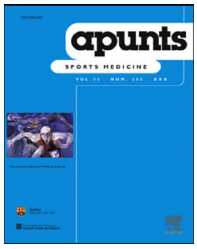
Apunts Sports Medicine 58 (2023) 100421

apunts SPORTS MEDICINE

www.apunts/org



ORIGINAL ARTICLE

Power and anaerobic capacity in female soccer: A comparison between different age-categories

Francine De Oliveira[a], Victor Gonçalves Corrêa Neto[b,c], Rafael José Silva Barbosa[d], Igor Ramathur Telles de Jesus[e], Jefferson da Silva Novaes[f], Estêvão Rios Monteiro[a,d,f,g,*]

[a] *Programa de PosGraduacão em Educacão Física, Escola de Educação Física e Desportos, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil*
[b] *School of Health Sciences, Gama e Souza University Center, Rio de Janeiro, RJ, Brazil*
[c] *Physical Education Graduate School, Estácio de Sá University (UNESA), Rio de Janeiro, RJ, Brazil*
[d] *Undergraduate Program in Physical Education, Augusto Motta University Center (UNISUAM), Rio de Janeiro, RJ, Brazil*
[e] *Postgraduate Program in Rehabilitation Sciences, Centro Universitário Augusto Motta (UNISUAM), Rio de Janeiro, RJ, Brazil*
[f] *Strength Training Laboratory (LABFOR), Universidade Federal de Juiz de Fora (UFJF), Minas Gerais, Brazil*
[g] *Undergraduate Program in Physical Education, IBMR University Center, Rio de Janeiro, RJ, Brazil*

Received 5 June 2023; accepted 3 July 2023
Available online 22 July 2023

KEYWORDS
Soccer;
Jumping;
Sport;
Sport specialization;
Youth category

Abstract
Introduction: Nowadays, female soccer can be considered one of fastest growing sports trends. However, investigations regarding female soccer players' performance are still scarce comparing to male soccer players. The purpose of this study was to compare the athletic profile of female soccer players from adult and youth categories of a professional soccer club.
Material and methods: Forty-two female soccer players from a professional soccer club were recruited for this investigation (adult category $n = 21$; youth category $n = 21$). Performance tests were randomly assigned. Aerobic capacity, sprint, change-of-direction ability, and power performance were assessed.
Results: There were no significant differences between groups for any of the proposed parameters. Also, better unilateral jump performance for the right leg was observed among adult players ($p = 0.05$).
Conclusions: The study suggests that there is no clear discrepancy between youth and adult categories regarding power, sprint, change-of-direction ability, and aerobic performance. However, a trend towards lower limb asymmetry was observed among adult players.

Introduction

Soccer is one of the most popular sports worldwide and this popularity is reflected by the amount of scientific research

* Corresponding author at: Postgraduate Program in Rehabilitation Sciences – Centro Universitário Augusto Motta (UNISUAM), Rua Dona Isabel 94, Bonsucesso, Rio de Janeiro, RJ, Brazil.
E-mail address: profestevaomonteiro@gmail.com (E.R. Monteiro).

https://doi.org/10.1016/j.apunsm.2023.100421

produced on the topic, however, most studies focus on investigating male soccer.[1] Currently, female soccer is one of the fastest growing sports trends around the world, which highlights the need for more robust investigations regarding female soccer player's performance especially across different age groups.[2]

Sprinting, jumping and change-of-direction (COD) abilities seem to play a significant role in this sport and are directly associated to power determinants of performance.[3] Additionally these demands may suffer the influence of an individual's aging process.[4] These actions can be classified as majorly anaerobic activities even though a soccer game depends mostly on aerobic metabolism.[4] In a typical soccer game, female players may cover ~10 km interspersed with short-duration and maximal intensity activities.[2]

Investigations have been conducted aiming to determine age-specific performance among male soccer players.[1,2] Previously, it was observed that despite an increase in volume and intensity of neuromuscular training, sprint and COD abilities seem to remain stable over the years which may highlight the need of a more appropriate training strategy during the specialization process.[5]

According to Kobal et al.[6] male soccer players of a professional category performed better than their counterparts on strength, power, and aerobic assessments, a trend that was not observed for sprinting performance. However, since men and women display different neuromuscular characteristics,[7] it is not clear whether this behavior would be observed on female categories. Therefore, this study aimed to compare the athletic profile of female soccer players from adult and youth categories of a professional soccer club. The authors hypothesized that adult players would perform better in all physical testing parameters.

