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ORIGINAL ARTICLE

A broader range of jump-performance characteristics associated with 50-m sprint performance in older children

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ABSTRACT

Although jump performance is associated with sprint ability in children, it remains unclear whether different jump tasks show similar relationships with sprint performance across chronological age and sex groups. This cross-sectional study examined associations between 50-m sprint performance and countermovement jump (CMJ), rebound jump (RJ), and standing long jump (SLJ) performance in 196 children aged 9–12 years. Participants were classified into 9–10- and 11–12-year groups and analyzed by sex. Overall and 10-m sectional sprint velocities were measured, and Pearson's and height-controlled partial correlations were calculated. SLJ was significantly associated with overall and all sectional sprint velocities in every group ($p < .05$), and its association with overall sprint velocity remained after controlling for height. CMJ was also associated with sprint velocity in all groups ($p < .05$). RJ-related variables showed limited associations in the 9–10-year group but were associated with overall velocity and a broader range of sprint sections in the 11–12-year group ($p < .05$). Collectively, these findings suggest that the jump-performance characteristics associated with sprint performance were broader in the older group. Because biological maturation was not assessed, this age-group pattern should not be interpreted as a longitudinal developmental change.
Keywords: performance analysis; stretch-shortening cycle; countermovement jump; rebound jump; standing long jump.

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INTRODUCTION

Sprint ability is one of the fundamental movement skills that improves markedly during growth and development (Barnett et al., 2016), and it represents an important component of physical fitness in school physical education and sports activities. During childhood, the development of morphological characteristics, such as height and lower-limb length, has been reported to contribute to increases in stride length and sprint velocity (Talukdar et al., 2022). By contrast, previous studies have shown that strength- and power-oriented training significantly improves sprint velocity (Kotzamanidis, 2006; Tottori & Fujita, 2019), indicating that the development of functional factors also contributes to improvements in sprint ability during childhood.

Sprinting consists of three phases: acceleration from a stationary start, maximal velocity, and deceleration, each of which is characterized by distinct mechanical demands (Nagahara et al., 2014). During childhood, growth-related development has been reported to enhance horizontal force production during the acceleration phase and reduce ground contact time during the maximal velocity phase (Colyer et al., 2020). These changes are thought to be partly attributable to the development of stretch–shortening cycle (SSC) ability, which enables the storage and reutilization of elastic energy within the muscle–tendon unit (Komi, 1984).

SSC movements are generally classified into slow SSC movements, which involve relatively long ground contact times (e.g., countermovement jump [CMJ]), and fast SSC movements, which involve short ground contact times (e.g., drop jump and rebound jump [RJ]). During childhood, the muscular and tendinous properties, pre-activation, and coordination required for SSC performance improve markedly. Accordingly, SSC ability has been shown to develop substantially during this stage (Lloyd et al., 2011; Radnor et al., 2018).

Numerous studies have examined the relationship between sprint ability and SSC performance during childhood. Jump height in the CMJ and squat jump is reportedly associated with 5-, 10-, and 20-m sprint times (Chanel et al., 2024). Similarly, standing long jump (SLJ) performance appears to be associated with 5- and 15-m sprint times (Yanci et al., 2017), as well as with 30-m sprint time (Veligekas et al., 2012). In addition, Tottori and Fujita (2019) reported that, in boys aged 9–12 years, an 8-week plyometric training program improved RJ and SLJ performance and significantly increased sectional sprint velocity and stride length after the 20–30 m interval during a 50-m sprint. These findings suggest that improvements in fast SSC ability may influence sprint performance from the latter part of the acceleration phase to the maximal velocity phase.

However, most previous studies involving children have examined the relationship between sprint performance and a single jump task. Consequently, limited evidence is available regarding the simultaneous assessment of CMJ (slow SSC), RJ (fast SSC), and SLJ within the same group of children, as well as the relationships of these variables with sprint performance. Lloyd et al. (2011) and Radnor et al. (2018) suggested that the developmental patterns of slow and fast SSC abilities may differ according to maturation stage around peak height velocity (PHV), owing to changes in neuromuscular function and muscle–tendon properties. In addition, Okudaira et al. (2026) reported a breakpoint at a maturity offset of +1.1 years in the improvement of sprint ability. Before this point, physical growth is the primary contributor to increases in sprint velocity, whereas after this point, both morphological and strength-related factors contribute, suggesting that the factors affecting sprint speed may vary according to maturation stage. Furthermore, Colyer et al. (2020) suggested that growth-related changes in sprint mechanics may differ between boys and girls. Together, these findings suggest that the relationships between different SSC abilities and sprint performance may vary according to developmental stage and sex during childhood. Clarifying associations between slow and fast SSC abilities and sprint performance across sex and chronological age groups may provide useful information for interpreting jump and sprint assessments in children.

Therefore, this study aimed to clarify the relationships between 50-m sprint performance, including sectional sprint velocities over 10-m intervals, and multiple jump performances (CMJ, RJ, and SLJ) in boys and girls aged 9–12 years. Based on previous findings, we hypothesized that CMJ and SLJ would be associated with 50-m sprint performance regardless of sex or age group, whereas RJ would show a stronger association in the 11–12-year group than in the 9–10-year group. We also hypothesized that the patterns of association between jump and sprint performances would differ across age and sex groups.

MATERIAL AND METHODS

Participants

This study included 196 elementary schoolchildren who did not routinely participate in sprint or plyometric training. The participants were classified into a 9–10-year group (57 boys and 36 girls) and an 11–12-year group (51 boys and 52 girls) (Table 1). None of the participants had orthopaedic limitations. Furthermore, they were not engaged in regular plyometric or resistance training during the study period. All participants regularly attended physical education classes. This study was approved by the Ethics Committee of Chubu Gakuin University (Certificate Number: C-20-0022). As all participants were under 18 years of age, written informed consent was obtained from both the participants and their parents prior to the start of the study.

