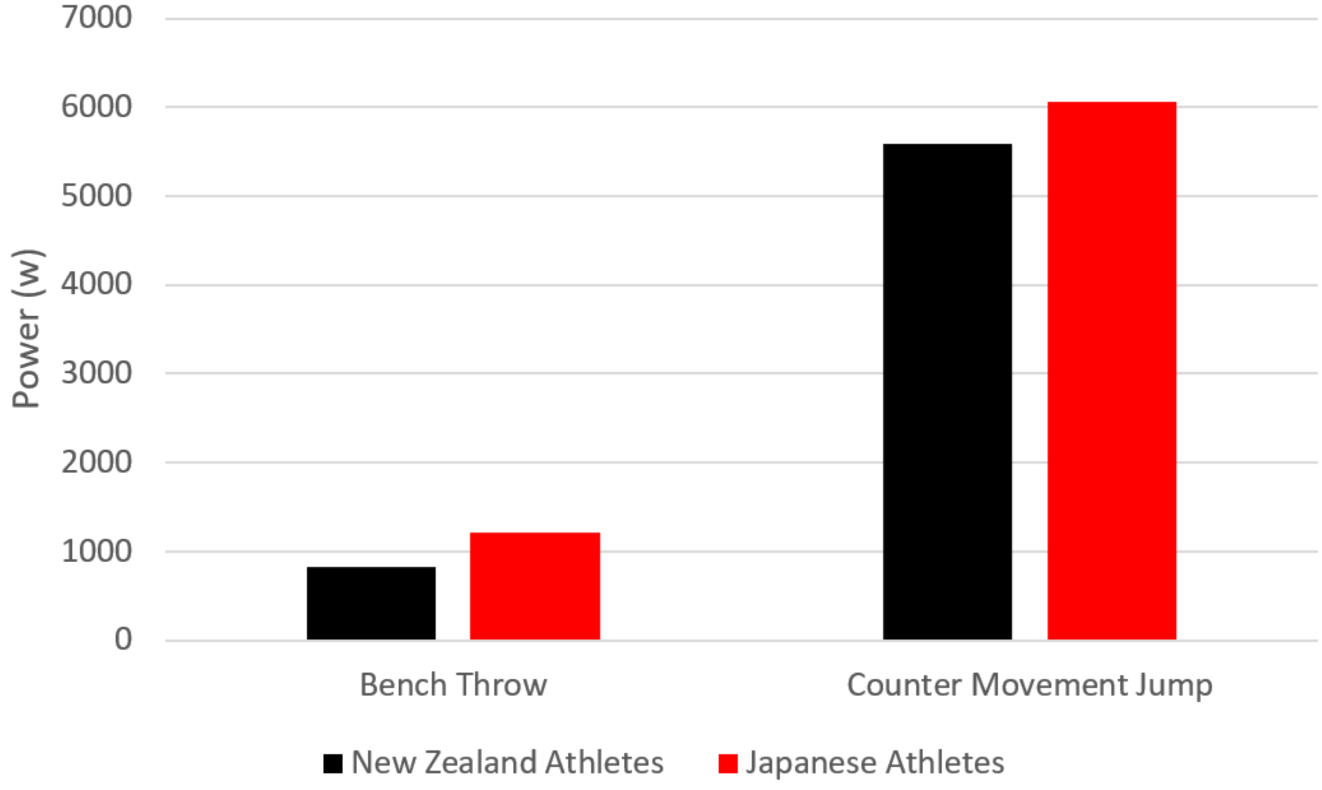

Figure 2 - Bench Throw and Counter Movement Jump as measures of upper and lower body power.

