Comparison of physical fitness and anthropometric profiles among Chilean female national football teams from U17 to senior categories

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Abstract:

Introduction: The anthropometric variables and the level of physical condition are decisive to assess the performance of elite players, for the same reason the sports scientific community is constantly searching for information on which values to discriminate between age ranges. The assessment of the anthropometrical profile and the physical fitness of elite female football players from different categories has not been fully studied. The aim of this investigation is to compare the body composition and the physical fitness variables among the three different categories of Chile's female national football teams, under-17 (U17), under-20 (U20) and senior. **Material and methods:** The investigation has a quantitative, transversal, descriptive and comparative character. Fifty-five female football players were analyzed during the national team calls period, 19 players where from the under-17 group (16.42 ± 0.84 years), 19 from the under-20 (18.63 ± 1.21 years) and 17 from the senior team (26.47 ± 4.7 years).. For the assessment of body composition, body mass, standing height, perimeters, sum of six skinfolds ($\Sigma 6$ skinfolds), muscle mass percentage (%MM) and body fat percentage (%BF) estimation where measured. For physical performance, in the squat test, relative strength (RS) and the estimation of a maximum repetition (1RM), time to complete 10 (T10) and 30 meters (T30), countermovement jump (CMJ) test and Yo-Yo Intermittent Recovery Test, level 1 (YYIR1) were performed. **Results:** The senior players showed less %BF ($p = 0.000$) and $\Sigma 6$ skinfolds ($p = 0.002$) than the U20 and U17 players. They also showed more %MM ($p = 0.000$), better performance in 1RM ($p = 0.015$), RS ($p = 0.003$) and YYIR1 ($p = 0.000$). The U20 players exhibit lower $\Sigma 6$ skinfolds, %BF and greater %MM than the U17. As for strength, the U20 players had better 1RM, RS and more distance covered in the YYIR1 than U17. **Conclusion:** Senior players exhibit better anthropometric profile, strength and aerobic capacity than the other two categories.

Key Words: testing fitness, women athletes, performance, body composition, neuromuscular, aerobic.

Introduction

Women's football development has grown in the last years and this is reflected in 2019's survey published by the International Federation of Association Football (FIFA) where 73% of the association members have participating their women's team, even thou in 2015 only 55% of the members had active their female teams (FIFA, 2019). Until today and in the international level, there are 13.360.000 females playing organized football. Furthermore, 4.065.068 are officially registered, from whom 945.068 are older than 18 years old and 3.120.000 are under the age of 18 (FIFA, 2019). In Chile there is still more to develop; 9,000 women's practice football in an organized way and of those, 870 players are registered in the under 18 age group and 870 players in the over 18 years group (FIFA, 2019). From this population of players, the national team coach nominees periodically 25 to 30 players that represent the country's elite players and they train in the national team's dependency, so they prepare to face their simile in each category in a continental or global level.

It appears that high-intensity endurance capacity has some prognostic value in identifying young players that have reached the elite level of female football (Datson et al., 2020; Mujika et al., 2009) or the potential to reach that level (Hoare & Warr, 2000). Talent development is a non-linear, dynamic construct, so serial measurements of performance are needed over time to truly understand the trajectory of the elite youth soccer player's development (Randell et al., 2021).

Anthropometry is the measurement methodology of the human body. Its objective is to quantify the morphological features and to provide an objective image of the growth status of the person. Morphological characteristics appear to be very important for selection in most sports disciplines, including elite women's football. For sports disciplines such as women's female, the morphological structure that affects sports performance has already been proposed (Masanovic, 2019). There are differences in body composition between

periods of the season (higher values of adipose tissue in the transition period vs. the competition period) (Madic et al., 2018), as well as differences in anthropometric values between categories (Ramos, Nakamura, Penna, Wilke, et al., 2019). Where maturation has an impact in anthropometry (stature, body mass, muscle mass and body fat) and in physical performance from girls and teenagers soccer players (O'Brien-Smith et al., 2020). It has been seen that the development of physical characteristics are not linear between consecutive maturation groups and female players may show a decrease in relative strength around the Peak High Velocity (PHV), that could generate an impact in the physical qualities like speed, change of direction and jumping power of the players (Lloyd & Oliver, 2012).

National and international reports exist where anthropometric differences between age categories have been shown (Doyle et al., 2020; Lillo et al., 2018; Ramos, Nakamura, Penna, Mendes, et al., 2019). For example, Brazilian's women senior team players possess more body mass and high than the U15, U17 and U20 players, also U15 players were shorter ($p < 0.01$) than all other age groups and were lighter ($p < 0.01$) than U20 players (Ramos, Nakamura, Penna, Mendes, et al., 2019). Irish female international football players showed anthropometric values of height and body mass similar for all age groups, from U15 to senior, although the senior age group were taller and heavier than U17 and U19 peer group (Doyle et al., 2020), without statistical significance. The anthropometric characteristics of elite senior players from Chile were described by Villaseca-Vicuña et al. (2021), showing a mean body mass of $60,25 \pm 4,88$ kg, high $163,15 \pm 5,27$ cm, sum of 6 skinfolds $63,93 \pm 13,70$ mm, muscle mass $47,08 \pm 2,46$ % and body fat percentage $26,07 \pm 2,42$ %.

