7114-JSM

The Journal of Sports Medicine and Physical Fitness 2017 ????;57(??):000-000
DOI: 10.23736/S0022-4707.17.07114-6

ORIGINAL ARTICLE

Anthropometric and performance characteristics of the German rugby union 7s team

Erich HOHENAUER [1, 2, 3] *, Alfred M. RUCKER [4], Peter CLARYS [3], Ursula M. KÜNG [2], Rahel STOOP [1], Ron CLIJSEN [1, 2, 3]

[1]Department of Business Economics, Health and Social Care, University of Applied Sciences and Arts of Southern Switzerland, Landquart, Switzerland; [2]Thim van der Laan, University College Physiotherapy, Landquart, Switzerland; [3]Department of Movement and Sport Sciences, Vrije Universiteit Brussel, Brussels, Belgium; [4]Department of Physiotherapy, Döpfer-Schulen, Regensburg, Germany

*Corresponding author: Erich Hohenauer, Department of Business Economics, Health and Social Care, University of Applied Sciences and Arts of Southern Switzerland, Weststrasse 8, CH-7302 Landquart, Switzerland. E-mail: erich.hohenauer@supsi.ch

ABSTRACT

BACKGROUND: Somatotyping is advantageous in sports for the optimal development of performance level and injury prevention. The aim of this study was to describe the anthropometric and physical performance characteristics of the German national rugby union 7s team. Seventeen male rugby players, classified as forwards (N.=9; 24.2±2.1 years) and backs (N.=8; 24.3±5.05 years) were assessed.
METHODS: Anthropometric measurements included: body height, weight, height to weight ratio (H/W), five skinfolds, biepicondylar humerus and femur breadth, upper arm- and calf girth, estimated lower body fat percentage and determination of the individual and mean somatotype. The physical performance tests included: sit-and-reach, handgrip strength, one minute of sit-ups, one minute of push-ups, vertical jump performance, peak power performance, bent arm hanging, 40-m sprint, and the Yo-Yo Intermittent Endurance Test.
RESULTS: The forward players were significantly taller (P=0.003), heavier (P=0.001) with a smaller H/W (P=0.009) compared to the backs. Humerus and femur bone breadths (P<0.05) and flexed upper arm and calf girths (P<0.05) were significantly different between the groups. Handgrip strength left (P=0.04), one minute of sit-ups (P=0.03), and peak power output (P=0.015) were also significantly different between the groups.
CONCLUSIONS: The data indicate that German forward and back players have a similar somatotype and performance level. However, a higher body mass of forward players could be advantageous in that their playing position is much more body contact intensive, and requires a significant amount of tackling. The nominative data of this study may assist coaches to detect weak links in rugby specific athletic performance.

(*Cite this article as:* Hohenauer E, Rucker AM, Clarys P, Küng UM, Stoop R, Clijsen R. Anthropometric and performance characteristics of the German rugby union 7s team. J Sports Med Phys Fitness 2017;57:_______. DOI: 10.23736/S0022-4707.17.07114-6)

Key words: Somatotypes - Athletic performance - Athletes - Football - Muscle strength.

Rugby union is an internationally played contact team sport in which two opposing teams try to carry an oval shaped ball to the end of a rectangular field, while preventing the other team from doing the same. The sport involves low-intensity aerobic exercises, combined with periods of intermittent, intensive anaerobic exercises.[1] Throughout the years multiple variations of the game have been developed, of which today the Rugby Union 15 variation, with each team having 15 players, is the most popular. A well-organized league system, ranging from amateur to elite level has been developed by the German rugby union, with hopes of furthering the sport of rugby in Germany. The union operates under the authority of the rugby Europe association, Europe's rugby managing association and implementer of the World Rugby Guidelines. In 2014, the German national 15s rugby team was promoted to the highest European rugby class in Europe. The German rugby union also tried to qualify for the Olympic Games in Rio de Janeiro 2016, where the faster, seven person a-side variation was played (Rugby union 7s).[2-4] Figures from world rugby show that it is increasingly popular amongst teenagers, who represent 22-39% of registered players in the top 5 rugby-playing nations.

