Romero-Caballero A, Varela-Olalla D, Löens-Gutiérrez C (2020) Science & Sports
https://doi.org/10.1016/j.scispo.2020.04.004

Fitness Evaluation in Young and Amateur Soccer Players: Reference Values for Vertical Jump and Aerobic Fitness in Men and Women.

Summary

Introduction: The evaluation of the physical condition is essential for being able to apply the results to the individual training planning. *Purpose:* The main objective of this study was to assess the physical condition of young and amateur soccer players. *Methods:* 362 soccer players (14.86±3.18 years; 1.66±0.14 meters; 56.62±12.91 kg) from 19 different teams participated in the study. The extensor strength of lower limbs was evaluated using a countermovement jump (CMJ) and the aerobic fitness was tested through the incremental run Leger test. Subsequently, the differences between the results of the different tests were analyzed according to gender (male and female), category (senior, U19, U16 and U14), position (goalkeeper, central defender, full back, midfielder, winger and striker) and competitive level (national, regional and local). *Results:* Statistically significant differences ($p<0.05$) were found in both tests according to gender and category. The competitive level was also a discriminatory variable in U19 and U14 categories for both tests. The analysis based on the position did not show significant differences in the CMJ. However, in the Leger test, fullbacks, midfielders and wingers obtained better results than the goalkeepers. *Conclusion:* In conclusion, the results of the CMJ and Leger tests in young and amateur soccer players must be analyzed individually, using specific reference values according to gender, category, position and competitive level, due to the differences found based on these variables.

Key Words: Physical Condition; Team Sports; Youth Players; CMJ; Leger Test.

Évaluation de la Condition Physique des Jeunes Footballeurs Amateurs: Valeurs de Référence pour le Saut Vertical et l'Aptitude Aérobie pour les Hommes et les Femmes.

Résumé

Introduction: L'évaluation de la condition physique est essentielle pour pouvoir appliquer les résultats à la planification de l'entraînement individuel. *Objectif:* L'objectif principal de cette étude était d'évaluer la condition physique des jeunes footballeurs amateurs. *Méthode:* 362 joueurs de football (14.86 ± 3.18 ans; 1.66 ± 0.14 mètres; 56.62 ± 12.91 kg) de 19 équipes différentes ont participé à l'étude. La force d'extension des membres inférieurs a été évaluée à l'aide d'un saut vertical (CMJ) et l'aptitude aérobie a été testée par le test de Leger. Ensuite, les différences entre les résultats des différents tests ont été analysées selon le sexe (homme et femme), la catégorie (senior, U19, U16 et U14), la position (gardien, défenseur central, arrière latéraux, milieu de terrain, ailier et attaquant) et niveau compétitif (national, régional et local). *Résultats:* Des différences statistiquement significatives ($p < 0.05$) ont été trouvées dans les deux tests en fonction du sexe et de la catégorie. Le niveau de compétition était également une variable discriminante dans les catégories U19 et U14 pour les deux tests. L'analyse basée sur la position sur la position n'a pas montré de différence significative dans le CMJ. Cependant, dans le test Léger, les arrières latéraux, les milieux de terrain et les ailiers ont obtenu de meilleurs résultats que les gardiens de but. *Conclusion:* En conclusion, les résultats des tests CMJ et Léger des jeunes footballeurs amateurs doivent être analysés individuellement, en utilisant des valeurs de référence spécifiques selon le sexe, la catégorie, la position et le niveau de compétition, en raison des différences constatées sur la base de ces variables.

Mots clés: Condition Physique; Sports d'Équipe; Jeunes Joueurs; CMJ; Test Léger.

1. Introduction

Soccer is the most popular sport in the world with approximately 265 million players and 5 million referees actively involved, which is roughly 4% of the world's population (1).

It is a sport in which performance depends on multiple factors, including technical, tactical, psychological and physical aspects (2). The technical and tactical skills have been considered as determining factors in the performance, although there are also studies that show the great influence of the physical condition during the competition (3). Likewise, there are investigations that show how physical abilities are a discriminating element among players of different competitive levels (4). In the same way, we can find works that give relevant importance to physical condition level as a performance determinant during matches, especially in forwards (5).