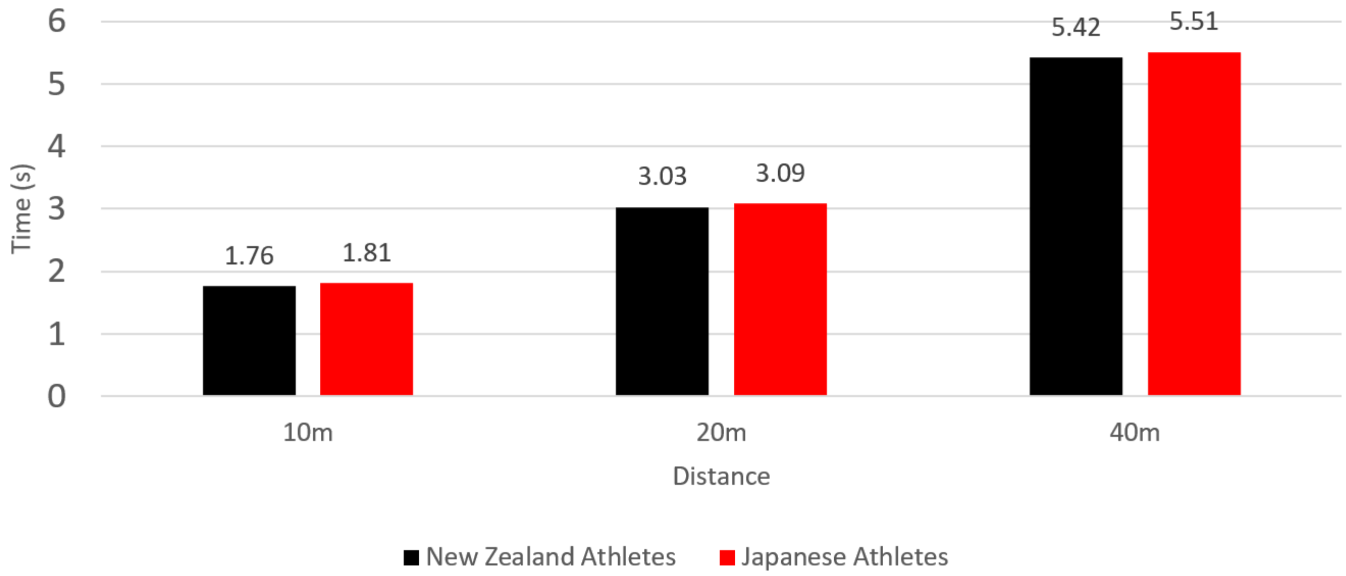

Figure 3 - 10m, 20m and 40m sprint times as measures of speed.

Table 2 - Means, Standard Deviations and Effect Sizes of the differences in results of Japanese and New Zealand Sub Elite level university-aged rugby union athletes.

Measure	Japanese Athletes	New Zealand Athletes	Effect Size (Cohen's d)
Height (cm)	178.89 ± 6.48	183.5 ± 7.77	0.65
Weight (kg)	93.9 ± 13.52	96.55 ± 9.39	0.23
Skinfolds - Σ8 (mm)	99.13 ± 30.43	92.96 ± 35.73	0.19
Sit and reach (cm)	13.15 ± 6.65	27.81 ± 7.27 *	2.11
Predicted 1RM back squat (kg)	168.14 ± 27.63	163.39 ± 24.01	0.18
Predicted 1RM bench press (kg)	111.44 ± 15.68	114.0 ± 15.59	0.16
Countermovement jump (w)	6056.91 ± 1599.14 *	5596.52 ± 1037.34	0.35
Countermovement jump (cm)	72.91 ± 6.69 *	59.68 ± 7.77	1.83
30kg Bench throw (w)	1215.38 ± 218.14 *	825.9 ± 209.54	1.82
60-second push-up muscular endurance test (reps)	65.63 ± 16.68 *	53.63 ± 12.87	0.81
60-second pull-up muscular endurance test (reps)	13.44 ± 6.37	11.77 ± 7.45	0.24
10m Sprint speed (sec)	1.81 ± 0.08	1.76 ± 0.08 *	0.63
20m Sprint speed (sec)	3.09 ± 0.13	3.03 ± 0.15	0.43
40m Sprint speed (sec)	5.51 ± 0.26	5.42 ± 0.3	0.32
5-0-5 Change of direction test (sec)	2.30 ± 0.1	2.33 ± 0.09	0.32
Multi-stage shuttle-run test (m)	2282.96 ± 347.85	2180 ± 238.33	0.35
Repeated sprint-ability test (sec)	0.25 ± 0.07 *	0.49 ± 0.3	1.30

* Significance at $p \leq 0.05$

DISCUSSION

To the authors’ knowledge, this is the first study to compare and contrast university-aged rugby athletes' physical capacities from a Tier 1 rugby-playing nation to a Tier 2 nation. This study sought to identify the key performance differences of developing athletes that may exist between the respective tiers. The study found very little difference between the New Zealand and Japanese athletes. However, significant differences in muscular endurance, repeated sprint ability, power production, 10m sprint speed and the flexibility of the hamstring and lumbopelvic region were unveiled. Despite the New Zealand athletes being both taller and heavier than their Japanese counterparts and having a lower sum of 8 skinfold measures, these differences were not significant. The Japanese athletes elicited superior change of direction speed and aerobic running capacities to the New Zealand athletes, however, these measures were also deemed not significant when results were analysed. It must be noted that 1RM strength measures found that the Japanese athletes had greater predicted 1RM back squat strength, and the New Zealand athletes had greater predicted 1RM bench press measures.