A rugby team is divided into two units. The forwards, who participate in several formations to gain space, and the backs, who primarily try to get the ball through the defenders with quick and agile play.[5, 6] Body mass and body composition as well as speed and repeated sprint ability are important physical and fitness characteristics for superior performance in rugby. Knowledge and adequate follow-up of body composition of competitive rugby players is important to guarantee an optimal development of the rugby-specific somatotype and performance level of rugby players. Several investigators have used anthropometric data and physiological capacity testing to evaluate the performance characteristics of rugby players.[7-9] Whilst there has been a tradition of testing athletes in laboratory conditions, the current trend is to use field tests of fitness where possible. The Eurofit test battery offers a range of fitness items to assess physiological functions such as strength, power, muscle endurance and aerobic power.[10] It is commonly believed that physical preparation should reflect the degree to which each component of fitness is relied upon in competition.[11] In 2011, Gabbett *et al.* investigated the relationship between anthropometric, physiological and skill qualities and playing performance in professional rugby league players.[12] Their results demonstrated that well-developed physical performance and anthropometric qualities were associated with effective playing performance. Key performance indicators and the development of notational analysis have also provided further information into specific playing profiles of successful teams and individuals.[13] Rugby league injury studies have reported the importance of high-level speed and endurance performance to reduce the incidence of injury.[14] Adequate follow-up of body composition and standardized physical fitness assessment of competitive rugby athletes is useful to guarantee optimal development of the player's position-specific physical performance profile and somatotype. The aim of this study was to comprehensively describe the specific somatotypes and the physical performance characteristics of the German national rugby union 7s forward and back players.

Materials and methods

In cooperation with the German rugby association (DRV), the male German rugby union 7s players (N.=17, mean age, 24.25±3.6 years) volunteered for this study. Anthropometric data and physical performance levels were obtained from 9 forward players (mean age, 24.16±2.14 years) and 8 back players (mean age, 24.33±5.05 years) after the regular competition season. Participants were excluded from the physical performance tests in cases of current injury or pain symptoms. This descriptive study was carried out in accordance to the declaration of Helsinki (ICH-GCP). The ethical committee of the Landesärztekammer Baden-Württemberg stated that no ethical approval was required for this study (reference no.: F-2016-085). All athletes provided written informed consent. The anthropometric and physical performance measurements were carried out on a single day. An ISAK-certificated examiner (RC) collected the anthropometric data according to the ISAK guidelines.[15]

Methods

Anthropometric measurements: The anthropometric measurements comprised the measurements of body height and body weight, waist and hip girth measurements. Additionally, five skinfold measurements were conducted (triceps brachii, subscapular, supraspinal, calf and biceps brachii). Moreover, biepicondylar humerus- and femur breadth and also flexed and tensed upper arm- and calf-girth were carried out to complete the anthropometric measurements. Standing body height was measured to the nearest 0.1 cm, using a GPM stadiometer (Zurich, Switzerland). Body weight and estimated lower body fat percentage were measured using the athlete modus of the TANITA-TBF 611 scale (Tokyo, Japan). The height/weight ratio was calculated by dividing the body height (in cm) by 100 and dividing this sum by the body weight (in kg). Extremity-, waist- and hip circumferences were measured with an anthropometric measuring tape, Rosscraft (White Rock, Canada) accurate up to 0.1 cm. The skinfold measurements were conducted with the Harpenden Skinfold Calliper, British indicators (Burgess Hill, United Kingdom) accurate up to 0.1 cm. The corrected upper arm girth was calculated by subtracting the skinfold thickness of the triceps (in mm) divided by 10 from the upper arm girth (in cm).

The corrected calf girth was calculated by subtracting the skinfold thickness of the calf (in mm) divided by 10 from the calf girth (in cm). Biepicondylar humerus and femur breadth were measured with the Campbell Small Bone Calliper 10, Rosscraft (White Rock, Canada) accurate up to 0.1 cm. All measurements were performed in three cycles and the mean values were calculated. The somatotype (endomorphy, mesomorphy or ectomorphy) was calculated with the somatotype software from Sweat Technologies (Geeveston, Australia), based on the method of Heath and Carter.[16] Additionally, the somatotype attitudinal distance (SAD), which represents the distance in three dimensions between an individual somatopoint and the group and position-related mean somatopoint on the somatochart, was calculated.

Physical performance measurements: Immediately after the anthropometric measurements, the physical performance level of the rugby players was tested using a modified Eurofit test battery. The Eurofit test battery was already used in the field of elite athletes [17] and shows a high intraclass correlation coefficients [ICC] above 0.7.[18] The participants were allowed to perform an individual stretching program for less than one minute before the examination. The participants had to complete eight performance tests in a specific order to make a reassessment possible and meaningful.

The performance tests were conducted in the following order: sit-and-reach test (flexibility), isometric handgrip strength left and right, vertical jump performance, one minute sit-up test, one minute push-up test, bent arm hanging test (upper extremity strength), 40-m-sprint and Yo-Yo Intermittent Endurance Test (YYIET). One examiner instructed the physical performance tests for each participant to avoid any undesirable interaction. Participants were instructed once to perform the tests to the maximum. The sit-and-reach test, isometric handgrip strength test and vertical jump performance test were conducted three times in succession without any break. The mean of the three values was used for the results in this study.