On a physical level, football is characterized by requiring intermittent efforts with sequences of actions that include different skills, the main one being the run. In addition, jumps are high intensity efforts that have been considered as important performance factors in this sport (6).

Although it exceeds the main objective of this work, in elite football coaches are in a constant search to identify and develop talented young players. There are numerous factors that can predispose young players to have a successful career in the professional world. Detection and prediction of future talents, given the multifactorial and changing nature of sports evolution, is really complex. However, there are studies that positively correlate the young players results in physical fitness tests with their competitive level during their adult stage (4).

Despite the discrepancies that can be found in the scientific literature about the usefulness of conducting physical tests for the early identification of football talent, its

usefulness for other purposes is much less questionable. According to Lidor, Côté, & Hackfort (7), data derived from physical tests can help trainers and physical trainers to setting goals based on the individual needs of each player. In this way, the training process would be improved, through greater adaptation and individualization of the contents. In addition, the results obtained in the tests can serve as a tool to improve feedback with the players, as well as to monitor their progress during the training process.

The evaluation of the physical condition is therefore essential for being able to apply results to the individual planning (8). However, it is necessary to choose tests that evaluate performance factors that really discriminate success possibilities during competition.

The main objective in soccer is to get more goals than the opponent. In this sense, the vertical jump is the second action that most frequently precedes the goal, only preceded by the straight-line sprint (9). In this study it was reported that 16% of the goals were subsequently scored to an aerial duel won thanks to a vertical jump.

In addition, several studies have demonstrated the close relationship between the results in vertical jump test and the time recorded in sprints of 10, 20 and 30 meters (10-12), which are the most recurrent distances during competition matches (2, 13).

Vertical jump measurement has been a recurring assessment in the evaluation of physical condition in soccer players during the last decades, especially through CMJ (14-16). This test has demonstrated great validity and reliability (17), even in children (18).

On the other hand, although the importance of having a high maximum oxygen consumption (VO_2max) in modern football has recently been questioned, several authors place the minimum threshold needed to possess the physiological attributes for

success at 60 ml//kg/min in elite men's football (19, 20). In women these values are around 52 ml/kg/min (2, 21). Therefore, the measurement of aerobic condition is important to assess the effectiveness of training programs and the physical condition of the players for the competition (22).

In the same way, VO_2max estimation from indirect field tests is a commonly used strategy in the evaluation of physical condition in soccer players. Among these, the Leger & Lambert test (23) stands out, which has been used multiple times for this purpose (24, 25) and it has a high correlation between the maximum speed reached in the test (maximum aerobic velocity) and the VO_2max ($r = 0.84$).

Therefore, the main objective of this study was to assess the physical condition of young and amateur soccer players from specific tests to the sport performed: extensor strength of lower limbs using a CMJ and the aerobic fitness through an incremental run test. In addition, the differences between the results of the different tests were analyzed according to the gender, category (age), position and competitive level. We hypothesize that differences in physical condition would differ not only based on competitive level, gender and category but also based on position.

2. Methods

2.1 Experimental Design

For the present study a descriptive design was used, through the evaluation of the physical abilities of soccer players, with the purpose of describing and analyzing their physical condition level. The dependent variables on the research were the height of a vertical jump (CMJ), the last level completed at the Leger test, the maximum speed reached in the Leger test and the estimated VO_2máx. The independent variables used were gender, category (age), position and competitive level.

125 ***2.2 Participants***

126 362 soccer players (326 males) from 19 different teams, whose characteristics can be
127 seen in table 1, participated in the study. All of them performed three 90-minute
128 workouts and one official match per week. For the results analysis, the sample was
129 divided according to the gender (male or female), category (senior, under-19, under-16
130 or under-14), competitive level (national, regional or local) and position (goalkeeper,
131 central defender, fullback, midfielder, winger or striker), as it appears in table 2.
132 According to the competitive level, the players grouped within the national category are
133 those of the highest competitive level, since they compete throughout the country.
134 Those of regional category travel within their region to play, which denotes an
135 intermediate competitive level, while those of local level only compete within their city.
136 Prior to the beginning of the investigation, and after being informed of the objective and
137 the tests that would be carried out, informed consent was obtained following the
138 instructions of the Declaration of Helsinki.

Table 1.

