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Comparison of Sports Performance and Kinanthropometric Profiles of Elite Female Basketball and Volleyball Players over the Course of a Competitive Season

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Abstract: In order to maximize sports performance of team sportswomen, knowledge of the player's characteristics in terms of different aspects and at different times of the season is needed. While the anthropometric and physical characteristics of men's sports teams have been extensively studied, research on women's basketball and volleyball is scarce. (1) Purpose: This study aims to contribute data about the anthropometric and physical characteristics of female basketball and volleyball players from elite women's teams (age: 24.3 ± 2.7 years; playing experience: 14.825 ± 2.8 years) (n = 23) with a two-fold objective: (1) to describe and compare the anthropometric characteristics of these two disciplines; and (2) to identify possible differences in various parameters of sports performance depending on the discipline. (2) Methods: The anthropometric profile includes the measurements recommended by the International Society for the Advancement of Kinanthropometry; the performance tests described aerobic and anaerobic power exercises. (3) Results: The overall somatotype of the players was moderate mesomorphic and low endomorphic (5.107–3.046–1.883). Statistical differences were found between the improvement of the physical performance level of female basketball players (77%) and female volleyball players (10%) from the first to the last measurement, with better results in most of the performance tests ($p < 0.05$). The sum of skinfolds was higher in female basketball players ($p > 0.05$). The percentage of fat-free mass correlated with improvements in lower body strength. (4) Conclusion: Lean body mass is an important predictor of exercise performance intensity. Excess fat mass is detrimental to the development of strength and endurance.

Keywords: kinanthropometry; basketball; volleyball; performance; women

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1. Introduction

Basketball and volleyball are highly complex team sports due to their technical, tactical, physical, psychological, and anthropometric demands [1]. A large number of studies describe the importance of high technical–tactical mastery and strong physical development to achieve performance in these sports disciplines [2,3]. Along this line, among all the performance factors affecting indoor team sports, both physical fitness and kinanthropometry are two aspects that should be considered. Physical fitness is defined as the ability to perform daily tasks with vigor and alertness, without undue fatigue and with sufficient energy to enjoy leisure activities and to cope with unforeseen emergencies. The same authors proposed a multifactorial component sports training style aimed at working on different components and behaviors that together lead to such performance. Specifically, this performance is linked to the importance of strength as a basic physical capacity, as well as to the capacities derived or resulting from it, both from the point of view of physical improvement and health and from the specific perspective of efficiency or performance [4,5].

Among these performance indicators, anthropometric determinants such as body composition, anthropometric dimensions, and athlete characteristics play a fundamental role in performance [6], given that kinanthropometry is a third physical attribute commonly associated with athletic performance [7]. Specifically, anthropometric parameters such as skinfold thickness [8], limb length [9,10] and body type [10] have been associated with performance in elite basketball or other modalities [7,10]. In that way, descriptive studies of anthropometric and body composition characteristics in most elite team sports have been conducted since the 1970s.

Cabañas defines kinanthropometry as “the area of application of the study of the size, shape, proportion, composition, maturation and major functions of the human being”, which is an area of science that deals with aspects that are of enormous importance to athletes. Obtaining this type of data provides us with information on the body composition of an athlete and is the most reliable method to use in sport certified by the International Society for the Advancement Kinanthropometry (ISAK). This relationship can also be extended to talent-identification processes [11,12], based on the assessment of anthropometric characteristics (e.g., body mass, height, body mass index); body composition (i.e., body fat percentage, lean mass index) [13]; and performance, specifically, power–strength–speed performances in jumping, sprinting, or throwing [14,15].

This anthropometric assessment allows us to objectify various variables of the human body [16], facilitating the monitoring and control of its distribution to guide the work of coaches and physical trainers [17]. In this sense, it is of interest to know the body condition of an athlete at a specific moment of his or her preparation and how to achieve conditions of maximum potential at a specific moment of the competitive season [18]. These data can be compared to standardized data from similar populations [19] and constitute an essential reference for considering nutritional strategies or individualized training programs [17,20] that aim to obtain morphological changes to improve competitive performance by means of non-invasive proposals. As we have said, this type of assessment is applied to high-level sports and, although logic leads us to believe that the greater the mastery of the athlete, the better their anthropometric and body composition data will be [21], there is a large amount of scientific evidence showing that, both in different sports and within the same sport, there are physical and performance differences between athletes [22,23].

These differences are currently evaluated either through anthropometric assessment and body composition analysis due to its ease of application and economy [24] in the prediction of sporting performance [8], or through physical tests in which aspects such as aerobic capacity are assessed. The following aspects are assessed for various reasons: aerobic capacity due to its importance in the resynthesis of phosphocreatine and lactate clearance of muscle activity; lactic anaerobic capacity due to the importance of developing the largest number of actions at maximum intensity for longer; the strength of the upper and lower body as disciplines that combine explosive movement structures that mostly end in jumping [25] as the main gesture of the rebounding or finishing action; the speed of movement concerning the importance of performing the greatest number of explosive actions with the greatest duration or intensity [26]; the repetition of efforts with incomplete recovery [27]; and agility as both disciplines require rapid movements in different directions [28] on a shared playing surface, either with different partners or with different opponents. Furthermore, although, to the authors’ knowledge, there are review studies in both disciplines that analyze specific tests for each discipline, there are no studies that compare all these previously described abilities in both disciplines.

In basketball, the importance of body size and proportions, particularly with regard to height, arm span, and leg length, is well-documented [29]. Thus, anthropometric characteristics were positively associated with rebounding and negatively associated with the frequency of missed balls [30]. García-Gil et al. [8] indicated that some anthropometric and physical characteristics of elite female basketball teams are parameters related to performance.

In volleyball, the aspects that mainly characterize players are jumping ability, power output, and strength [31]. Equally, anthropometric characteristics of athletes can influence the level of performance and help determine an appropriate physique for a given sport. The assessment of body composition (fat mass, fat-free mass) of athletes is one of the most valued aspects for checking fitness and physical condition, verifying the outcome of training programs and creating sport-specific profiles. In volleyball, numerous studies have addressed these issues [32,33]. According to Giannopoulos et al. [34], approximately 24% of volleyball players' attacking performance can be predicted by the linear combination of somatotype and muscle strength. Toselli et al. [35] showed that, in addition to skeletal dimensions, coaches should pay attention to body composition parameters, strengthening arm muscle mass and reducing fat mass, to achieve the player profile required in the highest divisions of volleyball for sporting success in this discipline.

Although both sports are studied from kinanthropometric and conditional points of view, to the authors' knowledge, there are no previous studies that have compared both sports.

Therefore, the main objectives of this research were (1) to determine the changes in anthropometric and body composition characteristics in elite female basketball and volleyball players over the course of a season, and (2) to establish possible relationships between these anthropometric measurements and different indicators of sporting performance.

