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Raquel Figueiredo da Costa

MULTIDIMENSIONAL AND MULTIMETHOD STUDY OF THE FEMALE RUGBY PLAYER

Dissertation submitted to the Faculty of Sport Sciences and Physical Education of the University of Coimbra, for the Degree of Master in Youth Sports Training

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Dissertation of Master in Youth Sports Training, submitted to the Faculty of Sport Sciences and Physical Education of the University of Coimbra. Supervisors: PhD Manuel João Coelho-e-Silva, PhD João Pedro Marques Duarte.

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“Não há transformação, sem ação”.

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For my Grandmother and Ruck, the keys for my progress today.

ABSTRACT

Rugby has been increasingly growing in Portugal in the last ten years, and women rugby too. In the present season (2019/2020), the Portuguese Rugby Federation (FPR) reported that of the 6011 federated athletes, 417 are female athletes. The main aim of this study was to obtain a multidimensional and multimethod profile of the Portuguese female rugby players and consequently compare it with soccer players. The sample comprised fourteen female rugby players (n=14) from the highest competitive level in the country (age 23.74 ± 1.43 years, stature 1.64 ± 1.7cm, and body mass 64.9 ± 2.8kg). Rugby players were assessed in whole body anthropometry, air displacement plethysmography (ADP), hand morphology, echocardiography, bioimpedance (BIA), food frequency questionnaire (FFQ), task and ego orientation in sport questionnaire (TEOSQ), aerobic fitness, Wingate anaerobic test, dynamometry isokinetic (flexors and extensors of the knee 60, 180°/s) and dynamometry manual tests. Results presented described the athlete in ADP (body volume: 62.611L), hand morphology (ratio 2D:4D: 1.03 [right] and 1.02 [left]), echocardiography (ventricular mass by body surface: 79.1g/cm2), BIA (total body water: 33.9L), TEOSQ (tasked orientation: 4.1), aerobic fitness (VO2máx = 43.2 mL.kg-1. min-1), WAnT (Absolute maximum mechanical power: 673 watt), isokinetic dynamometer (conventional ratio $60°{\cdot}s^{-1}$: 0.53; $180°{\cdot}s^{-1}$: 0.60), and handgrip test (30.7kg.f [right] and 33. kg.f [left]). By the end of the study, each participant and the club have an individual report that can be useful for training planning and definition of goals.

Key words: female athletes, rugby, body composition, anthropometry, metabolic pathways, muscle strength, motivational orientation, food intake

RESUMO

O rugby tem crescido cada vez mais em Portugal nos últimos 10 anos, assim como no feminino. Na corrente época (2019/2020) a Federação Portuguesa de Rugby (FPR) informou que dos 6011 atletas federados, 417 são do sexo feminino. O principal objetivo deste estudo foi obter o perfil multidimensional e multimétodo da jogadora portuguesa de rugby e, consequentemente, compará-lo com as jogadoras de futebol. A amostra é composta por catorze jogadoras de rugby (n=14) do mais alto nível competitivo do país (idade 23,74 ± 1,43 anos, estatura de 1,64 ± 1,7cm, e massa corporal 64,9 ± 2,8kg). As atletas foram avaliadas em antropometria corporal inteira, pletismografia de ar deslocado (ADP), morfologia da mão, ecocardiografia, bioimpedância (BIA), questionário de frequência alimentar (FFQ), questionário de orientação para a tarefa ou ego (TEOSQ), aptidão aeróbia, teste anaeróbio de Wingate, dinamometria isocinética (flexores e extensores do joelho 60°·s^{1,} 180°·s^{-1} e por fim dinamometria de preensão manual. Os resultados apresentados descreveram o atleta em ADP (volume corporal: 62.611L), morfologia da mão (rácio 2D:4D: 1,03 [direita] e 1,02 [esquerda]), ecocardiografia (massa ventricular por superfície corporal: 79,1g/cm2), BIA (água corporal total: 33,9L), TEOSQ (orientação para a tarefa: 4,1), aptidão aeróbia (VO2máx = 43,2 mL.kg-1. min-1), WAnT (potência mecânica máxima absoluta: 673 watts), dinamómetro isocinético (rácio convencional 60°/s: 0,53; 180°/s: 0,60) e teste de preensão manual (30,7kg.f [direita] e 33. kg.f [esquerda]).No final deste estudo, cada participante e o clube possuem um relatório individual que pode ser útil para o planeamento de treino e definição de objetivos.

Palavras-chave: atleta feminina, rugby, composição corporal, antropometria, vias metabólicas, força muscular, orientação motivacional, ingestão calórica

ABBREVIATIONS LIST

% - Percentage
ADP – Air Displacement Plethysmography
ASE – American Society of Echocardiography
BIA – Bioimpedance
BMC- Bone Mineral Content
BMD – Bone Mineral Density
Ca – Calcium
CI – Confidence Interval
Chol – Cholesterol
CV – Coefficients of variation
DAR – Diameter of the aortic root
DAE – Diameter of the left atrium
DSM-BIA – Bioimpedance measurement method segment direct multi-frequency
EAE – European Association of Echocardiography
EtOH – Ethanol
FPR – Portuguese Federation Rugby
FFM-ADP – Fat free mass by air displacement plethysmography
FFM-BIA - Fat free mass by bioimpedance
FFM-DXA – Fat free mass by dual energy x-ray absorptiometry
FFQ – Food Frequency Questionnaire
FM-ADP – Fat mass by air displacement plethysmography
FM-BIA - Fat mass by bioimpedance
FM-DXA – Fat mass by dual energy x-ray absorptiometry
HRmax – maximum heart rate
Kcal – calories
LST – Lean soft tissue
LV – Left ventricle
LVM – Left ventricle mass
LVPWD – Left ventricle posterior wall in diastole
R – Reliability coefficients
RC – Respiratory compensation point
RER – Respiratory exchange ratio
Rz – Resistance
SD – Standard deviation
SE – Standard error
SIV – Thickness of the interventricular septum
TAPSE – Tricuspid annular systolic excursion
TBW – Total body water
TEOSQ – Task and Ego Orientation in Sport
VE – Ventilation equivalent
$VECO_2$ – Carbon dioxide release
$VEVO_2$ – Respiratory equivalents of oxygen uptake
VO_2max – Maximal oxygen uptake
VT1 – First Ventilatory Threshold
WAnT – Wingate Anaerobic Test
Xc - Reactance

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CHAPTER I:
INTRODUCTION

Female rugby

Female rugby in Portugal started in 2000 including the rugby-15 format (R15). Few years later, in 2003, started a new variant characterized by a narrower number of players, that is seven (R7). In Portugal, the first club was *Escola Superior Agrária de Coimbra* (student union of AEESAC) that dominated opponents and attained the national championship. Currently the season is organized into two parts: firstly the Portugal Cup is settled to be composed of 10 players (another new variant R10), R15 and, finally, the season previews R7 tournaments to achieve the national championship.

The two variants correspond to distinct match demands and, obviously, require specific training methods. Also of interest are the expected functional profile of each specific position. The demands of rugby involve a variety of different specific levels of training to develop specific physical and physiological. Rugby players are supposed to complete high intensity episodes, in parallel to motor actions including physical contact and unpredictable resting time. (Duthie et al., 2003). Within a team exist different technical positions that required specific levels of conditioning to their positions. (Quarrie et al., 1995; Quarrie et al., 1996).

Match performance

Rugby is a sport of invasion and not collision, but sometimes there needs to be physical contact to achieve ground. This is the biggest difference to many other team sports and according to Dempsey (2002),collisions events have been reported to differentiate between competition standard, increase presentations of effort, muscle damage, neuromuscular fatigue and energy expenditure. This demonstrates the significant physical cost of collisions and highlights that players must be prepared for the most intense contact demands of competition. A study conducted in a male tournament with the purpose of quantifying the collision during a game it has been concluded that in an average of 28 to 42, depending on playing position, with the highest frequency in the forwards (Gabbett et al., 2012).

During a total match, rugby union players covered 5.820-6.512 meters (Rrones, Ortillo, Lanco, & Duardo, 2014). Backs covered significantly more distance than forwards: 6.356 vs. 5.498 meters, respectively. Meantime, between the first half and de second half, studies did not show significant differences (Rrones et al., 1994). According to Gabbett (2016), rugby players showed an average match speed of 125±16 m/min. During a 1-minute period of competition, the average speed was 160m/min across all position, with the greatest peak average speed observed for fullbacks, and the lowest peak average speed for middle forwards.

Internal load of rugby match

Rugby is an intermittent team sport characterized by repeated collision and high-intensity (Weaving et al., 2018). Relative to heart rate (HR) responses, according to a study that analyze 38 videos of Canadian matches in premier division league, forwards had a significantly higher average match than backs and also spent more time above 80% of their HR because they do more static exercises, e.g. tackling, scrum (Virr et al., 2014). Maximal HR in the treadmill was 198 bpm among forwards with peak game HR about 195 bpm and a mean HR of 173 bpm. Respective mean values for backs were lower, probably because their intervention in the game is less, e.g. sporadic sprints: they attained 195 bpm as maximal HR in the treadmill, in parallel to peak HR of 192 bpm during the game (mean: 161 bpm).

