

## Article

# Relationships between Players' Physical Performance and Small-Sided Game External Responses in a Youth Soccer Training Context

Daniel Castillo , Angel Lago-Rodríguez \* , Marta Domínguez-Díez, Silvia Sánchez-Díaz , Tara Rendo-Urteaga , María Soto-Célix and Javier Raya-González 

Faculty of Health Sciences, Universidad Isabel I, 09003 Burgos, Spain; daniel.castillo@ui1.es (D.C.); marta.dominguez.diez@ui1.es (M.D.-D.); silvia.sanchez2467@ui1.es (S.S.-D.); tara.rendo@ui1.es (T.R.-U.); maria.soto@ui1.es (M.S.-C.); javier.raya@ui1.es (J.R.-G.)

\* Correspondence: angel.lago@ui1.es

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**Abstract:** The aim of this study was twofold: 1) To compare players' physical performance and small-sided game (SSG) external responses among three young soccer age categories (i.e., under 14 (U14), under 16 (U16), and under 18 (U18)); and 2) to examine their relationships among physical performance and SSG external responses in each age category. Players' physical performance was evaluated via several tests and external responses were collected during a four vs. four plus goalkeepers SSG. Main results showed that while older players presented better linear straight sprinting tests (LSSTs) (U18 and U16 vs. U14,  $p < 0.01$ ), repeated sprint ability (RSA) (U18 vs. U16 and U14  $p < 0.01$ ), and change of direction ability (CODA) (U18 and U16 vs. U14,  $p < 0.01$ , ES = 2.34–2.72) performances, these differences were not consistent with their SSG external responses (U16 vs. U14,  $p < 0.01$ ; U18 vs. U16,  $p < 0.01$ ). Conversely, higher number of associations between players' physical performance and SSG external responses were found in younger players in comparison to the older ones. These results suggest that while greater physical performance in younger players (i.e., U14) could allow them to exhibit higher external responses, greater physical performance did not influence older players' (i.e., U18) SSG external responses.

**Keywords:** associations; physical fitness; external loads; training tasks; football

## 1. Introduction

Soccer practice imposes high physical demands on players, in terms of total distance covered at high-running velocities (i.e.,  $>21 \text{ km} \cdot \text{h}^{-1}$ ) and specific short-term and high-intensity actions, which could be a key factor to successfully developing soccer competence [1]. Literature has highlighted the importance of the experience and/or age of the players during match-play due to its influence over match-play external responses [2]. In this context, as the age of the players increases, external responses tend to decrease when senior soccer players are analyzed [3,4]. However, the older the players, the greater their responses in match-play in youth soccer [5,6]. As such, some studies have shown that older youth players (i.e., under 16 (U16)–under 18 (U18)) covered significantly more distance and distance at high speeds in comparison with younger players, in youth soccer academies [7]. In this sense, Saward et al. [8] reported that under 9–12 players (U9–U12) covered a total distance per minute lower than  $100 \text{ m} \cdot \text{min}^{-1}$ , while under 13–14 players (U13–U14) covered around  $110 \text{ m} \cdot \text{min}^{-1}$  and under 15–18 players (U15–U18) covered  $110\text{--}116 \text{ m} \cdot \text{min}^{-1}$  during matches. Moreover, Al Haddad et al. [9] observed higher peak velocity for U18 players ( $26.8 \text{ km} \cdot \text{h}^{-1}$ ) in comparison to U13 counterparts ( $23.4 \text{ km} \cdot \text{h}^{-1}$ ) during official match-play. Also, Harley et al. [10] presented that U16 players covered

higher sprinting distance than their U12 counterparts during official matches. Taking into account that age could modify external responses across categories, it seems necessary to organize training stimuli across soccer age categories in order to minimize the impact of soccer competition and, consequently, to establish the appropriate recovery strategies to optimize athletes' physical performance [7].

Small-sided games (SSGs) have become the main training task used by coaches to periodize soccer training, mainly due to evidence suggesting that these training drills improve players' physical condition [11] and their technical and tactical abilities [12]. SSGs lead players to experience similar situations to real match-play but in reduced playing spaces [13]. In addition, SSGs have been used as a talent identification tool in youth players, since they allow coaches to assess players' soccer expertise by means of the subjective evaluation of players' skills [14]. Moreover, the evaluation of running activities during SSGs across different age categories would help coaches to better design these tasks. However, only one study has recently quantified external responses during SSGs without varying the numerical structure of the SSG across age categories [15]. As such, previous researchers have shown that older youth players are imposed to higher external responses than younger ones in terms of total distance [16], while no significant differences were observed in the distance covered at high-speeds [17], however these studies were carried out in SSGs characterized by using numerical superiority. These aforementioned research works explain that external responses exhibited by players during SSGs have been associated with age. Thus, it would be relevant to know whether the same SSG could lead to different external responses among youth players from different age categories, in order to provide coaches with a better understanding of the training process aimed at maximizing on-field performance within each age category [18].

Given that soccer is a highly demanding team sport, players need to reach an optimal physical condition, even in the early stages, in order to cope with match-play demands and ensure players' soccer competence during game development [7], and indeed to reduce the possibility of injury risk [19]. This becomes even more relevant in youth soccer populations, since previous research has shown the necessity of an adequate level of physical conditioning, which may allow youth players to be promoted at professional levels [20]. Accordingly, one special concern of coaches is to assess the influence of the players' initial physical performance on subsequent external response shown during games and training tasks [21]. This knowledge could provide relevant information in terms of whether certain tasks are insufficient for players to achieve an expected intensity, or instead, are too demanding for some players. Unfortunately, there is no consensus in previous studies regarding what specific level of performance during physical testing would imply greater performance during match-play and SSGs [22,23]. Whereas some authors have reported a significant association between sprinting, repeated sprint ability (RSA) and the endurance capacity with match-play and SSG running performance [21,24,25]; other researchers did not report significant correlations between results from physical testing (e.g., endurance incremental test, sprinting) and performance during matches or SSGs [21,26]. To date, no scientific study has established a distinction for these associations among different age categories in a youth soccer context.

