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Original Article

What physical performance characteristics are related with age categories of elite young soccer players?

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Abstract
Aims: The purpose of this study was to compare the physical performance among young elite soccer players from different age categories (i.e., U15, U17, and U20) in a broad spectrum of abilities (sprint, change of direction ability, jump, anaerobic and aerobic capabilities) and to explore the relationship between these physical performances. Method: One hundred twenty-two young Brazilian soccer players were analyzed. The relationship and differences were assessed between physical performance in repeated sprint ability (RSA), sprint 10 and 20 meters, Yo-Yo IR1 test, countermovement jump, and change of direction ability (COD). Results: In sprint 10-m performance, U17 players were worse performance than U15 and U20 players ($p = <0.001$) and for sprint 20-m performance U17 category was faster when compared with the other categories ($p = 0.008$). For COD ability, results were favorable for U20 players (U15: $p = 0.001$; U17: $p = <0.001$) and U15 has worse performance (U17: $p = 0.018$; U20: $p = <0.001$). Performance for RSA variables, U20 players had better performance ($p \leq 0.001$), followed by U17 and U15 players. Likewise, performance in Yo-Yo IR1 were better for U20 players ($p \leq 0.001$), followed by U17 and U15 players. Jump performance was higher for U20 players. For relationship between physical performance according to category was observed that the number of significant relationships progressively reduced with increasing age category. In summary, this study revealed that the physical attributes that discriminated different age categories were 20-m time, RSA, COD ability, and distance performed on the Yo-Yo IR1.
Keywords: Abilities; Physical performance; Younger categories; training.

Introduction

Soccer is the most famous sport and has a lot of players over the world. This team sport is characterized by an intermittent nature and requires players to perform a plethora of movements quickly—i.e., sprinting, running, change of direction ability, jumping (Slimani & Nikolaidis, 2019). Therefore, staff, strength and conditioning coaches and scientific researchers seek to understand which physical characteristics determine success in this sport. In this sense, researchers have been identified different aspects according to player level, position, and age category. For example, younger players (i.e., under-15 [U15]) were faster than under-17 (U17), under-20 (U20), and senior age categories in very short distances (i.e., 5-m distance) (I. Loturco et al., 2018). In a study, Loturco et al. (2020) observed impairment in speed-related abilities and a gradual increase in change of direction (COD) deficit from younger to older age groups. In this regard, elucidating such aspects that differentiate the age categories can contribute to individualize training and the specific demands for improving adaptations and readiness (Slimani & Nikolaidis, 2019).

However, despite being a frequently investigated topic, the possible characteristics that differentiate age categories still sound controversial. For instance, Karahan (2016) showed higher agility and sprint performance over 10 and 20 meters for U19 than U17 and U15 players. On the other hand, Kobal et al. (2016) reported no differences in 20-m sprint performance between U17, U20, and professional soccer players. In a further comprehensive study, Loturco et al. (2020) observed that the linear speed at longer distances (i.e., 10- and 20-m) increases progressively during the specialization process; however, the same does not hold for acceleration performance at shorter distances (i.e., 5-m). Therefore, further studies are needed to elucidate such divergences; preferably with players from the same soccer team, as they are likely to be subjected to the same training program, a fact that allows us to eliminate bias in the training program during the specialization process (Loturco et al., 2020).

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Additionally, possible age category differences in other attributes (e.g., power, anaerobic, and aerobic capabilities) remain elusive (Slimani & Nikolaidis, 2019). The characterization of a broad spectrum of abilities throughout the specialization process can contribute to the structuring of the training program to overcome the limitations and weaknesses of each age category to build adult professional players who perform the different skills that are related to success in elite soccer in an optimal way (Slimani & Nikolaidis, 2019). Parallel to this characterization, an exploratory analysis of the correlation between the different attributes in each age category can help strength and conditioning professionals understand parameters which can be modified during the specialization process. Therefore, the present study aims (a) to compare if physical performance is influence by age categories (i.e., U15, U17, and U20) and (b) to explore the relationship between these different attributes in each age category.