Participant characteristics (mean ± sd).

Gender	Category	Age (years)	Height (metres)	Weight (kg)
Females	Senior (n=19)	19,74 ± 3,03	1,65 ± 0,06	60,05 ± 7,75
(n=36)	U19 (n=17)	15,43 ± 1,32	1,62 ± 0,06	56,72 ± 9,53
	Senior (n=34)	21,68 ± 2,14	1,77 ± 0,07	74,29 ± 8,93
Males	U19 (n=46)	16,61 ± 1,41	1,76 ± 0,06	67,05 ± 8,97
(n=326)	U16 (n=124)	14,22 ± 0,66	1,67 ± 0,09	57,01 ± 9,48
	U14 (n=122)	12,19 ± 0,71	1,56 ± 0,18	44,74 ± 7,74

139 Note: U19=under-19; U16=under-16; U14=under-14.

140

Table 2.

Sample distribution by gender, category, competitive level and position.

Gender	Category	Competitive Level	Position					
			GK	CD	FB	CM	WG	ST
Females (n=36)	Senior (n=19)	Autonomic (n=19)	2	4	3	7	0	3
	U19 (n=17)	Regional (n=17)	2	2	3	2	3	5
Males (n=326)	Senior (n=34)	National (n=14)	2	3	3	2	3	1
		Regional (n=20)	2	4	3	7	2	2
	U19 (n=46)	National (n=10)	0	1	1	2	3	3
		Regional (n=36)	6	2	3	10	8	7
	U16 (n=124)	Autonomic (n=19)	1	5	2	7	0	4
		Regional (n=105)	7	18	18	23	21	18
	U14 (n=122)	Autonomic (n=48)	3	10	9	9	10	7
		Regional (n=74)	6	13	11	17	16	11
Global by competitive level		National (n=24)	2	4	4	4	6	4
		Autonomic (n=86)	6	19	14	23	10	14
		Regional (n=252)	23	39	38	59	50	43
Global (n=362)			31	62	56	86	66	61

Note: GK=goalkeeper; CD=central defender; FB=fullback; CM=midfielder; WG=winger; ST=striker

2.3 Testing Procedures

The participants performed all the tests in a single day, in a session lasting approximately 60 minutes. The measurements were made in the second month of the season, during the last week before the start of the official competition. All tests were performed on an artificial grass surface of a soccer stadium (105x68 meters).

148 After a standardized 10-minute warm-up, consisting of continuous running, joint
149 mobility, dynamic stretching, 5 CMJ and 3 sprint progressions of 20 meters, physical
150 tests were performed. There is no consensus in the scientific literature about the
151 influence of a fatigue activity such as the Leger test on performance in the CMJ. While
152 some authors have found negative effects (26), other publications claim that it can
153 improve jump height (27). For this reason, it was decided to always perform the CMJ
154 first to avoid the possible influence of the Leger test on it. In addition, to avoid the
155 undesired effects of the waiting time, in the event that it exceeded 10 minutes between
156 tests, participants performed a re-warm-up protocol before each test. This consisted of
157 making 5 CMJ and 3 sprint progressions of 20 meters.
158 Firstly, the participants performed a CMJ jump that was measured by the MyJump2 iOS
159 app, installed on two different iOS devices (iPhone 8 and iPad Pro, both equipped with
160 slow motion function camera at 240 fps). This app was selected for its reliability and
161 scientifically proven validity (28). Then, all participants took part in the Leger test,
162 which consists in performing an incremental run test with changes of direction every 20
163 meters. The audio track was played through the stadium speakers. The participants ran
164 until exhaustion or until their pace was lower than that marked by the audio track, at
165 which time the researchers withdrew them from the test and noted their final result. The
166 maximum speed reached during the test was found through the equation provided by
167 Leger, Mercier, Gadoury, & Lambert (29):

168 $$Speed = last\ level\ number\ completed + 0.5*last\ level\ number\ completed$$

169 Similarly, the maximum oxygen consumption was determined using the equation
170 proposed by Leger, Mercier, Gadoury, & Lambert (29):

171 $$VO2max = 31{,}025 + 3{,}238*speed - 3{,}248*age + 0.1536*speed*age$$

172 In this equation, the age value remains stable at 18 for subjects above 18 years old.

2.4 Statistical Analysis

The normality of the data was checked through the Shapiro-Wilk test (when the groups sample sizes were less than 50) and Kolmogorov-Smirnov (when n > 50). In the same way, the homocedasticity of the data was analyzed by performing the Levene test. A student t-test was performed to compare the test results according to gender. Likewise, a one-way ANOVA was used to compare the mean values of each variable according to the category, competitive level and position, using Bonferroni's post hoc tests to assess the possible existence of significant differences between groups. All the analysis were performed using IBM SPSS Statistics 23.0 software (SPSS, Chicago, IL).