Design and procedures

This study employed a cross-sectional design to examine the relationships between 50-m sprint performance and multiple jump performances (CMJ, RJ, and SLJ) in elementary school children. Participants were classified into age groups (9–10 and 11–12 years) and by sex to examine age- and sex-specific patterns, and the relationships between sprint and jump performances were examined separately within each group.

The independent variables were CMJ jump height (CMJ-JH) as an index of slow SSC ability; RJ index, RJ jump height (RJ-JH), and RJ contact time (RJ-CT) as indices of fast SSC ability; and SLJ jump distance (SLJ-JD), as an index of horizontal jump performance. The dependent variable was mean sprint velocity over 50 m. Additionally, to examine section-specific patterns across the 50-m sprint, sprint velocities were calculated for each 10-m interval (0–10, 10–20, 20–30, 30–40, and 40–50 m). This approach enabled us to examine whether the associations with each jump variable were consistent or varied across different portions of the 50-m sprint.

One week before the experimental session, participants were instructed to practice all jump tasks used in this study while observing demonstrations provided by an instructor familiar with the testing procedures. On the testing day, the participants first completed a 10-min warm-up consisting of dynamic stretching. They then received a brief explanation of the tasks and performed one practice trial of each jump task. Following the warm-up, participants were given 2 min of rest and then performed one 50-m sprint trial and two trials each of the CMJ, RJ, and SLJ. For the analyses, the trials with the highest CMJ-JH, RJ-index, and SLJ-JD values were adopted.

The 50-m sprint was performed on an outdoor dirt track according to the method described by Tottori and Fujita (2019). CMJ and RJ were performed indoors on a floor surface using a mat switch system (Multi Jump Tester II, DKH, Tokyo, Japan) according to the method described by Hioki et al. (2023). SLJ was performed in an outdoor sandpit according to the method described by Tottori and Fujita (2019). All participants performed each test while wearing their own athletic shoes. A 30-s rest interval was provided between trials of the same task, and at least 5 min of rest was provided between different tasks.

For the 50-m sprint, participants were instructed to sprint maximally from a standing start. For the CMJ, participants were instructed to squat from an upright standing position to a self-selected depth and then jump upward as quickly and as high as possible. For the RJ, participants were instructed to perform five consecutive maximal jumps from an upright standing position while minimizing RJ-CT. For the SLJ, participants were instructed to jump as far forward as possible from an upright standing position using a countermovement of the legs.

Measures

To evaluate sprint performance, 50-m sprint time and sprint velocities for each 10-m interval were calculated. Sprint times were measured using electronic timing gates (NT7728C, NISHI, Tokyo, Japan). Timing gates were placed at the start line and at 10, 20, 30, 40, and 50 m; passing times at each point were recorded. Mean sprint velocity for each section was calculated by dividing the distance of each section by the corresponding section time.

The variables used to evaluate jump performance were CMJ-JH, RJ-JH, RJ-CT, RJ index, and SLJ-JD. For CMJ and RJ, flight and contact times were obtained from the mat switch system. CMJ-JH and RJ-JH were calculated using the equation adopted from Asmussen and Bonde-Petersen (1974): $JH = (9.81 \times \text{flight time}^2) / 8$. The RJ index was calculated by dividing jump height (m) by contact time (s). SLJ-JD was measured as the horizontal distance from the take-offline to the rearmost point of landing using a tape measure.

Statistical analysis

All statistical analyses were performed using IBM SPSS Version 25.0 (IBM, Armonk, NY, USA). The normality of the data in each group was confirmed using the Shapiro–Wilk test ($p > .05$).

To examine group differences, a two-way analysis of variance (ANOVA) was conducted with sex (boys and girls) and age group (9–10 and 11–12 years) as factors. The dependent variables were sprint velocity for each 10-m interval, namely 0–10 m ($V_{0\text{–}10m}$), 10–20 m ($V_{10\text{–}20m}$), 20–30 m ($V_{20\text{–}30m}$), 30–40 m ($V_{30\text{–}40m}$), and 40–50 m ($V_{40\text{–}50m}$); overall 50-m sprint velocity (V_{50m}); and jump variables (CMJ-JH, RJ-index, RJ-JH, RJ-CT, and SLJ-JD). Post-hoc comparisons were performed using the Bonferroni method when a significant interaction or main effect was observed.

The relationships between sprint and jump performances were examined using Pearson's correlation coefficient. Correlation analyses were conducted separately by age group and sex (boys aged 9–10 years, boys aged 11–12 years, girls aged 9–10 years, and girls aged 11–12 years), and the relationships between each jump variable and both sectional sprint velocities and V50m were calculated.

Additionally, partial correlation coefficients controlling for height were calculated to account for the influence of body size. The magnitudes of the correlation coefficients were interpreted as follows: .00 – .20, negligible; .20 – .40, low; .40 – .70, moderate; and .70 – 1.00, high (Guilford, 1956). All data are presented as mean ± standard deviation. The significance level was set at 5% for all analyses.