The sit and reach test was conducted using the sit-and-reach testing tool from Sporta de Waele (Zele, Belgium). The participants sat on the ground with their knees fully extended. The knee extension was controlled by an investigator who pushed the knees towards the ground while the test was being performed. The plantar side of the feet had to be in full contact with the vertical justified plate of the box. Participants were instructed to breathe out during the test and push the bar with straightened fingers slowly as far as possible.

The isometric handgrip strength was conducted using the Jamar® Plus Hand Dynamometer (Patterson Medical, Sutton-in-Ashfield, UK). The test was performed in a standing position with 90° flexion in the elbow joint. The participants were instructed not to touch their elbow on their body while performing the test. Then the participant alternately performed the isometric handgrip strength test with their left and right hand for three times each.

To estimate ability to generate lower body muscular power, a counter movement vertical jump performance test was conducted using the Just Jump plate (Probotics Inc., Huntsville, AL, USA). The participants were instructed to keep their hands on their hips and to extend their knees while performing the jump test. Peak power output from the counter movement vertical jump was calculated using the formula proposed by Sayers *et al.* (1999).[19]

The one-minute sit-up test was used to monitor the development of the athlete's abdominal strength and endurance of the abdominals and hip flexors. The participant was lying in a supine position on his back, with knees at a 90° angle with his feet fixed flat on the floor and his arms crossed over his chest. In this position, the participants had to perform as many sit-ups as possible. The angulus inferior scapulae had to touch the ground when moving downwards and the elbows had to touch their knees when moving up again to achieve one completed sit-up. The test was finished when the participants gave up or after one minute, whichever came first.

During the one-minute push-up test the participants were instructed to adduct their legs while performing the test. The elbows had to move sideways when raising and lowering the body to avoid main triceps muscle activation. Furthermore, the participant had to flex their elbows for a minimum of 90° and then had to fully extend the elbows to achieve one completed push-up. The aim of this test was to perform as many push-ups as possible in one minute. The test was finished when the participants gave up or after one minute, whichever came first.

During the bent arm-hanging test, the participants stood on a platform and could reach the bar (forearms in pronated position), which was attached to the wall. The participants had to bring their chin over the level of the bar and try to hold this position as long as possible. They were allowed to move their feet and/or flex or extend their knees respective to their hips. The test finished when the chin passed below the level of the bar.

After this test, the participants moved directly to the outdoor field for the sprint and endurance tests.

The 40-m-sprint test was conducted outdoor on a tartan track, using the Smartspeed Pro system from Fusion Sport (Brisbane, Australia). Running speed and running time during the 40-m sprints (0-10 m, 10-20 m, 20-30 m, 30-40 m) were measured. The participants were allowed to wear shoes without spikes.

After performing the 40-m sprint test, the participants had a break of approximately 60 minutes before performing the YYIET. This test consisted of repeated 20-m runs back and forth between the starting, turning and finishing lines, and at a progressively increased speed, which was controlled by audio beeps from a tape recorder[20].

Statistical analysis

Data are presented as means and standard deviations. Data analyses were carried out using the Statistical Package for Social Sciences for Windows (SPSS) v. 19.0. The Test of normality, using the Shapiro-Wilk test for small sample sizes, was conducted. Descriptive statistics (means and SD) were used to describe the differences between the forwards and backs of the German national rugby union 7s team. Differences between groups of players were analyzed using an unpaired *t*-test. Effect sizes are expressed as Cohen's *d* values of 0.2-0.49, 0.5-0.79 and over 0.8, which were considered small, medium and large. Significance level was set at P<0.05.

Results

Anthropometry

Analyzing the data, significant differences in body compositions were found. Forward players were significantly taller (P=0.003, *d*=1.98), heavier (P=0.001, *d*=2.01) and showed a significantly smaller height-to-weight ratio (P=0.009, *d*=1.39) compared to the backs. There were no significant differences between forward

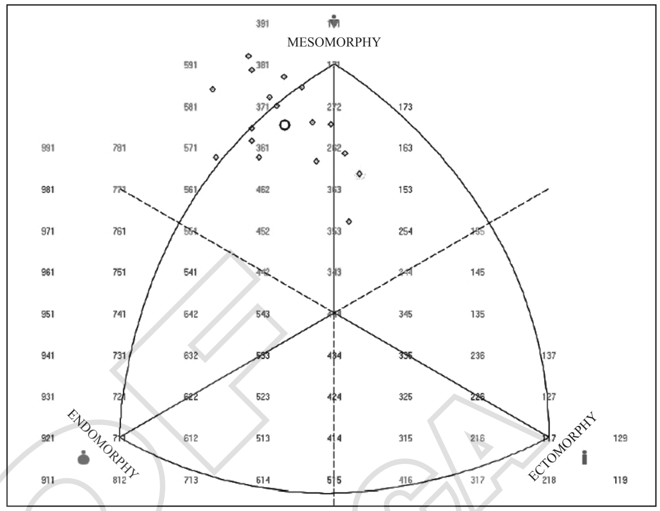

Figure 1.—Somatochart of the German national rugby union 7s team. The circle represents the mean somatotype of the team. The squares represent the somatotype of a single player.