Material & Methods

Participants

Participants of the present study were 122 young soccer Brazilian players of three different categories with descriptive characteristics of age: 14.0 ± 0.6 years; body mass: 60.6 ± 8.7 kg; stature: 169.5 ± 6.5 cm, for U15 players, age: 15.7 ± 0.6 years; body mass: 66.6 ± 7.2 kg; stature: 172.1 ± 6.5 cm for U17 players and age: 17.8 ± 0.8 years; body mass: 70.2 ± 8.3 kg; stature: 175.9 ± 8.2 cm, for U20 players. Players were free of injuries and health problems that interfered with the procedures and tests. Informed consent was obtained from the players and their legal guardians. This study was approved by the local University Ethics and Research Committee (protocol number: 29071420.0.0000.5054) in compliance with the Declaration of Helsinki.

The data were collected in the first two weeks of the pre-season of (2021) in the under 15, 17, and 20 categories. Procedures were realized in six days, with two different days for each age category. The assessment conducted were: repeated sprint ability (RSA), sprint in 10 and 20 meters, Yoyo test, countermovement jump, and change of direction ability (COD). On the first day, players realized anthropometric measures (height and body mass), countermovement jump, and Yoyo test. On the second day, soccer players realized 10-20m sprint, COD, and RSA. All tests occurred in the gram court. Players were familiarized with all test procedures.

Procedures

Anthropometric measures.

The body mass and stature were measured on the first day of assessment. The body mass was assessed using a digital balance (Oxer, model Home, ± 0.1 kg), and stature was measured with a portable stadiometer (Sanny, model Caprice, ± 0.1 cm).

Sprint test. Sprint test was realized for two distances, 10 and 20 meters. The players were positioned in the initial line, with a 1 m distance of the first photocell gate (Cefise, São Paulo, Brazil), and the second photocell was placed in 10 or 20 m. Players were oriented for realized the test faster as possible. The interval between the two trials was four minutes, and the best performance was utilized for analyses.

Repeated sprint ability test (RSA). Repeated sprint ability test consisted of six 40 m (20 + 20m with 180º turns) separated by 25 s of passive recovery (Rampinini et al., 2007). The players started the test 1m behind the line of the photocell gate (Cefise, São Paulo, Brazil), sprinted 20 meters, in the final line of 20 meters, turner 180°, and came back to the started line. After 25 seconds of recovery, the players begin a new sprint until they finished six sprints. Players were oriented to perform sprints faster as possible. The variables used were: the best sprint time (20 + 20 m) (RSA_{best}), the average time obtained from the six repeated sprints ($RSA_{average}$), decrease performance in the sprint ($RSA_{dec\%}$) calculated according to the formula: (RSAmean/RSAbest x 100) – 100 (Girard et al., 2011; Rampinini et al., 2007).

Yo-Yo test. The test utilized was the Yo-Yo intermittent recovery test level 1 (Yo-Yo IR1) test, which consisted of a 20 m shuttle run. The players realized two shuttle runs, with 10 s of active recovery. The test was carried out indoors, and a beep signal with increasing speeds guided the subjects. The test finished when the players could not reach the line at the beep signal on two consecutive occasions or give up the test. The total distance covered (m) was recorded as the result of the test (Krustrup et al., 2003).

Countermovement jump (CMJ).

Six CMJs, with 30 seconds rest, were performed. CMJ height was determined with a contact platform (Cefise, São Paulo, Brazil). Participants were oriented to keep their hands on the hips, flex their knees approximately 90°, and jump faster and in height. An average of six jumps was utilized for further analyses.

Change of direction (COD) ability.

