the Journal of Strength and Conditioning Research™

Unresisted Sprints Versus Heavy Resisted Sled Training: Relationships With Performance Indicators and Implications for Training Prescription in Elite Youth Rugby Players

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Abstract

Zabaloy, S, Freitas, TT, Gálvez-González, J, Tondelli, E, Pereira, LA, and Loturco, I. Unresisted sprints versus heavy resisted sled training: relationships with performance indicators and implications for training prescription in elite youth rugby players. *J Strength Cond Res* XX(X): 000–000, 2025—The aim of this study was to analyze the associations between sprint velocities achieved under unresisted and resisted (50% body mass [BM]) sprint conditions, squat 1-repetition maximum (squat 1RM) and its associated strength deficit (SDef; from 40 to 90% squat 1RM), and horizontal and vertical jump performance in elite youth rugby players. Twenty-five under-19 youth male rugby players ($n = 25$; age: 17.3 ± 0.9 years) participated in this study and completed the following tests during the preparation period leading up to the 2024 in-season period: unresisted and resisted 30-m sprints, squat 1RM, countermovement jumps, and standing long jumps. Results showed that unresisted and resisted sprint velocities were significantly associated with both jump tasks (r: 0.46–0.76; $p < 0.019$), while relative squat 1RM measures (i.e., 1RM relative to BM) demonstrated stronger correlations, compared with absolute 1RM values, with sprint velocities under both conditions, as well as with vertical and horizontal jump metrics (r: 0.40–0.74; $p < 0.045$). SDefs across the entire range of loads (i.e., 40–90% squat 1RM) were also significantly associated (r: 0.84–0.99; $p < 0.001$). In summary, the present findings highlight the importance of considering relative strength as an additional measure of strength performance, particularly when the primary objective is to enhance a wide range of sport-specific capabilities. Finally, the associations observed among all values of SDef indicate that reducing this strength-derived variable, especially under lighter loading conditions, is highly constrained or even impossible.

Key Words: sprint speed, youth athletes, athletic performance, resisted sprinting, team sports

Introduction

Maximum sprinting velocity (V_{max}) has been consistently reported as crucial for athletes in both individual and team sports (7,8,15). Specifically, in team sports (e.g., rugby and soccer), sprint velocity plays a crucial role in match-related outcomes (e.g., scoring goals, evading opponents, breaking tackles) (4,21), and has been identified as a clear distinguishing factor between age categories (from under-14 to senior) (27). For these reasons, improving sprinting ability is a primary training objective for athletes across various sports, including rugby union. To this end, coaches use a variety of training methods and tools to develop V_{max}, including traditional (i.e., unresisted), resisted sprint training (RST) (e.g., sleds or weighted vests), assisted methods (e.g., motorized assistance), and traditional resistance training and plyometrics (25). The use of RST as a strategy to induce positive adaptations for V_{max} has been widely investigated; however, findings remain conflicting regarding the most appropriate loads and volumes to program these training sessions (1,19,25). Indeed, the lack of consistency in the results reported in the literature (1,19,25) highlights the need for further investigation into factors related to the maximum velocity achieved during unresisted and heavy RST conditions (e.g., ≥50% of body mass [BM]). This could assist practitioners in designing and implementing sprint training programs more effectively.

A clearer understanding of the factors influencing V_{max} under different loading intensities requires analyzing the associations between these conditions and key performance metrics (i.e., vertical and horizontal jump distances, squat 1-repetition maximum [squat 1RM]), in athletes with distinct training backgrounds. For example, Martínez-Valencia et al. (14) reported that absolute and relative squat strength were moderately associated ($r > 0.63$, $p < 0.05$) with both resisted (30% BM) and unresisted sprint times in sprinters and soccer players. Nevertheless, no correlations were detected between sprint times and squat 1RM ($r < 0.153$). Similarly, Zabaloy et al. (24) reported that unresisted and resisted sprint times (i.e., from 0 to 80% BM) were strongly correlated with vertical jump height and V_{max} in senior amateur rugby players. Notably, the authors (24) observed no associations

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between resisted sprint times at 20–80% BM and squat 1RM, either in absolute or relative values. In addition, no studies to date have analyzed the associations between unresisted and resisted sprint velocities and strength deficit (i.e., SDef: the difference between the force produced at 1RM and that applied to submaximal loads) (13) across a wide range of squat loads (40–90% 1RM), nor their correlations with horizontal and vertical jump performance. This issue is crucial given the well-documented relationship between reduced SDef levels and superior sprint performance (13,26).