and back players concerning age (P=0.929, *d*=0.04), estimated lower body fat percentage (P=0.65, *d*=0.22) or BMI (P=0.44, *d*=0.38). There was no significant difference concerning mesomorphy (P=0.74, d=0.15), ectomorphy (P=0.46, *d*=0.35) and endomorphy (P=0.81, *d*=0.19) between the two groups. Figure 1 illustrates the individual somatotype of each forward and back

Table I.—*Anthropometric characteristics of the German national rugby union 7s team.*

	Team (N.=17)	Forwards (N.=9)	Backs (N.=8)
Age, years	24.25±3.6	24.16±2.14	24.33±5.05
Height, cm*	178.65±5.91	184.01±7.61	173.29±4.2
Weight, kg*	85.5±5.69	91.72±8.06	79.28±3.31
BMI	26.76±1.72	27.09±1.87	26.43±1.58
ELBF %	13.19±2.63	12.89±2.15	13.5±3.12
H/W ratio*	0.021±0.001	0.0201±0.001	0.0218±0.001
Bone breadths, cm			
Humerus*	7.30±0.20	7.57±0.18	7.03±0.23
Femur*	9.91±0.39	10.21±0.47	9.60±0.31
Girths, cm			
Arm flexed and tensed*	37.60±1.54	38.53±1.68	36.66±1.40
Calf*	39.66±1.69	40.77±2.30	38.56±1.09
Sum of 5 skinfolds	35.91±0.87	36.18±1.36	35.64±0.61
Endomorphy	2.5±0.74	2.46±0.77	2.54±0.71
Mesomorphy	6.53±0.84	6.6±1.08	6.46±0.61
Ectomorphy	1.31±0.64	1.43±0.85	1.19±0.44

Values are presented as means±SD.
BMI: Body Mass Index; ELBF%: estimated lower body fat percentage.
*Statistically significant difference between German forward and back players.

TABLE II.—*Physical performance characteristics of the German national rugby union 7s team.*

	Team (N.=17)	Forwards (N.=9)	Backs (N.=8)
Sit-and-reach, cm	27.91±5.19	27.06±4.76	28.75±5.63
HGS left, kg*	55.88±5.69	58.99±5.75	52.78±5.64
HGS right, kg	56.48±7.68	59.2±11.81	53.76±3.55
Vertical jump, cm	56.95±5.5	58.66±5.65	55.25±5.36
Peak power, W*	5277.22±479.55	5666.79±583.14	4887.64±375.95
Sit-up/min*	53.1±5.43	56.86±5.43	49.33±5.43
Push-up/min	54.64±7.78	54.71±9.48	54.57±6.08
BAH, s	32.21±10.9	32.83±12.3	31.59±9.5
40-m sprint, s	5.19±0.22	5.15±0.22	5.23±0.23
Time 0-10 m, s	1.16±0.07	1.62±0.09	1.6±0.05
Time 10-20 m, s	1.25±0.05	1.24±0.05	1.27±0.04
Time 20-30 m, s	1.15±0.06	1.14±0.05	1.16±0.08
Time 30-40 m, s	1.18±0.07	1.16±0.06	1.2±0.08
Speed 0-10 m, km/h	22.42±0.94	22.3±1.22	22.54±0.66
Speed 20-30 m, km/h	31.4±1.7	31.77±1.42	31.04±1.99
Speed 30-40 m, km/h	30.66±1.8	31.06±1.46	30.66±1.8
Yo-Yo Test, lanes	19.16±1.28	19.1±1.38	19.22±1.18

Values are presented as means±SD.
HGS: handgrip strength; BAH: bent arm hanging.
*Statistically significant difference between German forward and back players.

player and also the mean somatotype of forward and back players. The forward players showed significant differences compared to the back players in relation to humerus bone breadth (P<0.001, *d*=0.26), femur bone breadth (P=0.006, *d*=1.53), flexed and tensed upper arm girth (P=0.02, *d*=1.20) and calf girth (P=0.02, *d*=1.22). Table I gives a detailed overview of the anthropometric measurements.

Performance tests

During analysis of the results for the physical performance tests (Table II), significantly higher values for handgrip strength left (P=0.04, *d*=1.09) and sit-ups (P=0.03, *d*=1.38) were observed for the forward players compared to the backs. The peak power output during the counter movement vertical jump was significantly higher for the forward players, compared to the backs (P=0.01, *d*=1.58). No significant differences between forward and back players were found for the handgrip strength right (P=0.24, *d*=0.62), vertical jump performance (P=0.28, *d*=0.61), push-up performance (P=0.97, *d*=0.01), bent arm hanging test (P=0.83, *d*=0.11) and the sit-and-reach test (P=0.56, *d*=0.32). Looking at the running performance results, there were no significant differences between the forwards and the backs during the 40-m sprint (P>0.05, *d*=0.35) and the YYIET (P=0.88, *d*=0.09). Table II gives a detailed overview of all conducted physical examination tests.