RESULTS

Physical characteristics and measurement variables of the participants

The physical characteristics and measurement variables of the participants by sex and age group are shown in Table 1. Two-way ANOVA revealed no significant interaction effects for any sectional sprint velocity or for V50m ($F_{1,192}$ = 0.00–0.39, p = .584 – .988). By contrast, a significant main effect of age was observed for all sectional sprint velocities ($F_{1,192}$ = 28.14–44.75, p < .001), with the 11–12-year group showing higher sprint velocities than the 9–10-year group. No significant main effect of sex was observed for any sectional sprint velocity ($F_{1,192}$ = 0.06–0.56, p = .475 – .814). Moreover, no significant interaction effects were found for CMJ-JH ($F_{1,192}$ = 1.97, p = .162), RJ-JH ($F_{1,192}$ = 1.18, p = .279), or SLJ-JD ($F_{1,192}$ = 0.63, p = .427). However, a significant main effect of age was observed for CMJ-JH ($F_{1,192}$ = 15.20, p < .001), RJ-JH ($F_{1,192}$ = 19.93, p < .001), and SLJ-JD ($F_{1,192}$ = 48.76, p < .001), with the 11–12-year group showing higher values than the 9–10-year group. A significant interaction effect was observed for the RJ index ($F_{1,192}$ = 5.52, p = .020, η^2 = .028). Significant simple main effects of age group were found in both boys ($F_{1,106}$ = 7.67, p = .013) and girls ($F_{1,86}$ = 31.80, p < .001). A significant interaction effect was also observed for RJ-CT ($F_{1,192}$ = 9.10, p = .003, η^2 = .045). In girls, a significant simple main effect of age group was observed ($F_{1,86}$ = 8.37, p = .010). Furthermore, in the 9–10-year group, a significant simple main effect of sex was observed ($F_{1,91}$ = 5.92, p = .034).

Table 1. Physical characteristics and descriptive data of all measurements for the 9–10 and 11–12 years groups. *†

	Boys		Girls	
	9-10 years group (n = 57)	11-12 years group (n =51)	9-10 years group (n = 36)	11-12 years group (n = 52)
Age (y)	9.46 ± 0.50	11.43 ± 0.49	9.58 ± 0.50	11.52 ± 0.50
Height (m)	1.31 ± 0.47	1.43 ± 0.67	1.30 ± 0.60	1.43 ± 0.62
Body mass (kg)	27.84 ± 3.74	35.56 ± 7.87	27.17 ± 5.30	34.53 ± 5.43
$V_{0\text{-}10m}$ (m/s)	3.48 ± 0.21	3.77 ± 0.30**	3.49 ± 0.27	3.74 ± 0.31**
$V_{10\text{-}20m}$ (m/s)	5.41 ± 0.40	5.85 ± 0.47**	5.34 ± 0.42	5.78 ± 0.42**
$V_{20\text{-}30m}$ (m/s)	5.45 ± 0.46	6.00 ± 0.53**	5.40 ± 0.48	5.88 ± 0.46**
$V_{30\text{-}40m}$ (m/s)	5.29 ± 0.48	5.90 ± 0.54**	5.22 ± 0.52	5.81 ± 0.50**
$V_{40\text{-}50m}$ (m/s)	5.11 ± 0.49	5.79 ± 0.54**	5.05 ± 0.52	5.64 ± 0.52**
V_{50m} (m/s)	4.95 ± 0.39	5.46 ± 0.46**	4.90 ± 0.42	5.37 ± 0.42**
RJ-index (m/s)	1.08 ± 0.27	1.24 ± 0.33**	0.99 ± 0.24	1.36 ± 0.33**
RJ-JH (m)	0.17 ± 0.03	0.21 ± 0.04**	0.18 ± 0.03	0.22 ± 0.04**
RJ-CT (s)	0.17 ± 0.02	0.17 ± 0.02	0.18 ± 0.04	0.16 ± 0.02**
CMJ-JH (m)	0.25 ± 0.04	0.27 ± 0.05**	0.24 ± 0.04	0.26 ± 0.04**
SLJ-JD (m)	1.37 ± 0.17	1.61 ± 0.16**	1.35 ± 0.20	1.55 ± 0.19**

** $V_{0–10m}$ = sprint velocity of 0–10 m, $V_{10–20m}$ = sprint velocity of 10–20 m, $V_{20–30m}$ = sprint velocity of 20–30 m, $V_{30–40m}$ = sprint velocity of 30–40 m, $V_{40–50m}$ = sprint velocity of 40–50 m, V_{50m} = sprint velocity of 0–50 m, RJ-JH = jump height of rebound jump, RJ-CT = contact time of rebound jump, CMJ-JH = jump height of counter movement jump, SLJ-JD = jump distance of standing long jump. †**11–12 years group is significantly higher than 9–10 years group, p < .01; *11–12 years group is significantly higher than 9–10 years group, p < .05.*

Correlations between sprint performance and jump performance

The correlation coefficients by sex and age group are presented in Tables 2–5. Significant correlations between SLJ-JD and V_{50m} were observed in all groups (r = .617 – .722, moderate to high, p < .001). Additionally, SLJ-JD was significantly correlated with all sectional sprint velocities (boys aged 9–10 years: r = .654 – .729, moderate to high; boys aged 11–12 years: r = .655 – .705, moderate to high; girls aged 9–10 years: r = .660 – .699, moderate; girls aged 11–12 years: r = .479 – .617, moderate). Significant correlations between CMJ-JH and V_{50m} were observed in boys aged 9–10 years (r = .337, low, p = .010) and 11–12 years (r = .671, moderate, p < .001). In girls, significant correlations were also observed in both age groups (9–10 years: r = .639, moderate; 11–12 years: r = .617, moderate; p < .001), and similar relationships were generally observed for sectional sprint velocities. For RJ, in boys aged 9–10 years, only the RJ index showed a significant correlation with $V_{0–10m}$ (r = .275, low, p = .039), whereas no significant correlations were observed for the other sections, including V_{50m}. Similarly, no significant correlations were found between the other RJ variables and sprint velocity. In girls aged 9–10 years, only RJ-CT showed a significant correlation with $V_{20–30m}$ (r = −.345, low, p = .039), whereas no significant correlations were observed between the other sectional sprint velocities and the other RJ variables. In contrast, in boys aged 11–12 years, all RJ variables were significantly correlated with V_{50m} (RJ index: r = .541, moderate; RJ-JH: r = .526, moderate; RJ-CT: r = −.503, moderate; p < .001). Significant correlations were also observed for all sectional sprint velocities (p < .001). In girls aged 11–12 years, RJ index and RJ-JH were significantly correlated with V_{50m} (RJ-index: r = .578, moderate; RJ-JH: r = .648, moderate; p < .001), and significant correlations were also observed for all sectional sprint velocities (p ≤ .002).