Physiological profile

Meantime, oxygen uptake is considered an important factor. Previous studies showed that backs tended to attain higher values compared to forwards: 45.3 mL/kg/min and 39.7 mL/kg/min, respectively. As previously noted, rugby is an intermittent sport and consequently, anaerobic pathway is consensually an important factor while assessing the physiological profile of rugby players.

Wingate test (WAnT) is often used to measure the maximum intensity at a short phase using an ergometer cycle (Bell & Cobner, 2006). Theoretically, peak power output should be attained in the first seconds (5-10 seconds) and afterwards the mechanical power declines. The overall mean power over the 30 seconds of the Wingate test is a parameter of anaerobic capacity. Alternative tests, such as force-velocity test offer a valid alternative to estimate peak power, based on multiple trials using non-standardized braking forces, in contrast to the WAnT test that assumes a standardized braking load as 7.5% of body mass. Note, however, that the force-velocity test does not inform about mean power, which may be as important as peak power in sports like rugby

Morphology of rugby players

Body composition of players provides valuable information. The sports seems to accommodates substantial variation in terms of body mass and its components. The information if a requisite to prescribe an adequate dietary and also for monitoring the effects of training. According to Higham (2013), a greater body mass may be an advantageous during physical contacts for the ball, but when additional fat, a players power-to-weight ratio and metabolic efficiency may be compromised.

A systematic review made in 2019 with female rugby athletes, about the anthropometric characteristics and other subjects, concluded that the average of stature is 1.68±0.01m and body mass 67.4±1.5. Furthermore, they also analyzed the athletes according to their position and said that backs are shorter (1.66±0.02m vs 1.67±0.03m), lighter (63.7± 2.4kg vs 69.9± 2.2kg), and leaner (15.4± 3.1% vs. 18.1± 3.5%) (Sella et al., 2019).

Another study from 2016, characterized the anthropometric profile of female rugby player and here they grouped the athletes in forwards and backs and the results are similar in the stature variable, but in the body mass and fat mass the subjects are higher values in this study (n= 20 players, BM= 75.3±10.6, 61.8±7.0%; Fat Mass=34.5±5.4, 26.1±5.2%) (Sousa et al., 2016). Although both studies agree that forwards are heavier than backs and the values can create a profile rugby athlete. The difference between them in body mass, could be explain with the old idea that the athletes need a higher body mass because the impact, but in the last years the rugby search for a complete athlete. Relative to the demands of a forward require more body mass and more powerful on account of the fact that they are considered the ball conquerors (Nicholas, 1997; Scott et al., 2003). The backs do the final phase of a move so they need more speed, agility, and aerobic capacity to win advantage over the opponent (Nicholas, 1997; Scott et al., 2003). Also, the body mass is 75±10.6 and 61.8±7.0, respectively (Higham et al., 2014). Furthermore, anthropometric factors such as body composition, lean mass and height are important components of success, because higher amounts of lean mass increase an athlete power-to-weight ratio, who providing an advantage in tackles and scrums (Nicholas, 1997).

Other attributes of the rugby players

Motivation is another important key for success and is influenced by the task and ego. In the athletes involvement, most of them are focused on achieving the objectives and should be a positive achievement. TEOSQ is used to assess individual differences in tendency for emphasizing task and ego involving criteria for defining success in sport. in the questionnaire we can see that task orientation have more correlation and in the other size, ego orientation have less. (Dud, Chi, Newton, Walliing, & Catley 1995).

Available studies can be found in databases but only in another countries. The most of the research in the area is from the last ten years with an increase in the last few years with regard to anatomical construction and injury . The majority of the field studies were descriptive and considered the best elite athletes of the country where they are and the most studies are from America, England and Australia. Also, the majority of studies just compare the body composition, aerobic capacity and power between rugby positions or just provide us a profile of them.

There is a gap on comparative studies, taking as comparison the profile of the athletes with another sports. This study brings us the profile of Portuguese female rugby, characterized by body composition, aerobic and anaerobic capacity, power and nutrition. Previous studies were made in the same line of body composition, position in field and transition between age group.

Sergio Franco (2012) analyze 41 male athletes with the focus on lower limbs. Also take in account another values to increases the precision of lower limb volume estimated.

José Baptista de Almeida (2014) increased the sample and study the male athlete being in account the field position. Conclude that the elite players were heavier and larger in terms of fat-free mass and also a thigh volume higher and better scores in laboratory tests.

João Mateus (2015) compared three rugby positional groups and analyzed 53 athletes. Between the three groups (conquest, finishers and maneuverers) he observed that maneuverers seemed to be team engine with best physical abilities, test performance and game knowledge.

Aim

This study was aimed to profile functional body composition female adult Portuguese rugby players based on a multidimensional matrix of variables including multi-method approach of morphology, metabolic fitness outputs derived from short and middle term laboratory protocols in addition to strength given by dynamometry (hand grip and isokinetic of knee muscle actions) taking also into account goal orientations and food habits.

CHAPTER II:
METHODS

Study design

The scientific board and the ethics committee (CE/FCDEF-UC/00262017) of the Faculty of Sports Sciences and Physical Education of the University of Coimbra approved the research proposal. All participants, after verbal and written explanations of the experimental design and potential risks of the study, provided signed consent. All measurements were carried out in the biokinetics laboratory of the Faculty of Sports Science and Physical Education of the University of Coimbra University and Health School of the Polytechnical Institute of Coimbra. The same research team assessed all data on three occasions. The athletes, from different teams, were evaluated on the same day and place, on the same conditions and protocols, by experienced technicians. Total and appendicular anthropometry, body composition and nutrition, echocardiographic parameters, strength, aerobic performance, and goal orientation were considered.

Participants

The sample comprised 14 first Portuguese division female rugby players (age +/- sd) from three different teams representing the central region of Portugal. All athletes revealed preference by the right upper limb as well as the right lower limb in rugby-specific motor tasks (throw and kick). **Inclusion criteria:** (1) registered in the Portuguese Rugby Federation; (2) training at least three times and playing one game per week; (3) signing the informed consent declaration. **Exclusion criteria:** (1) history of musculoskeletal injuries in the 12 months before muscle strength evaluation test. The playing position varied according to the following distribution: centers (n=4), wingers (n=2), scrum-half (n=2), and forwards (n=5).

Age and training experience

In parallel with laboratory assessments, information regarding chronological age (the difference from observation day and birth date), the federated practicing years, as well as the occurrence of menarche (and menstrual cycle). The data corresponded to the period before the evaluations and were) with the collaboration of the coaches.

Anthropometry

A single experienced observer performed anthropometric measurements based on standard protocols (Lohman, Roche, & Martorell, 1988). The variables include body mass, stature, sitting height, circumferences, areas, volumes, and lengths. The athletes were weighed barefoot, using shorts and sports top on a SECA scale (model 770, Hanover, MD, USA), with an accuracy of 0.1 kg. A portable stadiometer Harpenden (model 98603, Holtain Ltd, Crosswell, UK), with an accuracy of 0.1 cm measured stature. All athletes take the anthropometric position of reference and ensure the orthogonality of the Frankfurt reference line relative to the scale. The sitting height was measured in Harpenden sitting height table (Holtain Lts, Crosswell, UK), with the same precision of 0.1 cm with the observer leveling the platform for support and length of the supporting surface.

With 0.1 cm precision circumferences, volumes and lengths were measured using an anthropometric tape on the left and right sides of the body. The subjects were standing with the upper limbs relaxed beside the trunk.

With a pen, marked six points in the upper limb (the ulnar styloid, the largest girth of the forearm, the olecranon, the largest girth of the arm, the distal insertion of the deltoid and the acromion), after the observer measured the five lengths between the points from distal to proximal (Rogowski, Ducher, Brosseau, & Hauntier, 2008).

The lower limbs were pen-marked in the points (the inferior gluteal line, maximal perimeter with the member relaxed and the femoral condyle). The two lengths in the thighs were measure between these points from distal to proximal.

Hand morphology (ratio 2D:4D)

The linear morphology of the hand considered all fingers, with the middle finger (3D) aligned with the cube and the radio. Both the palmar region of hand and forearm were in contact with the record sheet; the hand in pronation on a transverse plane with fingers in maximum extension and distance between each other. The measurements corresponded to the distances. Then, the ratio 2D:4D calculated for each hand.

Echocardiography

The same experienced observer, used one transthoracic cardiograph in the left lateral decubitus position, comprising an ultrasound device Vivid 3, with a multifrequency probe of 1.5 to 3.6 MHz (GE Vingmed Ultrasound, Horten, Norway). The evaluation considered the dimensions of the cardiac cavities and the thicknesses during rest. M-mode, guided by 2D, determined the diameter of the aortic root (DAR). This method is the most used because of its ability to determine the morphological parameters of the heart primarily. The incidence of the long axis left parasternal measured the diameter of the left atrium (DAE). The telediastolic and telesystolic diameters of the left ventricle (LV). The incidence of the long axis measured the thickness of the interventricular septum (SIV) and LV posterior wall in diastole (LVPWD), after the leaflets of the mitral valve, according to the American Society of Echocardiography (ASE) and the European Association of Echocardiography (EAE). Based on the above dimension, the cubic equation of ASE estimated the LV mass (LVM), modified and obtained by the autopsy of 52 cadavers by Devereux et al. (1986).