2. Materials and Methods

2.1. Participants

A total of 23 players (11 volleyball and 12 basketball players) were assessed at 2 points in the 2018-19 season: at a first point of data collection (T1) in September 2018, during pre-season; and a second point (T2) in January 2019, during the first competitive break. All female players were at an elite level in their respective disciplines. The volleyball players competed in the *Iberdrola League* belonging to the Royal Spanish Volleyball Federation. Several of these players previously represented a national team: 1 Spanish player, 2 Argentinian players, and 1 American player. The typical working week presented an average weekly training of 19.5 h (not including matches) consisting of 3 double training sessions of 120 min of technical–tactical aspects (morning) and 150 min of physical condition (afternoon) training (Mon, Wed, and Thurs); two days with a 180 min session, on Tuesday (180 min of physical condition) and Friday (180 min of technical–tactical aspects); one day of competition (Saturday); and one day of rest (Sunday).

As for basketball, these players competed in the *Día League* belonging to the Spanish Basketball Federation. The representation within this group of players in national teams was 3 Spanish players, 1 Croatian player, 1 Senegalese player, and 1 Swedish player. In this discipline, a typical working week had an average of 22.5 h of training (excluding competition). It included 3 double training sessions, 150 min of technical–tactical work (in the morning) and 180 min of physical work, on Monday, Wednesday, and Thursday; two sessions (Tues/Fri) of 180 min, in which physical and technical–tactical (Tuesday) or only tactical (Friday) aspects were worked on; the day of the match (Saturday/Sunday); and a rest day after the match (Table 1).

The work performed during the training sessions was agreed upon by the coaching staff and was therefore representative of the workload experienced during that period of the season [36,37]. We determined the sample size (TM = 323.97) using the G* Power package (version 3.1.9.2). The program was used for power analysis. The effect size for the two groups was large (D = 0.9), and assuming a power analysis as the outcome of the study, with at least 100 people (a minimum of 50 people per group) and a confidence level of 95% (margin of error of 0.05), gives a power of 80% [38].

Table 1. Continuous quantitative data.

	Age (Years)	Body Mass (kg)	Height (cm)	Experience in the Discipline (Years)	Years Played at Elite Level
		T1		**V**	
V	24.138 ± 2.78	69.882 ± 9.28	177.091 ± 6.50	15 ± 2.8	4.18 ± 2.2
B	26.004 ± 5.87	77.808 ± 12.40	178.833 ± 6.85		
		T2		**B**	
V	24.472 ± 2.77	70.073 ± 8.97	idem	14.65 ± 2.84	5 ± 1.13
B	26.311 ± 5.87	75.750 ± 11.45			

B: basketball; V: volleyball. T1: first moment: T2: second moment.

Before the study, it was determined that the participants were ready to play and train with guarantees. None of them had any injuries, allergies, or hormonal disturbances during data collection. In addition, none of the participants could be under the influence of any type of illegal drug or taking medication that affected body weight. Experimental procedures and associated risks and benefits were explained to each athlete, and each player signed a written consent form before starting the participation, always following the ethical guidelines dictated in the Helsinki Declaration of the World Medical Association, with Fortaleza actualization [39] for medical research on human beings and with the approval of the project of the Ethics Committee for Research Involving Human Participants of the University of the Basque Country, number: (M10_2017_216). It should be noted that the data obtained were treated with the utmost confidentiality and scientific rigor; their use was restricted by the guidelines of the research projects following the scientific method required in each case, complying with Organic Law 15/1999, of 13 December, on the Protection of Personal Data (LOPD). The procedures used respected the ethical criteria of the Responsible Committee for Human Experimentation (established by law 14/2007, published in the Official State Gazette no. 159).

2.2. Experimental Design of the Problem

The present descriptive and comparative study was conducted under non-experimental conditions (ecological validity), so the coaching staff and participants did not receive any input from the research team. The training data, competition schedule, and match results were provided by the coaching staff of the team [40].

2.3. Experimental Protocol and Evaluation Plan

The measurements (Figure 1) were taken at two points in the season (T1: September 2018, week 1 of mesocycle 1 of macrocycle 1, pre-season; T2: January 2019, week 13, mesocycle 1 of macrocycle 2, first competitive break) immediately before a training session. These periods were chosen as it was expected that there would be a substantial variation in the parameters to be monitored [41].

Measurements were performed in the sports hall where players train and compete in the same session, to avoid variations in environmental or biological conditions affecting the results [42]. In volleyball: El Ferial Sports hall—Haro—La Rioja (T1: humidity 42%; temperature 28.1 °C; T2: humidity 39%; temperature 14.9 °C. A humidity difference of 3% and temperature difference of 13.2 °C existed between times). In basketball: José Antonio Gasca Municipal Sports Centre—San Sebastián—Guipúzcoa (T1: humidity 71%; 28.7 °C. T2: humidity 47%; 16.4 °C. A humidity difference of 42.86% and temperature difference of 12.3 °C existed between times).

For the evaluation, pre-test actions were controlled by determining that no physical exercise was performed within 24 h prior to analysis. Within 4 h prior to the test, no solid or liquid food was to be ingested; only participants maintaining a correct state of hydration, and having last urinated and/or defecated 30 min prior to data collection, were considered [43].

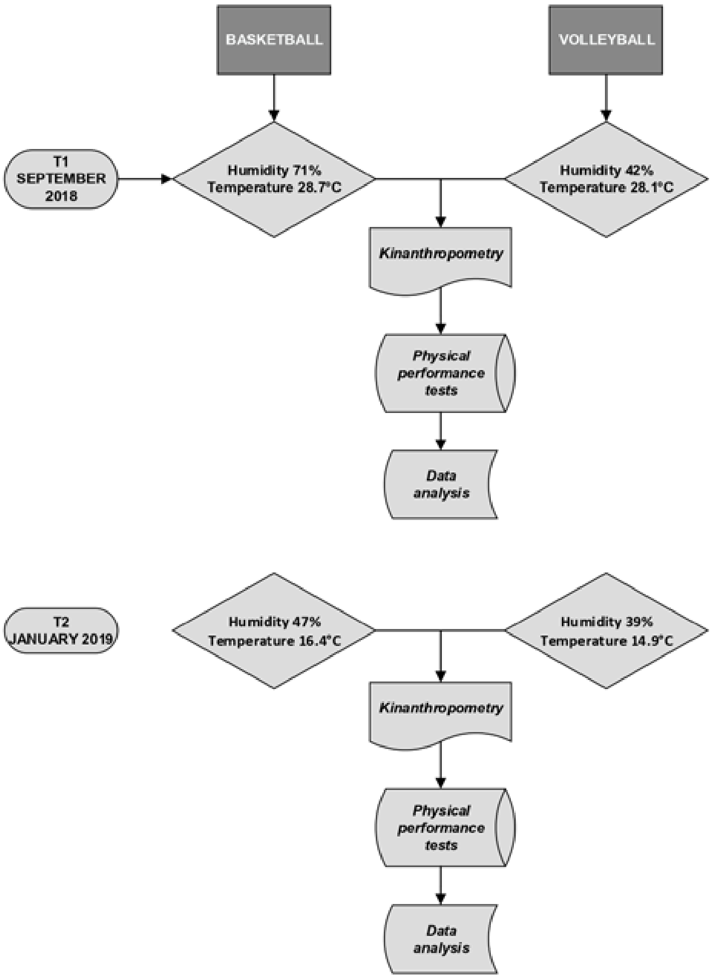

Figure 1. Data collection diagram.