To assess the change of direction ability were applied Illinois agility test. The setup of the test is precisely informed by Lockie et al. (2013). The players were positioned in the initial line, with a 1 m distance of the first photocell gate (Cefise, São Paulo, Brazil). The second photocell was set in the final line. The instructions placed for players were to perform the test as quickly as possible. Two trials were recorded, and the faster trial was utilized for analyses.

Statistical analyses

Physical performance data were presented in mean, standard deviation, and 95% confidence interval for different players' age categories. Shapiro Wilk's test checked the normality of the data. Levene's test verified homogeneity. Analysis of variance (ANOVA) one-way was utilized to compare physical fitness according to age category, and Bonferroni post hoc adjustment was utilized to identify possible significant differences.

When homogeneity of variances in variables of physical performance data is not assumed, Welchs' corrections and Games-Howell post hoc were utilized to identified significant differences. Correlation between physical performance variables according age category were assessed with Spearman test.

Effect sizes (d) were classified as trivial (d<0.2), small (0.2<d<0.6), moderate (0.6<d<1.2), large (1.2<d<2.0), very large (2.0<d<4.0), nearly perfect (d>4.0). Significance was set at $p < 0.05$. Statistical analyses were performed using JAMOVI 1.6.8 version and Statistical Package for the Social Science (SPSS, IBM Corporation®, New York, USA) 26 version.

Results

Descriptive values of the dependent variables of physical performance were presented in Table 1. The age categories present differences in height ($F_{(2,119)} = 7.34$; $p = 0.001$), weight ($F_{(2,119)} = 13.70$; $p = <0.001$), Sprint 10m ($F_{(2,116)} = 34.82$; $p = <0.001$), Sprint 20m ($F_{(2,116)} = 6.87$; $p = 0.002$), COD test ($F_{(2,83)} = 49.20$; $p = <0.001$), RSA_a ($F_{(2,112)} = 31.65$; $p = <0.001$), RSA_b ($F_{(2,112)} = 38.79$; $p = <0.001$), YoYo IR1 ($F_{(2,117)} = 60.63$; $p = <0.001$) and CMJ ($F_{(2,89)} = 32.67$; $p = <0.001$). Specifically, U20 players was taller than U15 ($p = 0.001$).

Results identified which U15 players has lower body mass than other categories (U17: $p = 0.001$; U20: $p = <0.001$). In sprint 10-m performance, U15 players were faster than U17 and U20 players ($p = <0.001$) and for sprint 20-m performance U17 category was faster when compared with the other categories ($p = 0.008$).

For COD ability, results were favorable for U20 players (U15: $p = 0.001$; U17: $p = <0.001$) and U15 has worse performance (U17: $p = 0.018$; U20: $p = <0.001$). Performance for RSA variables, U20 players had better performance ($p \leq 0.001$), followed by U17 and U15 players.

Likewise, performance in Yo-Yo IR1 were better for U20 players ($p \leq 0.001$), followed by U17 and U15 players. Jump performance was higher for U20 players. Other physical performance variables no presented significant differences. Differences and effect size in physical performance were presented in Figure 1.