3. Results

As can be seen in Table 3, the results of the women's teams in CMJ and Leger test are significantly lower (p=0.000) than those of the men's teams (-41% in senior category and -32% in U19 for CMJ; -47.6% in senior category and -43.3% in U19 for Leger test). Only in the CMJ the results of women resemble those of male U14 soccer players. We can also point out that male senior category players exceed the results of all the rest groups (p=0.000). On the contrary, there are no significant differences in the estimated VO_2max between the different male categories (p=0.06).

Table 3.

Comparison of test results according to gender and category (mean ± sd).

Gender & category	CMJ (cm)	Leger Level	Máx. speed Leger (km/h)	VO_2máx (ml/kg/min)
Fem U19	$20.65 \pm 5.05_{a}$	$4.76 \pm 1.75_{a}$	$10.38 \pm 0.87_{a}$	$39.87 \pm 5.01_{a}$
Fem Sen	$21.22 \pm 3.99_{a}$	$5.50 \pm 1.98_{ab}$	$10.75 \pm 0.99_{ab}$	$39.67 \pm 5.77_{a}$
Male U14	$22.02 \pm 4.59_{a}$	$6.89 \pm 1.85_{b}$	$11.45 \pm 0.92_{b}$	$49.93 \pm 4.67_{b}$
Male U16	$27.95 \pm 6.33_{b}$	$7.77 \pm 2.12_{c}$	$11.88 \pm 1.06_{c}$	$49.28 \pm 5.74_{b}$
Male U19	$30.46 \pm 6.39_{b}$	$8.40 \pm 1.91_{c}$	$12.20 \pm 0.96_{c}$	$48.47 \pm 5.15_{b}$
Male Sen	$36.17 \pm 5.28_{c}$	$10.50 \pm 1.24_{d}$	$13.25 \pm 0.62_{d}$	$52.01 \pm 3.71_{b}$

Note: The mean values in the same row that don't share the same subscript differ significantly ($p < .05$).

The results in the fitness tests also differ depending on the competitive level. Thus, as table 4 shows, within each category of male soccer players, the highest competitive players obtained the best results both in CMJ and in the Leger test. These differences are significant in U19 (CMJ p=0.000; Leger level p=0.16) and U14 (CMJ p=0.003; Leger level p=0.000) categories, but not in U16 (CMJ p=0.431; Leger level p=0.523).

Table 4.

Comparison of test results according to competitive level (mean ± sd).

Category and competitive level	CMJ (cm)	Leger level	Máx. speed Leger (km/h)	VO_2máx (ml/kg/min)
National U19	$38.78 \pm 4.51_a$	$11.50 \pm 0.71_a$	$13.75 \pm 0.35_a$	$55.10 \pm 2.12_a$
Regional U19	$28.14 \pm 4.69_b$	$8.21 \pm 1.80_b$	$12.11 \pm 0.90_b$	$48.07 \pm 5.01_a$
Autonomic U16	$29.01 \pm 4.85_a$	$8.05 \pm 1.68_a$	$12.02 \pm 0.84_a$	$49.10 \pm 4.76_a$
Regional U16	$27.76 \pm 6.57_a$	$7.71 \pm 2.18_a$	$11.86 \pm 1.09_a$	$49.31 \pm 5.92_a$
Autonomic U14	$23.55 \pm 4.77_a$	$7.79 \pm 1.67_a$	$11.89 \pm 0.83_a$	$52.05 \pm 4.46_a$
Regional U14	$21.04 \pm 4.23_b$	$6.32 \pm 1.73_b$	$11.16 \pm 0.87_b$	$48.57 \pm 4.31_b$

Note: The mean values in the same row that don't share the same subscript differ significantly ($p < .05$). Comparisons only analyzed within the same category.