a. *Kinanthropometry*

Anthropometric data were extracted according to the recommended ISAK techniques. The order of anthropometric data collection was:

(a) Body mass: a standardized method was used and was performed with a SECA scale (SECA®, Hamburg, Germany) with an ac-precision of 100 g.
(b) Height was obtained using a Holtain measuring rod (Holtain® Ltd., Dyfed, UK) according to the standard procedure.
(c) Skinfolds: were measured in triplicate using a Harpenden plicometer®. The sum of 8 skinfolds (mm) was calculated (biceps, triceps, subscapular, iliac creta, supraspinal, abdominal, front thigh, and calf).
(d) Bone diameters and muscle perimeters: diameters (cm) (humerusbiepicondileus, femur biepicondileus, and biostyloid) and perimeters (cm) (relaxed arm, contracted arm, forearm, wrist, thorax, waist, hip, thigh, calf, ankle, and mid-thigh) were measured with a Lufkin® metal tape measure.

All were performed under the same conditions and times under the marking and measurement procedures of the International Society for the Advancement of Kinanthropometry (ISAK, 2001). In addition, the same internationally certified anthropometrist (ISAK Level III Certificate #636739292925036707742) took measurements for all participants at both time points.

b. Warm-up

At the time of the sport performance tests, firstly, a standardized warm-up of 20 min was performed to adequately prepare the players for the tests to be performed. The warm-up included 5 min of jogging forwards and backwards, and exercises in waves of jumping on one leg (right and left, forwards and backwards), hip opening and closing, arm circulation, and heel running forwards and backwards. Acceleration and injury prevention exercises were undertaken such as hand planks from a standing position, jumps with trot from midfield, sprint from prone, lunge with trunk twist, squats with jump, explosive push-ups, hamstring stretches on trot, forward strides, zigzag running, and pyramid stretches from quadrupled. A full recovery period was observed between attempts and between exercises. These exercises were selected for testing as they have all been used to improve basketball performance [44], followed by a specific description–justification of each exercise to be performed.

c. Physical performance tests

Several physical fitness tests representing different aspects of basketball and volleyball were used to assess physical performance in each of these sports. The tests took place in the afternoon on the respective days in the sports hall under the conditions of humidity and temperature described above.

The order of the tests was as follows: squat jump (SJ), countermovement jump (CMJ), Abalakov jump (ABK), drop jump (DJ), medicine ball throw (3 kg), speed test without change of direction (20 m), sprint repeat ability with change of direction (RSA), Illinois agility test with change of direction (COD), and Yo-yo IRT intermittent endurance test (II).

c.1. Jumping (SJ, CMJ, ABK, DJ)

The Chronojump Bosco System® DIN-A1 contact platform [45] was used to collect these data. Controlled by a chronometric device that oversees timing the state changes in the detection device, the error of the microcontroller is 0.1%, giving a validity of 0.95 (CCI).

This device (Chronopic 3) was validated by the ACSM. Across the whole spectrum studied, with a low signal (corresponding to the contact time in a jump) the mean error was $0.04 \pm 0.18\%$, while with a high signal (time of flight) the mean error was $0.05 \pm 0.19\%$ [46].

Squat jump (SJ)

This exercise assesses the maximum concentric dynamic strength of the lower limbs. Its relation to basketball refers to jumping capacity and acceleration capacity [47]. It is an indicator of the percentage of fast fibers. To this manifestation is added a second factor of "contractile capacity", related to the capacity to synchronize the contraction of the fibers to have a more homogeneous value of instantaneous recruitment.

This index represents the maximum slow force developed in a slow concentric exercise derived from Hill's Law (squats or press at 45°). To reduce the margin of error, great care must be taken in the execution of the technique to ensure there is no repulsion before the jump and that it really starts from a static position of a half squat.

Countermovement Jump (CMJ [48]*)*

Participants started in a standing position with both feet together and were asked to jump as high as possible with a quick countermovement, keeping their hands on their hips. The flight time was used to calculate the change in the height of the body's center of gravity. The calculation of jump height took the take-off and landing positions of the body's center of gravity into consideration. Two trials per participant were allowed, separated by 1 min of recovery. The best result was recorded. The CMJ is characterized by a very low intertrial variability (coefficient of variation of 3.0%). The CMJ test showed the highest relationship with the explosive power factor ($r = 0.87$), i.e., the highest factorial validity. Based on these results, it can be concluded that the CMJ is one of the most reliable and valid field tests for the estimation of lower limb explosive power.

Abalakov's Jump (ABK)

Abalakov's jump assesses the explosive strength, as well as the maximum power of the lower body with the idea of estimating the "reflex-elastic-explosive" manifestation.

Considering the execution time of this exercise and the fact that approximately 50% of this time is damping (mainly eccentric), the stretch reflex is released in this phase and not in the acceleration phase. By the percentage difference between the heights reached in the Abalakov and in the CMJ, we can quantify these two heights produced by the arms and we define this as the arm utilization index. This jump test shows a high correlation coefficient (0.969–0.995) and low coefficient of variation (1.54–4.82%), with a factor analysis resulting in 82.90–95.79% of the variance of all jump tests [47].

Drop Jump (DJ [49])

This is a jump after a fall from a given height, starting from a position with the legs extended and with a downward movement. The continuous movement must be performed with the hands on the hips and the trunk straight. Determinants of the "reflex-elastic-explosive" manifestation verify and evaluate the "reflex-elastic-explosive" manifestation of force. Reliability shows results with an intraclass ratio coefficient of 0.70–0.92, a standard error of measurement of 8.5–18.4 mms, and a coefficient of variation of 3.6–6.4%.

c.2. Medicine ball throwing test (3 kg)

The conditional capacity of strength is fundamental in basketball, considering the characteristics of the effort in this sport, which is made up of short and intense efforts that lead to sporting success. Two tests are most commonly used in this sport to control and assess the effect of training on the upper body: the medicine ball throw for the assessment of power or the 1MR strength test of the bench press.

For the measurement of upper body strength, the medicine ball throwing test was used. The test–retest reliability of this test was r = 0.96–0.98, and its validity according to the intraclass correlation coefficient (ICC) was 0.98, which is between the means of each throwing mode (standing, kneeling, sitting, one-handed), and its correlation coefficient was r = 0.49; $p < 0.01$.

c.3. Speed test without change of direction (20 m), sprint repeat ability with change of direction (RSA), and Illinois COD agility test.

The MicroGate Witty Wireless Training Timer photoelectric cells® were used, which have a minimum resolution of 0.125 ms and an event delay of 1 ms and use redundant code with an information accuracy check and self-correction, with a pulse transmission accuracy of 0.4 ms.

Speed test (20 m) without change of direction

Participants could perform 2 trials for the 20 m sprint, starting in a stationary bipedal position, and the fastest attempt was recorded. The sprint was performed on the side of the basketball court and the time was recorded by photocells (Witty-Gate; MicroGate Timing Systems® S.R.L., Bolzano, Italy) placed at the start and finish lines. The 20 m sprint test demonstrated high levels of reliability (test–retest correlation coefficient of 0.91) and required no prior practice session, with intraclass correlation indices of 0.11–0.49 and coefficients of variation of 16.8–51.0% [50].