Football requires players to train various components of physical conditioning, including strength, speed, jump and aerobic capacity. Therefore, the assessment of physical condition in all its factors has been identified as an important contributor to selection in team sport athletes (Doyle et al., 2020). The implementation of appropriate, valid, and reliable aptitude tests is important to describe the profiles that fit the demands of the game (Turner et al., 2011). The players characteristics and demands of the women's game were already described elsewhere (Martínez-Lagunas et al., 2014). Players from 12 to 27 years' mean value were 4.34 to 4.96 s for 30 m sprint times, 28 to 50 cm for countermovement jump (CMJ), 45.1 to 55.5 mL/kg/min for maximal oxygen uptake (VO_{2max}) and 780 to 1379 m for the Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) (Martínez-Lagunas et al., 2014). The most mature player exhibit better performance in the sprint test, change of direction, CMJ and YYIR1 than the younger players (Emmonds et al., 2020). In 20 m sprint the senior players are significantly faster than the younger players (Ramos, Nakamura, Penna, Mendes, et al., 2019), the same thing occurs in agility tests while comparing senior players with players from 16-19 y (Mujika et al., 2009). In CMJ, the senior players show significantly better performance than the youth players (Mujika et al., 2009). The U20 players also show a significantly better performance in CMJ than the U15 and U17 players (Ramos et al., 2019). In terms of aerobic capacity, the senior players cover greatest distance in the YYIR1 than the younger players ($p < 0.05$) and the U20 covered more distance than the U17 and U15 players ($p < 0.05$) (Ramos, et al., 2019).

Research on football performance has increased significantly in the last two decades (Datson et al., 2014; Milanović et al., 2017). Football professionals and scientists are looking for key optimization factors that help improve the performance of elite players in different age categories (Doyle et al., 2020; Ramos et al., 2019). However, research on women's football is still significantly lower than that of men's football (Milanović et al., 2017). To our knowledge, there is no literature about Chile's elite female football players in terms of anthropometric and physical performance capacity in different age categories, that is why the aim of this study was to compare the body composition and several physical fitness variables between Chile's woman's national football teams category; U17, U20 and senior.

Material & methods

This was a quantitative, transversal, descriptive and comparative study that focused on the comparison of the anthropometric and physical profile of elite female football players across FIFA categories; U17, U20, and Senior. Assessments included standing height, body mass, sum of skinfolds, muscle mass, body fat, lower body strength maximal sprint speed, jump height and aerobic capacity. All measurements were performed at Chile's national team headquarters in 2020.

Participants

Fifty-five female football players participated in the study. All of them had international level and played in the different categories of Chile's national teams; nineteen players belonged to the under 17-year-old team (U17) category (mean $\pm$ SD: 16.42 ± 0.84 years), nineteen players belonged to the under 20-year-old team (U20) category 18.63 ± 1.21 years) and seventeen players belonged to the senior national team (Senior) (26.47 ± 4.7 years). This type of intervention does not alter normal football training, nor does it involve motor actions different from normal training or match practice. The present data arises from routine assessments performed in the national football teams in Chile. The Football Federation of Chile (FFCH) consented to the use of the athletes' test results for publication. The participants signed an informed consent document before the beginning of data collection and were free to withdraw from the study at any time. For those under the age of 18 years age parental or guardian signed consent was obtained. Before the football season began, all of the players had a complete medical examination. The study was conducted in accordance with the Declaration of Helsinki (WMA,

2013) and approved by the Institutional Ethics Committee of University Hospitals Virgen Macarena and Virgen del Rocío from Seville, Spain (C.P. RENFEFUTCHILE—C.I. 2355-N-20, 28 June 2021). The selected players were nominated by the coach of the related age category and represented Chile in an official tournament. Only field players were included in the study, so all goalkeepers were excluded from the analysis. The U17 team played international matches against Brazil and Colombia in the first semester of 2020, the U20 team played the U20 Southamerican Tournament (CONMEBOL) held in 2020 and the senior team played in the window of international FIFA match in November of 2020. At the evaluation moment, Chile had the senior team in 36th place from the FIFA Ranking.

Procedure

The anthropometric assessment and physical fitness test were scheduled in the first four days of each team's weekly training cycle using the same protocol proposed by Villaseca-Vicuña, Molina-Sotomayor *et al* (2021). The players were asked to avoid strenuous exercise 24 h pre testing, to prevent the effects of fatigue in the measurements. The warm-up was conducted by the fitness coach of each category, which consisted in a light jogging, multidirectional movements and dynamic stretching, followed by a specific warm-up for each test that lasted 15-20 minutes. The test temporality was: Day 1: anthropometric assessment and Squat test (ST). Day 2: linear speed, time to cover 10 m (T10) and 30 m (T30). Day 3: CMJ. Day 4: YYIR1. These tests are usually performed in women's football teams (Booyesen *et al.*, 2019; Doyle *et al.*, 2020; Lillo *et al.*, 2018; Ramos, Nakamura *et al.*, 2019; Villaseca-Vicuña, Molina-Sotomayor, *et al.*, 2021), because they give valid information for body composition and physical conditioning. All of the players were familiarized with the procedures and each player was encouraged to perform at her best.