Table 2. Correlation coefficients between 50-m sprint performance and various jumping abilities in the 9–10-year-old boys. *†‡

	V_{0-10m}	V_{10-20m}	V_{20-30m}	V_{30-40m}	V_{40-50m}	V_{50m}
RJ-index	r = .275* (0.015 to 0.499) p = .039	r = .165 (-0.099 to 0.408) p = .219	r = .177 (-0.087 to 0.419) p = .187	r = .167 (-0.098 to 0.410) p = .214	r = .115 (-0.150 to 0.365) p = .395	r = .174 (-0.091 to 0.416) p = .196
RJ-JH	R = .213 (-0.051 to 0.448) p = .112	R = .114 (-0.151 to 0.364) p = .397	R = .083 (-0.181 to 0.337) p = .538	R = .070 (-0.194 to 0.325) p = .605	R = .085 (-0.179 to 0.338) p = .529	R = .104 (-0.161 to 0.355) p = .442
RJ-CT	R = -.240 (-0.471 to 0.022) p = .073	R = -.173 (-0.415 to 0.092) p = .199	R = -.248 (-0.477 to 0.014) p = .063	R = -.235 (-0.467 to 0.027) p = .079	R = -.134 (-0.381 to 0.132) p = .322	R = -.209 (-0.445 to 0.054) p = .118
CMJ-JH	R = .315* (0.059 to 0.532) p = .017	R = .310* (0.054 to 0.528) p = .019	R = .332* (0.079 to 0.546) p = .012	R = .308* (0.051 to 0.526) p = .020	R = .350** (0.098 to 0.560) p = .008	R = .337* (0.084 to 0.549) p = .010
SLJ-JD	R = .654** (0.475 to 0.782) p < .001	R = .664** (0.487 to 0.788) p < .001	R = .678** (0.507 to 0.798) p < .001	R = .705** (0.545 to 0.816) p < .001	R = .729** (0.579 to 0.832) p < .001	R = .718** (0.563 to 0.824) p < .001

*Note. * V_{0-10m} = sprint velocity of 0-10m, V_{10-20m} = sprint velocity of 10-20m, V_{20-30m} = sprint velocity of 20-30m, V_{30-40m} = sprint velocity of 30-40m, V_{40-50m} = sprint velocity of 40-50m, V_{0-50m} = Sprint velocity of 0-50m, RJ-JH = jump height of rebound jump, RJ-CT = contact time of rebound jump, CMJ-JH = jump height of counter movement jump, SLJ-JD = jump distance of standing long jump. †Values in parentheses are 95% confidence intervals. ‡**p < .01, *p < .05.*

Table 3. Correlation coefficients between 50-m sprint performance and various jumping abilities in the 11–12-year-old boys. *†‡

	V_{0-10m}	V_{10-20m}	V_{20-30m}	V_{30-40m}	V_{40-50m}	V_{50m}
RJ-index	R = .517** (0.281 to 0.694) p < .001	R = .511** (0.274 to 0.689) p < .001	R = .534** (0.304 to 0.706) p < .001	R = .505** (0.267 to 0.685) p < .001	R = .530** (0.298 to 0.703) p < .001	R = .541** (0.311 to 0.710) p < .001
RJ-JH	R = .514** (0.278 to 0.692) p < .001	R = .485** (0.242 to 0.671) p < .001	R = .511** (0.274 to 0.689) p < .001	R = .509** (0.272 to 0.688) p < .001	R = .510** (0.272 to 0.689) p < .001	R = .526** (0.292 to 0.700) p < .001
RJ-CT	R = -.447** (-0.643 to -0.195) p < .001	R = -.503** (-0.684 to -0.264) p < .001	R = -.517** (-0.282 to -0.694) p < .001	R = -.446** (-0.642 to -0.194) p < .001	R = -.492** (-0.676 to -0.250) p < .001	R = -.503** (-0.684 to -0.264) p < .001
CMJ-JH	R = .665** (0.477 to 0.795) p < .001	R = .650** (0.456 to 0.785) p < .001	R = .625** (0.422 to 0.768) p < .001	R = .643** (0.447 to 0.780) p < .001	R = .651** (0.457 to 0.785) p < .001	R = .671** (0.485 to 0.799) p < .001
SLJ-JD	R = .655** (0.463 to 0.788) p < .001	R = .705** (0.534 to 0.821) p < .001	R = .703** (0.530 to 0.820) p < .001	R = .693** (0.516 to 0.813) p < .001	R = .701** (0.528 to 0.819) p < .001	R = .722** (0.558 to 0.832) p < .001