Repeated sprint ability test with change of direction (RSA)

The repeated sprint ability (RSA) has been considered for some years as a type of activity representative of the high-intensity movements performed by players in team sports. While performance in most intermittent sports is dominated by technical and tactical efficiency, the importance of RSA as a crucial physical component of performance in intermittent sports has been proposed, although it has been questioned. Furthermore, the development of fatigue in these sports has been related to the ability to repeat sprints with an overall coefficient of variation among participants for a total repeated sprint time of 2.3%.

Illinois COD agility test

The Illinois agility test, considered a standard agility test, was used to measure speed and agility, and the abilities to react, accelerate, decelerate, and change the direction of movement. The Illinois agility test is considered to be a standard agility test [51] because of its high validation and reproducibility [52], making it a standard test for quantifying directional ability change in female basketball players. The intraclass correlation coefficient and standard error of measurement values for the test were 0.96 (95% CI, 0.85–0.98) and 0.19 s, respectively. The validity of the COD IAGT according to a *t*-test was r = 0.31 [95% CI, 0.24–0.39]; $p < 0.05$ [53], indicating that the COD IAGT appears to be a reliable and valid test.

c.4. Intermittent Yo-Yo IRT endurance test (II)

For the endurance test we used the Yo-yo Pro 4.49 app®, an application for group testing and advanced individual testing to perform the intermittent yo-yo test (Recovery Level 1, 2 and Endurance Level 1, 2).

There is currently a strong trend in team sports to assess aerobic performance from an incremental and intermittent test with a pause, inspired by the 20 m SRT [54]. A clear example of this fact is the use of the YOYO IRT (YYrec) test at either of its two levels. Thus, the literature recommends the use of this test to measure the ability to repeat high-intensity intermittent efforts and/or the capacity to recover from this type of exercise. Therefore, its validity and applicability has been studied in several team sports, including basketball [54]. The validity of this test is based on the association obtained between the meters accumulated in the test and the total performance in competition (total meters run) and/or the meters run at high intensity (runs above 15 km/h). The relationships obtained in basketball are r = 0.77.

d. Data analysis

The samples were analyzed by two observers (J.M-A and Á.M-O). The technical error of measurement was calculated, accepting 5% for skinfolds and 2% for the rest of the measurements. Independent study variables were weight, height, skinfolds, muscle diameter, and bone diameter. Dependent variables of the study were percentage of adipose mass (%AM), percentage of fat-free lean mass (%FMM), percentage of bone mass (%BM), body mass index (BMI), waist–hip ratio (WHR), endomorphy, mesomorphy, and ectomorphy. In this study, the anthropometric somatotype method was used, which divides the morphostructure into fat-free lean mass (FFM), bone mass (BM), and adipose mass (AM).

e. Statistical analysis

All data are expressed as mean ± SD. To determine the normality of the variables considered, the Shapiro Wilk normality test (<30) was performed. The incidence of someone being overweight in the study sample was calculated using BMI. The percentage change (Δ%) from T1 to T2 in the outcome variables was calculated using the following formula: $[(T2 - T1)/T1] \times 100$. The parametric Student's t-test was applied assuming a normal distribution. Between-subject effect sizes were calculated using partial eta squared (η2p). Since this measure is likely to overestimate the effect size, values were interpreted [55] as no effect if $0 \leq \eta 2p < 0.05$; a minimal effect if $0.05 \leq \eta 2p < 0.26$; a moderate effect if $0.26 \leq \eta 2p < 0.64$; and a strong effect if $\eta 2p \geq 0.64$. Pearson's correlation analysis and Hopkins' magnitude of correlation [56] were applied. The magnitude of correlation coefficients was determined as trivial (r < 0.1), small (0.1 < r < 0.3), moderate (0.3 < r < 0.5), high (0.5 < r < 0.7), very high (0.7 < r < 0.9), near perfect (r > 0.9), or perfect (r = 1) [56], as well as Hopkins' probabilistic inference: 0.01/1/99 almost certainly beneficial; 0.2/7/93 probably beneficial; 2/34/64 possibly beneficial; 1/60/39 possibly trivial; 0.2/97/3 very likely trivial; 2/94/4 probably trivial; 28/70/2 possibly trivial; 76/24/0.2 likely harmful; 98/2/0.01 very likely harmful; 57/32/11 unclear; 10/58/32 unclear; 7/37/56 unclear [56].

The values of the measurements obtained were recorded in an Excel spreadsheet for further statistical analysis using the Software Package for Social Sciences for Windows, version 21.0 (SPSS, Inc., Chicago, IL, USA). The level of significance was $p < 0.05$.

3. Results

No injuries were recorded during the study. All participants attended the two days of assessments, so none were excluded. Thus, the final simple consisted of 23 players. Between data collection times, there were changes in some of the continuous qualitative data (Table 1). The changes in body parameters can be seen in Table 2. The variation in physical fitness scores can be seen in Table 3. Likewise, the changes in somatotype can be seen in Figure 2.

Table 2. Changes in body parameters between times.

EFBP								
	T1 (n = 12)	T2 (n = 12)	t	%Δ	*p*	η2p	Change Magnitude	Probabilistic Inference
Body mass (kg)	77.808 ± 12.40	75.75 ± 11.45		−2.645 ± 3.2	0.6768	0.172	Trivial	Probably beneficial
BMI (kg/m^2)	24.253 ± 3.02	23.605 ± 2.65		−2.672 ± 3.3	0.157931	0.597	Medium	Probably beneficial
Body fat (%)	20.46 ± 3.48	20.04 ± 2.95	2.201	−2.053 ± 9.2	0.750297	0.1315	Trivial	Possibly beneficial
∑8SF (mm)	132.43 ± 35.62	126.61 ± 27.33		−4.395 ± 13.5	0.657973	0.1832	Trivial	Possibly beneficial
Muscle mass (%)	33.94 ± 3.17	34.67 ± 2.69		2.151 ± 3.9	0.550339	−0.248	Medium	Possibly beneficial
Endomorphy	5.29 ± 0.99	5.16 ± 0.80		−2.457 ± 17.6	0.71217	0.1526	Trivial	Probably beneficial
Mesomorphy	3.56 ± 1.50	3.56 ± 1.36		0.0 ± 57.9	0.991	0.979	Large	Almost certain beneficial
Ectomorphy	1.91 ± 0.58	1.91 ± 0.58		0.0 ± 0.0	1	0.0	Trivial	Trivial
EFVP								
	T1 (n = 11)	T2 (n = 11)	t	%Δ	*p*	η2p	Change Magnitude	Probabilistic Inference
Body mass (kg)	69.882 ± 9.28	70.07 ± 8.97		0.269 ± 2.5	0.000721 **	−0.02093	Trivial	Possibly trivial
BMI (kg/m^2)	22.315 ± 3.07	22.36 ± 2.79		0.202 ± 2.5	0.975031	−0.0135	Trivial	Possibly trivial
Body fat (%)	19.03 ± 3.19	19.55 ± 4.02	2.228	2.73 ± 16.4	0.741617	−0.143	Trivial	Probably harmful
∑8SF (mm)	109.75 ± 25.89	113.98 ± 32.58		3.009 ± 23.5	0.801417	−0.1087	Trivial	Probably harmful
Muscle mass (%)	34.20 ± 3.75	35.68 ± 3.86		4.327 ± 13.4	0.373621	−0.388	Medium	Probably beneficial
Endomorphy	4.809 ± 0.8	5.08 ± 1.19		4.098 ± 10.3	0.681101	−0.1779	Trivial	Probably harmful
Mesomorphy	2.32 ± 1.25	2.66 ± 1.39		15.152 ± 11.2	0.532658	−0.271	Small	Possibly beneficial
Ectomorphy	1.86 ± 0.49	1.86 ± 0.49		0.0 ± 0.0	1	0.0	Trivial	Trivial