Sprint performance has been identified as an attribute of athletes that are sought after in various team sports (8). The New Zealand athletes were faster than the Japanese athletes over 40m (5.42sec vs 5.51sec), 20m (3.03sec vs 3.09sec) and significantly faster over 10m (1.76sec vs 1.81sec). These results show that the New Zealand athletes could accelerate faster from their starting positions to the 10m mark than the Japanese athletes. The ability to accelerate quickly is of great tactical and physiological importance in sports performance, where the critical aspects of the sport are determined by high velocity yet brief intermittent activities (8). It has been suggested that practitioners should focus on maximal sprint training for athletes to enable improvements in acceleration and sprint speed to increase the likelihood of transition to higher levels of play and future success (11). Superior acceleration abilities over the first few metres in a game's context may be more beneficial to performance than peak running velocity (8).

The strength measurements for both teams elicited mixed results. The superior back squat strength of the Japanese athletes (168.14 vs 163.39kg) was not shown to be significantly different, neither was the superior bench press strength of the New Zealand athletes (114 vs 111.44kg). Despite the Japanese athletes having superior lower limb power outputs and 1RM estimated back squat strength, the New Zealand athletes were significantly faster over the first 10m of the sprint. This phase has been described as the most important aspect of speed in sports performance, as the explosive acceleration can be translated into speed and maintained for short (10m) and extended (~30m) distances (15, 25). In addition, absolute strength and relative strength are critical to successful rugby union performance as these attributes have been deemed necessary for improved running economy, change of direction ability and force production when scrummaging and tackling (15). Despite the athletes of this study eliciting superior bench press and back squat strength values (108.1 ± 17kg and 139.5 ± 24kg) to those of the study published by Ball et al. (5), the values (140.6kg and 191.4kg) reported by Crewther et al. (9), however, are far superior to those elicited by the athletes of this study. Therefore, the athletes of this study should consider increasing their 1RM strength to further their chances of improved individual match performance and to progress to higher levels of rugby.

Japanese athletes elicited significantly greater power outputs during the BT (1215.39w vs 825.90w) and CMJ (6056.91w vs 5596.52w), respectively. Greater power levels allow for better performance during sport-specific activities such as jumping, tackling and breaking through the opposition's defensive line (2,3). Although the Japanese athletes showcased significantly greater power output, they elicited significantly slower sprint times over 10m. This may be due to, in part, a decreased ability to apply force during acceleration effectively. The superior hamstring and lumbopelvic flexibility and mobility of the New Zealand athletes may contribute to their superiority over the Japanese athletes in the sprint speed tests, particularly the 10m sprint.

Hamstring and lumbopelvic capacities have been reported to induce positive sprint performance and prevent hamstring injuries (29). This could explain the superior sprint performance of the New Zealand athletes during the sprint performance measures and may be a factor that differentiates between developing athletes of Tier 1 nations and those of Tier 2 nations. To support this notion, it has been stated that hamstring flexibility is a key factor for the execution of sport-specific skills such as sprinting, jumping, agility and kicking (20). However, despite the New Zealand athletes measured superior hamstring and lumbopelvic flexibility capacities, the Japanese athletes showcased superior CMJ abilities. This suggests that the transfer of lower body power into sprint speed qualities, such as rate of force development and the stretch shortening cycle properties during dynamic movement of the New Zealand athletes is superior. Further studies should investigate the correlation between flexibility levels of the hamstring and lumbopelvic region, acceleration, CMJ and sprint times in the current population.