Undoubtedly, further research is needed to address the limitations of current sprint training methods and the reported associations between key performance metrics and sprint velocity. In this context, this study aimed to examine the relationships between unresisted and resisted (50% BM) sprint velocities, squat 1RM (absolute and relative values), and the corresponding SDef across a range of loads, and vertical and horizontal jump performance in elite youth rugby players. Through this initial investigation, we hope to open a new avenue of research into the development of better and more effective sprint training strategies.

Methods

Experimental Approach to the Problem

This study used a descriptive, cross-sectional design to analyze the associations between unresisted and resisted sprint performance and selected key performance measures (i.e., SDef, squat 1RM, standing long jump [SLJ] and countermovement jump [CMJ]) in youth male rugby union players. Testing sessions were conducted at the beginning of the preseason, immediately after a 3-week offseason period, leading into the 2024 in-season period. The training volume and intensity, and the strategies and exercises used during this preparatory phase, were very similar to the training content and methods adopted by the players during their previous preseason phases, in accordance with the expectations and prescriptions of the coaching staff. All players underwent a medical assessment before the start of the season and completed the tests without any injuries or physical discomfort, as certified by the medical staff. In addition, after being informed of the purpose of the study and experimental procedures, and before participation, players and their legal guardians (for those younger than 18 years of age) provided written informed consent. The Federal University of São Paulo Research Ethics Committee approved the study (Case No. 6.621.221), which adhered to all ethical standards in accordance with the recommendations of the Declaration of Helsinki.

Subjects

Twenty-five under-19 elite male rugby players (n = 25; age: 17.3 ± 0.9 years; BM: 81.1 ± 11.2 kg; height: 177.5 ± 5.6 cm) volunteered to participate in this study. All players had a minimum of 5 years of playing experience and competed at the highest standard of national youth competition. They regularly participated in approximately 6 weekly training sessions, including 3 sprint and resistance training sessions and 2 to 3 rugby-specific training sessions at their local club facilities. Players completed the following assessments for 3 days, with 48-h intervals between sessions: (a) unresisted and resisted (50%BM) sprints for 10 and 30 m; (b) estimated squat 1RM; and (c) SLJs and CMJs. The physical tests followed validated procedures and were conducted before a general, standardized warm-up (e.g., light jogging, general mobility exercises, and unloaded squats), under the supervision of an experienced and accredited strength and conditioning coach.

Procedures

Anthropometrics. All anthropometric measurements were conducted following the recommendations of The International Society for the Advancement of Kinanthropometry (ISAK). Body mass was measured using an electronic scale (HD-366, Tanita Corporation, Japan) and body height was measured using a stadiometer and vertex (Rosscraft Innovations, Vancouver, Canada).

Unresisted and Resisted Sprints. Sprint times were recorded using single-beam timing gates with postprocessing software (Chronojump, Boscosystem, Barcelona, Spain), set at hip height and positioned at 0, 10, 20, 25, and 30 m. Players started in a 2-point split stance just behind a line 0.5 m from the first gate and sprinted with maximum effort until passing a 35-m cone to avoid early deceleration. After a specific warm-up consisting of sprints with progressively increasing distances (i.e., from 10 to 30 m) and intensities (i.e., 60–90% of perceived effort), players performed 2 unresisted 30-m sprints with a 3-minute recovery between trials. Subsequently, they completed one 30-m resisted sprint trial, pulling a sled (Fenix, Argentina; sled mass: 18 kg) attached to their waists with 50% BM. As previously mentioned, this relative sled load (i.e., 50% BM) was selected and defined in agreement with the rugby team's coaching staff, representing the minimum intensity of heavy sled loads to be considered a "tertiary training method" (25). This strategy was adopted to minimize the potential fatigue induced by heavy sled loading conditions, without compromising the objectives of the study. Sprint velocity at 10 and 30 m, and V_{max} were calculated for resisted (rVEL10, rVEL30, rV_{max}) and unresisted (VEL10, VEL30, V_{max}) sprint conditions.