(** highly significant change < 0.01). Note: Data are expressed as mean ± SD. Significance between T1 and T2 in EFVP/EFBPF was set at $p \leq 0.05$. ∑8SF, sum of eight skinfolds (tricipital, bicipital, abdominal, supraspinal, subscapular, subscapular, iliac crest, anterior thigh, and calf). The %Δ was calculated as [(T2 − T1)/T1] × 100.

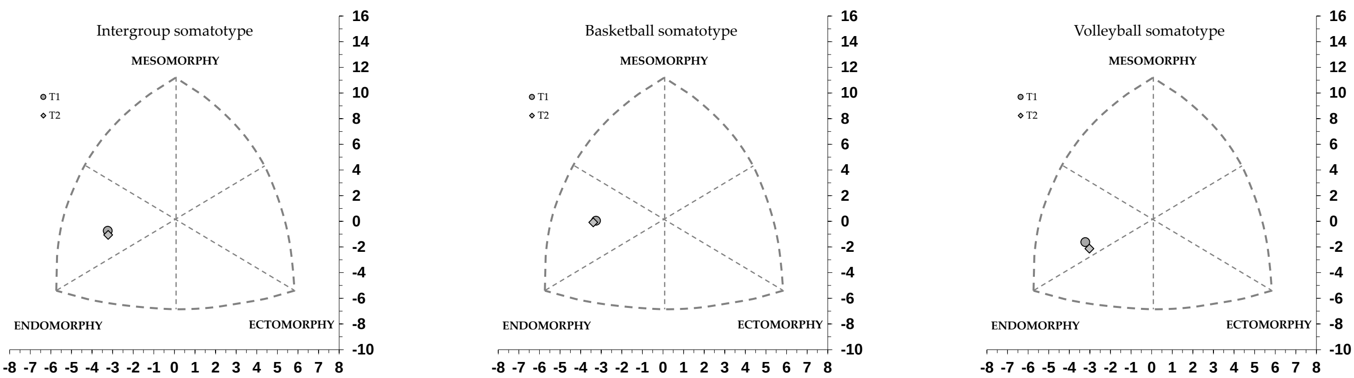

Figure 2. Intragroup somatotype status. Somatotype variation in both disciplines. Comparison of somatotype variation in both disciplines between time points.

At the level of somatotype and body composition, the body shape of the group members at the intergroup level at T1 was 5.09643–2.96096–1.88257. At T2 it was 5.11809–3.13009–1.88257. At the intragroup level, in basketball at T1, it was 5.29417–3.56092–1.90667; and at T2 it was 5.15625–3.559–1.90667 (Figure 2). This result represents a high correlation with the ability to repeat sprints (r = 0.7860; p = 0.0024).

The volleyball group presented at T1 4.88073–2.30645–1.85627 and at T2 5.07645–2.66109–1.85627.

At this point, at the somatotype level, we can observe in the basketball group that there was a high correlation between the endomorph component and the ability to repeat sprints (r = 0.7860; p = 0.0024).

Table 3. Variation in physical fitness scores.

	EFBP							
	T1 (n = 12)	**T2 (n = 12)**	**t**	**%Δ**	***p***	**η2p**	**Change Magnitude**	**Probabilistic Inference**
SJ (cm)	29.33 ± 4.52	32.71 ± 5.2	2.201	11.524 ± 16.6	0.029*	−0.2767	Small	Almost certain beneficial
CMJ (cm)	29.44 ± 5.41	32.55 ± 4.34		10.564 ± 16.5	0.136	0.1355	Trivial	Almost certain beneficial
ABK (cm)	34.3 ± 3.83	33.59 ± 3.93		−2.07 ± 7.9	0.699	0.1597	Trivial	Possibly harmful
DJ (cm)	29.22 ± 4.75	33.02 ± 5.18		13.005 ± 16.6	0.638	−0.764	Medium	Almost certain beneficial
Ball throw (m)	7.3 ± 0.92	7.69 ± 0.92		5.342 ± 8.2	0.303	−0.431	Small	Probably beneficial
20 m (s)	3.51 ± 0.23	3.45 ± 0.17		−1.709 ± 5.9	0.466	0.3029	Small	Possibly beneficial
RSA (s)	7.94 ± 0.43	7.77 ± 0.35		−2.141 ± 3.7	0.282	0.4499	Small	Possibly beneficial
Illinois (s)	18.52 ± 0.8	18.82 ± 0.61		1.62 ± 4.3	0.308	−0.426	Small	Possibly harmful
Yo-yo (m)	401.67 ± 387.67	656.67 ± 271.29		63.485 ± 115.6	0.678	−0.784	Medium	Almost certain beneficial
	EFVP							
	T1 (n = 12)	**T2 (n = 11)**	**t**	**%Δ**	***p***	**η2p**	**Change Magnitude**	**Probabilistic Inference**
SJ (cm)	25.99 ± 3.19	24.95 ± 1.19	2.228	−4.002 ± 11.3	0.335	0.436	Small	Probably harmful
CMJ (cm)	30.31 ± 3.53	31.25 ± 4.05		3.101 ± 2.2	0.0019 **	−0.277	Small	Probably beneficial
ABK (cm)	33.99 ± 4.98	34.73 ± 3.45		2.177 ± 3.1	0.0276 *	−0.2089	Small	Possibly beneficial
DJ (cm)	26.14 ± 3.82	27.06 ± 40.5		3.52 ± 6.6	0.1031	−0.261	Small	Probably beneficial
Ball throw (m)	7.15 ± 0.92	7.20 ± 1.08		0.699 ± 11.0	0.8234	−0.0563	Trivial	Probably trivial
20 m (s)	3.57 ± 0.19	3.5 ± 0.21		−1.961 ± 6.2	0.3257	0.322	Small	Possibly beneficial
RSA (s)	8.46 ± 0.77	8.51 ± 0.80		0.591 ± 6.3	0.7579	−0.0678	Trivial	Probably trivial
Illinois (s)	18.53 ± 0.88	18.87 ± 1.12		1.835 ± 3.8	0.1488	−0.351	Small	Possibly harmful
Yo-yo (m)	389.09 ± 207.95	500 ± 247.44		28.505 ± 42.6	0.0181 *	−0.5008	Medium	Almost certain beneficial

(* Significant change < 0.05; ** highly significant change < 0.01). Note: Data are expressed as mean ± SD. Significance between T1 and T2 in EFVP/EFBPF was set at $p \leq 0.05$. The %Δ was calculated as [(T2 − T1)/T1] × 100.