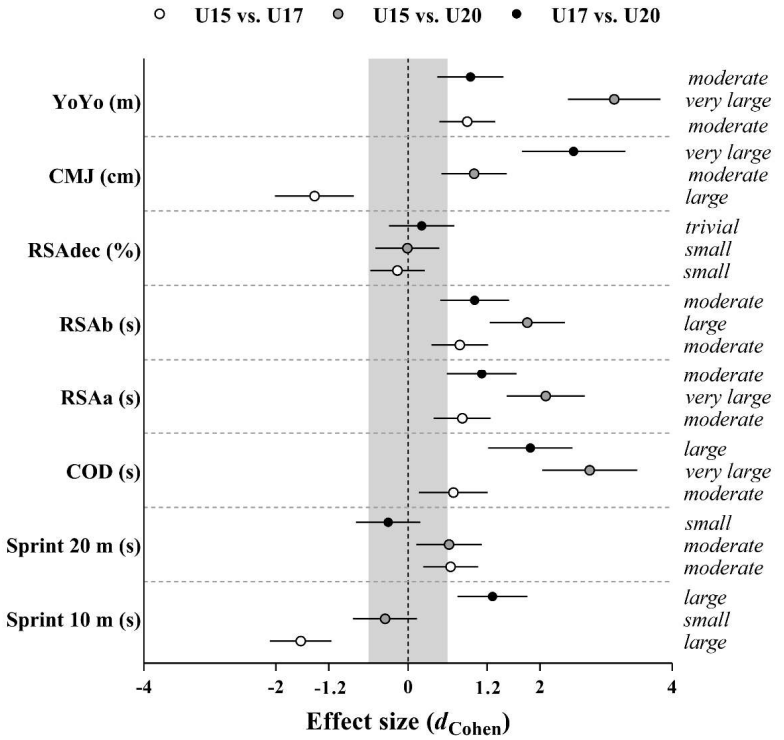

Figure 1. Differences in physical performance among age categories of soccer players. RSAa = repeated-sprint ability average; RSAb = repeated-sprint ability best; RSAdec% = repeated-sprint ability decrease; FI = fatigue index; COD = change of direction ability; CMJ = countermovement jump; Yo-Yo IR1 = Yo-Yo intermittent recovery level 1.

Table 1. Differences in body mass, height, and physical fitness between players' position.

Variables	Age categories		
	U15 (n = 46)	U17 (n = 48)	U20 (n = 28)
Height (cm)	169.57 ± 6.54	172.10 ± 6.57	175.96 ± 8.23[a]
Body mass (kg)	60.61 ± 8.74	66.69 ± 7.27[a]	70.29 ± 8.37[a]
Sprint 10-m (s)	1.56 ± 0.11	1.77 ± 0.14[a]	1.60 ± 0.11[b]
Sprint 20-m (s)	2.88 ± 0.28	2.60 ± 0.56[a]	2.73 ± 0.13[a]
COD ability (s)	16.15 ± 0.54	15.76 ± 0.60[a]	14.78 ± 0.44[a,b]
RSA_a (s)	7.87 ± 0.40	7.53 ± 0.42[a]	7.13 ± 0.24[a,b]
RSA_b (s)	7.48 ± 0.44	7.14 ± 0.41[a]	6.79 ± 0.23[a,b]
RSA_{dec} (%)	4.99 ± 3.72	5.49 ± 2.36	5.02 ± 2.12
FI (%)	-10.62 ± 4.60	-12.14 ± 6.35	-10.09 ± 3.69
CMJ (cm)	34.57 ± 3.88	29.17 ± 3.62[a]	38.39 ± 3.71[a,b]
Yo-Yo IR1 (m)	637.57 ± 130.25	911.25 ± 407.40[a]	1260.77 ± 284.67[a,b]

Notes. RSAa = repeated-sprint ability average; RSAb = repeated-sprint ability best; RSAdec% = repeated-sprint ability decrease; FI = fatigue index; COD = change of direction ability; CMJ = countermovement jump; Yo-Yo IR1 = Yo-Yo intermittent recovery level 1. Differences between players' categories: [a] U15 and [b] U17. Significant value: $P \leq 0.05$.

Figures 2, 3, and 4 describe the relationship between different capabilities for U15, U17, and U20, respectively. We observed that the number of significant relationships progressively reduced with increasing age category. For U15, we observed a significant correlation between 10-m, 20-m, and RSAa, RSAb, and RSAdec, and between COD ability, Yo-Yo IR1, and CMJ height (Figure 2). For U17, there was a significant correlation between performance in the 20-m sprint and COD ability (Figure 3). For U20, we did not observe a significant correlation between these attributes (Figure 4). These relationships were not significant in the U17 and U20 age categories.