Maximal Dynamic Strength. The assessment was conducted using a linear position transducer (Chronojump, Boscosystem, Barcelona, Spain) attached to the barbell to record movement velocity, following recent valid recommendations (23). The squat exercise was performed on a squat rack with a 20-kg Olympic barbell (Fenix, Argentina). Before the test, players completed a specific warm-up consisting of 3 sets of 3 repetitions, first with a barbell only (i.e., 20 kg) and then with a 40-kg load. Subsequently, they performed repetitions with progressively increasing loads, starting at 40 kg and increasing by 5–10-kg increments. Three repetitions were performed at each load, except for the highest loads, where 1 or 2 repetitions were completed. A 3-minute rest interval was provided between sets. The test concluded when players reached a mean propulsive velocity close to 0.5 m·second^{-1} (i.e., 80–85% 1RM). Once the assessment was concluded, 1RM values were estimated using the formula provided elsewhere (20), based on the fastest MPV attained (i.e., ≈0.5 m·second^{-1}) against the heaviest load lifted (i.e., ≈85% 1RM). Participants were verbally encouraged to execute the concentric phase of the lift at maximal intended velocity during every repetition. Squat 1RM (absolute and relative) and SDef (from 40 to 90% 1RM) were calculated using procedures described elsewhere in a similar athletic cohort (26).

Vertical and Horizontal Jumps. Before testing, players performed a 10-minute specific warm-up protocol consisting of unloaded

lunges and squats, followed by 3 sets of 2 repetitions of each jump. For the CMJ, participants executed a downward movement followed by full extension of the lower limbs, with the amplitude of the countermovement freely determined to avoid changes in jumping coordination. Three CMJ attempts were performed with 15-second intervals, and a 2-minute recovery between trials. Jumps were assessed using portable, uniaxial, dual force plates (Force Decks, FDLite V.2, VALD, Brisbane, Australia), and jump height was estimated using the impulse–momentum equation (3). For the CMJ, players were instructed to perform a maximal explosive effort, to jump and land on the same spot, and to land with their legs extended before flexing them on landing. Furthermore, for the SLJ, players completed 2 maximal horizontal jumps, separated by 15 seconds. Athletes were verbally encouraged to jump as far as possible while landing in a controlled manner (i.e., bouncing or losing balance was not permitted). An accurate measuring tape (Model CAM50, Jian Da, China) was used to measure the distance from the starting line to the nearest heel on landing. During both tasks, players were required to keep their hands on their hips, with the best attempt used for subsequent analysis.

Statistical Analyses

Data are reported as mean ± standard deviation (*SD*). Relative and absolute reliability were assessed using the Intraclass Correlation Coefficient (ICC) and Coefficient of Variation (CV). The Shapiro–Wilk test was applied to assess data normality. Correlation coefficients among variables were calculated using Pearson's product moment correlation, or Spearman's *Rho* in cases of non-normality, with the corresponding 95% confidence intervals (CI) reported in the tables. These correlations were qualitatively categorized as follows: <0.1 (trivial), 0.1–0.3 (small), 0.3–0.5 (moderate), 0.5–0.7 (large), 0.7–0.9 (very large), >0.9 (nearly perfect) (9). Statistical significance was accepted at $p < 0.05$.

Results

All reported measures exhibited acceptable to excellent absolute and relative reliability (CV < 6%; ICC >0.90). Table 1 gives the descriptive data for unresisted and resisted sprint, jump, and strength measures. The non-normal distribution identified for rVEL30 and rV_{max} likely reflects the inherent variability in sprint-related performance metrics, influenced by individual differences in sprinting technique, biomechanics, and neuromuscular function at maximal intensities. The concentration of higher performances with few lower outliers, commonly detected in highly trained populations, may further explain this outcome (6,7). The associations between unresisted and resisted sprint velocities and SLJ and CMJ measures are presented in Table 2. In brief, CMJ and SLJ were associated with all velocity measures at varying levels of correlation ($r = 0.46$ [standard error effect size; *SE*—ES: 0.21] to 0.76 [*SE*—ES: 0.22]; $p < 0.05$). Similarly, Table 3 reports the correlations among a range of strength parameters, unresisted and resisted sprint velocities, and jumps. The results showed that squat 1RM (both absolute and relative) was associated with both jump tasks and sprint-related measures ($r > 0.40$ [*SE*—ES: 0.21 to 0.22]; $p < 0.05$). Finally, Table 4 gives the significant associations were observed between all SDef values from 40 to 90% of squat 1RM ($r > 0.84$ [*SE*—ES: 0.22]; $p < 0.05$). Conversely, none of the SDef values were correlated with absolute or relative squat 1RM.