The study also evaluated accurately: left ventricle based on the diameters and thickness, its fractional shortening and ejection, right and left atrium areas, left ventricular volumes, maximum blood velocity and gradient in aortic valve, mitral and tricuspid valve annulus velocity through the Doppler Tissue, tricuspid annular systolic excursion (TAPSE) and heart rate.

Air displacement plethysmography (ADP)

Air displacement plethysmography (Bod Pod Composition System, model Bod Pod 2006 Life Measurement, Inc., Concord, CA, USA) estimated the body density (kg/L) through the assessment of the body volume. First of all, a scale incorporated into the plethysmograph measured the bodyweight with an accuracy of 0.01 kg. Then, a cylinder of 50.225 L calibrated the device. During testing, the participants used underwear and a cap, sitting in the chamber of the Bod Pod, motionless while the system estimates the body volume for two consecutive times. Considering test validity, when necessary, the Bod Pod system claimed the third measurement, obtaining a smaller difference than 150 mL. The calculated body density (body mass/body volume) estimated the percentage of the body fat, using the equation of Siri (1961): (%FM=((4.95/d-4.50)*100) and for underage participants the equation of Lohman. In the end, this percentage was converted into fat mass (FM-ADP) and then subtracted from the whole body mass, estimating the fat-free mass (FFM-ADP).

Bioimpedance

The examination of bioelectrical impedance (BIA 101 System Analyzer, Akern, Florence, Italy), allowed bicompartmental estimation of body composition from the resistance measurement (Rz) and reactance (Xc), impedance and phase angle (Coppini, Bottoni, Silva, & Waitzberg, 1998). In this process, the participants lied in the dorsal decubitus position, with the upper and lower right limb in abduction, at an angle of 45°. Current study variables considered the total body water, intracellular and extracellular of the individual as well as their percentage of the fat mass (FM-BIA), fat-free mass (FFM-BIA), body cell mass and muscle mass (Rodrigues, Silva, Monteiro, & Farinatti, 2001; Eickemberg, 2013).

Another body composition analysis considered a direct multi-frequency bioimpedance, quadrupole with eight electrodes (Inbody770 scanner (Inbody Bldg, Seoul, Korea). This device ensures greater accuracy and minimizes the error, with frequency 1, 5, 50, 250, 500, and 1000 kHz. The measurement time was approximately 60 seconds, with the subjects in shorts and a sports top in a standing position according to the protocol. With the report, considered variables were: skeletal muscle (kg), total body water (TBW, L), intracellular water (L), extracellular water (L), proteins (kg); minerals (kg), fat mass (kg and %), fat visceral area (cm^2), fat mass in the upper limbs, trunk and lower limbs (kg), basic metabolic rate (kcal), body cellular mass (kg) and the phase angle of the whole body.

Wingate anaerobic test (WAnT)

The Wingate test evaluated the anaerobic power of the rugby players. The test consists of pedaling for 30 seconds at maximum speed against a constant resistance force previously determined (body mass x 0.075 kg). It was used a cycle-ergometer Monark Peak Bike (model 824E) with a Baumer sensor (CH-8500 Frauenfeld model). The seat height adjusted according to their body size, and the leg needs to be incomplete extension when completing the cycle of movement. The considered warm-up protocol (Armstrong & Welsmn, 2000) included three sub-maximal sprints (2-3 seconds) against test resistance for five minutes. The testing battery also adopted static stretching, considering quadriceps, hamstrings, and adductors. The test started with the subject pedaling at a steady pace between 40 and 50 RPM, with only the resistance of the ergometer weights support. With a countdown of "3-2-1-go", the participant overreached the 60-RPM, and applied resistance force dropped starting the online data collection system. All the time, the subject was encouraged verbally, making an effort of 30 seconds at maximum speed. Extracted data considered 1 Hz and 50 Hz. Defined variables (1Hz) collected the absolute maximum mechanical power (watt), the relative maximum mechanical power (watt/kg), the absolute average mechanical power (watt), the relative average mechanical power, and fatigue index. In data extracted of 50 Hz were collected the absolute maximum mechanical power (watt); the relative maximum mechanical power; time at maximum mechanical power (ms), the absolute average mechanical power; the relative average mechanical power, the power drop, the maximum speed (RPM), power at maximum speed (watt), time at maximum speed (ms) and decline in power (watt).

Aerobic fitness

An incremental running test monitored in treadmill was used to measure the maximum oxygen uptake (VO2max) (Quasar, HP Cosmos, Germany). According to Buchfuhrer et al. (1983), increases in work rate should be selected so that the incremental part of the protocol is completed within 8-12min. After the blood draws, this is the first functional method that the athletes performed in the day of the measurements. The test starts with a warm-up of one minute in speed 7km/h with an inclination of 2%. With non-stop, the test start increasing 1 km/h maintaining a constant inclination in 2% until exhaustion. In the end of each level, the subject evaluated the previous level through his perception of effort (CR-10-Borg Scale). Using a portable analyser, blood lactate (mmol-L) was collected one and three minutes after completion the test (Lactate Pro Analyser, Arcay, Inc). Were used five criteria to obtain the value corresponding to the maximum consumption: 1) the existence of a "plateau" in oxygen consumption, despite an increase in exercise intensity (≤2ml.kg.min or ≤150ml.min); (2) blood lactate concentration exceeding 8 mmol/L; (3) a respiratory exchange ratio of 1.10 (4) Heart rate within 10% of the maximum value expected for the age; (5) impressionist sense of having reached a state of exhaustion (Howley, Basset, & Welch, 1995). According to Quark Cosmed, expired oxygen flow and carbon dioxide concentrations were measured breath by breath. We obtain the threshold and the VO2max from the data and from each one was extracted O2 uptake, heart rate (bmp), time it was occurred (s), speed it was occurred and the respiratory exchange ratio (RER). From respiratory equivalents of oxygen uptake (VEVO2) and carbon dioxide release (VECO2) both with pulmonary ventilation equivalent (VE), we obtain submaximal ventilatory thresholds. The lowest workload in which is observed an increase of VEVO2 without concomitant increase of VECO2 was considered the first ventilatory threshold (VT1) (Dekerle et al., 2003; Wasserman & Meilroy, 1964). The lowest workload in which concomitant VEVO2 and VECO2 increase was considered the respiratory compensation point (RC) (Dekerle et al., 2003; Wasserman & Meilroy, 1964). These two thresholds need two coincide with the first and second non-linear increases in ventilation (VE) (Dekerle et al., 2003). Eight reports were used to determine inter-observer variability. Two independent researches blindly reviewed the plots and determined VT1 and RC individually. For first ventilatory threshold (VT1), respiratory compensation point (RC) and VO2max reliability coefficients were: 0.93, 0.90 and 1.00, respectively. Coefficients of variation (CV) between researchers ranged from 0.3% to 2.7%.

Isokinetic dynamometry assessment (knee flexors and extensors)

The isokinetic evaluation considered the preferred member in an open kinetic chain by Biodex System 3 dynamometer (Shirley, NY, USA) at 60 and 180º/s. The test carried out with a five minutes warm-up in a cycle ergometer (814E Monark, Varberg, Sweden) with a resistance value corresponding to 2% of the body mass of the subject (Brown, 2000) cycling between 50 and 60 RPM, followed by static stretching of the quadriceps, hamstrings, and adductors, with a duration of 20 seconds each. The participants sat on the chair according to the manufacturer instructions; the lever arm aligned with the lateral condyle of the knee and the fixing strip to the tibial tarsal joint placed three to five cm of the medial malleolus of the tibia. The extension limit (0º) considered according to voluntary knee extension. 90º degrees obtained throughout knee flexion. Before the participants performing the test, a correction of the gravity effect of the lower limb and the severity of the lever arm was made by weighting the relaxed member at 30º position (Osterning, 1986). The participants were also instructed to, that during the test, have the arms crossed on his chest with the hands-on shoulders (Brown, 2000; De Ste Croix, Deixghan, & Armstrong, 2003). Participants performed three continuous repetitions for familiarization and then five maximal repetitions with 60 seconds interval between each. Outputs considered peak torque (PT) in Newton meter (N m), angle of PT obtainment, the mean torque, and the conventional ratio (Hamstrings/Quadriceps) using the program Acknowledge, version 4.1 (Biopac Systems, Inc).

Handgrip dynamometer

Handgrip used a manual dynamometer Lafayette (model 78010), adapted to the hand (metacarpals and phalanges) of each subject. The test was performed standing, with both arms extended laterally to the trunk. The evaluation considered both hands, using two trials and their results expressed in kilograms force (kg-f) with one decimal place. The verbal instructions focused on continuous pressure and arm position.