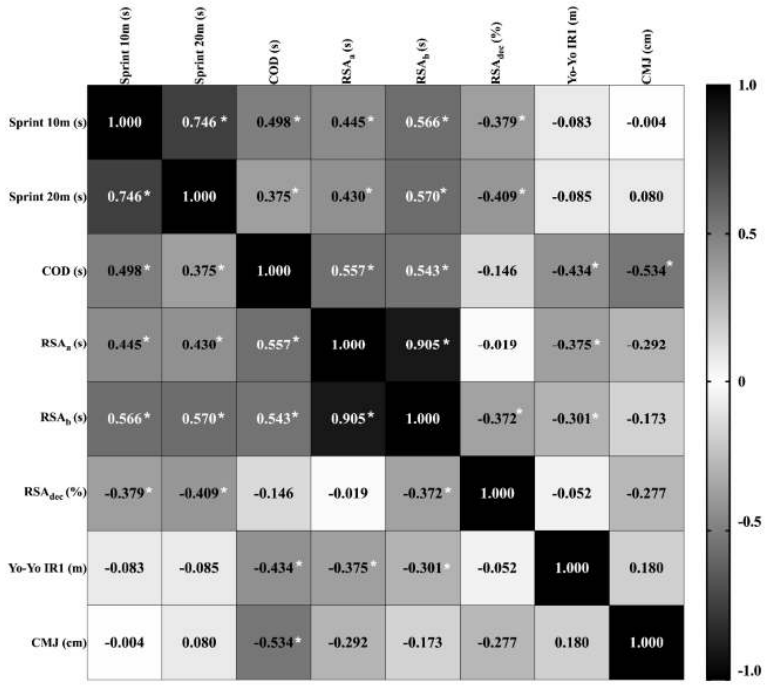

Figure 2. Relationship between physical performance variables for U15. *Significant relationship between variables ($p \leq 0.05$).

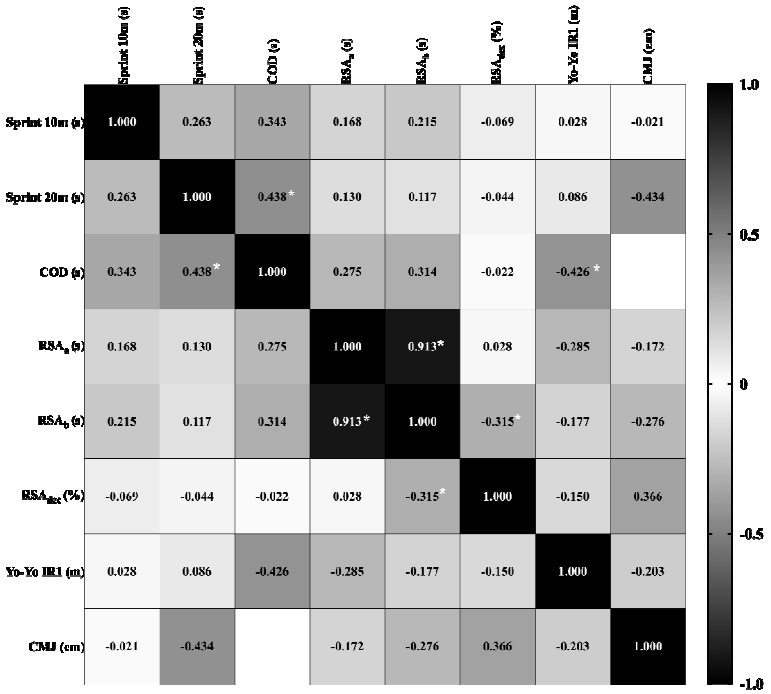

Figure 3. Relationship between physical performance variables for U17. *Significant relationship between variables ($p \leq 0.05$).