Discussion

This study aimed to investigate the associations between unresisted and resisted (50% BM) sprint velocities for various distances, squat 1RM, associated SDef values (from 40 to 90% 1RM), and horizontal and vertical jump performance in elite youth rugby players. The main findings were as follows: (a) Unresisted and resisted sprint velocities at 10 m, 30 m, and V_{max} were correlated with CMJ and SLJ distances at varying levels (r: 0.46–0.76; $p < 0.019$); (b) Squat 1RM (absolute and relative) demonstrated moderate to very large correlations (r: 0.47–0.74; $p < 0.045$) with unresisted and resisted sprint velocities, CMJ, and SLJ distances; (c) very large to nearly perfect associations were observed between all SDef values from 40 to 90% of squat 1RM (r: 0.84–0.99; $p < 0.001$), although these measures were not correlated with absolute or relative squat 1RM. This information may help coaches develop a more consistent understanding of the

Table 1

Descriptive data for unresisted and resisted sprint performance, strength, and jump measures in youth rugby players.*†

Variables	Mean	*SD*	Shapiro–Wilk (*p*)	Min	Max
SLJ (cm)	192.72	20.72	0.935	153.00	236.00
CMJ (m)	37.96	5.01	0.259	25.20	50.30
VEL10 (m·s^{-1})	5.31	0.22	0.570	4.82	5.68
VEL30 (m·s^{-1})	6.78	0.30	0.020	5.82	7.28
V_{max} (m·s^{-1})	8.42	0.57	0.063	6.66	9.23
rVEL10 (m·s^{-1})	3.35	0.19	0.153	2.87	3.66
rVEL30 (m·s^{-1})	4.06	0.35	<0.001	2.76	4.44
rV_{max} (m·s^{-1})	4.61	0.57	0.002	2.59	5.46
Squat 1RM (kg)	124.89	23.56	0.934	74.63	176.62
REL squat (kg·kg^{-1})	1.54	0.21	0.052	0.85	2.01
SDEF 90% 1RM (%)	4.60	2.80	0.556	0.86	11.00
SDEF 80% 1RM (%)	9.12	4.53	0.722	0.88	18.44
SDEF 70% 1RM (%)	13.35	5.63	0.548	2.68	24.22
SDEF 60% 1 RM (%)	17.28	6.08	0.572	5.40	28.35
SDEF 50% 1RM (%)	20.91	5.95	0.560	9.04	30.84
SDEF 40% 1RM (%)	24.24	5.42	0.366	13.60	32.13

*SLJ = standing long jump; CMJ = countermovement jump; VEL10 and VEL30 = mean sprint velocity for 10 and 30 m; V_{max} = maximum sprint velocity; rVEL10 and rVEL30 = mean sprint velocity for 10 and 30 m under resisted conditions; rV_{max} = maximum resisted sprint velocity; squat 1RM = 1-repetition maximum; REL squat = 1RM relative to body mass; SDef = strength deficit values from 40 to 90% 1RM.
†Data are presented as mean ± *SD*.