Food frequency questionnaire (QFA)

The study of regular food intake considered the validated semi-quantitative food frequency questionnaire (FFQ) (Lopes et al., 2000). The questionnaire consists of 86 items covering the intake of solid and liquid food during the 12 months before filling it in. In each item, the subject chooses an option from a *Likert* scale (from "never or less than once per month" to "6 or more times a day"). The food intake calculated after taking into account the frequency and portion of each item. The questionnaire identifies a base amount of calories (kcal) consumed, protein (%PTN), carbohydrate (%CH), total body fat (%TBF), saturated fat (%SF), monosaturated fat (%F/Mon), polyunsaturated fat (%/F/Pol) cholesterol (Chol, mg), dietary fiber (FIB, g), Ethanol (EtOH, g) and calcium (Ca, mg). It is an economic tool, straightforward, and able to distinguish the different patterns of inter-consumption (Sampson, 1985; Willett, 1994).

Task and ego orientation in sport questionnaire (TEOSQ)

The Portuguese version of TEOSQ revealed a psychometrically robust and transcultural accepted instrument that attempts to understand the prospective direction of the individual (Duda, 2001). The questionnaire considers 13 items with a *Likert* scale of five points, ranging from "1 - totally disagree" to "5 - I totally agree." Seven items are related to the task orientation (e.g., "I feel more successful in the sport when working hard"), and six are related to the orientation of the ego orientation (e.g., "I feel more successful in the sport when others make mistakes, and I do not").

Statistics

Cohen's d is an effect size used to indicate the standardized difference between two means. Can be calculated as the difference between the means divided by the pooled SD and qualitatively interpreted as follows: < 0.2 (trivial); 0.2-0.6 (small); 0.6-1.2 (moderate); 1.2-2.0 (large); 2.0-4.0 (very large); >4.0 (extremely large):

$$\frac{M2 - M1}{pooledtandard\ deviatio}$$

CHAPTER III:
RESULTS

Table 1 summarizes chronological age, training experience and indicators of body size. The current sample of female rugby players aged 16.6-35.6 years, is characterized by 164.4cm and 64.9kg. Meantime, appendicular anthropometry is presented in Table 2 and external morphology in completed by the shape of the hand (ratio 2D:4D) that is presented in Table 3. The echocardiographic exam permitted the measurement of several parameters which can be taking used to examine wall lipoatrophy on eccentric dilatation of the current sample into account similar standardized values from other samples of female athletes. This was presented in Table 4. In addition, Table 5 included information of bioimpedance when using a unifrequency advice and these details were completed with document data derived from a multifrequency analyzed (Table 6).

For the 2-component body composition assessment, this study used air displacement plethysmography and respective data in summarized in Table 7 that estimates a mean values of 23.4% of fat mean (lower than 31.1% estimated in Table 5, by using bioimpedance).

Regarding metabolic pathways, aerobic fitness provided several parameters presented in Table 9. It informs a mean value of 43.20 mL/Kg/min for this rugby sample. These data slued be interpreted in parallel to short-term maximal outputs presented in Table 8 (using 1 and 50 Hz sampling epoch). The players of this study attained 666 watt where data in obtained at 50Hz, slightly lower then 673 watt at 1 Hz. This alternative data is permitted by the peak bike as described in the section methods.

Regarding muscular strength, two ergometers were used. Firstly, the handgrip and afterwards the isokinetic assessment at the angular velocity of 60°/s and 180°/s. All statistics are presented in Tables 10 and 11.

Finally, the present study also previews the assessment of goal orientation and descriptive parameters were include in Table 12 for each item ad composed variables: ego (1.9), task orientation (4.1). It was also possible to profile food intake of the female rugby players as demonstrated in Table 13.

Table 1. Descriptive statistics for the chronological age and body size descriptors among adult female rugby players (n=14)

		range		mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
Chronological age	years	16.57	35.59	23.74	1.43	(20.65 to 26.82)	5.34
Training experience	years	1	15	8.7	1.3	(6.0 to 11.4)	4.7
Stature	cm	153.3	174.3	164.4	1.7	(160.6 to 168.2)	6.5
Sitting height	cm	82.9	96.2	88.3	1.0	(86.0 to 90.5)	3.9
Leg length	cm	70.4	82.2	76.2	0.9	(74.1 to 78.2)	3.5
Body mass	kg	51.5	90.6	64.9	2.8	(58.8 to 71.0)	10.6

SE (standard error); CI (confidence interval)

Table 2. Descriptive statistics for circumferences, lengths, estimated areas in the lowers limbs among adult female rugby players (n=14)

Measurement	laterality	sectional site	units	range		mean			standard deviation
				minimum	maximum	value	SE	(95% CI)	
Circumferences	left	proximal	cm	52.2	74.0	59.1	1.6	(55.8 to 62.5)	5.8
		medial	cm	47.0	60.1	52.1	1.1	(49.7 to 54.5)	4.2
		distal	cm	33.6	48.7	39.2	1.0	(37.1 to 41.3)	3.7
	right	proximal	cm	52.3	69.2	58.9	1.3	(56.1 to 61.8)	4.9
		medial	cm	45.6	60.6	52.5	1.1	(50.0 to 54.9)	4.2
		distal	cm	35.3	47.5	38.9	0.8	(37.1 to 40.7)	3.1
Areas	left	proximal	cm^2	217	436	281	15	(248 to 314)	58
		medial	cm^2	176	287	217	10	(197 to 238)	36
		distal	cm^2	90	189	124	6	(110 to 138)	24
	right	proximal	cm^2	218	381	278	13	(251 to 305)	47
		medial	cm^2	165	292	220	10	(200 to 241)	36
		distal	cm^2	99	180	121	5	(109 to 133)	20
Lengths	left	proximal	cm	10.0	12.6	11.1	0.2	(10.6 to 11.5)	0.7
		distal	cm	12.5	17.2	14.7	0.4	(13.9 to 15.5)	1.4
	right	proximal	cm	9.8	20.8	11.7	0.7	(10.1 to 13.2)	2.7
		distal	cm	12.3	17.6	14.7	0.4	(13.8 to 15.5)	1.5
Volume	left	total	L	4.00	7.27	5.24	0.29	(4.61 to 5.86)	1.08
	right	total	L	4.01	9.68	5.42	0.41	(4.54 to 6.31)	1.53

SE (standard error); CI (confidence interval)

Table 3. Descriptive statistics for hand morphology among adult female rugby players (n=14)

Laterality	sectional site	units	range		mean			standard deviation
			minimum	maximum	value	SE	(95% CI)	
Left	1D	cm	13.0	16.5	14.2	0.2	(13.7 to 14.8)	0.9
	2D	cm	16.2	21.0	18.5	0.3	(17.8 to 19.2)	1.3
	3D	cm	16.9	21.6	19.1	0.3	(18.4 to 19.8)	1.2
	4D	cm	15.9	20.3	18.2	0.3	(17.6 to 18.8)	1.0
	5D	cm	13.1	17.5	15.5	0.3	(15.0 to 16.1)	1.0
	ratio 2D:4D	cm	0.91	1.04	1.02	0.01	(1.00 to 1.04)	0.03
Right	1D	cm	12.8	15.7	14.1	0.2	(13.5 to 14.6)	0.9
	2D	cm	16.0	20.1	18.2	0.3	(17.5 to 18.8)	1.1
	3D	cm	14.4	20.9	18.4	0.4	(17.4 to 19.3)	1.6
	4D	cm	15.3	19.6	17.7	0.3	(17.0 to 18.4)	1.2
	5D	cm	12.7	16.9	15.0	0.3	(14.3 to 15.7)	1.3
	ratio 2D:4D	cm	0.97	1.07	1.03	0.01	(1.01 to 1.04)	0.03

SE (standard error); CI (confidence interval)

Table 4. Descriptive statistics for echocardiography parameters among adult female rugby players (n=14)

		range		mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
Telediastolic diameter LV	mm	48	60	54.0	1.1	(51.6 to 56.4)	4.2
Telesystolic diameter LV	mm	31	40	35.4	0.8	(33.7 to 37.0)	2.9
SIV	mm	6	7	6.4	0.1	(6.3 to 6.6)	0.3
Thickness of posterior wall	mm	6	7	6.3	0.1	(6.2 to 6.5)	0.3
Relative thickness of the wall	%	0.21	0.27	0.24	0.00	(0.23 to 0.25)	0.02
Ventricular mass by body surface	g/cm2	63	99	79.1	3.8	(71.0 to 87.3)	14.1
Fractional shortening	%	32	39	34.4	0.4	(33.5 to 35.4)	1.7
Fractional ejection	%	60	69	62.5	0.6	(61.1 to 63.9)	2.3
Root diameter of the aortic	mm	23	30	26.7	0.6	(25.3 to 28.1)	2.4
LA diameter	mm	26	37	32.9	0.8	(31.2 to 34.6)	2.9
LA area	cm^2	10	16	12.7	0.6	(11.5 to 13.9)	2.1
RA area	cm^2	10	16	12.0	0.6	(10.8 to 13.2)	2.1
End-diastolic volume	mL	108	181	142.8	6.9	(127.8 to 157.7)	25.9
End-systolic volume	mL	38	70	53.1	2.8	(47.0 to 59.1)	10.4

SE (standard error); CI (confidence interval)