Test protocol

Anthropometric Assessments: After a minimum of 24-hour rest and an overnight sleep the body composition assessment was performed. All anthropometric measurements were collected with participants wearing a sports bra and shorts. The body composition assessment involved the players' body mass (kg), standing height (cm), perimeters (cm) and skinfolds (mm) from each player. The sum of 6 skinfolds were analyzed ($\Sigma 6$ skinfolds; Triceps, Subscapular, Supraspinale, Abdominal, Front Thigh, and Medial Calf) for the muscle mass (%MM) and body fat (%BF) percentage estimation. This procedure is endorsed by the International Society for the Advancement of Anthropometry (ISAK). The same protocol has been used in different studies analyzing women's football players' anthropometry (Almagiá Flores *et al.*, 2008; Lillo *et al.*, 2018; Mujika *et al.*, 2009; Villaseca-Vicuña, Molina-Sotomayor, *et al.*, 2021). All of the measurements were realized by an expert in Chile's national team staff with an ISAK II certification. For the skinfolds measurement a slim guide caliper was used (Rosscraft®, British Columbia, Canada) with a 0.2 mm accuracy.

Squat Test: this test has been validated to assess the lower body strength level in football players (Jiménez-Reyes *et al.*, 2016; Pareja-Blanco *et al.*, 2020; Torres-Torrel *et al.*, 2017). The specific warm-up consisted in 3 sets of 3 repetitions each of back squats with a load of 20 kg. During the test each player performed 3 back squats with 20 kg followed by a 3 min rest, then they did 3 back squat repetitions with 30 kg, a linear encoder (Chronojump®, Barcelona, Spain) was attached to the bar to determine the bar velocity and acceleration, simultaneously the information was recorded into a computer. The concentric phase of the exercise was encouraged to be performed as fast as possible. No participant went to failure in any of the sets. The variables analyzed were a) Mean Propulsive Velocity (MPV) with a load of 20 kg (MPV 20kg) and with 30 kg (MPV 30kg); b) Relative strength (RS) and c) the estimation of one-repetition maximum (1RM). The variables analyzed were determined through a linear transducer. The fastest repetition for each load was analyzed for the MPV. The RS is obtained by dividing 1RM/body mass and the estimation of 1RM was based in the MPV of the highest load reached during the test (30 kg), with the formula proposed by Pareja-Blanco *et al.* (2020) for female athletes; $\%1RM = (-42,196 MPV^2 - 31,018 MPV + 112,937)$. The Intraclass Correlation Coefficient (ICC) and the Coefficient of Variation (CV) to know the absolute and relative reliability in the VMP 20kg (ICC = 0.985 CV = 3.91%), (ICC = 0.994 CV = 1.45%), (ICC = 0.978 CV = 3.05%), and VMP 30kg (ICC = 0.994 CV = 3.86%), (ICC = 0.993 CV = 2.01%), (ICC = 0.980 CV = 3.60%) for U17, U20 and senior, respectively.

Ten-Meter Linear Sprint Test (T10) and Thirty-Meter Linear Speed Test (T30): these two linear speed tests are usually used to assess the acceleration capacity and the maximum speed of the female football players (Hammami *et al.*, 2020; Villaseca-Vicuña, Molina-Sotomayor, *et al.*, 2021). The specific warm-up consisted in 5 progressive sprints of 30 m. During the test each player performed 3 maximal effort sprints separated with 3 minutes of a rest period. This test was performed over natural grass and with football shoes, during the morning and with ambient conditions of 15°C and relative air humidity of 54%. There were 3 photocell timing gates (Microgate® Bolzano, Italia) placed; at the beginning, 10 and 30 m. The players started at 0.5 m behind the first pair of photocell in a two-point split stance and were instructed to start when ready and run as fast as possible, the fastest time on T10 and T30 were used for the analysis. The 0-10 m (T10) was indicator the acceleration speed and the 0-30 m (T30) indicated the maximum speed of the player. The ICC and CV for T10 was (ICC = 0.856 CV = 1.64%), (ICC = 0.984 CV = 1.73%), (ICC = 0.944 CV = 1.84%) for U17, U20 and senior,

respectively. The ICC and CV for T30 was (ICC = 0.999 CV= 0.70%), (ICC = 0.999 CV = 1.11%), (ICC = 0.980 CV = 0.58%) for U17, U20 and senior, respectively.

Countermovement jump test (CMJ): Frequently used to assess lower limb power in female football players (Doyle et al., 2020; Ramos, Nakamura, Penna, Mendes, et al., 2019; Villaseca-Vicuña, Otero-Saborido, et al., 2021). The specific warm-up consisted in jumping five times to a 40 cm height box. The test started with the player standing tall and with both hands on the hips, hands where kept on hips during the complete CMJ to avoid hands influence on jumping high. Then the participant went down until approximately 90° knee flexion and immediately went up as fast as possible and jumping as much as she could, the landing was with both legs at the same time (Gil-Rey et al., 2015). All participants completed 3 maximal effort trials over the contact platform Optojump Microgate®, (Bolzano, Italy) and had 3 min for recovery between each repetition. The maximal high (cm) was analyzed. The ICC and CV was (ICC = 0.992 CV = 3.12%), (ICC = 0.999 CV = 1.86%), (ICC = 0.998 CV = 2.49%) for U17, U20 and senior, respectively.