From a practical approach, it would be interesting to analyze the influence of players' physical performance on their external responses during training tasks across age categories, so that coaches could better establish the more appropriate individual stimulus for each player [18]. Therefore, the aim of this study was twofold: (1) To compare players' physical performance and small-sided game (SSG) external responses among three soccer age categories (i.e., U14, U16, and U18); and (2) to examine the relationships among physical performances and SSG external responses for each age category. The hypotheses of the study were as follows: (1) Older players exhibit better physical performances; (2) older players show higher SSG external responses than younger ones; and (3) sprinting and RSA tests are related to distance covered at high velocities during SSGs for all categories.

## 2. Materials and Methods

### 2.1. Participants

Forty-eight young soccer players aged between 13 and 18 years (age:  $15.82 \pm 1.80$  years, height:  $167.2 \pm 11.6$  cm, body mass:  $58.41 \pm 10.57$  kg, body mass index (BMI)  $20.78 \pm 2.37$  kg·m<sup>-2</sup>, %Fat:  $18.81 \pm 5.93$ ) took part in the study. Players were classified according to their age into three groups: Under 14 years (U14, age:  $13.94 \pm 0.25$  years, height:  $156.6 \pm 10.3$  cm, body mass:  $50.41 \pm 9.57$  kg, BMI:  $20.50 \pm 3.07$  kg/m<sup>-2</sup>, %Fat:  $24.41 \pm 4.50$ ); under 16 years (U16, age:  $15.71 \pm 0.47$  years, height:  $170.4 \pm 5.9$  cm, body mass:  $59.49 \pm 7.84$  kg, BMI:  $20.41 \pm 1.79$  kg·m<sup>-2</sup>, %Fat:  $15.72 \pm 3.01$ ); and under 18 years (U18, age:  $18.07 \pm 0.73$  years, height:  $176.0 \pm 7.6$  cm, body mass:  $66.49 \pm 7.19$  kg, BMI:  $21.47 \pm 1.95$  kg·m<sup>-2</sup>, %Fat:  $15.51 \pm 3.43$ ). Participants belonged to the same soccer academy whose teams competed at the maximum competitive level for each age category. Training hours (h) of practice per week were 4.5 h for U14, 6.0 h for U16, and 7.5 h for U18 players. The inclusion criteria were: (1) To be enrolled for playing official competitions with the club involved in this investigation; (2) to be part of the normal training sessions; and (3) not having experienced any muscular or skeletal injuries during a month prior to the assessment. Although goalkeepers participated in this study playing in the SSGs, they were excluded from the statistical analysis due to their special role. Participants and parents or tutors were informed of the procedures, methods, benefits, and possible risks of participating in the study before giving their written informed assent (players) or consent (parents). They were also informed of their right to voluntarily withdraw from the study at any given time. The sample was made up for all players from the different age categories that met the inclusion criteria and they (or their parents) signed the prior informed consent. This investigation was performed in accordance with the Declaration of Helsinki (2013) and was approved by the Ethics Committee of the University (Code: FU11-PI002) before recruitment.

### 2.2. Procedures

We used a comparative and correlational design to describe, compare, and examine the associations between physical performance during testing sessions and physical responses during SSGs across different young age categories. The use of SSGs was adopted due to the following reasons: (1) This tool allows for youth soccer-specific skill proficiency to be assessed for talent identification purposes [14]; and (2) similar playing spaces are commonly used with players aged between 12 and 18 years old. Players' physical performance was evaluated, in this order, by linear straight sprinting tests (LSST), RSA, and change of direction ability (CODA). Each player performed the LSST over a distance of 40 m, the RSA and the 505 change of direction test (i.e., 505-COD) interspersed with 5 min of active recovery. Soccer players were previously familiarized with the different physical performance tests throughout 6 weeks of the preseason. Three days after physical testing, the SSGs were carried out, and data from SSG external responses were collected using global positioning systems (GPS) as measures of total distance (TD), distance and number of actions at different speeds, and total number of accelerations and decelerations at different intensities. Soccer players were previously familiarized with the use of GPS devices during the previous month to the investigation. Prior to the physical assessments and SSGs, players undertook a 20-min standardized warm-up, consisting of 5 min of slow jogging, followed by 8 min of strolling locomotion and finishing with 7 min of progressive sprints and accelerations. Players were advised not to perform any type of physical exercise during the 48 h preceding both physical testing and SSG sessions, and participants were given advice about diet and hydration guidelines. All tests and SSGs were performed in the afternoon (6–8 pm) on an outdoor soccer pitch (17–22 °C, 60–70% humidity).

### 2.3. Physical Performance Measures

*Linear straight sprinting test (LSST).* Participants performed 2 maximal sprint trials of 40 m length (i.e., SPR40), interspersed with a 90 s rest period between sprints, and split times were recorded at 5 m (i.e., SPR5) and 10 m (i.e., SPR10) [27]. Players' starting position was 0.5 m behind the first timing gate

(Microgate Polifemo, Bolzano, Italy) placed 0.4 m above the ground. Time recording was automatically activated as participants passed the first gate; that is, at the 0 m line, and they were asked to run as fast as possible to the finish by crossing the line located at 40 m. The fastest trial for each distance was used for further analysis. The software Witty Manager (Microgate™, Bolzano, Italy) was used to download the sprint test data.

*Repeated Sprint Ability (RSA).* The RSA test consisted of 5 maximal sprints of 30 m with 30 s of active recovery, according to the procedures developed by Castagna et al. [28]. As such, a maximal effort was required in each sprint bout and strong verbal encouragement was provided by coaches and researchers throughout all the 5 × 30 m trials. The sprint time was measured using two photoelectric cells (Microgate™, Bolzano, Italy) set at 0 m and 30 m. As indicators of RSA performance, the best sprint time (i.e., RSAbest) and the sum of sprint times (i.e., RSAtotal) were considered [29].

*Change of Direction Ability (CODA).* The test used to evaluate the CODA was the 505-COD test, which consisted of players, after running 10 m without the ball, sprinting forward to a line 5 m ahead and pivoting 180° before returning to the start position [30]. A photocell (Microgate™, Bolzano, Italy) located over the start/finish line was used to record the time. The recovery time between trials was 90 s rest.