Methods

This was a cross-sectional study in which the sample was selected by convenience. Participants (adult category $n = 21$; youth category $n = 21$) were assessed at the end of the pre-season. The participants were evaluated at the same of the day, aiming to avoid the influence of the circadian rhythm. Each participant was instructed to wear comfortable clothing for testing procedures and had received an authorization from their medical department to participate in the present investigation. Participants were instructed to avoid any vigorous exercise and caffeine or alcohol ingestion 12 h prior testing and were familiarized with testing procedures.

Procedures

Initially, anthropometric measurements and information regarding the subject's general playing positions were collected. Height was measured to the nearest 0.1 cm and body mass to the nearest 0.1 kg. Descriptive statistics are displayed on Table 1. This study was conducted according to the Declaration of Helsinki, and the Augusto Motta University Centre Institutional Review Board approved the present investigation (#4.800.595) and appropriate consent has been obtained. Participants performed a standard warm-up with a 10-min duration in which the athletes performed low-intensity jogging during the first 5 min. Ballistic movements to the lower limbs were added during the last 5 min. Following warm-up, the Yo−Yo intermittent recovery test level 1 (YO−YO), 10-m acceleration (10 m), 20-m speed test (20 m), the 505 agility test (505) and the vertical jump (VJ) were performed. The testing order was randomized as testing procedures were conducted on the lower limbs aiming to avoid residual fatigue.

Table 1 Descriptive statistics (mean and standard deviation).

	Adults	Youth
Age (years)	23.33 ± 5.25	15.71 ± 1.35
Height (m)	1.62 ± 0.07	1.62 ± 0.05
Weight (kg)	60.53 ± 7.97	56.36 ± 5.00
Body Mass Index (kg/m^2)	23.09 ± 2.67	21.51 ± 2.07

Exclusion criteria consisted of (a) any kind of musculoskeletal injury that led to training absence for eight days or more in the six months prior to testing; (b) individuals who had ingested caffeine or alcohol during the last 12 h prior testing. All participants were informed of the benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in this study.

Yo−Yo intermittent recovery test level 1 (YO−YO)

To evaluate the individual's ability to repeatedly perform an intense exercise, the YO−YO test was conducted.[8] The test was carried out on running tracks and consisted of 20-m shuttle-runs performed at increased speeds with a 10-s active recovery in 5-m distance between runs until exhaustion. Audio cues were broadcasted using a CD-player. A pre-test attempt was conducted aiming to familiarize subjects with the testing protocol. Testing was conducted until exhaustion.[8] Maximal oxygen consumption (VO_2max) was estimated through the following equation: (Distance (m) * 0,084 + 36,4).

10-Meter acceleration (10 m) and 20-m sprint

The 10 m test was conducted aiming to assess subject's ability to accelerate.[9, 10] The purpose is to complete the test as fast as possible. For referencing, a cone was placed 70 cm behind the starting point. Subjects performed two attempts with a 2-min interval between them and the fastest trial was used for statistical analysis. Subjects running speed was evaluated in a 20 m sprint test.[10] For referencing, a cone was placed 70 cm behind the starting point. Subjects performed two attempts with a 2-min interval between them and the fastest trial was used for statistical analysis. Photocells were placed at 0, 10, and 20 m (Speed Test 6.0 CEFISE, Nova Odessa, SP, Brazil).

XX. 505 agility test (505)

The 505 was used to assess the subject's ability to change direction.[11] Subjects should perform a half-turn (180°) over their dominant and non-dominant limb after a 15 m sprint.[12]

Subjects performed two attempts for each limb. The best performance was used for statistical analysis.

Vertical jump (VJ)

Lower limb power was measured through vertical jump performance.[13] Testing was conducted on a force platform measuring jump height, contact time, and flight time. Subjects should with feet shoulder width apart and hands akimbo and testing was conducted using the same pre-defined order: squat jump, bilateral countermovement jumped, and unilateral countermovement jump. Subjects performed two attempts with a 2-min interval between them. The highest jump in centimeters (cm) was used for statistical analysis.