Yo-Yo Intermittent Recovery Test, level 1 (YYIR1): this test is frequently used to assess the intermittent capacity in women's football players (Bangsbo et al., 2008; Doyle et al., 2020; Villaseca-Vicuña, Molina-Sotomayor, et al., 2021). The specific warm-up consisted in 10 progressive sprints of 20 m with change of direction. The players completed the YYIR1 test once, as described (Bangsbo et al., 2008). The total distance covered by a player was used as the performance measure.

Statistical analysis

For the descriptive analysis mean and standard deviation (mean $\pm$ SD) were calculated. The ICC and CV were obtained to know the absolute and relative reliability of the variables that were measured more than two times. The Kolmogorov-Smirnov test was performed to see in the variables had normality distribution. In addition, the homogeneity of variances was checked with Levene's test. A one-way analysis of variance was used to examine the category's differences. Post hoc analysis were done with Tukey o Games-Howell 's test. For the magnitude of the differences between groups the Effect Size (ES) was analyzed though Eta². Statistical significance was set at $p \leq 0.05$ and the Confidence Interval (CI) al 95% for all of the measures. The SPSS software (SPSS IBM®, Version 22, New York, USA) package was used for analysis.

Results

Anthropometric variables are reported in table 1. The $\Sigma 6$ skinfolds is significantly different among categories ($p = 0.002$), the senior players exhibit better results than the other categories. The senior players had less %BF and more %MM than the other category players ($p = 0.000$).

Table 1. Anthropometric characteristics of the tree age group categories of Chile's female football players.

		U17 (n = 19)		U20 (n = 19)		Senior (n = 17)		Intergroup Comparisons	
Age group		(M $\pm$ DE)	IC 95%	(M $\pm$ DE)	IC 95%	(M $\pm$ DE)	IC 95%	P value	Eta ²
Standing Height (cm)		161.72 $\pm$ 6.35	158.45-164.99	159.50 $\pm$ 4.30	157.42-161.58	162.05 $\pm$ 5.33	159.30-164.79	0.319	0.047
Body mass (kg)		58.52 $\pm$ 7.34	54.74-62.30	57.44 $\pm$ 5.19	54.94-59.95	56.57 $\pm$ 4.85	54.07-59.06	0.646	0.018
$\Sigma 6$ skinfolds(mm)		80.77 $\pm$ 25.59	66.59-92.91	72.21 $\pm$ 23.14 ^a	59.05-81.36	52.02 $\pm$ 12.53 ^{ab}	46.87-59.77	0.002	0.212
% BF		30.11 $\pm$ 3.50	28.30-31.91	27.81 $\pm$ 4.23 ^a	25.35-29.43	24.03 $\pm$ 2.64 ^{ab}	22.88-25.60	0.000	0.317
% MM		43.82 $\pm$ 3.17	42.46-45.72	46.14 $\pm$ 3.03 ^a	44.68-47.61	48.74 $\pm$ 2.04 ^{ab}	47.69-49.79	0.000	0.320

*Mean $\pm$ Standard Deviation (M $\pm$ SD) and Confidence Interval (CI 95%). Effect Size of Eta² (0.01: small, 0.06: medium, 0.14: large). One-way ANOVA. Tukey o Games-Howell's Post hoc according to Levene's test. Superscript: ^a = different from U17, ^b = different from U20. BF: Body Fat; MM: Muscle Mass.

The physical fitness variables are reported in table 2. 1RM and RS are statistically different between categories, were the senior group the strongest one ($p < 0.005$). There are differences between senior and U17 players in the T10 ($p = 0.005$). In YYIR1 there are differences ($p = 0.000$), the senior and the U20 players exhibit better performance than the U17. There were no significant difference in between groups for the MPV 20kg, MPV 30kg, CMJ and T30.

The differences by category in anthropometric variables are represented in figure 1 and the differences by category in physical fitness variables are represented in figure 2.

Table 2. Physical performance of the tree age group categories of Chile's female football players.

Age group	U17 (n = 19)		U20 (n = 19)		Senior (n = 17)		Intergroup Comparisons	
	(M ± DE)	IC 95%	(M ± DE)	IC 95%	(M ± DE)	IC 95%	P value	Eta ²
MPV 20kg(m/s)	1.10 ± 0.13	1.07-1.21	1.14 ± 0.09	1.10-1.20	1.15 ± 0.06	1.11-1.19	0.544	0.004
MPV 30kg(m/s)	0.98 ± 0.10	0.92-1.04	1.03 ± 0.10	1.00-1.10	1.04 ± 0.08	0.99-1.08	0.539	0.020
1RM(kg)	78.12 ± 20.07	66.63-89.48	86.80 ± 15.65 ^a	79.90-94.01	98.79 ± 12.74 ^{ab}	91.44-104.14	0.015	0.011
RS	1.33 ± 0.72	1.14-1.99	1.52 ± 0.3 ^a	1.36-1.68	1.73 ± 0.18 ^a	1.63-1.82	0.003	0.012
CMJ(cm)	26.43 ± 3.03	25.22-28.35	26.92 ± 5.89	24.98-30.66	27.96 ± 1.98	26.36-28.41	0.782	0.011
T10(s)	2.03 ± 0.09	1.98-2.07	1.96 ± 0.11	1.89-2.00	1.90 ± 0.06 ^a	1.87-1.94	0.005	0.213
T30(s)	4.87 ± 0.20	4.74-4.94	4.74 ± 0.22	4.62-4.83	4.68 ± 0.14	4.63-4.78	0.031	0.085
YYIR1(m)	1091.76 ± 222.60	977.31-1206.21	1429.47 ± 320.5 ^a	1274.99-1583.95	1571.35 ± 311.27 ^a	1362.30-1682.39	0.000	0.296