Physical Performance Tests

In terms of sports performance, it can be observed (Table 3) that in basketball there was an improvement in 77% of the T2 tests. In volleyball, on the other hand, although there was an improvement in several results, it can be seen that improvements were smaller than those in the previous discipline, with a difference of 10%.

At the percentage level, the greatest changes observed were centered on the intermittent endurance test, with an increase in the results of 68.485% and 28.505%, respectively. In turn, we can observe that in SJ there is an increase of 11.524% in basketball and a decrease of 4.002% in volleyball (Figure 3). In CMJ there was an increase of 10.564% in basketball and a decrease of 3.101% in volleyball; in DJ there was an increase of 13.055% in basketball and an increase of 3.520% in volleyball; and in Yoyo IRT there was an increase of 63.485% in basketball and an increase of 28.505% in volleyball.

There were no significant differences ($p > 0.05$) between groups and between times for either body parameters or performance tests.

Strong correlations (Figure 3) were found at the intergroup level, greater than or equal to 0.50 of 19.444% of %AM and %FMM with CMJ, ABK, 20m, and agility. A high correlation was shown of endomorphy with CMJ (r1: −0.6270; r2: −0.5050), and of mesomorphy with medicine ball throwing (r1: 0.5403; r2: 0.5814). At the intragroup level in basketball, we found a strong correlation, greater than or equal to 0.5 of 52.778% of %FMM with SJ, CMJ, ABK, DJ, medicine ball throw, 20 m, RSA, agility, and Yo-yo IRT II. A high correlation was also found of %FMM with CMJ, DJ, RSA, agility, and Yo-yo IRT II; of endomorphy with SJ (r1: −06373), CMJ (r1: −0.6269; r2: −0.5928), ABK (r1: −0.5711), DJ (−0.6463; −0.6516), medicine ball throw (r1: 0.5338; 0.5687), 20m (r1: 0.5808), RSA (r1: 0.6093; r2: 0.7861), agility (r2: 0.5594), and Yo-yo IRT II (r1: −0.5023; r2: 0.7407); and of mesomorphy with J and medicine ball throw (r1: 0.6656; r2: 0.6229). In volleyball, the results of strong correlation, greater than and equal to 0.50, accounted for 23.611%, and were those of %AM with CMJ, medicine ball throwing, 20 m, RSA, and agility. There was a high correlation of %FMM with CJM, ABK, and 20 m; of the endomorphy with CMJ (r1: −0.6471), medicine ball throw (r1: −0.6293), and RSA (r1: 0.5231); and of mesomorphy with RSA (r2: −0.5426) and Yo-yo IRT II (r1: 0.6241; r2: 0.7387).

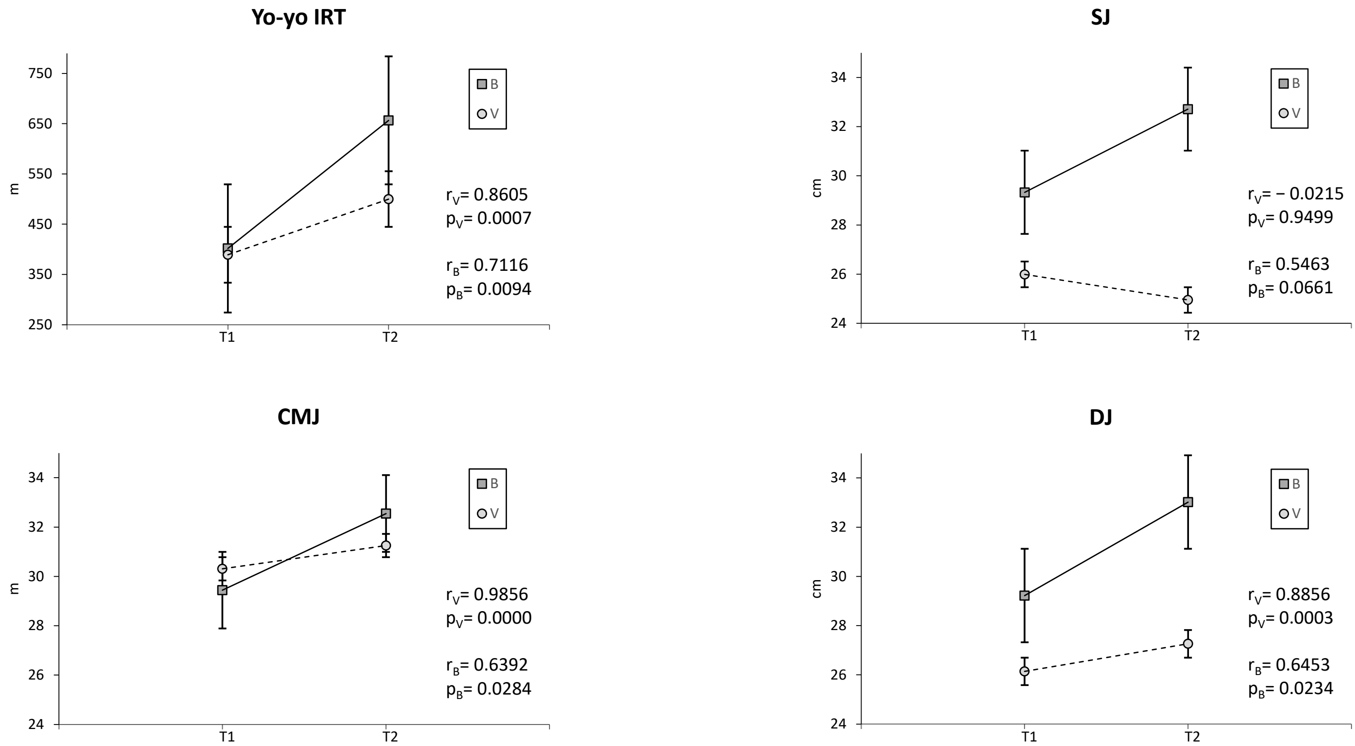

Figure 3. High quantitative changes established between disciplines and fitness tests.

At the intergroup level there was no correlation equal to or greater than 0.75. If we look at correlations greater than or equal to 0.75 in basketball, %AM was related to jumping at T1 (SJ: r = −0.7508 (very high); p = 0.0049 and with CMJ: r = −0.7544 (very high); p = 0.0046), and at T2 with running (RSA: r = 0.7738 (very high); p = 0.0031 and Yo-yo IRT II: r = −0.8090 (very high); p = 0.0014). The %FMM value is related to running and agility (RSA: r = −0.8051 (very high); p = 0.0016 and Illinois: r = −0.8243 (very high); p = 0.0010). It can also be seen in endomorphy with running (RSA: r = 0.7860 (very high); p = 0.0024). Volleyball showed a strong correlation with jumping (ABK: r = 0.8304 (very high); p = 0.0016).