Statistical analysis

The Kolmogorov−Smirnov normality test was used to assess data distribution. The results are displayed as mean and standard deviation. The intraclass correlation coefficient (ICC), expressed as $(MS_b - MS_w) / [MS_b + (k\text{-}1)\ MS_w)$, was used to assess data reliability. ICC values lower than <0.40 were considered to be poor, $0.40 \leq ICC < 0.75$ were reasonably good and an ICC ≥75 indicated excellent reliability. Paired Student *T*-tests were used to assess intragroup differences and Independent *T*-tests were used to asses intergroup differences. Data were entered into IBM SPSS Statistics 20 software for analysis and the level of significance was set at 5% ($p \leq 0.05$).

Results

Table 2 indicates better performance in the unilateral jump for the right leg compared to the left leg in the adult group ($p = 0.05$), but no statistically significant differences were found between groups ($p > 0.05$) as well as in intragroup and intergroup bilateral vertical jump comparisons ($p > 0.05$). Similarly, Table 3 indicates that there were also no significant differences between groups for any of the proposed parameters.

Discussion

The key finding from the present investigation was that there were no statistically significant differences between groups for any of the investigated parameters. However, a statistically significant difference was observed in unilateral vertical jump performance among adult female soccer players. These results do not corroborate the authors' initial hypothesis.

There has been an increased scientific interest in analyzing performance parameters among female soccer players. Ramos et al.[1] compared anthropometric and physical fitness of a female national football team. According to their investigation, senior female players presented superior performance than the younger categories in all tests, except for the CMJ, in which no difference was detected in comparison with "under 20″ category. According to previous research, female performance on high-intensity tasks such as CMJ performance may improve up to 17 years of age, presenting no further increase until female players turned 21.[15] In the present investigation it was possible to observe the lack of statistically significant differences regarding performance on the CMJ between categories. This finding, besides corroborating the hypothesis of the previously cited study, allow us to hypothesize that this further increase in performance may not occur for a longer period than that previously mentioned in the literature.

The inter-limb asymmetry observed among female adult players in the present sample may have been the result of the demands inherent to the sport. Inter-limb asymmetry is a common issue among soccer players, since many of the tasks performed during matches are executed unilaterally.[16] It is suggested that inter-limb asymmetry, assessed through a variety of testing procedures, may promote higher injury rates.[17] Trecoci et al.[18] investigated asymmetries in COD ability between different age categories noticing that subjects in the U16 category were more asymmetrical than the ones in U18, U17, and U15. According to the authors, maturity-related variations in body shape may contribute to imbalances in bilateral activities.

Female soccer players are at risk of suffering lower limb injuries such as ankle sprains and anterior cruciate ligament injury despite of their training experience, especially when playing in artificial turf.[19] Considering the physical demands imposed during soccer, such as power and sprint performance, strength training strategies have been used for player's development and aiming to reduce injury risk in this population, regardless of sex and age category. Pardos-Mainer et al.[16] investigated the effects of an 8-week strength and power training on interlimb asymmetries and performance of adolescent soccer players. Compared to soccer training alone, the use of an in-season training program could improve speed, and COD performance.[16] Also, besides the well-established improvements on performance, the use of a strength training program is indicated when aiming to restore lower limb alignment during landing[20] and improve lower limb stability.[21]

Table 2 Lower limb power performance (mean ± standard deviation).

Groups	Vertical jump (VJ)				Unilateral VJ (cm)		
	Height (cm)	CT (s)	FT (s)	CM (cm)	Right	Left	Left
Adults ($n = 21$)	28.99 ± 3.86	274.14 ± 73.33	441.10 ± 40.20	30.58 ± 3.57	15.19 ± 2.73[a]	16.22 ± 2.28	
Youth ($n = 21$)	28.07 ± 3.24	300.52 ± 85.08	456.90 ± 31.92	29.61 ± 3.14	15.33 ± 2.47	15.45 ± 2.35	

[a] Statistical difference within group ($p = 0.05$). CT, contact time; FT, flight time; CM, countermovement.

Table 3 Cardiorespiratory, sprint, and change-of-direction performance (mean ± standard deviation).