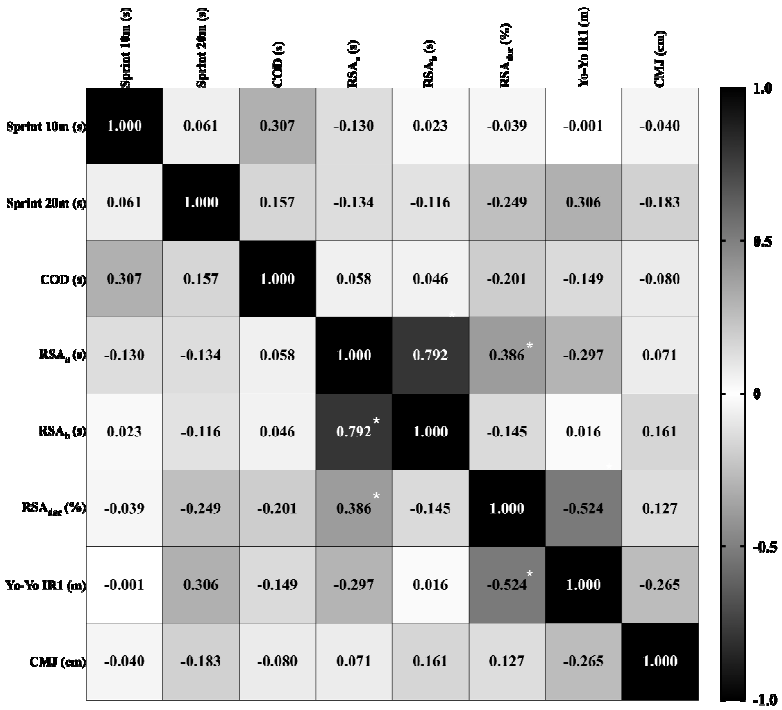

Figure 4. Relationship between physical performance variables for U20. *Significant relationship between variables ($p \leq 0.05$).

Discussion

The purpose of the presented study is to compare if physical performance is influence by age categories and explore the correlation between the different physical performance for each age category. The main results observed were that 1) U17 and U20 players had better performance in sprint 20-m, RSA, COD ability, and Yoyo IR1 distance than U15 elite soccer players; therefore, these attributes seem improve parallel to the specialization

process in young soccer players; 2) we observe that the strength of the relationships between speed-abilities, COD ability, power, anaerobic and aerobic capacities is progressively reduced with the process of specialization. These results suggest that the magnitude of adaptations in each of these attributes is not linear and professional coaches should consider age categories specifics performance.

In the present study, we observed that U15 players were faster in the 10-m sprint than U17, but with no difference when compared to U20. For the 20-m sprint, U17 and U20 were faster than U15. Our findings are partially in line with previous studies, which reported that at short distances, U15 players were faster than U17, U20 and seniors (I. Loturco et al., 2018). However, for longer distances (e.g., 20-m), there was increased progressively during the specialization process (Kobal et al., 2016; I. Loturco et al., 2018). Our findings can be explained, at least in part, by the interference phenomenon caused by the gradual increase in soccer-specific training content (ie, aerobic demand) from earlier to later stages of specialization (Docherty & Sporer, 2000; Loturco et al., 2020; Loturco et al., 2015). This explanation is supported by the gradual increase in the performance of the RSAa, RSAb, and Yo-Yo-IR1 test, which illustrate an improvement in the anaerobic/aerobic capacity. Although plausible, future investigations should focus on the effects of the proportion of each type of training (i.e., speed, power, anaerobic/aerobic) throughout the specialization process to test such hypotheses in young soccer players.

About the COD ability, we observed that there was a gradual improvement from U15 to U17 and U17 to U20 age categories. Our results disagree with a previous study that did not observe differences between U15, U17, and U20 for COD ability performance (Loturco et al., 2020). On the contrary, it was observed that senior soccer players had worse COD ability than young age categories (Loturco et al., 2020). Such divergences between our results and previous findings may be in the characteristics of the training in each study (and therefore the soccer club). For example, COD ability appears to be improved by sessions that include specific COD workouts in soccer players' training routines (e.g., acceleration and deceleration drills, planned, and unplanned agility tasks) (Irineu Loturco et al., 2018; Young et al., 2015). It is plausible to suggest that the soccer club in which the evaluations in the present study were carried out may have dedicated training sessions aimed at improving this skill. This explanation is supported by studies that suggest that was no improvement in overall performance when only technical-tactical training is performed (Jeffreys et al., 2018; Staynor et al., 2017). Therefore, reinforcing the important role of sessions aimed at improving this important skill; since that the COD ability is one of the essential characteristics for a top-level league and was the capacity that best discriminant young players selected or not selected to play in professional teams (Loturco et al., 2020).