4. Discussion

Although it is true that there are numerous studies that describe the manifestations and relationships of body composition and some aspects of sports performance [6], to the best of the authors' knowledge, there is no previous research that relates body composition and sports performance in women's basketball [4] and elite women's volleyball with such a wide battery of tests. Therefore, one of the main objectives of the present comparative and descriptive study was to determine the variation in body composition throughout the competitive season of elite female basketball [41] and volleyball players [57], and the relationship established between body composition and sports performance and its variation throughout a high-level competitive season with regard to different variables related to their specialty.

In this sense, body composition and upper and lower body explosive strength were measured by measuring jumping power in several variants, 20-meter acceleration capacity, sprint repetition ability, agility, and intermittent endurance capacity. In the authors' opinion, the results are consistent with the importance of these variables in both sport specialties [58,59].

The main important findings of this study indicate the following: (a) a variation in mesomorphy in the volleyball group of 14.458%; (b) at the sporting level there are positive percentage differences in basketball of 11.524% in SJ, 10.564% in CMJ, 13.055% in DJ, and 63.485% in the Yoyo IRT (II), and in volleyball of 28.505% in Yoyo IRT (II); and (c) relating to the previous parameters, there was a high correlation between (i) %AM-SJ (r: −0.7508), %AM-CMJ (r: −0.7544), %AM-RSA (r: 0. 7738), and %AM-YoyoIRT (r: −0.8090), %FMM-RSA (r: −0.8051), %FMM-Illinois (r: −0.8243), and endomorphy-RSA (r: 0.7860) in basketball, and (ii) %FMM-ABK (r: 0.8304) in volleyball. In summary, our main results support the hypothesis that variation in anthropometric parameters is related to sports performance outcomes in elite female basketball and volleyball players [60].

No statistically significant changes ($p > 0.05$) were found in any of the observed variables between the first data collection point (T1—September) and the second (T2—January), neither at the intergroup nor at the intragroup level based on Pearson's correlation coefficient (<0. 10: non-existent; >0.10: weak; >0.39: moderate; >0.70: strong; >0.90: very strong) [61]. This is mainly due to the fact that these are high-level players with a long sporting career in which morphological changes, as long as there are no drastic modifications in their eating and/or sporting habits, remain relatively stable. Furthermore, the four months of separation between T1 and T2 would not be sufficient to provoke, as we have said, a disproportionate change. Nevertheless, the correlations obtained were statistically significant strong or very strong correlations [61]; at the intragroup level the correlation was 1.388%, and at the intergroup level it was 13.888% in basketball [62] and 5.555% in volleyball. Regarding the magnitude of the correlations found, we focus on those that are equal to or higher than 0.75, strong or very strong (Figure 4). We interpret this specific coefficient as a measure of the strength of the relationship in the context of the scientific question posed [63].

The results obtained illustrate (Tables 2 and 3) that in basketball, except for FMM, all the parameters studied showed a decrease in the results obtained at T1 and T2. In volleyball, on the other hand, an increase in the values obtained at both times (Table 3) can be observed, apart from BM. In general, there was no significant percentage increase or decrease in the body parameters measured except for mesomorphy in volleyball, which showed an increase of 14.458%. However, changes in body parameters, however small, are manifested in changes in overall somatotype (Figure 2); this relationship was already corroborated in various sporting and athletic disciplines [64].

The body shape of the group members at the intergroup level at T1 was moderate endomorphism and low mesomorphism and ectomorphism (5.09643–2.96096–1.88257), presenting moderate relative adiposity with low relative skeletal muscle development and large volume per unit height. At T2, it was moderate endomorphism and mesomorphism and low ectomorphism (5.11809–3.13009–1.88257), showing moderate relative adiposity, moderate relative skeletal muscle development, and large volume per unit height. At the intragroup level, in basketball, moderate endomorphism and mesomorphism and low ectomorphism [65] at both T1 (5.29417–3.56092–1.90667) and T2 (5.15625–3.559–1.90667) (Figure 2) were found. This result presented a high correlation with the ability to repeat sprints ($r = 0.7860$; $p = 0.0024$) [64]. The volleyball group presented moderate endomorphism and low mesomorphism and ectomorphism at T1 (4.88073–2.30645–1.85627) and at T2 (5.07645–2.66109–1.85627) [66].

In relation to the physical fitness tests, the data observed in Table 3 show that in basketball there was an improvement in T2 in practically all the tests carried out. On the other hand, in volleyball, although there were improvements, these were not significant in percentage terms. This fact can be related to two anthropometric aspects. First, it has been seen how these improvements are produced in tests related to the improvement in strength in the lower body by increasing %FMM [67], and above all, the fact that in the discipline of basketball there is a loss of %AM, since the AM has an independent negative relationship with the performance of jumping tests [68]. This does not occur in volleyball, where, on the contrary, %AM increases between T1 and T2, with no significant percentage improvements in this test. Second, a great improvement was observed in the intermittent endurance test in both disciplines, as a consequence of the improvement in %FMM. In the case of basketball, adding a loss in AM to this makes the improvement in this discipline more than double that of volleyball. These data are reflected in the correlations, equal to or greater than 0.75, that are established for these factors between %AM with jumping factors and with factors of moving one's own body weight in space over a period of time, coupled with an improvement in %FMM.