*Mean ± Standard Deviation (M ± SD) and Confidence Interval (CI 95%). Effect Size of Eta² (0.01: small, 0.06: medium, 0.14: large). One-way ANOVA. Tukey o Games-Howell's Post hoc according to Levene's test. Superscript: ^a = different from U17, ^b = different from U20. MPV: Mean Propulsive Velocity; 1RM: one-repetition maximum in back squat test; RS: Relative Strength; CMJ: Countermovement jump test; T10: Ten-Meter Linear Sprint Test; T30: Thirty-Meter Linear Speed Test; YYIR1: Yo-Yo Intermittent Recovery Test level 1.

Figure 1. Differences by category in anthropometric variables; (A) Sum of 6 skinfolds, (B) Body fat percentage, (C) Muscle mass percentage. ^a different from U17, ^b different from U20.

Figure 2. Differences by category in physical fitness variables; (A) one-repetition maximum in back squat test (B) Relative Strength (1RM/Body mass), (C) Ten-Meter Linear Sprint Test, (D) Yo-Yo Intermittent Recovery Test level 1. ^a different from U17, ^b different from U20.

Discussion

The objective of this study was to make a comparison of the physical fitness and anthropometrical profile of Chile's U17, U20 and Senior women national football team players. The results from our study showed differences in $\Sigma 6$ skinfolds, %MM and %BF ($p < 0.05$) between groups, where the senior players exhibit better body composition than the other category players. This results are in accordance with Mujika et al. (2009), who found differences in Spanish first division senior and second division youth players, where the senior players had 74.4 mm and the U20 95.1 mm in the $\Sigma 6$ skinfolds ($p < 0.001$), showing a 28% difference. Differences from our results were found in Ramos et al. (2019), publication, where the females players from Brazil national football team had no statistical difference in the $\Sigma 6$ skinfolds between categories U17, U20 and senior. Lillo et al. (2018), found no statistical differences in $\Sigma 6$ skinfolds, %BF nor %MM between U17, U20 and senior national teams football players from Chile in 2016. In terms of in body mass and standing height, our results showed no difference in between categories, the same was shown in Brazilian national team players (Ramos et al., 2019) and previous studies in Chilean national teams players (Lillo et al., 2018). This results are different from those found in the Irish international female players by Doyle et al. (2020) were the body mass ($ES = 0.40$ and $ES = 0.62$) and standing height ($ES = 0.56$ and $ES = 0.40$) were different between the senior and youth teams (U17 and U20), respectively. Based in the these results, we could explain the anthropometric characteristics of body mass and standing height by the possible differences in the maturation status of the players and the level of training. The maturation in the different phases of the physical development that in the female adolescence goes from 10 to 19 years (Lloyd & Oliver, 2012) and could have an impact in the body mass, standing height, %MM and /BF (O'Brien-Smith et al., 2020). Other influencing factor is the training status, and how it affects the body composition or the coach considerations, there they sometimes consider technical, tactical and psychological skills as well (Sæther, 2017).

In terms of absolute and relative strength, our results showed differences between categories ($p < 0.05$); the senior players manifested greater strength manifestation than the U17 and U20 players. There were no differences in RS between U20 and senior players. This results are in line with Kobal et al. (2016) study in Brazilian male football teams categories were senior team exhibit better performance in 1RM and RS than the U17 and U20 ($p < 0.05$). Lehance, Binet, Bury, & Croisier (2009) showed different results with Belgian male football players, where there were no differences between categories in terms of absolute and relative strength. No studies for female players were found in terms of age categories and strength manifestation in female football. Our results could be explained by the greater experience in lifting weights and strength training in the senior players in comparison with U17 and U20. Also the finalization of the maturation process and the acquisition of neuromuscular adaptations may benefit the senior players, where changes in strength could be explained mainly by training (Coelho E Silva et al., 2010; Lloyd & Oliver, 2012; Meylan et al., 2014; Wrigley et al., 2014).

In CMJ there were no differences between categories ($p < 0.05$) in our study. Differences between categories were observed in Ramos et al., (2019) study, the differences in CMJ between categories were only between senior and U20 vs U17. Doyle et al., (2020) found something similar, where significant differences existed between senior and U17. The two studies cited above showed differences in the older categories (senior and U19) vs U17. In the study from Villaseca-Vicuña et al., (2021) in the Chilean senior female football players showed a strong association in strength (1RM and RS) and the jumping capacity in, but that association was not shown in this study with the difference categories. Apparently, in younger age group categories the jumping differences may also vary (Emmonds et al., 2020; Jeras et al., 2020; Vescovi et al., 2011).