*Note. * V_{0-10m} = sprint velocity of 0-10m, V_{10-20m} = sprint velocity of 10-20m, V_{20-30m} = sprint velocity of 20-30m, V_{30-40m} = sprint velocity of 30-40m, V_{40-50m} = sprint velocity of 40-50m, V_{0-50m} = Sprint velocity of 0-50m, RJ-JH = jump height of rebound jump, RJ-CT = contact time of rebound jump, CMJ-JH = jump height of counter movement jump, SLJ-JD = jump distance of standing long jump. †Values in parentheses are 95% confidence intervals. ‡**p < .01, *p < .05.*

Table 4. Correlation coefficients between 50-m sprint performance and various jumping abilities in the 9–10-year-old girls. *†‡

	$V_{0\text{-}10m}$	$V_{10\text{-}20m}$	$V_{20\text{-}30m}$	$V_{30\text{-}40m}$	$V_{40\text{-}50m}$	V_{50m}
RJ-index	R = .189 (-0.148 to 0.488) p = .269	R = .218 (-0.119 to 0.510) p = .200	R = .294 (-0.038 to 0.568) p = .082	R = .220 (-0.118 to 0.511) p = .198	R = .243 (-0.093 to 0.530) p = .153	R = .248 (-0.087 to 0.533) p = .144
RJ-JH	R = .189 (-0.149 to 0.487) p = .269	R = .046 (-0.287 to 0.369) p = .792	R = .056 (-0.277 to 0.378) p = .744	R = .046 (-0.287 to 0.369) p = .792	R = .040 (-0.293 to 0.363) p = .819	R = .067 (-0.267 to 0.387) p = .698
RJ-CT	R = -.118 (-0.430 to 0.219) p = .494	R = -.254 (-0.538 to 0.081) p = .135	R = -.345* (-0.605 to -0.019) p = .039	R = -.266 (-0.546 to 0.069) p = .118	R = -.313 (-0.582 to 0.017) p = .063	R = -.287 (-0.562 to 0.046) p = .090
CMJ-JH	R = .588** (0.322 to 0.768) p < .001	R = .627** (0.377 to 0.793) p < .001	R = .609** (0.350 to 0.781) p < .001	R = .605** (0.345 to 0.779) p < .001	R = .615** (0.359 to 0.785) p < .001	R = .639** (0.393 to 0.800) p < .001
SLJ-JD	R = .692** (0.470 to 0.831) p < .001	R = .696** (0.476 to 0.834) p < .001	R = .663** (0.428 to 0.814) p < .001	R = .660** (0.423 to 0.812) p < .001	R = .699** (0.482 to 0.836) p < .001	R = .712** (0.501 to 0.843) p < .001

*Note. *$V_{0\text{-}10m}$ = sprint velocity of 0-10m, $V_{10\text{-}20m}$ = sprint velocity of 10-20m, $V_{20\text{-}30m}$ = sprint velocity of 20-30m, $V_{30\text{-}40m}$ = sprint velocity of 30-40m, $V_{40\text{-}50m}$ = sprint velocity of 40-50m, $V_{0\text{-}50m}$ = Sprint velocity of 0-50m, RJ-JH = jump height of rebound jump, RJ-CT = contact time of rebound jump, CMJ-JH = jump height of counter movement jump, SLJ-JD = jump distance of standing long jump. †Values in parentheses are 95% confidence intervals. ‡**p < .01, *p < .05.*

Table 5. Correlation coefficients between 50-m sprint performance and various jumping abilities in the 11–12-year-old girls. *†‡

	$V_{0\text{-}10m}$	$V_{10\text{-}20m}$	$V_{20\text{-}30m}$	$V_{30\text{-}40m}$	$V_{40\text{-}50m}$	V_{50m}
RJ-index	R = .425** (0.172 to 0.625) p = .002	R = .565** (0.345 to 0.726) p < .001	R = .546** (0.321 to 0.713) p < .001	R = .569** (0.351 to 0.729) p < .001	R = .578** (0.362 to 0.735) p < .001	R = .578** (0.362 to 0.735) p < .001
RJ-JH	R = .479** (0.237 to 0.665) p < .001	R = .640** (0.444 to 0.777) p < .001	R = .618** (0.415 to 0.762) p < .001	R = .605** (0.398 to 0.753) p < .001	R = .624** (0.423 to 0.766) p < .001	R = .648** (0.456 to 0.782) p < .001
RJ-CT	R = -.183 (-0.434 to 0.095) p = .194	R = -.260 (-0.498 to 0.014) p = .062	R = -.255 (-0.494 to 0.019) p = .068	R = -.260 (-0.498 to 0.014) p = .062	R = -.296* (-0.526 to -0.025) p = .033	R = -.272 (-0.507 to 0.001) p = .051
CMJ-JH	R = .452** (0.204 to 0.645) p < .001	R = .639** (0.443 to 0.776) p < .001	R = .592** (0.381 to 0.745) p < .001	R = .588** (0.375 to 0.742) p < .001	R = .599** (0.390 to 0.749) p < .001	R = .617** (0.413 to 0.761) p < .001
SLJ-JD	R = .479** (0.238 to 0.665) p < .001	R = .617** (0.414 to 0.762) p < .001	R = .593** (0.383 to 0.746) p < .001	R = .605** (0.398 to 0.753) p < .001	R = .582** (0.367 to 0.737) p < .001	R = .617** (0.413 to 0.761) p < .001