Table 5. Descriptive statistics for body composition by bioelectric impedance analysis among adult female rugby players (n=14)

		range		mean			standard
		minimum	maximum	value	SE	(95% CI)	deviation
Reactance	ohms	495	620	541	9	(521 to 561)	35
Impedance	ohms	51	77	66	2	(61 to 71)	8
Fat mass	kg	12.0	40.5	20.7	2.1	(16.3 to 25.2)	7.7
	%	19.5	44.7	31.1	1.7	(27.4 to 34.8)	6.4
Fat free mass	kg	55.3	80.5	68.9	1.7	(65.2 to 72.6)	6.4
	%	35.9	50.1	44.3	1.1	(41.9 to 46.7)	4.2
Body cellular mass	Kg	17.2	24.2	21.3	0.5	(20.2 to 22.4)	1.9
	%	25.1	37.6	33.2	0.9	(31.2 to 35.2)	3.5
Muscle mass	Kg	21.2	29.7	26.4	0.6	(25.0 to 27.7)	2.4
	%	45.3	50.6	48.2	0.4	(4 to 7.349.0)	1.5
Total body water	L	26.9	39.9	33.9	1.0	(31.8 to 35.9)	3.6
	%	44.0	60.4	52.6	1.1	(50.2 to 54.9)	4.0
Extra cellular water	L	11.2	19.2	14.4	0.6	(13.2 to 15.7)	2.2
	%	38.9	48.1	42.5	0.6	(41.1 to 43.8)	2.4
Intra cellular water	L	15.7	22.1	19.4	0.5	(18.4 to 20.4)	1.7
	%	51.9	61.1	57.5	0.6	(56.2 to 58.9)	2.4

SE (standard error); CI (confidence interval)

Table 6. Descriptive statistics for body composition assessed by multifrequency bioimpedance analysis among adult female rugby players (n=14)

		range		mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
Skeletal muscle	kg	20.9	30.8	26.5	0.7	(24.9 to 28.1)	2.7
Total body water	L	27.9	40.1	34.9	0.9	(32.9 to 36.9)	3.3
Intracellular water	L	17.5	25.1	21.9	0.6	(20.6 to 23.1)	2.0
Extracellular water	L	10.4	15.0	13.0	0.4	(12.2 to 13.8)	1.3
Proteins	kg	7.5	10.8	9.4	0.3	(8.9 to 10.0)	0.9
Minerals	kg	2.8	4.1	3.4	0.1	(3.1 to 3.6)	0.4
Fat mass	kg	10.0	40.6	18.5	2.2	(13.6 to 23.4)	8.1
	%	16.2	44.2	25.8	1.8	(21.9 to 29.7)	6.5
Fat visceral area	cm^2	40.4	203.5	73.1	11.8	(47.4 to 98.8)	42.5
Basic metabolic rate	kcal	1194	1558	1383	31	(1315 to 1451)	113
Body cellular mass	kg	25.1	36.0	31.3	0.8	(29.5 to 33.1)	2.9
Whole body phase angle		5.3	7.0	6.1	0.2	(5.8 to 6.5)	0.6

SE (standard error); CI (confidence interval)

Table 7. Descriptive statistics for body composition assessed by air displacement plethysmography among adult female rugby players (n=14)

		range		mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
Body mass	kg	53.000	91.891	65.798	2.731	(59.898 to 71.698)	10.219
Body volume	L	49.685	92.095	62.611	3.052	(56.018 to 69.204)	11.419
Thoracic gas volume	L	2.315	3.542	3.059	0.097	(2.850 to 3.268)	0.362
Body density	$kg{\cdot}L^{-1}$	0.998	1.075	1.044	0.005	(1.034 to 1.055)	0.018
Fat free mass	kg	39.1	56.6	48.9	1.3	(46.1 to 51.8)	4.9
	%	31.2	89.5	73.3	3.9	(64.9 to 81.8)	14.7
Fat mass	kg	6.5	42.4	16.3	2.4	(11.2 to 21.5)	8.9
	%	10.5	46.1	23.4	2.2	(18.7 to 28.2)	8.3

SE (standard error); CI (confidence interval)

Table 8. Descriptive statistics for functional and physiological outputs derived from the 30-second Wingate Test among adult female rugby players (n=14)

		range		mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
1Hz: Absolute maximum mechanical power	watt	488	823	673	23	(622 to 724)	88
1Hz: Relative maximum mechanical power	$watt \cdot kg^{-1}$	9.1	12.2	10.5	0.3	(9.9 to 11.0)	1.0
	$watt \cdot kg_{FFM}^{-1}$	12.1	16.6	13.8	0.4	(13.0 to 14.6)	1.4
	$watt \cdot kg^{-1} \cdot L^{-1}$	45.3	83.7	65.2	3.3	(58.0 to 72.4)	12.4
1Hz: Absolute average mechanical power	watt	366	545	464	14	(435 to 494)	51
1Hz: Relative average mechanical power	$watt \cdot kg^{-1}$	6.0	8.0	7.2	0.1	(6.9 to 7.5)	0.5
	$watt \cdot kg_{FFM}^{-1}$	8.6	11.0	9.5	0.2	(9.1 to 9.9)	0.7
	$watt \cdot kg^{-1} \cdot L^{-1}$	30.5	58.9	44.9	1.9	(40.7 to 49.1)	7.2
1Hz: Fatigue Index	%	23.4	39.1	30.6	1.4	(27.5 to 33.7)	5.4
50HZ: Absolute maximum mechanical power	watt	388	823	666	28	(605 to 728)	106
50HZ: Relative maximum mechanical power	$watt \cdot kg^{-1}$	9.1	12.2	10.4	0.3	(9.9 to 11.0)	1.0
50HZ: Time at maximum mechanical power	ms	1.2	6.0	2.4	0.4	(1.7 to 3.2)	1.4
50HZ: Absolute average mechanical power	watt	336	543	462	15	(430 to 494)	56
50HZ: Relative average mechanical power	$watt \cdot kg^{-1}$	6.0	8.0	7.2	0.1	(6.9 to 7.5)	0.5
50HZ: Power drop	watt	263	596	400	25	(346 to 454)	93
	$watt \cdot kg^{-1}$	4.5	8.5	6.2	0.3	(5.5 to 6.9)	1.2
50HZ: Maximum speed	rpm	108.0	131.0	120.5	2.0	(116.2 to 124.8)	7.5
50HZ: Power at maximum speed	watt	435	851	648	29	(585 to 711)	109
50HZ: Time at maximum speed	ms	3.2	8.4	5.8	0.3	(5.0 to 6.5)	1.3
50HZ: Decline in power	watt	218	504	361	23	(311 to 410)	86

SE (standard error); CI (confidence interval)

Table 9. Descriptive statistics for aerobic fitness outputs derived from the progressive treadmill running test among adult female rugby players (n=13)

variable	units	range		Mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
VT1: O_2 uptake	$L{\cdot}min^{-1}$	1.58	2.28	1.92	0.06	(1.78 to 2.06)	0.23
	$mL{\cdot}kg^{-1}{\cdot}\ min^{-1}$	23.00	33.00	29.72	0.70	(28.20 to 31.25)	2.52
	% VO2peak	64.17	79.60	70.60	1.52	(67.29 to 73.91)	5.48
VT1: Heart rate	bpm	119	164	148	4	(140 to 156)	13
VT1: Time	s	60	150	102	6	(88 to 115)	23
VT1: Speed	$Km{\cdot}h^{-1}$	7	9	8.1	0.1	(7.8 to 8.4)	0.5
VT1: RER		0.69	1.00	0.80	0.02	(0.76 to 0.85)	0.08
RC: O_2 uptake	$L{\cdot}min^{-1}$	2.12	2.86	2.45	0.07	(2.31 to 2.59)	0.24
	$mL{\cdot}kg^{-1}{\cdot}\ min^{-1}$	26.60	42.80	38.17	1.43	(35.05 to 41.29)	5.17
	% VO2peak	76.36	97.14	90.35	1.59	(86.88 to 93.82)	5.74
RC: Heart rate	bpm	151	187	174	3	(169 to 180)	9
RC: Time	s	120	360	272	19	(231 to 314)	69
RC: Speed	$Km{\cdot}h^{-1}$	8	12	10.7	0.3	(10.0 to 11.4)	1.1
RC: RER		0.90	1.09	0.98	0.02	(0.95 to 1.02)	0.06
Max: O_2 uptake	$L{\cdot}min^{-1}$	2.29	3.24	2.72	0.08	(2.55 to 2.88)	0.27
	$mL{\cdot}kg^{-1}{\cdot}\ min^{-1}$	29.30	49.70	43.20	1.49	(39.95 to 46.45)	5.37
Max: Heart rate	bpm	163	197	182	2	(177 to 187)	8
Max: Time	s	180	510	385	22	(337 to 434)	80
Max: Speed	$Km{\cdot}h^{-1}$	9	16	13	0	(12 to 14)	2
Max: RER		0.99	1.25	1.11	0.03	(1.05 to 1.17)	0.10
Final Stage							
Blood lactate	$mmol{\cdot}L^{-1}$	8.5	14.8	10.6	0.5	(9.4 to 11.7)	1.9

SE (standard error); VT1 (ventilatory threshold 1); RER (respiratory exchange ratio); RC (respiratory compensation point)