#### 2.4. Small-Sided Game (SSG)

The SSG was played as a four-a-side plus goalkeepers in which players had to defend/attack an official soccer-goal. This SSG was played in a 30 m-length and 20 m-width pitch size, that is, a playing area of 600 m<sup>2</sup> and an individual interaction space of 75 m<sup>2</sup> per player [14]. The relative pitch proportions were kept constant and had the same length-to-width ratio as an official soccer field (i.e., 1.46). Players completed 4 bouts of 4 min, with a 3 min passive rest break between bouts [31]. The team was organized in four squads according to offensive/defensive roles (one goalkeeper, two defensive players and two offensive ones) and the same players always played against the same opponents [32]. All players received standardized instructions on the purpose of the game, which was to win each bout as a normal competitive match. Coaches did not provide any strategic or tactical feedback. Minor rule modifications were applied, including playing without the off-side rule, restarting the game after a goal by the goalkeeper, and awarding kick-ins to the opposing side of the player who last touched the ball [31].

#### 2.5. External Responses

External responses encountered by players during SSG were assessed using GPS devices (WIMU PRO™, RealTrack Systems, Almería, Spain) operating at a sampling frequency of 10 Hz, as previous authors reported with youth soccer players [32]. Participants wore a fitted body vest, in which a GPS device was inserted in the pocket located at the back of a purpose-built harness throughout the SSGs. The microsensor devices were activated 15 min before the start of each testing session, following the manufacturer's guidelines. Data were downloaded to a computer after the SSG protocol and analyzed offline using a customized software package (WIMU SPRO, Almería, Spain). The validity and reliability of these devices have been reported to be used with soccer players [33]. The TD covered was taken as a key outcome measure with further distance measures derived for different high-intensity actions at different speeds previously used in youth soccer players [32]: Cruising (14.1–21.0 km·h<sup>−1</sup>) and sprinting (>21.0 km·h<sup>−1</sup>). In addition, number of sprints (>21 km·h<sup>−1</sup>) and maximum velocity (Vel<sub>max</sub>) were registered. Also, the number of accelerations (Acc) and decelerations (Dec) and their intensity categories were recorded as in a previous study [34]: low-intensity acceleration (LAcc; 1–2.5 m·s<sup>−2</sup>), medium-intensity acceleration (MAcc; 2.5–4 m·s<sup>−2</sup>), high-intensity acceleration (HAcc; >4 m·s<sup>−2</sup>), low-intensity deceleration (LDec; −1/−2.5 m·s<sup>−2</sup>), medium-intensity deceleration (MDec; −2.5/−4 m·s<sup>−2</sup>), and high-intensity deceleration (HDec; <−4 m·s<sup>−2</sup>).

#### 2.6. Statistical Analysis

Data are presented as mean ± standard deviations (SD). Normality of data distribution and homogeneity of variances were tested using the Kolmogorov–Smirnov and Levene tests,

respectively. All analyzed variables had a normal distribution, and parametric techniques were applied. The coefficient of variation (CV) was used to assess the variability of each physical performance test and SSG external variables for each category by the formula  $CV = (SD \cdot \text{mean}^{-1}) \times 100$ . A one-way analysis of variance (ANOVA) with a least significant difference post hoc comparison (Bonferroni correction) was used to examine physical performances and SSG external responses mean differences among age categories (i.e., U14, U16 and U18). Practical significance was assessed by calculating Cohen's effect size (ES) [35]. ES of above 0.8, between 0.8 and 0.5, between 0.5 and 0.2, and lower than 0.2 were considered as large, moderate, small, and trivial, respectively. Paired comparisons among age categories for each variable were expressed using mean differences, calculated as: Mean difference (%) = ((mean 1 – mean 2)/mean 2)  $\times$  100. Pearson's product-moment correlation coefficient ( $r$ ) with a 90% confidence interval (CI) was used to examine the relationship between physical test and physical SSG responses for each age-level group. The following scale of magnitudes was used to interpret the correlation coefficients: <0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; and >0.9, nearly perfect [36]. If the 90% confidence limits (CLs) overlapped small positive and negative values, the magnitude was deemed unclear; otherwise, the magnitude was deemed to be the observed magnitude [36]. Data analysis was carried out using the IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set at  $p < 0.05$ .

### 3. Results

Results observed for the players' physical performances among age categories are shown in Table 1. U14 players obtained the worst performance for the LSST ( $p < 0.01$ ; ES = 1.32–4.54), RSA ( $p < 0.01$ ; ES = 2.66–3.89) and CODA ( $p < 0.01$ ; ES = 2.34–2.72) in comparison with U16 and U18 players. In addition, U16 players presented worst performance in the SPR40 ( $p < 0.01$ ; ES = 1.26) and RSAbest ( $p < 0.05$ ; ES = 0.91) compared to U18 players.

Results obtained for the players' SSG external responses among categories are shown in Table 2. U14 players showed lower HAcc ( $p < 0.05$ ; ES = 0.98) in comparison to U16 players. Moreover, U14 players covered less distance at sprinting intensity ( $p < 0.05$ ; ES = 0.84) and performed a lower number of sprints ( $p < 0.05$ ; ES = 0.91) and HAcc ( $p < 0.01$ ; ES = 1.46), and higher LAcc ( $p < 0.05$ ; ES = 1.20) compared to U18 players. No significant differences ( $p > 0.05$ ) in physical demands were observed between U16 and U18 soccer players.

Tables 3 and 4 show the relationships between players' physical performance and SSG external responses shown by youth soccer players. For U14 category, players who performed a higher number of sprints during SSGs were faster at SPR5, SPR10, SPR40, and 505-COD tests ( $r = -0.57/-0.65$ ;  $\pm 0.31-0.27$ , large,  $p < 0.05-0.01$ ). In addition, higher TD and distance covered at cruising and sprinting negatively correlated with SPR40 ( $r = -0.50/-0.64$ ;  $\pm 0.34-0.27$ , large,  $p < 0.05-0.01$ ). Moreover, U14 players who were faster in SPR5 covered higher distance cruising and achieved higher  $Vel_{max}$  ( $r = -0.53/-0.56$ ;  $\pm 0.32-0.31$ , large,  $p < 0.05$ ). Likewise, greater HAcc during SSG were associated with faster SPR5 and SPR10 ( $r = -0.56/-0.64$ ;  $\pm 0.31-0.27$ , large,  $p < 0.01$ ). On the other hand, greater distance covered at cruising correlated with RSA performances ( $r = -0.53/-0.67$ ;  $\pm 0.32-0.26$ , large,  $p < 0.05-0.01$ ). Additionally, players who presented worse performance in RSAmean and 505-COD performed higher LDec and LAcc ( $r = 0.51/0.62$ ;  $\pm 0.33-0.29$ , large,  $p < 0.05-0.01$ ), respectively. For the U16 category, players who were faster in SPR10 covered greater TD and distance at cruising during SSG ( $r = -0.60/-0.64$ ;  $\pm 0.29-0.27$ , large,  $p < 0.05$ ), and those players with better performance in SPR40 covered greater TD ( $r = -0.56$ ;  $\pm 0.31$ , large,  $p < 0.05$ ). For the U18 category, no significant ( $p > 0.05$ ) associations were observed.