Our results showed differences in T10 for the senior and U17 teams, this results are in line with Ramos et al., (2019) results, who showed that Brazilian senior players had better performance in T20 than the other categories ($p < 0.05$). Doyle et al., (2020) showed differences between Irish female football categories, were the senior where faster than the U20 and U17 in T10 (1.89 vs 1.92 vs 1.95 s), T20 (3.26 vs 3.32 vs 3.36 s) y T30 (4.57 vs 4.64 vs 4.70 s), respectively. In our results there were no statistical differences between categories in T30. It has been shown that the senior players that show better performance in the strength and speed profile exhibit better jump and sprint ability (Marcote-Pequeño et al., 2019). This could indicate that strength is associated with sprint and jumping ability in senior players. Nevertheless, in the studies were the biggest difference is exposed in sprint and jumping are girls (younger than 18 years old) (Murtagh et al., 2018). In this case, that's why after the PHV is possible to find no differences in neuromuscular test like jump and sprint (Lloyd & Oliver, 2012). This could explain the similarities between categories in CMJ and T30 results. More information is needed to determine the sensitivity of this test in different age categories of football players.

Finally, in terms of aerobic capacity, our results show differences in YYIR1 ($p = 0.000$) between categories, were the senior and U20 players performed better than the U17. There was no difference between senior and U20 teams. Our results are similar to Irish players report (Doyle et al., 2020), were the senior category had better performance (1457 m) than the U17 (981 m, $ES = 1.88$) and U19 teams (883 m, $ES = 2.31$) ($p = 0.001$). The differences found in Doyle et al., (2020) study may be because the aerobic fitness level may increase with age (Mujika et al., 2009) and the U20 players from our study are older than the players from Irish categories, also there may be no differences as the Chilean U20 and senior team had the exact same training

methodologies. The YYIR has been able to discriminate the differences in physical conditioning, competitive level and age (Bangsbo *et al.*, 2008; Doyle *et al.*, 2020; Krstrup *et al.*, 2005; Ramos *et al.*, 2019). In Brazilian players, the senior team covered a 45% more distance than the U20 (Ramos *et al.*, 2019). In the same line, Bradley *et al.*, (2014) showed that a combination of 92 senior elite players from European counties had better performance (1774 m) in the Yo-Yo Intermittent Test Level 2 than a combination of 42 European national team players U20 (1490 m). The senior players covered more distance than the U20 ($p < 0.01$) (ES = 0.6). Also, Mujika *et al.*, (2009) found differences in YYIR1 in senior and younger players from Spanish first and second division ($p < 0,001$), the senior players had a 32% better performance than the U20 with 1224 vs 826 m, respectively.

Conclusions

The results from this study show that the senior players have a more athletic anthropometric profile, better performance in strength and aerobic capacity than the U20 and U17 players. The jumping ability and sprint in 30 m showed no difference between categories, so the need of strategies to work in lower limb power should be taken into consideration. The aerobic capacity gradually increased through age categories, this could mean that is a variable could be associated to the training status and the maturation process. The neuromuscular performance in football is key, so we should focus in training strength, plyometric and sprints progressively through their development, so they can have a better and safer football career. For this reason, any training program designed to develop physical performance characteristics for football players must be strategically planned, individualized and age appropriate to address the influence of growth and maturation. The long-term sports development of international female players should be a key priority for the development pathways of female national team players in the different age categories. Finally, it has been shown that the anthropometric characteristics and the level of physical condition of the players are important attributes for football performance, therefore, this study provides reference data on elite players of different categories in Chilean football according to their age range that can used to guide the development of systems, monitoring, selection and evaluation of the effectiveness of training programs.

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References

- Almagiá Flores, A. A., Rodríguez Rodríguez, F., Barraza Gómez, F. O., Lizana Arce, P. J., & Jorquera Aguilera, C. A. (2008). Anthropometric profile of chilean women football players(in spanish). *International Journal of Morphology*, 26(4), 817–821. <https://doi.org/10.4067/S0717-95022008000400006>
- Bangsbo, J., Iaia, F. M., & Krstrup, P. (2008). The Yo-Yo Intermittent Recovery Test. *Sports Medicine*, 38(1), 37–51. <https://doi.org/10.2165/00007256-200838010-00004>
- Booyesen, M. J., Gradidge, P. J. L., & Constantinou, D. (2019). Anthropometric and Motor Characteristics of South African National Level Female Soccer Players. *Journal of Human Kinetics*, 66(1), 121–129. <https://doi.org/10.1515/hukin-2017-0189>
- Bradley, P. S., Bendiksen, M., Dellal, A., Mohr, M., Wilkie, A., Datson, N., Orntoft, C., Zebis, M., Gomez-Diaz, A., Bangsbo, J., & Krstrup, P. (2014). The Application of the Yo-Yo Intermittent Endurance Level 2 Test to Elite Female Soccer Populations. *Scandinavian Journal of Medicine and Science in Sports*, 24(1), 43–54. <https://doi.org/10.1111/j.1600-0838.2012.01483.x>
- Coelho E Silva, M. J., Figueiredo, A. J., Simões, F., Seabra, A., Natal, A., Vaeyens, R., Philippaerts, R., Cumming, S. P., & Malina, R. M. (2010). Discrimination of U-14 soccer players by level and position. *International Journal of Sports Medicine*, 31(11), 790–796. <https://doi.org/10.1055/s-0030-1263139>
- Datson, N., Hulton, A., Andersson, H., Lewis, T., Weston, M., Drust, B., & Gregson, W. (2014). Applied physiology of female soccer: An update. *Sports Medicine*, 44(9), 1225–1240. <https://doi.org/10.1007/s40279-014-0199-1>
- Datson, N., Weston, M., Drust, B., Gregson, W., & Lolli, L. (2020). High-intensity endurance capacity assessment as a tool for talent identification in elite youth female soccer. *Journal of Sports Sciences*, 38(11–12), 1313–1319. <https://doi.org/10.1080/02640414.2019.1656323>
- Doyle, B., Browne, D., & Horan, D. (2020). Differences in anthropometric and physical performance characteristics between U17, U19, and Senior Irish female international football players. *International Journal of Sports Science and Coaching*. <https://doi.org/10.1177/1747954120968191>
- Emmonds, S., Scantlebury, S., Murray, E., Turner, L., Robsinon, C., & Jones, B. (2020). Physical Characteristics of Elite Youth Female Soccer Players Characterized by Maturity Status. *Journal of Strength and Conditioning Research*, 34(8), 2321–2328. <https://doi.org/10.1519/JSC.0000000000002795>
- FIFA. (2019). Women's Football Member Associations Survey Report. *Federation Internationale de Football*