Table 10. Descriptive statistics for output simple and combined parameters extracted from isokinetic strength dynamometry of the knee muscle actions (extension and flexion) among adult female rugby players (n=14)

Variables				range		mean			standard
Angular speed	Action	Parameter	units	minimum	maximum	Value	SE	(95% CI)	deviation
60 °·s-1	Extension	peak torque	N·m	98	190	149.8	7.4	(133.7 to 165.9)	27.8
		mean torque	N·m	64	135	103.4	5.9	(90.7 to 116.1)	22.0
		peak torque angle	°	27	76	61.7	3.0	(55.2 to 68.3)	11.3
	Flexion	peak torque	N·m	56	101	78.4	3.78	(70.2 to 86.5)	14.0
		mean torque	N·m	41	82	64.9	3.3	(57.7 to 72.2)	12.5
		peak torque angle	°	17	55	36.9	3.3	(29.7 to 44.0)	12.3
		Ratio H/Q	N·m / N·m	0.47	0.62	0.53	0.01	(0.50 to 0.55)	0.04
180 °·s-1	Extension	peak torque	N·m	47	124	98.6	5.8	(86.2 to 111.1)	21.5
		mean torque	N·m	32	95	72.9	5.0	(62.2 to 83.7)	18.6
		peak torque angle	°	50	75	59.4	2.0	(54.9 to 63.8)	7.6
	Flexion	peak torque	N·m	27	85	58.9	4.0	(50.1 to 67.6)	15.1
		mean torque	N·m	19	71	50.4	3.9	(41.9 to 58.9)	14.8
		peak torque angle	°	10	43	26.9	3.3	(19.9 to 33.9)	12.2
		Ratio H/Q	N·m / N·m	0.43	10.75	0.60	0.02	(0.55 to 0.65)	0.09

SE (standard error); CI (confidence interval)

Table 11. Descriptive statistics of the parameters obtained from the hand grip strength test among adult female rugby players (n=14)

variables		range		mean			standard deviation
laterality	units	minimum	maximum	value	SE	(95% CI)	
Left	kg·f	25	36	30.7	0.9	(32.6 to 28.8)	3.3
Right	kg·f	28	38	33.0	1.0	(35.1 to 31.0)	3.6

SE (standard error); CI (confidence interval

Table 12. Descriptive statistics for items of the goal orientation in sport questionnaire (TEOSQ) and principal components extracted among adult female rugby players (n=14)

		range		mean			standard
		minimum	maximum	value	SE	(95% CI)	deviation
I am the only one who can do the play or skill	#	1	3	1.6	0.2	(1.2 to 2.1)	0.7
I learn a new skill and it makes me want to practice more	#	3	5	4.6	0.2	(4.2 to 4.9)	0.6
I can do better than my friends	#	1	4	2.6	0.3	(1.8 to 3.3)	1.3
The others cannot do as well as me	#	1	4	2.2	0.3	(1.5 to 2.9)	1.2
I learn something that is fun to do	#	3	5	4.6	0.2	(4.2 to 4.9)	0.6
Others mess up but I do not	#	2	5	3.9	0.2	(3.4 to 4.4)	0.9
I learn a new skill by trying hard	#	3	5	3.6	0.2	(3.3 to 4.0)	0.6
I work really hard	#	1	3	2.1	0.2	(1.6 to 2.5)	0.8
I score the most points/goals/hits. etc	#	4	5	4.5	0.1	(4.2 to 4.8)	0.5
Something I learn makes me want to go practice more	#	1	5	1.8	0.3	(1.1 to 2.5)	1.2
I am the best	#	1	5	3.4	0.3	(2.9 to 4.0)	0.9
A skill I learn really feels right	#	3	5	4.4	0.2	(3.9 to 4.8)	0.7
I do my very best	#						
Ego orientation	#	1.0	2.8	1.9	0.2	(1.5 to 2.3)	0.7
Task orientation	#	3.6	4.9	4.1	0.1	(3.9 to 4.4)	0.4

SE (standard error); CI (confidence interval)

Table 13. Descriptive statistics for the nutrient facts obtained from the application of the food frequency questionnaire (FFQ) among adult female rugby players (n=14)

		range		mean			standard deviation
		minimum	maximum	value	SE	(95% CI)	
Calories	kcal	1397	4156	2474	267	(1887 to 3061)	924
Proteins	%	23.1	31.4	25.9	0.7	(24.2 to 27.5)	2.6
Carbohydrates	%	39.0	62.0	52.4	2.4	(47.2 to 57.7)	8.3
Fat	%	13.2	33.5	21.7	2.0	(17.2 to 26.2)	7.0
Saturated fat	%	3.0	8.8	5.8	0.5	(4.7 to 6.8)	1.7
Monounsaturated fat	%	5.6	19.1	10.2	1.3	(7.3 to 13.0)	4.5
Cholesterol	mg	199	1182	444	77	(274 to 613)	267
Fibers	g	15.0	96.0	31.9	6.6	(17.3 to 46.5)	22.9
Ethanol	g	0.0	10.2	1.5	0.8	(-0.3 to 3.4)	2.9
Calcium	mg	542	2453	1207	181	(809 to 1605)	626

SE (standard error); CI (confidence interval)

CHAPTER IV:

DISCUSSIOIN

The current study was aimed to obtain a multidimensional profile of Portuguese female rugby players. The sample was composed of 14 adult female athletes from three clubs of Portugal Midlands that participated in the highest competitive level. Data collection was performed by experienced technicians and it was possible to asses whole-body composition using concurrent technologies and anthropometry for appendicular information. The battery also considered functional tests and information about goal orientations as well as food habits. Finally, echocardiographic parameters were also part of this study.

This contribution would serve for diagnosis of individual objectives for the female rugby players and, in general, to set a profile for the next generation of Portuguese players. The current study confirmed that, on average, rugby players were not taller, heavier than the general Portuguese population and regarding body composition, although a substantial discrepancy was found between methods, both reported the female rugby player as having an excessive amount of fat mass. So, the information about food habits may be relevant for an intervention among top athletes, particularly for the prescription of changes to fit the typical diet of athletes.

When compared to Portuguese Midlands soccer players who were profiled by the same research group based on identical methods, the current rugby players were characterized by slightly higher values on % fat mass, better performances on isokinetic strength outputs but attained poorer levels of performance in metabolic fitness (WAnT and running test in the treadmill).

This section is now offering a discussion of the results of the current study taking into account a comparison between the sample of rugby players and the one from a soccer study. When adequate, additional information is added, obtained from scientific literature.

Sport Participation

In the present season 2019/2020, Portuguese Rugby Federation (FPR) reported 6011 athletes, from which 5594 are male and 417 are female. Regarding its geographic distribution, there were registered 66 female athletes in the north of the country, 115 female athletes in the center and 236 in the south. Those numbers show us how the sport had a small sample, mainly in female players. However, this numbers are increasing along of the years. In another panorama we have soccer, the sport king, with 154452 athletes: 148958 males and 5494 females.

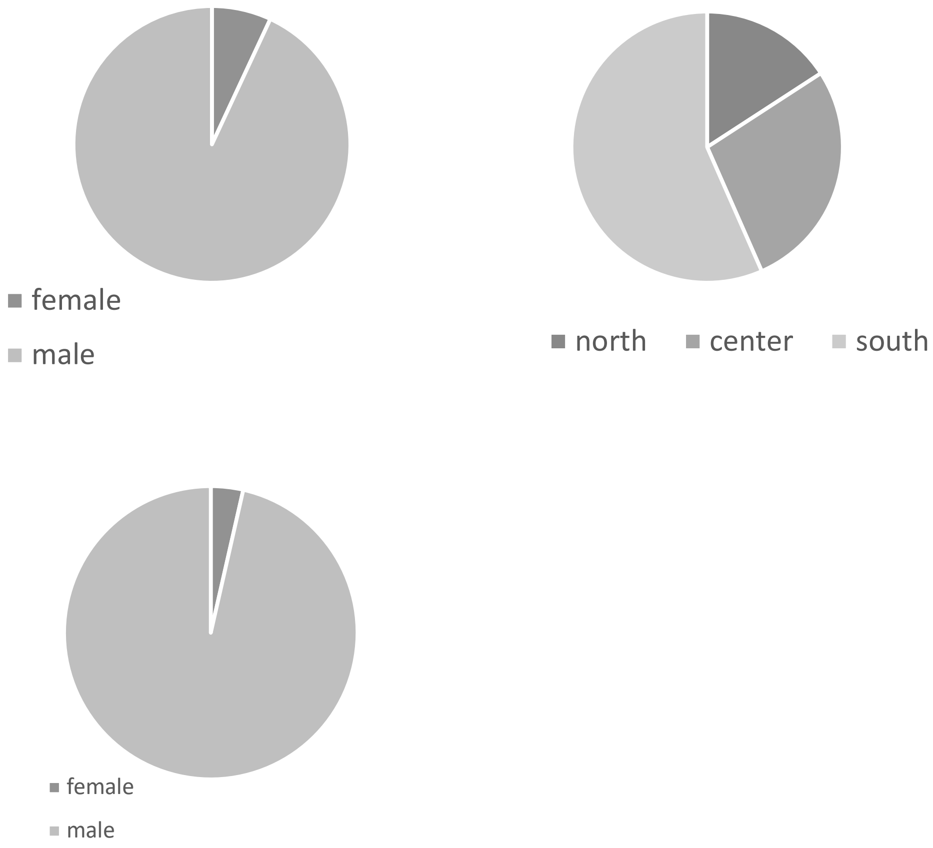

Fig.1 Number of rugby and soccer players athletes

Body Size and Anthropometry

Female rugby players register values of 164 cm in stature and 64.9 kg for body mass. When compared to other countries who dominate rugby, Portugal has shorter population and consequently shorter athletes (stature 168 cm) (Sousa et al., 2016). Mean body mass was 6kg higher than soccer players (Daniela Costa, 2017). Could be a result of the demand for readiness for body contact demand in rugby. Soccer players showed higher volume in lower limbs then rugby players (left limb 5.60±1.47 L, right limb 5.73±1.52L vs left limb 5.24±1.08 L, right limb 5.42±1.53L) respectively.