**Table 1.** Differences in the players' physical performance among age categories.

|              | U14 (n = 16)     |        | U16 (n = 16)     |        | U18 (n = 16)     |        | Pair Comparisons (Mean Differences %; ES, Interpretation) |                       |                      |
|--------------|------------------|--------|------------------|--------|------------------|--------|-----------------------------------------------------------|-----------------------|----------------------|
|              | Mean $\pm$ SD    | CV (%) | Mean $\pm$ SD    | CV (%) | Mean $\pm$ SD    | CV (%) | U14 vs. U16                                               | U14 vs. U18           | U16 vs. U18          |
| LSST         |                  |        |                  |        |                  |        |                                                           |                       |                      |
| SPR5 (s)     | 1.14 $\pm$ 0.06  | 2.85   | 1.06 $\pm$ 0.07  | 4.37   | 1.04 $\pm$ 0.07  | 1.90   | 7.61; 1.32, large **                                      | 9.13; 1.55, large **  | 1.41; 0.22, small    |
| SPR10 (s)    | 2.00 $\pm$ 0.08  | 1.96   | 1.78 $\pm$ 0.09  | 2.68   | 1.73 $\pm$ 0.09  | 1.58   | 12.45; 2.54, large **                                     | 15.17; 3.12, large ** | 2.42; 0.46, small    |
| SPR40 (s)    | 6.34 $\pm$ 0.27  | 0.94   | 5.55 $\pm$ 0.25  | 0.82   | 5.26 $\pm$ 0.21  | 0.80   | 14.25; 3.04, large **                                     | 20.54; 4.54, large ** | 5.50; 1.26, large ** |
| RSA          |                  |        |                  |        |                  |        |                                                           |                       |                      |
| RSAbest (s)  | 5.15 $\pm$ 0.21  | 2.29   | 4.58 $\pm$ 0.22  | 2.15   | 4.38 $\pm$ 0.20  | 2.67   | 12.58; 2.66, large **                                     | 17.56; 3.71, large ** | 4.42; 0.91, large *  |
| RSAtotal (s) | 26.57 $\pm$ 1.15 | 0.44   | 23.54 $\pm$ 1.07 | 0.42   | 22.75 $\pm$ 0.82 | 0.52   | 12.90; 2.74, large **                                     | 16.83; 3.89, large ** | 3.48; 0.84, large    |
| CODA         |                  |        |                  |        |                  |        |                                                           |                       |                      |
| 505-COD (s)  | 2.52 $\pm$ 0.13  | 1.90   | 2.30 $\pm$ 0.06  | 2.25   | 2.24 $\pm$ 0.08  | 2.99   | 9.41; 2.34, large **                                      | 12.67; 2.72, large ** | 2.98; 0.93, large    |

ES: Effect size; SD: Standard deviation; CV: Coefficient of variation; LSST: Linear straight sprinting tests; SPR5: Time to cover a distance of 5 m; SPR10: Time to cover a distance of 10 m; SPR40: Time to cover a distance of 40 m; RSA: Repeated sprint ability; CODA: Change of direction ability. \* Significant level set at  $p < 0.05$ ; \*\* Significant level set at  $p < 0.01$ .

**Table 2.** Differences in the physical demands encountered by soccer players in a small-sided game among age categories.

|                                            | U14 (n = 16)     |        | U16 (n = 16)     |        | U18 (n = 16)     |        | Pair Comparisons (Mean Differences %; ES, Interpretation) |                       |                      |
|--------------------------------------------|------------------|--------|------------------|--------|------------------|--------|-----------------------------------------------------------|-----------------------|----------------------|
|                                            | Mean $\pm$ SD    | CV (%) | Mean $\pm$ SD    | CV (%) | Mean $\pm$ SD    | CV (%) | U14 vs. U16                                               | U14 vs. U18           | U16 vs. U18          |
| TD (m)                                     | 1762 $\pm$ 108   | 6.11   | 1696 $\pm$ 248   | 39.37  | 1713 $\pm$ 94    | 31.14  | 3.90; 0.37, small                                         | 2.88; 0.49, moderate  | 0.00; 0.10, trivial  |
| High-intensity actions at different speeds |                  |        |                  |        |                  |        |                                                           |                       |                      |
| Cruising (m)                               | 194 $\pm$ 85     | 43.62  | 235 $\pm$ 88     | 46.54  | 208 $\pm$ 71     | 42.03  | 17.30; 0.47, small                                        | 6.50; 0.17, trivial   | 13.06; 0.34, small   |
| Sprinting (m)                              | 4 $\pm$ 6        | 145.10 | 8 $\pm$ 7        | 216.89 | 10 $\pm$ 9       | 211.80 | 47.50; 0.55, moderate                                     | 61.14; 0.84, large *  | 25.98; 0.32, small   |
| Sprints (n)                                | 1 $\pm$ 1        | 106.07 | 2 $\pm$ 1        | 308.68 | 2 $\pm$ 2        | 341.81 | 15.05; 0.90, large                                        | 4.09; 0.91, large *   | 12.90; 0.12, trivial |
| Vel <sub>max</sub> (km·h <sup>-1</sup> )   | 21.96 $\pm$ 3.33 | 15.16  | 22.42 $\pm$ 1.35 | 24.02  | 23.30 $\pm$ 2.08 | 21.80  | 2.04; 0.20, small                                         | 5.73; 0.49, small     | 3.76; 0.51, moderate |
| Short-term and high-intensity actions      |                  |        |                  |        |                  |        |                                                           |                       |                      |
| Acc (n)                                    | 279 $\pm$ 32     | 11.57  | 269 $\pm$ 48     | 39.00  | 256 $\pm$ 21     | 28.52  | 3.83; 0.26, small                                         | 8.91; 0.86, large     | 4.89; 0.37, small    |
| Dec (n)                                    | 268 $\pm$ 27     | 10.05  | 264 $\pm$ 51     | 40.14  | 255 $\pm$ 21     | 28.36  | 1.48; 0.10, trivial                                       | 5.17; 0.55, moderate  | 3.64; 0.26, small    |
| LAcc (n)                                   | 215 $\pm$ 29     | 13.69  | 201 $\pm$ 38     | 38.68  | 185 $\pm$ 21     | 28.31  | 7.09; 0.42, small                                         | 16.45; 1.20, large *  | 8.74; 0.54, moderate |
| MAcc (n)                                   | 57 $\pm$ 9       | 15.89  | 57 $\pm$ 12      | 35.40  | 59 $\pm$ 10      | 26.70  | 0.00; 0.00, trivial                                       | 2.38; 0.14, trivial   | 2.38; 0.13, trivial  |
| HAcc (n)                                   | 7 $\pm$ 3        | 50.36  | 11 $\pm$ 5       | 87.22  | 13 $\pm$ 5       | 110.05 | 37.42; 0.98, large *                                      | 48.23; 1.46, large ** | 17.28; 0.45, small   |
| LDec (n)                                   | 191 $\pm$ 21     | 10.98  | 185 $\pm$ 38     | 40.24  | 183 $\pm$ 24     | 29.06  | 2.92; 0.18, trivial                                       | 4.43; 0.36, small     | 1.46; 0.09, trivial  |
| MDec (n)                                   | 60 $\pm$ 9       | 15.45  | 59 $\pm$ 13      | 36.60  | 55 $\pm$ 9       | 24.45  | 2.49; 0.13, trivial                                       | 10.61; 0.63, moderate | 7.92; 0.40, small    |
| HDec (n)                                   | 17 $\pm$ 6       | 35.59  | 18 $\pm$ 6       | 38.02  | 18 $\pm$ 6       | 45.49  | 15.05; 0.50, small                                        | 4.09; 0.12, trivial   | 12.90; 0.37, small   |