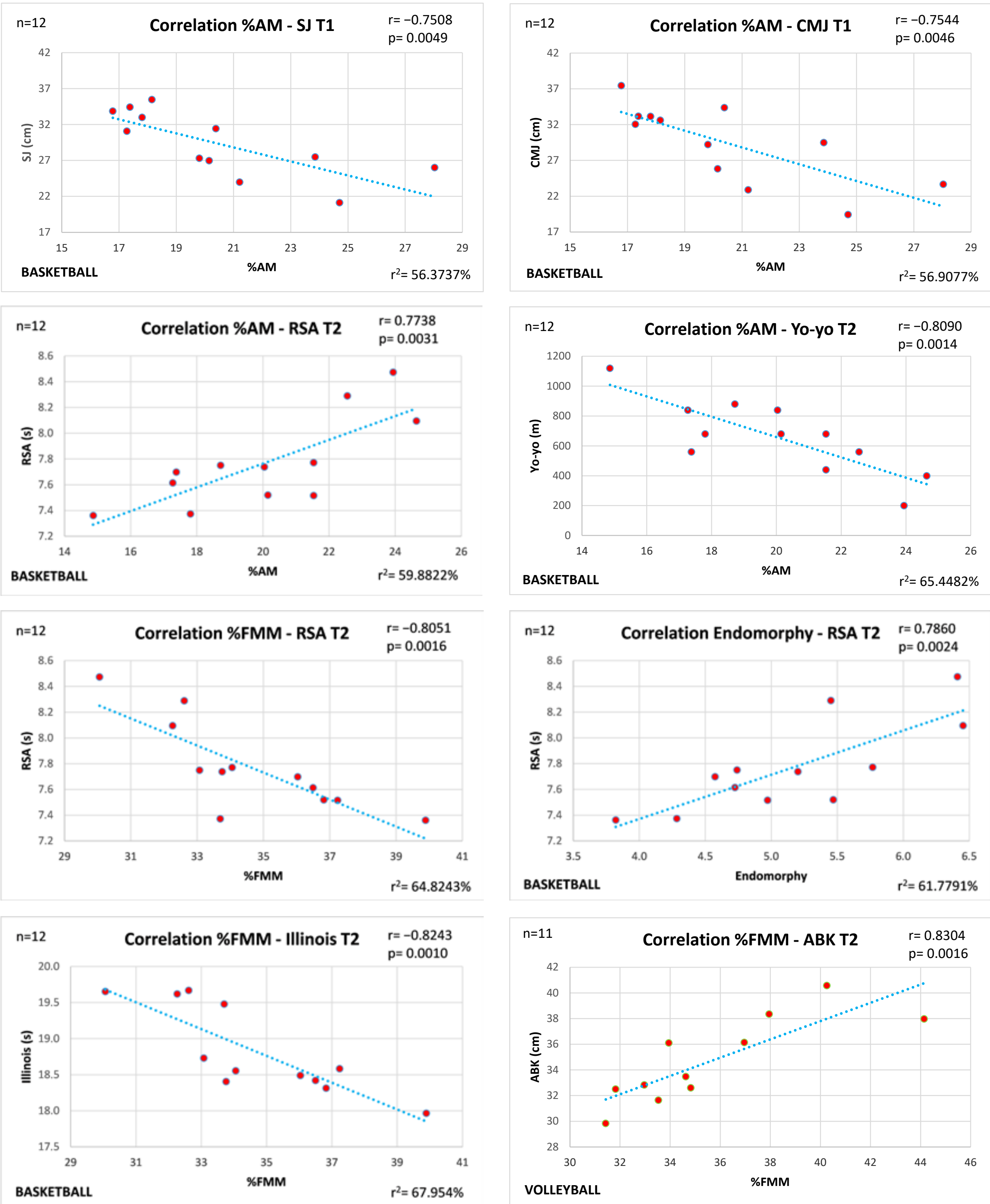

Figure 4. High correlations established between disciplines and physical fitness tests.

Continuing with the relationship between body composition data and performance in physical fitness tests in volleyball, the correlation data obtained between the endomorph component and the RSA are results [69] related to the practice and type of training in this sport discipline, such as intervallic training and plyometrics [70]. In this regard, when analyzing covariation relationships, the correlation coefficients found in basketball are high and significant (r = 0.7738; p = 0.0031) both between RSA and %AM ( ) and between RSA and %FMM (r = −0.8051; p = 0.0016) [71]. This can also be observed in other disciplines [72]. The ability to repeat sprints has also been influenced by the increase in isokinetic strength (muscle power) found in this group of players; as we have said, this fact is positively related to the increase in FMM and the decrease in AM.

Likewise, the correlation established between %AM and intermittent endurance running also shows very strong results (r = −0.8090; p = 0.0014) [73]. Specifically, the anthropometric characteristic of successful competitors in all events involving running is low body fat content, and the relationship between body fat and running time has already been studied and demonstrated [74]. However, the literature does not state that body fat stores are close to 25–30% in women and, although an excess of body fat has no useful function for the athlete, it is true that the immune system is impaired in women when body fat is below 10–15%, leading to immediate consequences such as a drop in the levels of estrogen circulating in the body.

Agility was classically defined simply as "the ability to change direction quickly" [75] and was redefined as "rapid and accurate whole-body movement with changes in speed, direction or pattern of movement in response to a stimulus" [76]. In this study, agility showed a high relationship with %FMM (r = −0.8243; p = 0.0010) [77] due to the fact that one of the physical factors limiting this skill is the strength levels at both concentric and eccentric levels to quickly and effectively accelerate and decelerate the body with control to prepare for a change of direction [78]. Reactive agility and a well-developed lean mass are the key to success [79] in this skill. In general, a higher fat percentage and higher endomorphy are significantly related to lower performance in relative aerobic capacity, 20-m sprint, and agility; with improved %FMM, performance in agility [80] and in cyclic body weight translation [81] is found to improve.

The improvement in %FMM also influences the high correlation in volleyball with respect to the Abalakov jump (ABK: r = 0.8304; p = 0.0016), so we can highlight the negative role of excess body mass and fat and the positive role of strength and power [82].

We therefore believe that more studies are needed on high-level athletes in athletic specialties of speed and the specific agility in basketball [75] and volleyball [66]. In addition, given the continuing and increasing specificity of sports training, the best comparison would be one that analyzed athletes of the same specialty and the same level of performance. The ultimate aim of this research, in addition to expanding scientific knowledge on the influence of body composition in women who participate in high-performance basketball and volleyball, is to help coaches and athletes to optimize their training loads [83] by determining the training load peaks of each athlete. Therefore, a future line of research would be to study the extent to which the inclusion of training stimuli according to the values obtained in this study influences the variables that were analyzed.

5. Conclusions

Although the intra-sport morphological changes between T1 and T2 were slight (involving experienced players over a period of less than six months between T1 and T2), the close relationship between body composition and sporting performance was demonstrated, and more specifically we can conclude the following:

- The percentage of fat-free mass correlated with improvements in lower body strength applied in endurance exercises, with the ability to repeat sprints, and with the ability to perform some of the types of jumping involved in these sports disciplines.
- Lean body mass is an important predictor of strength for athletic performance.

- Excess fat mass is detrimental to strength, and especially to lower extremity performance and endurance.
- Tests directly related to the specific technical gesture and to the sport competition in question have been improved (jumps with previous eccentric phase and improved recovery from high-intensity intermittent efforts).
- Thus, it has been shown how, in those players with a higher % fat, the results in the tests are substantially lower, as can be seen in the tests involving aerobic power (yo-yo test) and lower body power.
- Dietary and nutritional management of athletes aimed at reducing fat mass and increasing fat-free mass can help improve strength development with consequent improvements in health and performance.

In this way, we can see that performing a body composition assessment and monitoring the evolution of body composition throughout the competitive season is useful as a tool for monitoring the health and performance of our athletes.

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Institutional Review Board Statement: The study was conducted in accordance with the ethical guidelines dictated in the Declaration of Helsinki of the World Medical Association (2014) for medical research on human beings and with the approval of the project of the Ethics Committee for Research on Human Beings of the University of the Basque Country, number M10_2017_216. It should be noted that the data obtained have been treated with the utmost confidentiality and scientific rigor; their use being restricted by the guidelines of the research projects following the scientific method required in each case, complying with Organic Law 15/1999, of 13 December, on the Protection of Personal Data (LOPD). The procedures used have respected the ethical criteria of the Responsible Committee for Human Experimentation (established by law 14/2007, published in the BOE number 159).

Informed Consent Statement: Experimental procedures, associated risks and benefits were explained to each athlete, and each player signed a written consent form before starting the participation.

Data Availability Statement: To promote transparency of the data supporting the results reported in the article, the authors have established the data availability statement. The data associated with this article are not publicly available but are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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