Comparison of results of stature (St), body mass (BM) and percentage of fat mass (% Fat) according to *Cohens d* they are all small but how we can see, rugby athlete has all the measures higher.

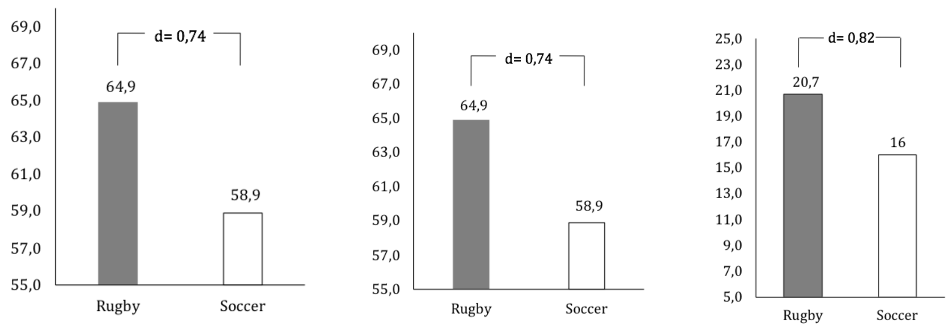

Fig.2 Results of stature, body mass and fat mass with the cohens d

Hand morphology

Randy, Simpson, Manning and Kilduff (2013) evaluated hand morphology in male athletes involved in various sports (soccer, table tennis, athletics) and concluded that male athletes with low right hand 2D:4D compared with their left hand 2D:4D have higher VO2max then male athletes with high right 2D:4D compared with left 2D:4D. However, in this female sample of rugby players, it was not possible to find substantial differences in the hand morphology or digit ratio (2D:4D) compared to previous research among soccer players (Costa, 2017) female soccer athletes 2D:4D was 1.29 for left hand and 1.028 for right hand. These ratios values were very similar with the current findings: 1.02, 1.03 respectively for left and right hands.

Body Composition and Food Intake

Bioelectrical impedance (BIA) and air displacement plethysmography provided concurrent reports. Fat mass assessed by unifrequency bioimpedance was estimated as 20.7 kg, which is substantial larger than 16.3 kg derived from air displacement plethysmography. Respective value for fat-free mass by bioimpedance was 68.9 kg. This was substantially larger than 48.9 kg obtained by plethysmography. In summary, future research needs to consider combined technologies to produce a 4-component model of body composition assessment.

Meanwhile, it was possible to expose the sample of female rugby players by a multi-frequency tetrapolar bioimpedance device which allows more information. Consequently, body cellular mass was 21.3kg, muscle mass 26.4 kg, total body water 33.9. These mean values are crucial to produce diet prescription for protein daily uptake and also for hydration and ergonomic supplementation. Basic metabolic rate was 1383 kcal. Future research may estimate the needs to cover energy demands of daily physical activity (by using accelerometry) and also energy expenditure due to training and competitions. The diet of adult athletes according to accurate estimated of physical activity components is crucial to attain optimal body size which is believed to be essential for performance and injury prevention. Many players carrying more weight and imbalance muscle mass for total body mass are probably at a higher risk for sport injuries, particularly overuse episodes.

A review study of injuries in female rugby was executed from 2013 until 2017. The sample is composed by the team that dominated rugby in the World for the past 20 years - Black Ferns from New Zealand. Over this five-year period there were a total of 26070 claims that results in an average of 5214 total claims per-year. As reported for injury body part, the most common were in lower limb (n=1577), knee (n=1007), upper limb (n=576) and shoulder (n=324). Regarding the type of injury soft tissue (n=1581) with the higher numbers, fracture with a notable difference (n=691) and concussion (n=126) (D. king, P.Hume, Hardaker, Cummins, Clark, Pearce & Gissane, 2018).

Previous study conducted in England by Clare Doyle and Keith George (2003) reported more results on injuries in elite participation in women's rugby. They analyze a total of 35 female athletes in one season (2001-2002) and categorize the injuries according to the position, the phase of play, severity and site. The results are similar in both studies most injuries occur in the lower limb (knee n=6, ankle n=5), and with higher numbers to forwards (n=21) compared to backs (n=6).

Harty et al. (2019) determined the body composition in a semi-professional team of rugby (n = 101, 19.7 years, females), and estimated fat mass values as 19.8 kg (fat free mass: 55.5). Note that this study of British rugby players had more 11 kg for the same amount of fat-mass.

The food intake questionnaire used in the present study corresponds to a semi-quantitative approach. It was validated by Lopes et al (2000) at the Department of Hygiene and Epidemiology, Faculty of Medicine, university of Oporto for the general population Cultural variation from Porto area compared to Midlands and also secular changes (food habits are supposed to change over the past two decades). The test was not restricted to athletes and a multi-method approach, confirming the current information and probably a diary self-report may obtain valuable information. This information would have been crucial for national team rugby players that often train and compete for a short period of the season, prior to international games. Long term changes in body composition require accurate information about the athlete and respective families including cultural and religious background.

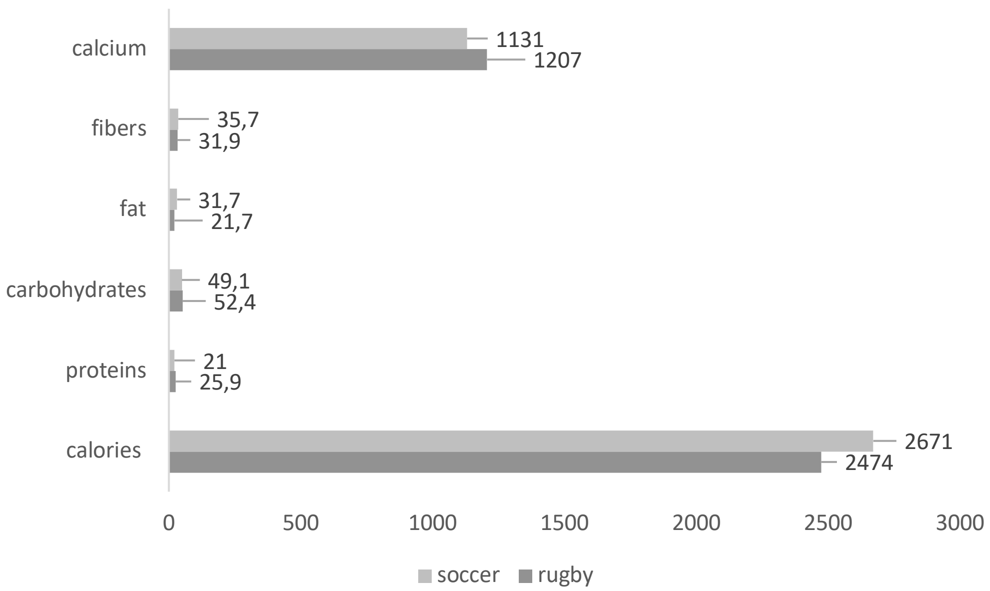

Fig. 3 Results of food intake questionnaire of soccer and rugby players

We analyzed the results from the soccer team in order to compare them with rugby. In both teams, the results reported similar numbers in each variable. As we can observe, the soccer athletes register a higher food intake in 200kcal comparing to rugby and these values are closed to recommendations (2373 kcal) (Nunes et al., 2018). The fat values for both groups are at the reference values (20-35%) (DGS, 2016). Regarding protein, we conclude that rugby consume more compared to soccer (2.38, 2.58g/kg), and both sports assume higher values than the references (1.2-2.1g/kg) (Nunes et. al, 2018). Finally, when looking at the carbohydrates they present proper intake values, taking into account that high-intensity sports and glycolytic nature are considered (DGS, 2016).

<u>Metabolic Pathways</u>

Rugby comprises a large amount of body contact combined with episodes of high intensity running efforts, interspersed with bouts of recovery ranging from few seconds to few minutes. Consequently, physical and physiological demands of the game are reflected in the physical fitness of players who are supposed to be particularly ready in terms of maximal speed, muscle power, agility and aerobics. (Gabbett, Kelly, & Pezet, 2007).