ES: Effect size; SD: Standard deviation; CV: Coefficient of variation; TD: Total distance; Vel<sub>max</sub>: Maximum velocity; Acc: Accelerations; Dec: Decelerations; LAcc: Number of low accelerations (1.00–2.78 m·s<sup>-2</sup>); MAcc: Number of medium accelerations (2.78–4.00 m·s<sup>-2</sup>); number of high accelerations (>4.00 m·s<sup>-2</sup>); LDec: Number of low decelerations (−1/−2.78 m·s<sup>-2</sup>); MDec: Number of medium decelerations (−2.78/−4.00) m·s<sup>-2</sup>; number of high accelerations <−4.00 m·s<sup>-2</sup>). \* Significant level set at  $p < 0.05$ ; \*\* Significant level set at  $p < 0.01$ .

**Table 3.** Relationships (r) with a 90% confidence interval (CI) between the players' physical performance and the high-intensity actions at different speeds supported during the small-sided game in each age category.

| Age-Category | Test         | TD (m)            | Cruising (m)       | Sprinting (m)     | Sprints (n)        | Vel <sub>max</sub> (km·h <sup>-1</sup> ) |
|--------------|--------------|-------------------|--------------------|-------------------|--------------------|------------------------------------------|
| U14          | SPR5 (s)     | −0.39; ±0.37, M   | −0.56; ±0.31, L *  | −0.41; ±0.37, M   | −0.59; ±0.30, L *  | −0.53; ±0.32, L *                        |
|              | SPR10 (s)    | −0.40; ±0.37, M   | −0.58; ±0.30, L *  | −0.41; ±0.37, M   | −0.57; ±0.31, L *  | −0.40; ±0.37, M                          |
|              | SPR40 (s)    | −0.50; ±0.34, L * | −0.64; ±0.27, L ** | −0.50; ±0.34, L * | −0.65; ±0.27, L ** | −0.38; ±0.37, M                          |
|              | RSAbest (s)  | −0.36; ±0.37, M   | −0.53; ±0.32, L *  | −0.22; ±0.41, S   | −0.39; ±0.37, M    | −0.16; ±0.42, ?                          |
|              | RSAtotal (s) | −0.39; ±0.37, M   | −0.67; ±0.26, L ** | −0.41; ±0.37, M   | −0.45; ±0.35, M    | −0.07; ±0.43, ?                          |
|              | 505-COD (s)  | 0.15; ±0.42, ?    | −0.31; ±0.39, M    | −0.44; ±0.36, M   | −0.61; ±0.29, L ** | −0.13; ±0.42, ?                          |
| U16          | SPR5 (s)     | 0.34; ±0.39, M    | 0.35; ±0.38, M     | 0.15; ±0.42, ?    | 0.28; ±0.40, S     | 0.02; ±0.43, ?                           |
|              | SPR10 (s)    | −0.60; ±0.29, L * | −0.64; ±0.27, L *  | 0.14; ±0.42, ?    | 0.34; ±0.39, M     | 0.07; ±0.43, ?                           |
|              | SPR40 (s)    | −0.56; ±0.31, L * | −0.60; ±0.29, L *  | 0.13; ±0.42, ?    | 0.30; ±0.40, S     | 0.02; ±0.43, ?                           |
|              | RSAbest (s)  | 0.37; ±0.37, M    | 0.44; ±0.36, M     | −0.03; ±0.43, ?   | 0.08; ±0.42, ?     | −0.14; ±0.42, ?                          |
|              | RSAtotal (s) | 0.48; ±0.34, M    | 0.50; ±0.34, L     | −0.01; ±0.43, ?   | 0.18; ±0.42, ?     | −0.01; ±0.43, ?                          |
|              | 505-COD (s)  | 0.01; ±0.43, ?    | −0.10; ±0.42, ?    | −0.11; ±0.42, ?   | −0.02; ±0.43, ?    | −0.08; ±0.42, ?                          |
| U18          | SPR5 (s)     | −0.16; ±0.42, ?   | −0.27; ±0.40, S    | −0.10; ±0.42, ?   | −0.35; ±0.38, M    | −0.15; ±0.42, ?                          |
|              | SPR10 (s)    | −0.05; ±0.43, ?   | −0.13; ±0.42, ?    | −0.01; ±0.43, ?   | −0.12; ±0.42, ?    | −0.05; ±0.43, ?                          |
|              | SPR40 (s)    | −0.06; ±0.43, ?   | −0.14; ±0.42, ?    | −0.11; ±0.42, ?   | −0.09; ±0.42, ?    | −0.20; ±0.41, S                          |
|              | RSAbest (s)  | −0.05; ±0.43, ?   | −0.07; ±0.43, ?    | −0.25; ±0.40, S   | −0.08; ±0.42, ?    | −0.21; ±0.41, S                          |
|              | RSAtotal (s) | −0.16; ±0.42, ?   | −0.18; ±0.42, ?    | −0.13; ±0.42, ?   | −0.05; ±0.43, ?    | −0.13; ±0.42, ?                          |
|              | 505-COD (s)  | −0.08; ±0.42, ?   | −0.27; ±0.40, S    | −0.40; ±0.37, M   | −0.30; ±0.40, S    | −0.49; ±0.34, M                          |