Table 2

Relationships between horizontal and vertical jump performance and resisted and unresisted sprint velocity in youth rugby players.*

Variable	SLJ	CMJ	VEL10	VEL30	V_{max}	rVEL10	rVEL30
CMJ							
Pearson's r	0.712						
p	<0.001						
Upper 95% CI	0.864						
Lower 95% CI	0.442						
VEL10							
Pearson's r	0.467	0.549					
p	0.019	0.005					
Upper 95% CI	0.728	0.776					
Lower 95% CI	0.088	0.196					
VEL30							
Spearman's rho	0.486	0.475	0.885				
p	0.014	0.016	<0.001				
Upper 95% CI	0.739	0.733	0.948				
Lower 95% CI	0.112	0.098	0.753				
V_{max}							
Pearson's r	0.607	0.544	0.736	0.860			
p	0.001	0.005	<0.001	<0.001			
Upper 95% CI	0.808	0.773	0.876	0.974			
Lower 95% CI	0.278	0.190	0.481	0.871			
rVEL10							
Pearson's r	0.470	0.490	0.507	0.402	0.531		
p	0.018	0.013	0.010	0.047	0.006		
Upper 95% CI	0.730	0.742	0.752	0.796	0.765		
Lower 95% CI	0.092	0.118	0.141	0.164	0.171		
rVEL30							
Spearman's rho	0.730	0.672	0.528	0.576	0.501	0.808	
p	<0.001	<0.001	0.007	0.003	0.012	<0.001	
Upper 95% CI	0.873	0.843	0.764	0.791	0.748	0.912	
Lower 95% CI	0.471	0.377	0.169	0.234	0.132	0.606	
rV_{max}							
Spearman's rho	0.761	0.719	0.579	0.649	0.566	0.576	0.932
p	<0.001	<0.001	0.002	<0.001	0.003	0.003	<0.001
Upper 95% CI	0.889	0.868	0.793	0.831	0.786	0.791	0.970
Lower 95% CI	0.523	0.453	0.238	0.341	0.220	0.235	0.850

*CI = confidence interval; SLJ = standing long jump; CMJ = countermovement jump; VEL10 and VEL30 = mean sprint velocity for 10 and 30 m; V_{max} = maximum sprint velocity; rVEL10 and rVEL30 = mean sprint velocity for 10 and 30 m under resisted conditions; rV_{max} = maximum resisted sprint velocity.

physical attributes underlying traditional (unresisted) and resisted sprint performance, particularly under heavier sled loading conditions (i.e., 50% BM). Furthermore, it highlights the important role of relative strength and explosive tasks, such as vertical and horizontal jumps, in enhancing sprint performance across different phases (e.g., acceleration and maximum velocity). In addition, it sheds light on the potential value of using distinct loading conditions (i.e., unresisted and resisted sprint training) to improve sprint velocity.

The associations between CMJ and SLJ distances and the sprint performance measures presented in this study are consistent with the findings of a recent systematic review (17), which reported moderate-to-strong correlations between jump height and unresisted sprint times. Nevertheless, the inclusion of horizontal jumps and heavy resisted sprints in this study provides novel insights, because both vertical and horizontal jumps showed a tendency for stronger correlations with heavy resisted loads (i.e., 50% BM) and distances (i.e., from 10 to 30 m to V_{max}). This finding is not surprising and can be attributed to several factors: (a) The "slow stretch-shortening cycle" that occurs during both tasks, as opposed to unloaded maximum sprints (22); (b) The interdependence of vertical and horizontal force vectors, including the resultant vector, in sprint performance (10). It is important to recognize this interdependence rather than assuming the dominance of one vector (i.e., horizontal) over the other (i.e., vertical) (10). Hence, we challenge the classical assumption that horizontally oriented exercises (e.g., horizontally oriented jumps) preferentially enhance the acceleration phase of sprinting (e.g., 0–10 m). In summary, both jump tasks may contribute to sprint performance development; however, a greater shared variance was observed under the resisted sprinting condition. In terms of strength performance, several authors have consistently highlighted that strength is a fundamental quality influencing numerous physical and technical skills, often assessed through the squat 1RM (12,13). Relative strength in the squat exercise has previously been reported (13,26) to be moderately associated with jump performance and sprint velocity (r: 0.38–0.77; $p < 0.05$) in elite athletes (e.g., rugby union players and elite sprinters). These findings align with our results, where both jump tests and all sprint velocities (regardless of loading condition or distance) were associated with absolute and relative squat 1RM. Notably, the associations were stronger (as also observed in the effect sizes) when strength values were normalized to BM, indicating that relative squat 1RM is a better performance indicator than absolute strength measures. To further support this, the authors (5) previously demonstrated that team-sport athletes with higher relative half-squat values outperformed their weaker and less powerful counterparts in all speed- and power-related