However, according to Reed, de Souza, & Williams (2014), soccer is also characterized by high intensity intermittent efforts requiring oxidative and non-oxidative systems. Taking into account the previous information, both rugby and soccer tend to be played at submaximal levels for heart rate (HR) following a pattern that is not stable.

In a study made in 2012 about running demands and heart rate responses in men rugby, the athletes spent most of the time playing at HR between 81-90%, in women the same can be predicted (Luis et al., 2012).

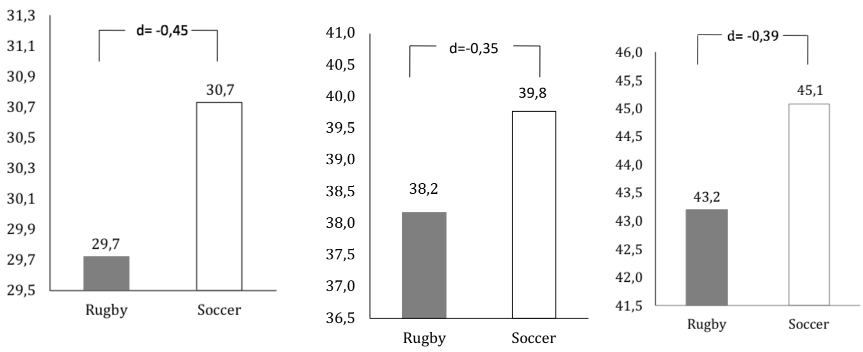

Fig.4 Values of VT, VT2 and VO2peak

All three variables presented in Figure 4 register higher values for soccer when compared to rugby players, although the differences were trivial or small. Maximum oxygen uptake corresponds to the average data produced at the final level, when speed increased to such a velocity that participant is unable to continue. However, note that the transition between running speeds require an adaptive period so, the average information needs to be obtained for a period of 3 to 5 minutes. In addition, considering that the total testing effort should not overcome 12-15 minutes, the protocol should be designed to start at an adequate running speed and avoid an excessive number of testing levels that would require too much time and fatigue. Other protocols adopt shorter periods of 60 seconds for each level and increase running speed every minute. In this context, participants are exposed to a standardized initial running speed (usually 8 km per hour) and velocity increases 1 km/h every minute until exhaustion. Well trained athletes tend to discontinue their efforts about 21-23 km/h representing a duration of 13-15 minutes. In this situation, maximal oxygen uptake corresponds to the highest values of two consecutive episodes of 15 seconds (a fraction of 30´) and is termed VO2 peak value. It does not correspond to the adaptive ventilatory ability of the individual.

As this test can be affected by peripheral fatigue (lower limb force, e.g.), it is often established that the protocol should last no more than 12-15 minutes. So, the protocol adopting a standardized starting speed and adopting a 1-minute progression of 1 km/h rate of increment may be useful for a second visit after 72 hours in order to perform an individualized protocol based on the candidate's running speeds.

Another relevant decision about the quality of the protocols and obtained data refers to criteria for verification of maximal exertion. The literature has a consensus about maximal hear rate >90% of the theoretical values (although few authors mention >95%), respiratory exchange ratio (>1.05 or 1.10), a plateau of 2mL/kg/min on oxygen uptake when running speed or slope is increased, exhaustion expressed by the participant and blood lactate > 8mmol/L.

Descriptive statistics may adopt a standardized protocol, while for monitoring players over a season or to assess responsiveness of athletes before and after a mesocycle, it is recommended to set-up a specific protocol adjusted to the individual characteristics of the observed participant.

WAnT corresponds to a popular test that has been widely employed to assess anaerobic performance using a cycle ergometer (Froese & Houston, 1987). Comparing the results of this study with female adult players from other sports such as soccer (Costa, 2017), the absolute maximal power and average power over 30 seconds suggested rugby players as attaining better values for peak power although a modest *Cohen's d.* Note, however, that Wingate is being criticized for adopting a standardized braking force which motivated the application of force-velocity test as an alternative protocol, particularly to obtain a more accurate value for peak power. Nevertheless, being a promising test, the force-velocity protocol does not inform about average power and this is probably more related to match performance in team sports than short episodes of 5-8 seconds. Among adolescent male roller hockey players, those who participated in European Championship were characterized by better performances in the mean values derived from Wingate test. (Coelho-e-Silva et al. 2012).

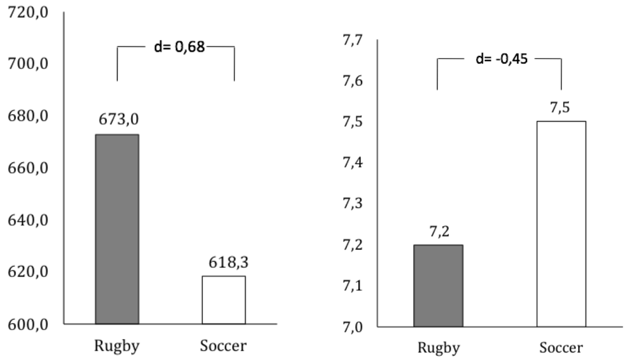

Fig.2 Cohens d relative to the two variables of soccer and rugby from WAnT

Muscle Strength

Knee flexors and extensors in concentric mode assessed using the angular speed out 60°·s^{-1} reported a peak torque 149 N·m for extensors (quadriceps) and 78.4 N·m for flexors (hamstrings). At 180°·s^{-1} the peak torque assumed lower values for quadriceps (98.6 Nm) compared to the previous angular speed. Respective value for flexors was 58.9N·m, confirming that, again, slower angular velocities produced higher isokinetic strength values. Among soccer players (Costa, 2017), values were 145.7 N·m for extensors and 84.8 N·m for flexors at 60°·s^{-1}, while at the angular speed of 180°·s^{-1}, peak torque was 97.4 N·m for extensors and 66.6±11.2 N·m (Costa, 2017). In the flexion, the hamstrings of the soccer players produced better values than rugby athletes of the current study and this could be explained. Another study reporting team sports, handball and soccer players, were assessed at 60°·s^{-1} with torque values for quadriceps and hamstrings, respectively 166N·m and 95.4N·m. (Risberg, et al., 2018).

Considering the conventional H/Q ratio, the recommended index value of 0.60 is generally accepted as the guideline for assessing the integrity and injury prevention (Coombs & Garbutt, 2002). In the previous cited studies, H/Q assumed values of 0.59 at $60°{\cdot}s^{-1}$ and 0.69 at $180°{\cdot}s^{-1}$ (Costa, 2017), and 0,58 for handball and 0.59 for soccer (Risberg et al. 2018). Among rugby players of the current study the ratio was slightly lower than recommended: 0.53 at $60°{\cdot}s^{-1}$ and plotted on the target value for the angular speed of $180°{\cdot}s^{-1}$ (0.60).

Mateus (2015) studied the senior rugby player and concluded that the backs having lighter body mass, presented higher values of the ratio under discussion, in contrast to peers acting on other playing positions. By inference, playing position may be seen a risk factor for the integrity of the knee.

Goal Orientation

The sample of this study showed that is more task-involved (4.1) than ego-involved (1.9). This means that the athletes enjoy the process that is involved in the task with the purpose of achieving goals. When comparing the results of soccer with rugby in ego we concluded that rugby players tend to have a small higher value, which can be explained by the greater number of years of sport practice. Compared to Mateus (2015), the athletes with more years of practice showed the same results.

Practical Applications

As stated in the introduction, rugby is growing in Portugal with a special focus on female athletes. Comparing with other regions, the center of Portugal is the region with less teams but the second with the greatest number of female athletes. The main limitation of this study is that only athletes from the center of the country were analyzed. Taking into account the reduced number, 14-year-old athletes play for the seniors, so the sample has a big amplitude age. So, there is a huge heterogeneity in the age of the athletes analyzed, with the youngest being 15 years old and the oldest one being 33 years old and already having a son. In spite of that, this is the first study made in Portugal focusing on the female rugby athlete, providing us a lot of information that can be used to grow in this sport. Also continues a line of a project that studies the male rugby players and we adapted that procedures with the same team of evaluators.

CHAPTER V:

CONCLUSION

The present study provides us with a multidimensional and multimethod analysis of the female rugby players that had been assessed in the study to the athletes and those who work with them. This tool that can be used to plan future training and delineate individual and collective goals.

The athletes in morphology profile showed higher values of fat but a good performance. According to their international peers, the sample has higher performance levels. Also, we found deficits that could be a starting point to improve the training planning and accessory workout. Great advantages to implement new methodologies of work and prevent injury. Comparing rugby with soccer brings the advantage of the organization of training levels being equal since kids.

Future research could separate the athletes according to their position in field, since in elite countries it happens. Also study the transition to the senior year cause coincide with pubertal jump. Associate an invasive measure of corporal composition and from there calculating fat-free mass or soft lean tissue, and may associate these factors with performance. Study of injury associated with unilateral study of lesions associated with unilateral instability and study the bilateral differences

Rugby is a sport that could grow more in Portugal if starts pay attention to the details. If the clubs, coaches, trainers spend time to learn and look at multidimensional profiles of the athletes since kids, they will have the answers to optimize the capacities of their teams and to achieve higher levels of performance.

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