*Note. *$V_{0\text{-}10m}$ = sprint velocity of 0-10m, $V_{10\text{-}20m}$ = sprint velocity of 10-20m, $V_{20\text{-}30m}$ = sprint velocity of 20-30m, $V_{30\text{-}40m}$ = sprint velocity of 30-40m, $V_{40\text{-}50m}$ = sprint velocity of 40-50m, $V_{0\text{-}50m}$ = Sprint velocity of 0-50m, RJ-JH = jump height of rebound jump, RJ-CT = contact time of rebound jump, CMJ-JH = jump height of counter movement jump, SLJ-JD = jump distance of standing long jump. †Values in parentheses are 95% confidence intervals. ‡**p < .01, *p < .05.*

Partial correlations after controlling for height

Partial correlations between V_{50m} and the jump variables after controlling for height are presented in Table 6. The relationship between SLJ and V_{50m} remained significant in all groups even after controlling for height (partial r = .612 – .702, p < .001). Significant partial correlations with V_{50m} were also observed for CMJ-JH in all groups (partial r = .323 – .585, $p \le .014$). For the RJ variables, significant partial correlations with V_{50m} were found for the RJ index and RJ-JH in the 11–12-year group for both boys and girls (boys aged 11–12 years: partial r = .429 and .389; girls aged 11–12 years: partial r = .645 and .665; $p \le .006$). In contrast, no significant partial correlations were observed between V_{50m} and either the RJ index or RJ-JH in the 9–10-year group. For RJ-CT, significant negative partial correlations with V_{50m} were found in boys aged 9–10 years (partial r = −.277, p = .037), boys aged 11–12 years (partial r = −.447, p = .001), and girls aged 11–12 years (partial r = −.367, p = .007).

Table 6. Partial correlation coefficients between V50m and jumping abilities, controlling for height. *†

	Boys		Girls	
	9-10 years group	11-12 years group	9-10 years group	11-12 years group
RJ-index	Partial R = .227 *p* = .089	Partial R = .472** *p* < .001	Partial R = .246 *p* = .148	Partial R = .624** *p* < .001
RJ-JH	Partial R = .123 *p* = .364	Partial R = .435** *p* = .002	Partial R = .074 *p* = .667	Partial R = .653** *p* < .001
RJ-CT	Partial R = -.294* *p* = .027	Partial R = -.482** *p* < .001	Partial R = -.282 *p* = .095	Partial R = -.353* *p* = .010
CMJ-JH	Partial R = .347** *p* = .008	Partial R = .598** *p* < .001	Partial R = .607** *p* < .001	Partial R = .574** *p* < .001
SLJ-JD	Partial R = .719** *p* < .001	Partial R = .645** *p* < .001	Partial R = .661** *p* < .001	Partial R = .593* *p* < .001

*Note. * RJ-JH = jump height of rebound jump, RJ-CT = contact time of rebound jump, CMJ-JH = jump height of counter movement jump, SLJ-JD = jump distance of standing long jump. †**p < .01, *p < .05.*

DISCUSSION

This study examined the relationships between 50-m sprint performance and multiple jump performances in elementary school children, with a particular focus on chronological age groups (9–10 and 11–12 years) and sex. SLJ was consistently associated with V_{50m} and sectional sprint velocities across all age- and sex-specific groups. CMJ performance was also associated with sprint velocity in all groups, although the correlation patterns varied by age and sex. RJ variables (RJ- index, RJ-JH, and RJ-CT) showed limited associations with sprint velocity in the 9–10-year group in both sexes, whereas they were associated with a broader range of sprint sections in the 11–12-year group. These findings largely supported our hypotheses that SLJ and CMJ would be associated with sprint performance across age and sex groups and that RJ-related associations would be stronger in the 11–12-year group, although sex-related patterns were inconsistent across jump variables. Collectively, the results suggest that the range of jump-performance characteristics associated with sprint performance appeared broader in the older age group. However, because this study used a cross-sectional design, this pattern should not be interpreted as evidence of within-individual developmental change, underlying mechanisms, or training effects.

When age groups were compared, the 11–12-year group showed significantly higher values than the 9–10-year group for all sectional sprint velocities, including V_{50m}. Similar trends were observed for the jump variables (RJ-index, RJ-JH, CMJ-JH, and SLJ-JD) (Table 1). Previous studies have shown that sprint and jump performances generally increase during childhood and early adolescence in association with changes in body size, muscle strength, power, neuromuscular coordination, and muscle–tendon properties (Papaiakovou et al., 2009; Radnor et al., 2018; Retzepis et al., 2025). The present age-group differences are broadly consistent with performance patterns previously reported in relation to age and biological maturation. However, because children within the same chronological age group may differ substantially in biological maturity, the higher sprint and jump performances observed in the 11–12-year group should be interpreted cautiously. These differences may partly reflect inter-individual variability in biological maturation rather than chronological age alone. In contrast, significant interactions between sex and age group were observed for the RJ-index and RJ-CT, indicating that the age-group differences in RJ-related fast SSC performance were not uniform between boys and girls. Previous studies have reported age- and sex-related differences in reactive strength and leg stiffness across developmental stages (Laffaye et al., 2016). In addition, growth and maturation are associated with changes in the neuromuscular control and muscle–tendon properties underlying fast SSC performance (Radnor et al., 2018; Retzepis et al., 2025). Therefore, sex-related differences in the timing of maturation and in the development of neuromuscular and muscle–tendon characteristics may partly underlie the interaction effects observed for the RJ-index and RJ-CT. However, because biological maturation was not directly assessed in this study, these interpretations remain tentative.