SPR5: Time to cover a distance of 5 m; SPR10: Time to cover a distance of 10 m; SPR40: Time to cover a distance of 40 m; RSA: Repeated sprint ability; 505-COD: Change of direction test; TD: Total distance; Vel<sub>max</sub>: Maximum velocity. Correlation magnitude: ?, unclear; S, small; M: moderate; L, large; VL, very large; NP, near perfect. \* Significant level set at  $p < 0.05$ ; \*\* Significant level set at  $p < 0.01$ .

**Table 4.** Relationships (r) with a 90% confidence interval (CI) between the players' physical performance and the short-term and high-intensity actions supported during the small-sided game in each age category.

| Age-Category | Test         | Acc (n)               | Dec (n)               | LAcc (n)               | MAcc (n)              | HAcc (n)                 | LDec (n)                | MDec (n)              | HDec (n)              |
|--------------|--------------|-----------------------|-----------------------|------------------------|-----------------------|--------------------------|-------------------------|-----------------------|-----------------------|
| U14          | SPR5 (s)     | 0.00; $\pm 0.43$ , ?  | 0.12; $\pm 0.42$ , ?  | 0.19; $\pm 0.41$ , ?   | −0.39; $\pm 0.37$ , M | −0.64; $\pm 0.27$ , L ** | 0.38; $\pm 0.37$ , M    | −0.22; $\pm 0.41$ , S | −0.44; $\pm 0.36$ , M |
|              | SPR10 (s)    | −0.01; $\pm 0.43$ , ? | 0.15; $\pm 0.42$ , ?  | 0.13; $\pm 0.42$ , ?   | −0.26; $\pm 0.40$ , S | −0.56; $\pm 0.31$ , L ** | 0.43; $\pm 0.36$ , M    | −0.22; $\pm 0.41$ , S | −0.47; $\pm 0.35$ , M |
|              | SPR40 (s)    | −0.04; $\pm 0.43$ , ? | 0.17; $\pm 0.42$ , ?  | 0.01; $\pm 0.43$ , ?   | −0.02; $\pm 0.43$ , ? | −0.35; $\pm 0.38$ , M    | 0.37; $\pm 0.37$ , M    | −0.04; $\pm 0.43$ , ? | −0.45; $\pm 0.35$ , M |
|              | RSAbest (s)  | 0.00; $\pm 0.43$ , ?  | 0.12; $\pm 0.42$ , ?  | 0.10; $\pm 0.42$ , ?   | −0.23; $\pm 0.41$ , S | −0.29; $\pm 0.40$ , S    | 0.44; $\pm 0.36$ , M    | −0.35; $\pm 0.38$ , M | −0.44; $\pm 0.36$ , M |
|              | RSAtotal (s) | 0.10; $\pm 0.42$ , ?  | 0.31; $\pm 0.39$ , M  | 0.23; $\pm 0.41$ , S   | −0.27; $\pm 0.40$ , S | −0.25; $\pm 0.40$ , S    | 0.62; $\pm 0.29$ , L ** | −0.21; $\pm 0.41$ , S | −0.44; $\pm 0.36$ , M |
|              | 505–COD (s)  | 0.40; $\pm 0.37$ , M  | 0.45; $\pm 0.35$ , M  | 0.51; $\pm 0.33$ , L * | −0.22; $\pm 0.41$ , S | 0.02; $\pm 0.43$ , ?     | 0.59; $\pm 0.30$ , L    | 0.15; $\pm 0.42$ , ?  | −0.31; $\pm 0.39$ , M |
| U16          | SPR5 (s)     | 0.10; $\pm 0.42$ , ?  | 0.00; $\pm 0.43$ , ?  | 0.22; $\pm 0.41$ , S   | −0.17; $\pm 0.42$ , ? | −0.31; $\pm 0.39$ , M    | 0.00; $\pm 0.43$ , ?    | −0.13; $\pm 0.42$ , ? | 0.24; $\pm 0.41$ , S  |
|              | SPR10 (s)    | 0.27; $\pm 0.40$ , S  | 0.21; $\pm 0.41$ , S  | 0.35; $\pm 0.38$ , M   | 0.02; $\pm 0.43$ , ?  | −0.16; $\pm 0.42$ , ?    | 0.20; $\pm 0.41$ , ?    | 0.02; $\pm 0.43$ , ?  | 0.52; $\pm 0.33$ , L  |
|              | SPR40 (s)    | 0.31; $\pm 0.39$ , M  | 0.34; $\pm 0.39$ , M  | 0.41; $\pm 0.37$ , M   | 0.03; $\pm 0.43$ , ?  | −0.23; $\pm 0.41$ , S    | 0.37; $\pm 0.37$ , M    | 0.01; $\pm 0.43$ , ?  | 0.52; $\pm 0.33$ , L  |
|              | RSAbest (s)  | 0.15; $\pm 0.42$ , ?  | 0.21; $\pm 0.41$ , S  | 0.25; $\pm 0.40$ , S   | −0.08; $\pm 0.42$ , ? | −0.33; $\pm 0.39$ , M    | 0.26; $\pm 0.40$ , S    | −0.11; $\pm 0.42$ , ? | 0.34; $\pm 0.39$ , M  |
|              | RSAtotal (s) | 0.23; $\pm 0.41$ , S  | 0.28; $\pm 0.40$ , S  | 0.33; $\pm 0.39$ , M   | 0.01; $\pm 0.43$ , ?  | −0.29; $\pm 0.40$ , S    | 0.31; $\pm 0.39$ , M    | −0.02; $\pm 0.43$ , ? | 0.40; $\pm 0.37$ , M  |
|              | 505–COD (s)  | 0.14; $\pm 0.42$ , ?  | 0.13; $\pm 0.42$ , ?  | 0.27; $\pm 0.40$ , S   | −0.15; $\pm 0.42$ , ? | −0.43; $\pm 0.36$ , M    | 0.24; $\pm 0.41$ , S    | −0.13; $\pm 0.42$ , ? | −0.15; $\pm 0.42$ , ? |
| U18          | SPR5 (s)     | −0.39; $\pm 0.37$ , M | −0.19; $\pm 0.41$ , ? | −0.22; $\pm 0.41$ , S  | −0.29; $\pm 0.40$ , S | −0.06; $\pm 0.43$ , ?    | −0.02; $\pm 0.43$ , ?   | −0.47; $\pm 0.35$ , M | 0.12; $\pm 0.42$ , ?  |
|              | SPR10 (s)    | −0.22; $\pm 0.41$ , S | −0.20; $\pm 0.41$ , S | −0.09; $\pm 0.42$ , ?  | −0.26; $\pm 0.40$ , S | 0.02; $\pm 0.43$ , ?     | −0.08; $\pm 0.42$ , ?   | −0.55; $\pm 0.32$ , L | 0.43; $\pm 0.36$ , M  |
|              | SPR40 (s)    | −0.31; $\pm 0.39$ , M | −0.39; $\pm 0.37$ , M | −0.16; $\pm 0.42$ , ?  | −0.28; $\pm 0.40$ , S | 0.02; $\pm 0.43$ , ?     | −0.26; $\pm 0.40$ , S   | −0.44; $\pm 0.36$ , M | 0.32; $\pm 0.39$ , M  |
|              | RSAbest (s)  | −0.24; $\pm 0.41$ , S | −0.34; $\pm 0.39$ , M | −0.13; $\pm 0.42$ , ?  | −0.23; $\pm 0.41$ , S | 0.07; $\pm 0.43$ , ?     | −0.27; $\pm 0.40$ , S   | −0.36; $\pm 0.37$ , M | 0.41; $\pm 0.37$ , M  |
|              | RSAtotal (s) | −0.23; $\pm 0.41$ , S | −0.38; $\pm 0.37$ , M | −0.04; $\pm 0.43$ , ?  | −0.34; $\pm 0.39$ , M | −0.05; $\pm 0.43$ , ?    | −0.27; $\pm 0.40$ , S   | −0.43; $\pm 0.36$ , M | 0.39; $\pm 0.37$ , M  |
|              | 505–COD (s)  | 0.10; $\pm 0.42$ , ?  | 0.07; $\pm 0.43$ , ?  | 0.29; $\pm 0.40$ , S   | −0.28; $\pm 0.40$ , S | −0.21; $\pm 0.41$ , S    | 0.19; $\pm 0.41$ , ?    | −0.35; $\pm 0.38$ , M | 0.02; $\pm 0.43$ , ?  |