Discussion

Anthropometric characteristics

In 2014, Vaz *et al.* investigated the fitness levels as a function of playing positions in elite rugby union players.[11] The authors concluded that physical performance and anthropometric characteristics of elite rugby players vary according to their playing positions. Several studies have shown that forward players tend to be taller and heavier compared to back players at elite and sub-elite levels.[21-24] These results are in line with the findings in this study given the significant results concerning height and weight of the forward players compared to the back players. Crewther *et al.*, instead, identified significant relationships between body height and peak force and peak power.[21] As a consequence, the smaller and lighter back players revealed a higher performance output compared to the forward players, which could be explained by their specific movement patterns within a game. It has been demonstrated that successful rugby union teams assign taller and heavier players in the front positions and smaller and lighter players in the back positions.[25, 26] In general, this is due to the physically more intensive job description of the team's forwards. In rugby union the forward players are involved in significantly more rucks and mauls than the backs.[27] Therefore they require more mass than the backs, who are more creators and finishers and therefore need to be faster.[26] In a recently published study it has been demonstrated that in general lower division rugby players are significantly shorter and lighter compared to 1st division rugby players.[28] Our study results are in line with these results, showing that the German forward players were taller and heavier compared to the backs.

The forward players who are more involved in tackles and scrum participation, need a high mesomorphic and endomorphic body compositions to resist and absorb high impacts. These strength and mass factors could have a positive impact on the game. This led to the assumption that the forward players should have higher performance values compared to their team mates. However, neither the estimated lower body fat percentage nor the mesomorphic or endomorphic shape of the German rugby players differed between the forward and back players. In contrast, another study demonstrated that forward players reached the highest mesomorphy and the lowest ectomorphy compared to back players.[9] The back players reached the highest ectomorphy and lowest mesomorphy compared to the forward players. These findings are in line with the results of Quarrie *et al.*, indicating that a rugby forward player should reach higher levels of mesomorphy and lower levels of ectomorphy compared to a back player.[8] Although a high percentage of body fat may have some advantages in contact sports for tackling and collisions, it negatively affects performance since excess in body fat increases metabolic demand during exercise.[29] Even so, several studies of elite players demonstrated that forward players have a larger percentage of body fat compared to back players.[22, 23, 28] The anthropometric profile of the German rugby union team is different compared to the profiles described in the literature. The team's somatotype appears very homogeneous at this point, which is due to the status of the current development stage of the players. Depending on the individual position of a player, development of specific player position somatotypes might help the German rugby union team to adapt to the different positional requirements.

Performance characteristics

Handgrip strength can be associated with upper body strength and physical activity.[30, 31] Horsley *et al.* demonstrated a strong correlation between handgrip strength and lateral rotator cuff strength and suggested that assessment of grip strength could be used as a tool for assessing readiness to perform sporting activity.[32] In rugby, a high handgrip strength may be an advantage to bind properly during scrums.[8] Furthermore, handgrip strength provides an objective index of the functional integrity of the upper extremity.[33] In our study, a significant difference between German forward and back players was found for handgrip strength. The forward players yielded higher strength values but only for the left-hand side.

In rugby, it is believed that the level of upper body strength can discriminate between a successful and a less successful team.[34] Crewther *et al.* showed that elite forward players achieved significantly higher one-repetition bench press results compared to back players.[22] These results are in line with McMaster *et al.* who found that sub-elite forward players were moderately stronger (upper body strength) compared to back players.[35] Maud *et al.* found that the mean amount of sit-ups/min was not significantly different between rugby union forward and back players on amateur level.[36] Based on these results it can be assumed that these strength parameters between forward and back players are significantly different on the elite level but not on an amateur level. In our study, the sit-up performance of the German forward players was significantly higher in comparison to the backs. For the push-up test and bent arm hang test, no significant differences were found between German forward and back players.

Hamstrings strain injuries are common injuries in sports.[37, 38] Hamstrings injuries are, after thigh hematomas, the second most common injury in rugby union and the incidence is significantly higher for back players compared to forward players.[39] It has been speculated that the faster acceleration and higher number of performed sprint activities probably contribute to the significantly higher incidence between backs and forward players.[39, 40] It was demonstrated that improved muscle flexibility may reduce the incidence of hamstrings muscle injuries.[41, 42] The sit-and-reach test indicated that the German backs had similar flexibility compared to the forward players.