- Association, 1–113. <https://img.fifa.com/image/upload/nq3ensohyxpuxovcovj0.pdf>
- Gil-Rey, E., Lezaun, A., & Los Arcos, A. (2015). Quantification of the perceived training load and its relationship with changes in physical fitness performance in junior soccer players. *Journal of Sports Sciences*, 33(20), 2125–2132. <https://doi.org/10.1080/02640414.2015.1069385>
- Hammami, M. A., Ben Klifa, W., Ben Ayed, K., Mekni, R., Saeidi, A., Jan, J., & Zouhal, H. (2020). Physical performances and anthropometric characteristics of young elite North-African female soccer players compared with international standards. *Science and Sports*, 35(2), 67–74. <https://doi.org/10.1016/j.scispo.2019.06.005>
- Hoare, D. G., & Warr, C. R. (2000). Talent identification and women's soccer: An Australian experience. *Journal of Sports Sciences*, 18(9), 751–758. <https://doi.org/10.1080/02640410050120122>
- Jeras, N. M. J., Bovend'Eerd, T. J. H., & McCrum, C. (2020). Biomechanical mechanisms of jumping performance in youth elite female soccer players. *Journal of Sports Sciences*, 38(11–12), 1335–1341. <https://doi.org/10.1080/02640414.2019.1674526>
- Jiménez-Reyes, P., Pareja-Blanco, F., Rodríguez-Rosell, D., Marques, M. C., & González-Badillo, J. J. (2016). Maximal Velocity as a Discriminating Factor in the Performance of Loaded Squat Jumps. *International Journal of Sports Physiology and Performance*, 11(2), 227–234. <https://doi.org/10.1123/ijsp.2015-0217>
- Kobal, R., Freitas, T., Alberto, F., Requena, B., Barroso, R., Rossetti, M., Jorge, R. M., Carvalho, L., Pereira, L. A., & Loturco, I. (2021). Curve Sprint in Elite Female soccer Players : Relationship with Linear Sprint and Jump Performance. *International Journal of Environmental Research and Public Health*, 18(February). <https://doi.org/10.3390/ijerph18052306>
- Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2005). Physical demands during an elite female football game: Importance of training status. *Medicine and Science in Sports and Exercise*, 37(7), 1242–1248. <https://doi.org/10.1249/01.mss.0000170062.73981.94>
- Lehance, C., Binet, J., Bury, T., & Croisier, J. L. (2009). Muscular strength, functional performances and injury risk in professional and junior elite soccer players. *Scandinavian Journal of Medicine and Science in Sports*, 19(2), 243–251. <https://doi.org/10.1111/j.1600-0838.2008.00780.x>
- Lillo, C., Jorquera, C. J., & Roco, A. R. (2018). Morphological Profile of Female Professional Football Players in Chile. *Medisur*, 16(2), 248–258.
- Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength and Conditioning Journal*, 34(3), 61–72. <https://doi.org/10.1519/SSC.0b013e31825760ea>
- Madic, D. M., Andrasic, S., Gusic, M., Molnar, S., Radanovic, D., & Trajkovic, N. (2018). Seasonal body composition variations in adolescent soccer players. *International Journal of Morphology*, 36(3), 877–880. <https://doi.org/10.4067/S0717-95022018000300877>
- Marcote-Pequeño, R., García-Ramos, A., Cuadrado-Peñañiel, V., González-Hernández, J. M., Gómez, M. Á., & Jiménez-Reyes, P. (2019). Association between the force–velocity profile and performance variables obtained in jumping and sprinting in elite female soccer players. *International Journal of Sports Physiology and Performance*, 14(2), 209–215. <https://doi.org/10.1123/ijsp.2018-0233>
- Martínez-Lagunas, V., Niessen, M., & Hartmann, U. (2014). Women's football: Player characteristics and demands of the game. In *Journal of Sport and Health Science* (Vol. 3, Issue 4, pp. 258–272). <https://doi.org/10.1016/j.jshs.2014.10.001>
- Meylan, C. M., Cronin, J., Hopkins, W. G., & Oliver, J. (2014). Adjustment of measures of strength and power in youth male athletes differing in body mass and maturation. *Pediatric Exercise Science*, 26(1), 41–48. <https://doi.org/10.1123/pes.2013-0029>
- Milanović, Z., Sporiš, G., James, N., Trajković, N., Ignjatović, A., Sarmento, H., Trecroci, A., & Mendes, B. M. B. (2017). Physiological Demands, Morphological Characteristics, Physical Abilities and Injuries of Female Soccer Players. *Journal of Human Kinetics*, 60(1), 77–83. <https://doi.org/10.1515/hukin-2017-0091>
- Mujika, I., Santisteban, J., Impellizzeri, F. M., & Castagna, C. (2009). Fitness determinants of success in men's and women's football. *Journal of Sports Sciences*, 27(2), 107–114. <https://doi.org/10.1080/02640410802428071>
- Murtagh, C. F., Brownlee, T. E., O'Boyle, A., Morgans, R., Drust, B., & Erskine, R. M. (2018). Importance of speed and power in elite youth soccer depends on maturation status. *Journal of Strength and Conditioning Research*, 32(2), 297–303. <https://doi.org/10.1519/JSC.0000000000002367>
- O'Brien-Smith, J., Bennett, K. J. M., Fransen, J., & Smith, M. R. (2020). Same or different? A comparison of anthropometry, physical fitness and perceptual motor characteristics in male and female youth soccer players. *Science and Medicine in Football*, 4(1), 37–44. <https://doi.org/10.1080/24733938.2019.1650197>
- Pareja-Blanco, F., Walker, S., & Häkkinen, K. (2020). Validity of Using Velocity to Estimate Intensity in Resistance Exercises in Men and Women. *International Journal of Sports Medicine*, 41(14), 1047–1055. <https://doi.org/10.1055/a-1171-2287>
- Ramos, G. P., Nakamura, F. Y., Penna, E. M., Mendes, T. T., Mahseredjian, F., Lima, A. M., Garcia, E. S.,