SPR5: Time to cover a distance of 5 m; SPR10: Time to cover a distance of 10 m; SPR40: Time to cover a distance of 40 m; RSA: Repeated sprint ability; 505-COD: Change of direction test; Acc: Accelerations; Dec: Decelerations; LAcc: Number of low accelerations (1.00–2.78 m·s<sup>−2</sup>); MAcc: number of medium accelerations (2.78–4.00 m·s<sup>−2</sup>); number of high accelerations (>4.00 m·s<sup>−2</sup>); LDec: Number of low decelerations (−1/−2.78 m·s<sup>−2</sup>); MDec: Number of medium decelerations (−2.78/−4.00) m·s<sup>−2</sup>; number of high accelerations <−4.00 m·s<sup>−2</sup>). Correlation magnitude: ?, unclear; S, small; M: moderate; L, large; VL, very large; NP, near perfect. \* Significant level set at  $p < 0.05$ ; \*\* Significant level set at  $p < 0.01$ .

#### 4. Discussion

The aim of this study was twofold: (1) To compare players' physical performance and small-sided game (SSG) external responses among three soccer age categories (i.e., U14, U16, and U18); and (2) to examine the relationships among physical performances and SSG external responses in each age category. This investigation will allow coaches to understand whether players' external responses are related with players' initial physical performance in three different youth soccer age categories. Contrary to the hypothesis established for this study, the main results showed that while older players presented a better physical performance during testing, these differences were not consistent in the external loads encountered by soccer players among the categories during the SSG. In addition, a higher number of associations between players' physical performance and SSG external responses were found in younger players in comparison to the older ones.

Previous research has shown the importance of physical conditioning in the early stages in the development of players being able to determine the specific competence of top soccer players [37,38]. Our results showed that U16 and U18 players obtained better performances in LSST, RSA, and CODA in comparison to U14 players. These results coincide with those studies which compared players' physical performance in these age categories. For instance, Mendez-Villanueva et al. [39] observed a better performance in a 10 m sprint test in U16 players vs. U14 counterparts; Buchheit et al. [6] showed that older players achieved higher peak velocity over 40 m distance than younger ones; and Sánchez-Sánchez et al. [40] presented better RSA results in the U16 and U18 players in comparison with the U14 players. Moreover, other studies also reported better performance in 20 m sprint and RSA in older players [6,39]. On the other hand, looking at the comparison between U16 and U18 age categories, other authors observed better acceleration and RSA performances in the younger players [41,42]. However, our findings showed that U16 players presented a worst performance at the SPR40 and RSAbest compared to U18 players. These differences could be explained by the competitive level of the evaluated youth soccer players [43]. Finally, with regard to the CODA test, our results are in contrast with those that did not present differences in the agility test as the age of players increases [44]. Obviously, these results are different due to the different characteristics and nature of the CODA test characterized by a greater number of CODs and a longer time to execution. Further research would be necessary to be able to discriminate the physical performance among categories.