As can be seen in Table 5, the results of the CMJ do not differ in the analysis depending on the position (p=0.848). In the Leger test, the wingers (p=0.019), midfielders (p=0.018) and fullbacks (p=0.043) obtained significantly better results than the goalkeepers. The rest of the differences between players of different positions were not statistically significant.

Table 5.

Comparison of test results according to position (mean ± sd).

Position	CMJ (cm)	Leger level	Máx. speed Leger (km/h)	VO_2máx (ml/kg/min)
Goalkeepers	$25.95 \pm 6.68_{a}$	$6.21 \pm 1.97_{a}$	$11.10 \pm 0.99_{a}$	$44.83 \pm 5.31_{a}$
Central def.	$25.97 \pm 8.42_{a}$	$7.30 \pm 2.46_{ab}$	$11.65 \pm 1.23_{ab}$	$48.23 \pm 6.72_{ab}$
Fullbacks	$26.18 \pm 5.93_{a}$	$7.73 \pm 1.83_{b}$	$11.87 \pm 0.91_{b}$	$49.53 \pm 5.43_{b}$
Midfielders	$26.01 \pm 7.20_{a}$	$7.75 \pm 2.37_{b}$	$11.88 \pm 1.18_{b}$	$48.86 \pm 6.74_{b}$
Wingers	$25.53 \pm 6.47_{a}$	$7.84 \pm 2.06_{b}$	$11.92 \pm 1.03_{b}$	$50.33 \pm 4.95_{b}$
Strikers	$24.54 \pm 5.66_{a}$	$7.13 \pm 2.21_{ab}$	$11.56 \pm 1.11_{ab}$	$47.75 \pm 5.79_{ab}$

Note: The mean values in the same row that don't share the same subscript differ significantly ($p < .05$).

4. Discussion

The main objective of this research was to assess the physical condition of young and amateur soccer players. The extensor strength of lower limbs was evaluated using a CMJ jump and the aerobic fitness through the Leger test. In addition, differences in test results were analyzed according to gender, category (age), demarcation and competitive level. The results obtained showed statistically significant differences both in CMJ and in the Leger test according to gender, category and competitive level. In the Leger test, statistically significant differences were also found in the analysis based on the position. In contrast, the results in the CMJ test were not significantly different in the position analysis.

The assessment of physical fitness in soccer, and especially the measurement of vertical jump and the aerobic fitness, has aroused considerable interest in recent years. As a result we can find numerous studies that address this issue. However, to our knowledge,

most of these investigations have been carried out in samples with elite male players in senior (30) and U19 categories (31). There are few studies that analyze the results of young players with lower competitive levels (8). In addition, few works study the physical condition in women soccer players (21, 32), and even less include female samples with a non-professional competitive level.

The results of this study for CMJ are lower than those reported by Salinero et al. (8) in the same categories (28 cm vs 22 cm in U14, 33 cm vs 26 cm in U16 and 36 cm vs 30 cm in U19) and also lower than those published by Soarez, Fragoso, Massuça, & Barrigas (33) in U14 (33 cm vs 26 cm) or by Rebelo et al. (34) in U19 (40 cm vs 30 cm). In the senior male category, our data are also lower (40-45 cm vs 36 cm) than those reported by other authors (6, 15, 32). Similarly, the results of the female group in CMJ are lower than those provided by other studies (16, 32), both in senior category (28-31 cm vs 21 cm) as in U19 (29 cm vs 21 cm).

In our opinion, the large and recurring discrepancies found in the results of our study, in comparison with the previous investigations, can be understood in large part due to differences in the competitive levels of the samples. In our work, the majority of the participants competed in local categories while in the above-mentioned investigations, professional senior soccer players or young elite players were evaluated. On the other hand, the measuring instruments used were also different. In the cited studies, force platforms were used in most cases, while in our work it was measured through the MyJump2 iOS App. However, due to the proven validity and reliability of this application for measuring vertical jump (28, 35), we consider that the differences in the results are more related to the competitive level of the subjects than to the instruments of measure. In addition, this hypothesis is reinforced when we select, for comparison with other studies, only the results of U19 players in the national category. In this case,

our results are comparable (40 vs 39 cm) to those provided by Rebelo et al. (34) in elite U19.