With regard to the relationships between sprint performance and the different jump variables, SLJ-JD was significantly correlated with V_{50m} regardless of sex or age group; it also showed significant moderate-to-high correlations with multiple sectional sprint velocities from $V_{0–10m}$ to $V_{40–50m}$ (Tables 2–5). Previous studies have similarly reported significant associations between SLJ and 30-m sprint time in children aged 9–12 years (Veligekas et al., 2012) and between horizontal jump performance and linear sprint ability in children and adolescents aged 8–16 years (Yanci et al., 2017). Additionally, a study of junior athletes aged 9–14 years reported that SLJ was associated with 5–10 m sprint time even in a partial correlation analysis that accounted for the effect of age in months (Oku et al., 2024). Thus, the present findings are consistent with previous evidence and suggest a strong association between SLJ-JD and sprint performance in both boys and girls aged 9–12 years. Because physique has been reported to influence sprint performance (Peñailillo et al., 2016), we examined the relationship between sprint performance and SLJ after controlling for height. Significant associations between SLJ and V_{50m} remained in all groups even after height was controlled for (Table 6). These findings suggest that, in boys and girls aged 9–12 years, the association between SLJ performance and sprint performance is not explained solely by physique but may also reflect the ability to generate horizontal propulsion (Oku et al., 2024) and movement technique (Veligekas et al., 2012). The horizontal orientation of force production required in both SLJ and sprinting may partly account for this relationship. During sprint acceleration, performance depends not only on the magnitude of ground reaction force but also on the ability to orient the resultant force forward (Morin et al., 2011), and horizontal jump performance has been associated with both sprint acceleration and maximal sprint speed (Lin et al., 2023). Notably, SLJ-JD was significantly associated with sprint velocity across all 10-m sections in all sex and age groups, suggesting that its relationship with sprint performance extended beyond the initial acceleration section but was observed throughout the 50-m sprint. Therefore, SLJ may serve as a simple field-based indicator of sprint-related horizontal propulsive ability in boys and girls aged 9–12 years. However, because the present study did not directly assess force magnitude and force orientation, this mechanism could not be confirmed.

Regarding the relationship between CMJ and sprint velocity, significant correlations were observed in boys in both age groups, and the strength of these relationships tended to be greater in the 11–12-year group than in the 9–10-year group (Tables 2–3). In girls, moderate-to-high correlations were already observed in the 9–10-year group, and similar associations were observed in the 11–12-year group (Tables 4–5). Previous research involving children aged 10–12 years has also reported a moderate association between CMJ performance and 30-m sprint time (Veligekas et al., 2012), which is consistent with the present findings. CMJ-JH is commonly considered a measure of lower-limb strength and power and was used as an index of slow SSC-related vertical jump performance and (Markovic et al., 2004; Petrigna et al., 2019). Although the direction of force application differs between CMJ and sprinting, greater CMJ performance may reflect a capacity to generate lower-limb power, which may partly account for its association with sprint velocity across multiple 10-m sections. Furthermore, differences in the patterns of association between CMJ and sprint performance between boys and girls may be influenced by sex-related differences in biological and neuromuscular development. Although central pubertal activation may begin at approximately the same age in boys and girls, clinical signs of puberty may appear earlier in girls following this activation, such that boys and girls of the same chronological age may be at different stages of endocrine and physical development (Demir et al., 2023). Moreover, girls generally reach biological maturation earlier than boys, and the timing and magnitude of maturation-related changes in strength and power may differ between sexes (Malina et al., 2010; Retzepis et al., 2025). Furthermore, changes in lower-limb neuromuscular control associated with maturation may differ between boys and girls. While boys showed improvements in vertical jump height and the ability to attenuate impact forces upon landing as they matured, no such adaptations were observed in girls (Quatman et al., 2006); furthermore, ankle and hip joint stiffness increased with maturation in boys but not in girls, suggesting that sex differences exist in force distribution and coordination among lower-limb joints (Ford et al., 2010). Considering these findings, the moderate-to-high CMJ–sprint correlations observed in younger girls and the stronger correlations observed in older boys may be related to sex-related differences in the timing of biological maturation and neuromuscular development. However, this study did not evaluate biological maturation, hormonal status, muscle activity, or inter-joint coordination. Future longitudinal studies should incorporate direct indicators of biological maturation together with neuromuscular and biomechanical measurements to determine whether these factors contribute to the sex- and age-group-related patterns in the CMJ–sprint relationship.

Regarding the relationship between RJ and sprint velocity, limited associations between RJ-related variables and sprint velocity were observed in the 9–10-year group in both sexes (Tables 2–5). In contrast, in the 11–12-year group, the RJ-index, RJ-JH, and RJ-CT were significantly associated with V_{50m} and all sectional sprint velocities in boys, whereas the RJ-index and RJ-JH were significantly associated with V_{50m} and all sectional sprint velocities in girls (Tables 2–5). Therefore, compared with the 9–10-year group, RJ-related variables in the 11–12-year group were associated with sprint velocity across a broader range of 10-m sections. This pattern suggests that fast SSC-related characteristics may be more closely associated with sprint performance in older children, rather than being related to a specific sprint section alone. Although the specific RJ variables associated with sprint velocity differed between boys and girls in the 11–12-year group, the principal pattern was that RJ-related variables were associated with a broader range of sprint sections in the older group for both sexes. Because the RJ involves jumping with short ground contact times, RJ-related variables reflect the ability to generate large forces during brief ground contact. Previous studies using hopping have reported age-related differences in RSI, leg stiffness, and muscle activity before and after ground contact, with older children showing higher RSI and different neuromuscular activation patterns than younger children (Lloyd et al., 2012). Furthermore, the development of SSC function with growth and maturation has been associated with changes in muscle–tendon stiffness, muscle pre-activation, and other neuromuscular characteristics (Lloyd et al., 2011; Radnor et al., 2018). In addition, a longitudinal study spanning PHV showed that changes in relative vertical stiffness, maximal force, and leg stiffness accounted for a substantial proportion of the changes in maximal sprint velocity in boys (Meyers et al., 2016). Taken together, these findings suggest that the broader associations observed between RJ variables and sprint velocity in the 11–12-year-old group may be related to age- and maturation-related development of the neuromuscular and muscle–tendon characteristics involved in fast SSC performance. Although RJ-related variables were associated with sprint velocity across multiple 10-m sections, sectional velocity alone cannot identify the kinetic, kinematic, or neuromuscular characteristics underlying these associations. Therefore, the mechanical basis of the relationships between RJ performance and sprint velocity remains unclear. Future longitudinal studies incorporating direct indicators of biological maturation and biomechanical measurements are needed to clarify how changes in fast SSC-related characteristics relate to changes in sprint performance across childhood.