Successful backs need explosive leg power to accelerate and create opportunities for their team mates.[11, 43] Vertical jump performance has been proven to be good indicator for leg power.[44] During a "lineout", an explosive and maximum jump height is crucial to success during this maneuver. It has been demonstrated that back players are able to jump significantly higher than forward players on amateur level.[36] These results were also observed on elite level by Nakamura *et al.* and Carlson *et al.*[45, 46] In our study, no significant differences were found between German backs and forward players for vertical jump performance. Forward players showed significantly higher peak power output values during the vertical jump performance compared to the backs. These results show the necessity for assessing vertical jump performance in rugby union on elite level.

While the forward players spend more time in rucks, mauls and scrums, the running demand of backs is greater to carry the ball down the field.[47] As a consequence backs are expected to cover larger distances during endurance tests compared to forward players. It has been demonstrated that backs cover significantly greater distances compared to forward players.[48, 49] In contrast to these studies, the German backs did not cover a larger distance during the YYIET test compared to the forward players which can be explained by the homogenous physical performance demands in 7s rugby.

Backs have to accelerate after receiving the ball and spend more time in higher speed zones compared to forward players to create opportunities for the wing players.[47, 50] Therefore, running speed is a key component in rugby union.[51] In general, the back players demonstrate to be faster with a higher acceleration compared to forward players.[22, 52, 53] Barr *et al.* investigated speed and sprint momentum in rugby union players over a 40-m distance.[52] The authors showed that back players were able to have significantly greater initial and also maximal sprint velocity compared to forward players. In a comparable study, back players also produced greater initial sprint times between 2 and 5-m compared to forward players.[53] These results are in line with those from Crewther *et al.*, who demonstrated that elite back players were faster and had higher velocities during the 10-m and 20-m sprint compared to the elite forward players.[22] Looking at the sprint-test results, no significant differences were found between the German backs and forward players, neither in the total 40-m sprint time nor in any of the 40-m sections.

Our results indicate that the level of development in the German team appears to be very similar between all groups, and could serve as a base level to start modelling the players' requirements regarding their assigned positions. The authors of this study agree with Higham *et al.* who concluded that rugby 7s is a complex team sport which requires a combination of fitness and physical ability.[54] Although some physical prerequisites for the rugby game are important, it should be stressed that a rugby player who does not match the ideal profile might still be successful due to other factors (*e.g.* technical, tactical or mental strength).[43, 55, 56] The results of this study indicate that the German rugby team is still developing physically. To analyze the anthropometric and physical performance development of the German national rugby team, follow-up measurements are required. In further research, the effect of specific training interventions on the anthropometric and physical performance status will be analyzed. The German national Rugby 7s team is in an early stage of development because of its comparative youthfulness in the competitive sports arena. With time, the physical ability of players will rise to manage challenges of more power requirements at the contact points and being able to move quicker to create scoring opportunities, eventually reaching similarities in body composition and physical demands that can also be recognized in the more established rugby league players.[57]

Conclusions

Somatotyping and physical performance measurements indicate the importance of muscularity and running speed in rugby. Taller, more agile, heavier and stronger forward players who can undertake more tackles during a game, can be a possible advantage in rugby. Explosive leg power and a higher running speed of the backs could probably lead to more ball possession during the game, which possibly increases the offensive chances of the forward players. The knowledge and adequate follow-up of body composition and physical performance in rugby is important to reduce the risk of injuries and to guarantee an optimal development of the rugby specific somatotype. The nominative data of this study may assist other coaches to detect weak links in rugby specific athletic performance. Our future research will continue to focus on a comparison of the collected data with the results of international professional rugby teams to optimize the training and development of the German national rugby team.

References

1. Brewer J, Davis J. Applied physiology of rugby league. Sports Med 1995;20:129-35.
2. Barié A, Grossner T, Streich N. Verletzungen beim Rugby Union – Literaturrecherche und Datenauswertung des Olympiastützpunktes Rhein-Neckar Heidelberg. Sportorthop Traumat 2013;29:101-11.
3. German Rugby Union (DRV); 2014 [Internet]. Available from: www.rugby-verband.de [cited 2017, Jun 27].
4. Dulcinea F. Rules and History of Rugby; [Internet]. Available from: www.findingdulcinea.com/guides/Sports/Rugby.xa_1.html [cited 2017, Jun 27].
5. World Rugby; 2014 [Internet]. Available from: www.worldrugby.org [cited 2017, Jun 27].
6. Delahunt E, Byrne RB, Doolin RK, McInerney RG, Ruddock CT,

Green BS. Anthropometric profile and body composition of Irish adolescent rugby union players aged 16-18. J Strength Cond Res 2013;27:3252-8.