- Prado, L. S., & Coimbra, C. C. (2019). Comparison of Physical Fitness and Anthropometrical Profiles Among Brazilian Female Soccer National Teams From U15 to Senior Categories. *Journal of Strength and Conditioning Research, Publish Ah*(40). <https://doi.org/10.1519/jsc.0000000000003140>
- Ramos, G. P., Nakamura, F. Y., Penna, E. M., Wilke, C. F., Pereira, L. A., Loturco, I., Capelli, L., Mahseredjian, F., Silami-Garcia, E., & Coimbra, C. C. (2019). Activity Profiles in U17, U20, and Senior Women's Brazilian National Soccer Teams During International Competitions: Are There Meaningful Differences? *Journal of Strength and Conditioning Research, 33*(12), 3414–3422. <https://doi.org/10.1519/JSC.0000000000002170>
- Randell, R. K., Clifford, T., Drust, B., Moss, S. L., Unnithan, V. B., De Ste Croix, M. B. A., Datson, N., Martin, D., Mayho, H., Carter, J. M., & Rollo, I. (2021). Physiological Characteristics of Female Soccer Players and Health and Performance Considerations: A Narrative Review. *Sports Medicine, 51*(7), 1377–1399. <https://doi.org/10.1007/s40279-021-01458-1>
- Sæther, S. A. (2017). Characteristics of professional and non-professional football players - An eight-year follow-up of three age cohorts. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 13–18. <https://doi.org/10.26773/mjssm.2017.09.002>
- Torres-Torrel, J., Rodríguez-Rosell, D., & González-Badillo, J. J. (2017). Light-load maximal lifting velocity full squat training program improves important physical and skill characteristics in futsal players. *Journal of Sports Sciences, 35*(10), 967–975. <https://doi.org/10.1080/02640414.2016.1206663>
- Turner, A., Walker, S., Stenbridge, M., Coneyworth, P., Reed, G., Birdsey, L., Barter, P., & Moody, J. (2011). A testing battery for the assessment of fitness in soccer players. *Strength and Conditioning Journal, 33*(5), 29–39. <https://doi.org/10.1519/SSC.0b013e31822fc80a>
- Vescovi, J. D., Rupf, R., Brown, T. D., & Marques, M. C. (2011). Physical performance characteristics of high-level female soccer players 12-21 years of age. *Scandinavian Journal of Medicine and Science in Sports, 21*(5), 670–678. <https://doi.org/10.1111/j.1600-0838.2009.01081.x>
- Villaseca-Vicuña, R., Molina-Sotomayor, E., Zabaloy, S., & Gonzalez-Jurado, J. A. (2021). Anthropometric Profile and Physical Fitness Performance Comparison by Game Position in the Chile Women's Senior National Football Team. *Applied Sciences, 11*(5), 2004. <https://doi.org/10.3390/app11052004>
- Villaseca-Vicuña, R., Otero-Saborido, F. M., Perez-Contreras, J., & Gonzalez-Jurado, J. A. (2021). Relationship between Physical Fitness and Match Performance Parameters of Chile Women's National Football Team. *International Journal of Environmental Research and Public Health, 18*(16), 8412. <https://doi.org/10.3390/ijerph18168412>
- Wrigley, R. D., Drust, B., Stratton, G., Atkinson, G., & Gregson, W. (2014). Long-term soccer -specific training enhances the rate of physical development of academy soccer players independent of maturation status. *International Journal of Sports Medicine, 35*(13), 1090–1094. <https://doi.org/10.1055/s-0034-1375616>