Overall together, SLJ, CMJ, and RJ appear to capture different aspects of jump performance because they differ in both movement direction and the temporal characteristics of SSC function. SLJ primarily reflects horizontal jump performance, CMJ reflects vertical jump performance associated with the slow SSC as well as general lower-limb power, and RJ reflects performance associated with the fast SSC. The present findings suggest that sprint performance in children is associated with multiple jump-performance characteristics and that the range of these associations was broader in the 11–12-year group. Accordingly, assessing all three jump tasks may provide a more comprehensive understanding of sprint-related jump performance than assessing any single task alone. However, because force orientation, SSC kinetics, muscle activity, and joint mechanics were not directly measured, the specific mechanical and neuromuscular characteristics represented by each task cannot be determined from the present data.

From an applied perspective, the present findings suggest that jump assessment and training in children may be informed by considering multiple jump-performance characteristics rather than focusing on a single type of task. Although SLJ and CMJ may be informative across the examined age range, RJ may provide additional assessment information in older children. In training programs, fast SSC tasks may be incorporated progressively alongside horizontal and vertical jump activities when children demonstrate sufficient strength, coordination, movement competency, and technical readiness. Such progression is consistent with youth plyometric training models that recommend adjusting SSC demands according to growth, maturation, and training competence (Lloyd et al., 2011). However, the present study was cross-sectional and did not examine training effects or directly assess biological maturation. Therefore, these findings do not establish a fixed age-based training sequence or demonstrate that the progressive inclusion of fast SSC training improves sprint performance. They provide a rationale for considering fast SSC tasks alongside horizontal and vertical jump activities according to each child's developmental and technical readiness. Longitudinal and intervention studies are needed to determine whether such training progression is associated with, or contributes to, changes in sprint performance during childhood.

This study has several limitations. First, as this was a cross-sectional study, the observed relationships should be interpreted as associations rather than evidence of causal or within-individual developmental mechanisms. The findings, therefore, do not indicate that improvements in SLJ, CMJ, or RJ performance directly lead to improvements in sprint performance, nor do the longitudinal changes within individuals. Second, biological maturation was not assessed. Because chronological age does not fully capture inter-individual variability in maturity status, particularly during late childhood and early adolescence, maturation-related differences within each age group may have influenced the observed associations between jump and sprint performances. Third, sprint kinetics, kinematics, and neuromuscular characteristics were not evaluated. Although sprint velocity was calculated for each 10-m section, these measures do not provide direct information on ground reaction forces, force orientation, ground contact time, step characteristics, joint kinematics, muscle activity, or leg stiffness. Consequently, the specific mechanical and neuromuscular mechanisms underlying the relationships between SLJ, CMJ, RJ, and sprint velocity could not be determined. Nevertheless, the present findings suggest that the range and pattern of SSC-related jump-performance characteristics associated with sprint performance may vary across chronological age and sex groups. Future longitudinal studies should combine validated indicators of biological maturation with kinetic, kinematic, and neuromuscular measurements to clarify how changes in jump-performance characteristics relate to sprint performance during childhood.

CONCLUSIONS

This study demonstrated that the relationships between 50-m sprint performance and multiple jump performances in elementary school children vary according to chronological age and sex groups. SLJ performance was consistently associated with overall and sectional sprint velocities in boys and girls aged 9–12 years, indicating that SLJ is a consistent field-based indicator associated with sprint performance across the examined age groups. CMJ performance was also associated with sprint velocity in all groups, with larger correlation coefficients observed in older boys and moderate-to-high correlations already present in younger girls. In contrast, RJ-related variables showed limited associations with sprint performance in the 9–10-year group but were associated with a broader range of sprint sections in the 11–12-year group. Together, these findings indicate that SLJ, CMJ, and RJ capture partly distinct jump-performance characteristics associated with sprint performance and that the older age group showed associations with a broader range of these characteristics. Assessing multiple jump tasks may, therefore, provide a more comprehensive profile of the jump-performance characteristics associated with sprint performance than relying on a single task. However, because this study was cross-sectional and did not directly assess biological maturation or sprint biomechanics, the observed age- and sex-group patterns cannot be interpreted as longitudinal developmental changes or causal mechanisms. Future longitudinal and intervention studies incorporating direct measures of biological maturation and biomechanics are needed to determine how changes in these jump-performance characteristics relate to changes in sprint performance during childhood.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Contributions are specified according to the CRediT (Contributor Roles Taxonomy) as follows: Conceptualisation: Y.H and R.H. Methodology: Y.H, K.S. and R.H. Formal analysis: Y.H. and R.H. Investigation: Y.H, K.S. and R.H. Data curation: Y.H. and R.H. Writing – original draft: Y.H and R.H. Writing – review & editing: Y.H, K.S. and R.H.

All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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