Groups	YO−YO IRT 1		10 m Acceleration (m/s)	20 m Velocity (m/s)	505AT (m/s)	
	Distance (m)	**VO_2 máx**			**Right**	**Left**
Adults (n = 21)	815.24 ± 255.34	43.25 ± 2.14	1.99 ± 0.09	3.39 ± 0.15	2.55 ± 0.14	2.57 ± 0.13
Youth (n = 21)	775.24 ± 175.94	42.91 ± 1.48	1.99 ± 0.08	3.41 ± 0.08	2.61 ± 0.11	2,58 ± 0,07

YO−YO IRT 1, Yo−Yo intermittent recovery test; 505AT, 505 agility test.

Considering the sports specialization process, the adequate development of motor competency is primordial, and dependent not only on the maturational processes but also on the adequate stimulation of fundamental motor skills.[22] The use of an adequate integrated neuromuscular type of training during sports specialization may have resulted in an early mastery of physical capabilities reflecting on the absence of differences between categories. Intermittent efforts are predominant during soccer activities and have been correlated to number of sprints and distance covered during a match, however, in this sample there was no significant differences in Yo-Yo performance between categories. This finding conflicts with the results from the study conducted by Haugen et al.[23] who aimed to quantify differences regarding VO_2 max performance considering player's level, as well as age and playing position. According to their investigation, VO_2 max seems to trend towards higher levels in higher playing levels. Conflicting findings may arise from the clear discrepancy between sample sizes, since Haugen et al.[23] provided data from 199 female soccer players between the years of 1989 and 2007.

Additionally, when conducting a one-sample T test aiming to compare our sample to the data provided by Haugen et al.,[23] it was observed that both of the present categories had lower VO_2 max values when compared to their "junior" and "national categories.[23] There is no information regarding the use of any physical training program besides specific soccer training, which difficult raising hypothesis regarding the actual motives behind these differences in physical readiness.

This study has limitations. Firstly, regarding the evaluation of cardiorespiratory fitness, the authors would like to highlight that even though no laboratory measurements were conducted, the proposed testing procedure raises ecological validity and it's well established as a testing tool for soccer players. Secondly, the authors' didn't have access to the athletes' strength training periodization and programming which limited the discussion. Also, the authors reinforce that these results can't be extrapolated to male soccer players.

Conclusions

The findings of this investigation provide insights on the characteristics of different female soccer categories. The study suggests that there is no clear discrepancy between youth and adult categories regarding power, sprint, change-of-direction ability, and aerobic performance. Considering the lack of differences between groups, the authors hypothesize that, in the process of sports specialization, other physical qualities might be more relevant than power performance which may imply that in this age gap, the maturation process didn't seem to affect performance in tests that rely on power performance and this may be a result of the training protocols conducted by the sport's club which the authors did not have access to.

However, a trend towards lower limb asymmetry was observed among adult players. Thus, the use of strength training can be suggested as a way to mitigate possible muscle imbalances arising from the practice, as well as to reduce injury risk resulting from limb asymmetry since the use of strength training and its periodization model was not well defined in the present sample, which may have influenced the results.

Conflicts of interest

The authors declare that they have no competing interest.

Confidentiality of data

The authors declare that no patient data appear in this article.

Funding

The authors report no funding.

References

1. Ramos GP, Nakamura FY, Penna EM, Mendes TT, Mahseredjian F, Lima AM, et al. Comparison of physical fitness and anthropometrical profiles among Brazilian Female Soccer National Teams from U15 to senior categories. J Strength Cond Res. 2021;35(8):2302−8.
2. Kobal R, Carvalho L, Jacob R, Rosseti M, Oliveira LP, Carmo EC, et al. Comparison among U-17, U-20, and professional female soccer in the GPS profiles during Brazilian championships. Int J Environ Res Public Health. 2022;19(24):16642.
3. De Oliveira F, Paz GA, Corrêa Neto VG, Alvarenga R, Neto SRM, Willardson JM, et al. Effects of different recovery modalities on delayed onset muscle soreness, recovery perceptions, and performance following a bout of high-intensity functional training. Int J Environ Res Public Health. 2023;20(4):3461.