Repeated-sprint performance (i.e., RSA) is believed to be a significant predictor of match physical performance in professional adult soccer players (Rampinini et al., 2007). In young soccer players, this seem occurs and may be influenced by maturational status (Mendez-Villanueva et al., 2011). In our study, U20 players were better performance in RSA than other categories. Likewise, Sánchez-Sánchez et al. (2019) identified better sprint times in the U16 and U18 players than the U14 players, and fatigue measures (RSAchange% and RSAdec%) were similar between categories. Similar results were indicated that the categories U17 and U18 have higher performance in RSA average than younger categories (Buchheit et al., 2010). This gradual improvement, as mentioned above, may be due to the increase in soccer-specific training content that occurs with the specialization process (Loturco et al., 2020; Loturco et al., 2015). These stimuli, when occupying most of the training, can contribute to improvement in RSA performance, as well as in the distance covered in the Yo-Yo IR1 test. Parallel to this, the maturation process can contribute to development of these attributes.

Regarding the relationships between the different attributes observed in the present study, we found a gradual reduction in the number and strength of relationships in the U15 category, for U17 and for U20. For example, at U15 we observed a significant relationship between 10-m and 20-m time and COD ability (r = 0.49, r = 0.37, respectively). For U17 players, there was a significant relationship between 20-m performance and COD ability (r = 0.43). For the U20, these relationships were not significant (see Figure 4). These results indicate that the adaptations that take place in parallel to the specialization process do not occur with the same pattern and/or magnitude. For example, in the present study the 20-m performance was better in U17 and U20 than U15 categories; however, no differences between U17 and U20 were observed for 20-m, suggesting a plateau. On the other hand, the performance on COD ability was higher on U17 than U15, and it was also higher on U20 than U17, suggesting a gradual improvement along the specialization process. Such divergent changes between these attributes can explain the reduced strength of the relationship between these attributes. This divergent behavior can be due to the characteristics of the training and maturation process. Future studies may investigate which factor is decisive to optimize the different attributes, such as acceleration, velocity, COD ability, RSA in the different age categories.

Conclusions

In summary, this study revealed that the physical attributes that discriminated different age categories were 20-m time, RSA, COD ability, and distance performed on the Yo-Yo IR1. More precisely, U20 soccer players qualified best scores than U15 and U17 (except for 20-m). Interestingly, the strength of the relationships

between these parameters reduced in parallel with the specialization process—i.e., from U15 to U17, and from U17 to U20 In contrast, it was carried out with 122 of higher-level young soccer players of three different age categories who trained in the same soccer club, following the similar technical, physical, and tactical training programs. This reinforces the applicability and relevance of our findings.

Practical applications

From our results, it can be inferred that the 20-m performance, RSA, COD ability and distance performed on the Yo-Yo IR1 become less correlated with categories progression. Soccer players in the U17 and U20 categories present better scores in these capabilities than U15 peers. Furthermore, we observe that the strength of the relationships between acceleration, velocity, COD ability, power, anaerobic, and aerobic capabilities is progressively reduced with the process of specialization. These attributes seem to present adaptations of different changes patterns and magnitude as players approach the professional/adult category (i.e., U20). From this findings, strength and conditioning professionals can use these performance indicators to assist in setting up age category specific training programs.

Conflicts of interest

We declare not have any conflicts of interest to declare.

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