7. Quarrie KL, Feehan M, Waller AE, Cooke KR, Williams S, McGee R. The New Zealand Rugby Injury and Performance Project: alcohol use patterns within a cohort of rugby players. Addiction 1996;91:1865-8.
8. Quarrie KL, Wilson BD. Force production in the rugby union scrum. J Sports Sci 2000;18:237-46.
9. Holway FE, Garavaglia R. Kinanthropometry of Group I rugby players in Buenos Aires, Argentina. J Sports Sci 2009;27:1211-20.
10. Eston R, Reilly T. Kinanthropometry and exercise physiology laboratory manual New York: Routledge Taylor & Francis Group; 1996.
11. Vaz L, Morais T, Rocha H, James N. Fitness profiles of elite portuguese rugby union players. J Hum Kinet 2014;41:235-44.
12. Gabbett TJ, Jenkins DG, Abernethy B. Relationships between physiological, anthropometric, and skill qualities and playing performance in professional rugby league players. J Sports Sci 2011;29:1655-64.
13. Hughes MD, Bartlett RM. The use of performance indicators in performance analysis. J Sports Sci 2002;20:739-54.
14. Gabbett TJ, Domrow N. Risk factors for injury in subelite rugby league players. Am J Sports Med 2005;33:428-34.
15. Marfell-Jones M, Olds T. International standards for anthropometric assessments Potchefstroom, South Africa 2006
16. Carter J. The Heath-Carter anthropometric somatotype; instruction manual. wwwsomatotypeorg/Heath-CarterManualpdf 2002;
17. Keane A, Scott MA, Dugdill L, Reilly T. Fitness test profiles as determined by the Eurofit Test Battery in elite female Gaelic football players. J Strength Cond Res 2010;24:1502-6.
18. Tsigilis N, Douda H, Tokmakidis SP. Test-retest reliability of the Eurofit test battery administered to university students. Percept Mot Skills 2002;95:1295-300.
19. Sayers SP, Harackiewicz DV, Harman EA, Frykman PN, Rosenstein MT. Cross-validation of three jump power equations. Med Sci Sports Exerc 1999;31:572-7.
20. Bangsbo J, Iaia FM, Krustrup P. The Yo-Yo intermittent recovery test : a useful tool for evaluation of physical performance in intermittent sports. Sports Med 2008;38:37-51.
21. Crewther BT, Kilduff LP, Cook CJ, Cunningham DJ, Bunce PJ, Bracken RM, *et al.* Scaling strength and power for body mass differences in rugby union players. J Sports Med Phys Fitness 2012;52:27-32.
22. Crewther BT, Lowe T, Weatherby RP, Gill N, Keogh J. Neuromuscular performance of elite rugby union players and relationships with salivary hormones. J Strength Cond Res 2009;23:2046-53.
23. Scott AC, Roe N, Coats AJ, Piepoli MF. Aerobic exercise physiology in a professional rugby union team. Int J Cardiol 2003;87:173-7.
24. Jarvis S, Sullivan LO, Davies B, Wiltshire H, Baker JS. Interrelationships between measured running intensities and agility performance in subelite rugby union players. Res Sports Med 2009;17:217-30.
25. Hendricks S, Karpul D, Lambert M. Momentum and kinetic energy before the tackle in rugby union. J Sports Sci Med 2014;13:557-63.
26. Olds T. The evolution of physique in male rugby union players in the twentieth century. J Sports Sci 2001;19:253-62.
27. Deutsch MU, Kearney GA, Rehrer NJ. Time - motion analysis of professional rugby union players during match-play. J Sports Sci 2007;25:461-72.
28. Fontana FY, Colosio A, De Roia GF, Da Lozzo G, Pogliaghi S. Anthropometrics of Italian Senior Male Rugby Union Players: From Elite to Second Division. Int J Sports Physiol Perform 2015;10:674-80.
29. Meir R, Newton R, Curtis E, Fardell M, Butler B. Physical fitness qualities of professional rugby league football players: determination of positional differences. J Strength Cond Res 2001;15:450-8.
30. Aadahl M, Beyer N, Linneberg A, Thuesen BH, Jorgensen T. Grip strength and lower limb extension power in 19-72-year-old Danish men and women: the Health2006 study. BMJ Open 2011;1:e000192.
31. Leong DP, Teo KK, Rangarajan S, Lopez-Jaramillo P, Avezum A, Jr., Orlandini A, *et al.* Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. Lancet 2015;386:266-73.
32. Horsley I, Herrington L, Hoyle R, Prescott E, Bellamy N. Do changes in hand grip strength correlate with shoulder rotator cuff function? Shoulder Elbow 2016;8:124-9.
33. Myers DB, Grennan DM, Palmer DG. Hand grip function in patients with rheumatoid arthritis. Arch Phys Med Rehabil 1980;61:369-73.
34. Baker D. Comparison of upper-body strength and power between professional and college-aged rugby league players. J Strength Cond Res 2001;15:30-5.