4. Elam C, Aagaard P, Slinde F, Svantesson U, Hulthén L, Magnusson PS, et al. The effects of ageing on functional capacity and stretch-shortening cycle muscle power. J Phys Ther Sci. 2021;33 (3):250—60.
5. Loturco I, Jeffreys I, Abad CCC, Kobal R, Zanetti V, Pereira LA, et al. Change-of-direction, speed and jump performance in soccer players: a comparison across different age-categories. J Sports Sci. 2020;38(11—12):1279—85.
6. Kobal R, Loturco I, Gil S, Abad CCC, Cuniyochi R, Barroso R, et al. Comparison of physical performance among Brazilian elite soccer players of different age-categories. J Sports Med Phys Fitness. 2016;56(4):376—82.
7. Shultz SJ, Perrin DH, Adams MJ, Arnold BL, Gansneder BM, Granata KP. Neuromuscular response characteristics in men and women after knee perturbation in a single-leg, weight-bearing stance. J Athl Train. 2001;36(1):37—43.
8. Krustrup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, et al. The YO—YO intermittent recovery test: physiological response, reliability, and validity. Med Sci Sports Exerc. 2003;35(4):697—705.
9. Lockie RG, Schultz AB, Callaghan SJ, Jeffriess MD, Berry SP. Reliability and validity of a new test of change-of-direction speed for field-based sports: the Change-of-Direction and Acceleration Test (CODAT). J Sports Sci Med. 2013;12(1):88—96.
10. Altmann S, Ringhof S, Neumann R, Woll A, Rumpf MC. Validity and reliability of speed tests used in soccer: a systematic review. PLoS One. 2019;14(8):e0220982.
11. Kadlubowski B, Keiner M, Hartmann H, Wirth K, Frick U. The relationship between change of direction tests in elite youth soccer players. Sports. 2019;7(5):111.
12. Tomáš M, František Z, Lucia M, Jaroslav T. Profile, correlation and structure of speed in youth elite soccer players. J Hum Kinet. 2014;40:149—59.
13. Heishman AD, Daub BD, Miller RM, Freitas EDS, Frantz BA, Bemben MG. Countermovement jump reliability performed with and without an arm swing in NCAA division 1 intercollegiate basketball players. J Strength Cond Res. 2020;34(2):546—58.
14. Vescovi JD, Rupf R, Brown TD, Marques MC. Physical performance characteristics of high-level female soccer players 12-21 years of age. Scand J Med Sci Sports. 2011;21(5):670—8.
15. Pardos-Mainer E, Bishop C, Gonzalo-Skok O, Nobari H, Pérez-Gómez J, Lozano D. Associations between inter-limb asymmetries in jump and change of direction speed tests and physical performance in adolescent female soccer players. Int J Environ Res Public Health. 2021;18(7):3474.
16. Ascenzi G, Filetti C, Di Salvo V, Nuñez FJ, Suarez-Arrones L, Ruscello B, et al. Inter-limb asymmetry in youth elite soccer players: effect of loading conditions. PLoS One. 2022;17(6): e0269695.
17. Trecroci A, Rossi A, Dos'Santos T, Formenti D, Cavaggioni L, Longo S, et al. Change of direction asymmetry across different age categories in youth soccer. PeerJ. 2020;8:e9486.
18. Xiao M, Lemos JL, Hwang CE, Sherman SL, Safran MR, Abrams GD. Increased risk of ACL injury for female but not male soccer players on artificial turf versus natural grass: a systematic review and meta-analysis. Orthop J Sports Med. 2022;10(8). 23259671221114353.
19. Noyes FR, Barber-Westin SD, Tutalo Smith ST, Campbell T. A training program to improve neuromuscular and performance indices in female high school soccer players. J Strength Cond Res. 2013;27(2):340—51.
20. Porrati-Paladino G, Cuesta-Barriuso R. Effectiveness of plyometric and eccentric exercise for jumping and stability in female soccer players—a single-blind, randomized controlled pilot study. Int J Environ Res Public Health. 2021;18(1): 294.
21. Font-Lladó R, López-Ros V, Montalvo AM, Sinclair G, Prats-Puig A, Fort-Vanmeerhaeghe A. A pedagogical approach to integrative neuromuscular training to improve motor competence in children: a randomized controlled trail. J Strength Cond Res. 2020;34(11):3078—85.
22. Haugen TA, Tønnessen E, Hem E, Leirstein S, Seiler S. VO2max characteristics of elite female soccer players, 1989—2007. Int J Sports Physiol Perform. 2014;9(3):515—21.