Table 3

Relationships between jump performance, resisted and unresisted sprint velocity, and maximum squat strength in youth rugby players.*

Variable	SLJ	CMJ	VEL10	VEL30†	V_{max}	rVEL10	rVEL30†	rV_{max}†
1RM SQ								
Pearson's r	0.520	0.554	0.457	0.445	0.499	0.279	0.570	0.617
p	0.008	0.004	0.022	0.026	0.011	0.176	0.003	<0.001
Upper 95% CI	0.759	0.779	0.722	0.715	0.747	0.607	0.788	0.814
Lower 95% CI	0.158	0.204	0.075	0.061	0.130	−0.130	0.226	0.293
REL SQ								
Pearson's r	0.746	0.717	0.582	0.404	0.634	0.554	0.672	0.615
p	<0.001	<0.001	0.002	0.045	<0.001	0.004	<0.001	<0.001
Upper 95% CI	0.881	0.867	0.794	0.689	0.823	0.779	0.843	0.813
Lower 95% CI	0.497	0.449	0.242	0.010	0.319	0.203	0.377	0.291
SDEF 90								
Pearson's r	0.292	0.269	0.050	−0.027	0.086	−0.056	0.219	0.335
p	0.166	0.204	0.815	0.902	0.691	0.793	0.302	0.110
Upper 95% CI	0.622	0.606	0.445	0.381	0.473	0.355	0.572	0.650
Lower 95% CI	−0.126	−0.151	−0.360	−0.425	−0.329	−0.450	−0.202	−0.079
SDEF 80								
Pearson's r	0.262	0.236	0.046	−0.021	0.122	−0.063	0.200	0.328
p	0.217	0.267	0.829	0.923	0.570	0.770	0.347	0.118
Upper 95% CI	0.602	0.584	0.442	0.386	0.501	0.349	0.558	0.646
Lower 95% CI	−0.159	−0.185	−0.364	−0.421	−0.296	−0.455	−0.221	−0.087
SDEF 70								
Pearson's r	0.262	0.228	0.052	−0.062	0.141	−0.045	0.189	0.303
p	0.216	0.284	0.809	0.773	0.511	0.833	0.376	0.150
Upper 95% CI	0.602	0.578	0.446	0.350	0.515	0.365	0.550	0.630
Lower 95% CI	−0.158	−0.193	−0.359	−0.454	−0.278	−0.441	−0.232	−0.114
SDEF 60								
Pearson's r	0.282	0.233	0.066	−0.034	0.156	−0.010	0.267	0.362
p	0.181	0.272	0.760	0.873	0.466	0.962	0.207	0.082
Upper 95% CI	0.616	0.582	0.457	0.374	0.526	0.395	0.605	0.668
Lower 95% CI	−0.137	−0.188	−0.347	−0.432	−0.264	−0.412	−0.153	−0.048
SDEF 50								
Pearson's r	0.321	0.248	0.089	−0.017	0.172	0.049	0.318	0.397
p	0.126	0.242	0.678	0.939	0.421	0.820	0.130	0.055
Upper 95% CI	0.642	0.592	0.476	0.389	0.538	0.444	0.640	0.690
Lower 95% CI	−0.094	−0.172	−0.326	−0.417	−0.249	−0.361	−0.098	−0.007
SDEF 40								
Pearson's r	0.380	0.268	0.127	0.047	0.187	0.149	0.420	0.470
p	0.067	0.205	0.555	0.826	0.382	0.486	0.042	0.020
Upper 95% CI	0.679	0.606	0.504	0.442	0.549	0.521	0.704	0.734
Lower 95% CI	−0.028	−0.152	−0.292	−0.363	−0.234	−0.270	0.020	0.083

*CI = confidence interval; SLJ = standing long jump; CMJ = countermovement jump; VEL10 and VEL30 = mean sprint velocity for 10 and 30 m; V_{max} = maximum sprint velocity; rVEL10 and rVEL30 = mean sprint velocity for 10 and 30 m under resisted conditions; rV_{max} = maximum resisted sprint velocity; 1RM SQ = 1-repetition maximum; REL SQ = 1RM relative to body mass; SDef = strength deficit values from 40 to 90% 1RM.