With regard to the influence of age on players' external responses in youth soccer, previous studies have shown that older players exhibited greater running activity, with most studies being focused on official match-play [2,10,20]. However, to our knowledge, fewer studies have analyzed players' SSG external responses, reporting higher responses as age increases [15–17]. For instance, Lemes et al. [17] presented greater TD ( $473.0 \pm 36.2$  vs.  $434.4 \pm 42.1$  m) covered and lower percentage of distance covered at low intensity ( $0\text{--}6.9 \text{ km}\cdot\text{h}^{-1}$ ) ( $38.2 \pm 0.7$  vs.  $42.2 \pm 0.5$  m) for U14 players in comparison to their U13 counterparts during a 3 vs. 3+1 SSG format. Indeed, Rabano-Muñoz et al. [16] observed that U19 players covered higher TD than U17 players during a 4 vs. 4+2 SSG format. Otherwise, the results obtained in our study are in line with those observed by López-Fernández et al. [15], who did not report significant differences in the TD covered across the three age categories (i.e., U14, U16 and U18) during a 4 vs. 4 SSG format. This controversy could be explained due to the different SSG characteristics, because a similar structure to real-play was used in our study, in which no superiority was used, which implies that the dynamics of the collective organization leads to lower individual interaction spaces [13]. In addition, while some authors showed higher distance at high-speeds during the SSG as the age of players increases 4 vs. 4+2 SSG format [16], others did not find significant differences during a 3 vs. 3+1 SSG format [17]. Indeed, some authors found that U14 players showed greater acceleration value at the highest intensity ( $>2.75 \text{ m}\cdot\text{s}^{-2}$ ) than U16–U18 players during a 6 vs. 6 SSG format [15]. In this context, our study showed that U14 players completed lower HAcc in comparison to U16 and U18 players. Additionally, U14 players covered less distance at sprinting intensity and performed a lower number of sprints and HAcc, and higher LAcc compared to U18 players. Since this research

is inconclusive, further studies would be necessary to understand the external responses showed by players during different SSG formats across all ages in youth soccer.

Most research has focused on the associations between physical test performances and match-play external and internal responses encountered by players in order to determine the construct validity of some field tests and to optimize the talent identification process in senior and young soccer players, respectively [9,24,28]. As such, the validity of certain fitness tests, such as sprinting over short and long distances, repeated sprint sequences, and intermittent running test, has been demonstrated based on their association with total distance, number of high-intensity actions, and sprints performed during a match-play [25,26]. In addition, the appropriate use of these tests for talent selection and development of players in soccer academies confirm that age could affect the absolute and relative intensity of speed-related actions during matches [9,20]. However, from a practical approach, it would also be interesting to examine the association between players' physical performance and the external responses during training tasks, with the aim of knowing whether the players' physical performance is determinant on their soccer competence. In this context, Castillo et al. [21] suggested that an improvement of the sprint capacity could allow players to cover greater distances at high-intensities during SSGs in U16 players.

Looking at the differences aforementioned on the physical performance and external responses across ages, it would be convenient to differentiate the associations depending on players' age, because this has not been previously considered. Regarding this, results found in this study for U14 players showed that: (1) Faster players in SPR40 covered higher TD and distance covered at cruising and sprinting; (2) faster players in SPR5, SPR10, SPR40, and 505-COD tests performed higher sprints; (3) faster players in SPR5 covered greater distance cruising and achieved higher  $Vel_{max}$ ; (4) better players in RSA covered greater distance at cruising; (5) faster players in SPR5 and SPR1 performed greater HAcc; and (6) better players in RSAMean and 505-COD performed higher LDec and LAcc. Moreover, for U16 players, the results indicated that players who were faster in SPR10 covered greater TD and distance at cruising, and those players with better performance in SPR40 covered greater TD. Finally, for U18 players, no significant associations between the testing performances and the external SSG responses were observed. Therefore, our results suggest that, for U14 players, better physical performance, as defined by faster sprint, RSA, and CODA performances, could help them to cover longer distances at cruising and sprinting and perform a higher number of sprints during SSGs, and consequently to optimize the on-field player performance [18]. Otherwise, in U16 players, a better performance in SPR10 and SPR40 only allows players to cover longer absolute distances, whereas no associations were found for U18 players. These differences across age categories could be explained based on evidence suggesting that as players' age increases they are able to occupy larger areas and the distance between players and the stretch index are higher during the SSG [31]. Thus, a better collective organization could hinder players' ability to achieve their maximal individual performance during SSGs, since it has been shown that tactical and strategic requirements of the game are likely to modulate on-field players' activity patterns independently of players' physical capacities [22]. Nevertheless, if soccer players across all age categories get an optimal physical capacity while the game requires less external responses from them as they grow, then older players with higher physical capacity will show a better recovery among maximal efforts and, subsequently, may accumulate low-related fatigue, what it would produce a reduction of the injury risk [45].

The main limitation of this study was the small sample size in regard to the number of players in each category. However, this is the first investigation analyzing the association between testing and external responses during SSG in youth soccer across different age categories. Likewise, for further investigation, it would be convenient to analyze these relationships across different ages at a higher standard of play. Another limitation was not addressing players' endurance capacity, as measured via Yo-Yo intermittent performance, due to its construct validity. However, to our knowledge, the novelty of this study was the consideration of initial RSA and CODA performances on the external SSG responses across different ages in youth soccer. A further limitation was the lack of internal measures

such as heart rate intensities and perceived exertion and/or wellbeing variables, although the external responses were registered by means of TD, speeds, accelerations, and decelerations during the SSGs. Finally, there is a necessity to relate players' physical performance with players' external responses both in matches and training tasks in order to optimize the training process in youth soccer.

## 5. Conclusions

The findings of our study showed that, although older players presented better physical performance during testing in comparison to younger ones, these differences were not consistent with the external responses shown by soccer players among the three age categories during the SSG. Therefore, the dynamics of the collective organization could affect the external responses during the development of the training tasks in youth soccer. In addition, a higher number of associations between players' physical performance and SSG external responses were found in younger players in comparison to the older ones. Therefore, while a better performance in younger players could allow them to exhibit greater external responses (i.e., U14), a greater physical performance in older players (i.e., U18) did not imply an increase of SSG external responses due to the tactical requirements or dynamics of the game.

**Author Contributions:** D.C. and J.R.-G. conceived and designed the study. D.C., J.R.-G., M.D.-D., S.S.-D., T.R.-U., and M.S.-C. collected data. D.C. and A.L.-R. analyzed and interpreted the data and D.C., J.R.-G., M.D.-D., and A.L.-R. drafted the manuscript. S.S.-D., T.R.-U., and M.S.-C. revised the manuscript and D.C. and J.R.-G. approved the final version. All authors have read and agreed to the published version of the manuscript.

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