In relation to the Leger test, our data are very similar to those published by Nassis, Geladas, Soldatos, Sotiropoulos, Bekris, & Souglis (36) in a study conducted with non-professional senior soccer players (11.2 vs. 10.5 levels). On the contrary, the data we present corresponding to the maximum speed reached in U19 category prove to be lower than those reported by Aziz, Tan, & Teh (31), in their research with national level U19 players (13.6 vs 12.2 km/h). However, as we have previously pointed out with the CMJ, if we select only U19 with national competitive level, our results in these parameters prove to be even higher (13.6 vs 13.75 km/h).

Regarding the comparison of the results in the tests according to age and position, Salinero et al. (8) and Soarez et al. (33) found no significant differences in CMJ with players aged 10 to 17, as in our study. On the contrary, Rebelo et al. (34) show significant differences between the fullbacks and midfielders compared to the rest of the players. In this study with elite U19 sample, the goalkeepers, central defenders and forwards jumped between 4 and 5 cm more in CMJ. Haugen et al. (16) present results in the same line in their work with an elite female sample. In this case the midfielders jumped about 2 cm less than the goalkeepers, defenders and forwards. On the other hand, Sporis et al. (30) found significant differences in the vertical jump of the goalkeepers (48.5 cm) compared to the rest of the positions (44-45 cm).

In the Leger test, in our study, statistically significant differences can be observed in the last level completed and the maximum speed reached according to age and competitive level. However, these differences are not appreciated in the VO_2max values presented. This may be due to the fact that these values have been estimated using the equation proposed by Leger, Mercier, Gadoury, & Lambert (29) and not directly measured,

which may lead to an underestimation between 1.5 and 5.5 ml/kg/min according to previous studies (37). For this reason, it is important to note that the results of the Leger test must be analyzed according to the maximum speed reached or the last level completed, losing reliability if they are analyzed based on the estimated VO2max. Finally, the available scientific evidence holds that there are significant differences in the aerobic fitness between the goalkeepers and the field players, having the goalkeepers a significantly lower level in the estimated VO_2max due to the results in the incremental run test (38-40). On the contrary, the cited studies found no differences between the field players. These data are in accordance with the results of our study, in which the goalkeepers were also the ones who obtained the worst results and no significant differences were found among field players. These facts can be explained according to the mechanical and physiological demands of the different positions.

5. Conclusions

Following the results of the study and comparisons with other similar publications, we consider that the results in physical fitness tests, specifically those that have been carried out in this investigation (CMJ and Leger test), are influenced by gender, category, competitive level and position of subjects. In this way, we consider necessary the evaluation of the physical condition according to parameters specific to each particular context. On the contrary, there is a risk of reaching spurious conclusions by comparing the results of the tests with data from samples with different characteristics than the one to be evaluated.

In this sense, this study presents reference values for CMJ and Leger test, in a sample with a mainly local competitive level. In addition, results of women soccer players in senior and U19 categories, with a non-professional competitive level, are presented. In

our opinion, this is something not yet sufficiently described by the scientific community.

6. Limitations

Finally, and regarding the limitations of the study, it is necessary to point out the absence of instruments to objectively assess the degree of fatigue of the subjects during the Leger test, being very complicated to ensure that the participants ran until exhaustion. In addition, there was a numerical decompensation according to gender and competitive level, since our sample is mainly male and with a local competitive level. For this reason, the results of this work may reflect the reality of most of the low playing standards soccer clubs, and not so much of academies with higher competitive levels. In this way, we consider that more studies are needed and with more balanced samples, which incorporate comparisons based on the competitive level and gender to advance in the understanding of this field of knowledge. In the same line it is necessary to use instruments such as pulsometers or portable lactate analyzers to assess the level of fatigue of the subjects during the Leger test, to ensure that it is done until exhaustion.

Conflict of Interest

No conflicts of interest and no sources of funding are declared.

Acknowledgments

Thanks to all the players who have participated in this study, as well as to all the physical trainers, coaches and soccer clubs who have allowed us access to the sample and helped during the data collection.

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