The Japanese athletes showcased significantly lower decrements in performance of the RSAT. Performance decrements of 0.25 seconds between the fastest of twelve 20m sprint efforts, repeated every 20 seconds, and the slowest of the Japanese athletes compared to 0.49 seconds of the New Zealand athletes illustrate a greater resistance to sprint fatigue. Overall, the repeated sprint times showcased by the Japanese athletes were faster than those measured for the New Zealand athletes. Greater resistance to sprint fatigue, or faster recovery between sprints, is beneficial to performance in rugby union because it allows the athlete to perform dynamic running-based activities faster and more often (33). The ability to execute repeated bouts of prolonged high-intensity exercise, such as repeat sprints and an efficient recovery capacity, is a sought-after attribute that discriminates between athletes of higher levels and those of lower levels of competition (24).

The intermittent nature of sports, such as rugby union, with varying velocities and intensities, stresses all three energy systems (4). Therefore, aerobic power and well-developed aerobic systems are critical to team selection and on-field success, as it has been cited as a major factor in aiding recovery after bouts of high-intensity exercise (18). The Japanese and New Zealand athletes participating in the current study showcased MSSRT distances of 2282.96m and 2180.0m, respectively. These distances were calculated to give predicted VO^2_{max} values of 56.5 and 54.5 ml.kg.min, respectively. These values are comparable to those elicited by professional athletes (48.4-55.6 ml.kg.min) (13). The superior aerobic capacities illustrated by Durandt (13) have been shown to differentiate between elite and athletes who compete at the sub-elite levels. Therefore, the maintenance and improvement of the aerobic capacity of the current study participants will assist with successful on-field performance, thus increasing the capacity and the likelihood of progressing towards higher levels of rugby.

The Japanese athletes elicited superior muscular endurance over the New Zealand athletes for one (push-ups) of the two measures employed. Superior muscular endurance capacities of rugby union athletes indicate an ability to perform repeated muscle contractions, which is a match requirement of rugby union athletes at all levels. Athletes are required to make tackles and carry the ball into contact, often at high velocities. Therefore, any rugby union athlete's ability to perform repeated contractions without fatigue is a highly valued attribute (28). Development or sub-elite athletes who possess a wide variety of well-developed physical capacities such as strength, power, speed, CODS, agility and aerobic power who can transfer these qualities into successful on-field performance are more likely than those who do not possess them or cannot transfer them to progress to playing rugby union at the elite and professional levels.

CONCLUSION

The current investigation found that the physical characteristics of New Zealand and Japanese sub-elite university-age rugby players are similar, with few significantly different measures. However, the Japanese athletes showcased superior lower-body power (~8.2%), upper-body power (~47%), muscular endurance (~22%) and repeated sprint abilities (~96%). Research has stated that these attributes, when well developed, are desirable qualities elicited by professional rugby union athletes (2,31).

The New Zealand athletes showcased significantly superior 10m sprint speed (~2.8%) and hamstring and lumbopelvic flexibility (~111.5%). Speed has been identified as an attribute that discriminates between athletes of different levels (18, 19, 31). It has also been reported to increase the likelihood of successful rugby union performance (31). Hamstring and lumbopelvic flexibility have also been reported to be a key factor for performing sport-specific skills (20).

RECOMMENDATIONS AND PRACTICAL APPLICATIONS

Off-field programming for both the New Zealand and Japanese athletes should include variations of Olympic lifting to promote the improvement of rate of force development and impulses generation during gym-based training, to elicit higher lower body power outputs and enhance acceleration and sprint speed which has been identified as discriminating factors between professional level athletes and sub-elite level athletes. In addition, On-field programming for the Japanese athletes should emphasise sprint technique training to improve their application of their superior squat strength to sprint performance.

New Zealand athletes should also emphasise lower limb strength development to better meet the demands of rugby competition and increase the likelihood of progressing to higher levels of rugby union play. They should also employ training programmes focussing on muscular endurance training to improve upper body push and pull capacities as well as repeated sprint abilities.

The optimisation of flexibility and mobility of the Japanese athletes should be considered to improve training and match performance and to prevent injury incidences or minimise the effects thereof.

Future Research

Future investigation should include the assessment of movement competencies and proficiencies of both cohorts, as this underpins performance by decreasing the risk of injury and increasing athletic performance. Future investigations should also seek to determine how the athletes produce and apply force to performance as it relates to speed and anaerobic power in a match-specific setting. This can be achieved with a concurrent on-field assessment of physiological profile and competency assessed via GPS Time Motion Analysis study. This study should seek to investigate the movement characteristics and demands of sub-elite rugby union play.

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