35. McMaster DT, Gill ND, Cronin JB, McGuigan MR. Force-Velocity-Power Assessment in Semiprofessional Rugby Union Players. J Strength Cond Res 2016;30:1118-26.
36. Maud PJ. Physiological and anthropometric parameters that describe a rugby union team. Br J Sports Med 1983;17:16-23.
37. Croisier JL. Factors associated with recurrent hamstring injuries. Sports Med 2004;34:681-95.
38. Petersen J, Holmich P. Evidence based prevention of hamstring injuries in sport. Br J Sports Med 2005;39:319-23.
39. Brooks JH, Fuller CW, Kemp SP, Reddin DB. Epidemiology of injuries in English professional rugby union: part 1 match injuries. Br J Sports Med 2005;39:757-66.
40. Deutsch MU, Maw GJ, Jenkins D, Reaburn P. Heart rate, blood lactate and kinematic data of elite colts (under-19) rugby union players during competition. J Sports Sci 1998;16:561-70.
41. Dadebo B, White J, George KP. A survey of flexibility training protocols and hamstring strains in professional football clubs in England. Br J Sports Med 2004;38:388-94.
42. Gabbe BJ, Finch CF, Bennell KL, Wajswelner H. Risk factors for hamstring injuries in community level Australian football. Br J Sports Med 2005;39:106-10.
43. Duthie G, Pyne D, Hooper S. Applied physiology and game analysis of rugby union. Sports Med 2003;33:973-91.
44. Young W, McLean B, Ardagna J. Relationship between strength qualities and sprinting performance. J Sports Med Phys Fitness 1995;35:13-9.
45. Nakamura FY, Pereira LA, Moraes JE, Kobal R, Kitamura K, Cal Abad CC, *et al.* Physical and physiological differences of backs and forwards from the Brazilian National rugby union team. J Sports Med Phys Fitness 2016;
46. Carlson BR, Carter JE, Patterson P, Petti K, Orfanos SM, Noffal GJ. Physique and motor performance characteristics of US national rugby players. J Sports Sci 1994;12:403-12.
47. Nicholas CW. Anthropometric and physiological characteristics of rugby union football players. Sports Med 1997;23:375-96.
48. Darrall-Jones JD, Jones B, Till K. Anthropometric, Sprint, and High-Intensity Running Profiles of English Academy Rugby Union Players by Position. J Strength Cond Res 2016;30:1348-58.
49. Cahill N, Lamb K, Worsfold P, Headey R, Murray S. The movement characteristics of English Premiership rugby union players. J Sports Sci 2013;31:229-37.
50. Cunniffe B, Proctor W, Baker JS, Davies B. An evaluation of the physiological demands of elite rugby union using Global Positioning System tracking software. J Strength Cond Res 2009;23:1195-203.
51. Duthie GM, Pyne DB, Marsh DJ, Hooper SL. Sprint patterns in rugby union players during competition. J Strength Cond Res 2006;20:208-14.
52. Barr MJ, Sheppard JM, Gabbett TJ, Newton RU. Long-term training-induced changes in sprinting speed and sprint momentum in elite rugby union players. J Strength Cond Res 2014;28:2724-31.
53. Cross MR, Brughelli M, Brown SR, Samozino P, Gill ND, Cronin JB, *et al.* Mechanical Properties of Sprinting in Elite Rugby Union and Rugby League. Int J Sports Physiol Perform 2015;10:695-702.
54. Higham DG, Pyne DB, Anson JM, Eddy A. Physiological, anthropometric, and performance characteristics of rugby sevens players. Int J Sports Physiol Perform 2013;8:19-27.

55. Meir R. Training for and competing in sevens rugby: practical considerations from experience in the International Rugby Board World Series Strength Cond J 2012;34:76-86.
56. Hughes M, Jones R. Patterns of play of successful and unsuccessful teams in men's 7-a-side rugby union In: Reilly T, Cabri J, Araujo D. Science and Football V The Proceedings of the Fifth World Congress on Science and Football. London, New York: Routledge Taylor & Francis Group; 2005. p. 247-52.
57. Jones B, Till K, Barlow M, Lees M, O'Hara JP, Hind K. Anthropometric and Three-Compartment Body Composition Differences between Super League and Championship Rugby League Players: Considerations for the 2015 Season and Beyond. PLoS One 2015;10:e0133188.

Funding.—The Thim van der Laan Foundation (Landquart, Switzerland) provided financial support.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Acknowledgements.—The authors are grateful to Dr. Florian Kreuzpointner, from the Department of Biomechanics in Sports of the Technische Universität München, for providing consultations.

Article first published online: April 28, 2017. - Manuscript accepted: April 11, 2017. - Manuscript revised: February 22, 2017. - Manuscript received: October 18, 2016.