†Spearman's correlation coefficients.

measures (i.e., 5- to 20-m sprint velocity, change of direction, and vertical jump height). Furthermore, a novel and relevant finding of this study is that SDef values recorded across a wide spectrum of loads (ranging from 40 to 90% 1RM) were strongly interrelated ($r > 0.84$; ES > 1.23; $p < 0.001$), providing further evidence that this strength-derived variable has limited potential for development, as previously demonstrated in a training study (12) and a cross-sectional study comparing exercises performed in traditional and ballistic forms (11).

Regarding the participants' training exposure (i.e., 3 times per week, 45 to 60 minutes per session) and the resistance training programs performed before the study, it is important to note that they regularly used loads ranging from 60 to 90% 1RM during their resistance training sessions. However, they performed ballistic exercises (e.g., jump squats) at lighter loads (i.e., ≤30–40% 1RM) less frequently, typically only once per week. This may help explain our findings, where the large-shared variance observed in the SDef correlations ($R^2 = 0.70–0.96$) further suggests that, for these players, a reduction in SDef is unlikely unless ballistic exercises under light loads—or even unloaded conditions—are consistently incorporated into their training routines (e.g., 2–3 times per week) (11,13). Nonetheless, this remains a hypothesis based on previous studies involving rugby and soccer players (11,13,26), which must be confirmed through intervention studies conducted with highly trained individuals and elite athletes. Even under these circumstances, it is worth highlighting that the authors emphasize the importance of reducing SDef, thereby enabling the application of greater peak forces against relatively lighter loads.

This study is inherently limited by its cross-sectional design, which prevents the drawing of more robust conclusions from the results. Accordingly, additional studies are clearly needed to further confirm the stability of SDef values and the efficacy of lighter loading conditions—and the use of mixed training programs comprising unloaded and light-loaded ballistic exercises—in enhancing strength-power capabilities and,

Table 4

Relationships between absolute and relative squat strength and the corresponding strength deficits in youth rugby players.*

Variable	Statistic	1RM SQ	REL SQ	SDEF 90	SDEF 80	SDEF 70	SDEF 60	SDEF 50
REL SQ	Pearson's r	0.676						
	p	<0.001						
	Upper 95% CI	0.846						
	Lower 95% CI	0.384						
SDEF 90	Pearson's r	−0.076	0.100					
	p	0.725	0.642					
	Upper 95% CI	0.338	0.484					
	Lower 95% CI	−0.465	−0.316					
SDEF 80	Pearson's r	−0.127	0.065	0.980				
	p	0.555	0.765	<0.001				
	Upper 95% CI	0.292	0.456	0.991				
	Lower 95% CI	−0.504	−0.348	0.953				
SDEF 70	Pearson's r	−0.137	0.075	0.961	0.996			
	p	0.524	0.728	<0.001	<0.001			
	Upper 95% CI	0.282	0.464	0.983	0.998			
	Lower 95% CI	−0.512	−0.339	0.910	0.991			
SDEF 60	Pearson's r	−0.126	0.116	0.946	0.987	0.996		
	p	0.557	0.589	<0.001	<0.001	<0.001		
	Upper 95% CI	0.292	0.496	0.977	0.994	0.998		
	Lower 95% CI	−0.504	−0.301	0.878	0.969	0.991		
SDEF 50	Pearson's r	−0.095	0.193	0.921	0.960	0.975	0.990	
	p	0.659	0.367	<0.001	<0.001	<0.001	<0.001	
	Upper 95% CI	0.321	0.553	0.965	0.983	0.989	0.996	
	Lower 95% CI	−0.480	−0.228	0.823	0.908	0.943	0.978	
SDEF 40	Pearson's r	−0.030	0.322	0.843	0.873	0.896	0.929	0.971
	p	0.889	0.125	<0.001	<0.001	<0.001	<0.001	<0.001
	Upper 95% CI	0.378	0.642	0.930	0.944	0.954	0.969	0.987
	Lower 95% CI	−0.428	−0.094	0.667	0.725	0.771	0.840	0.933

*CI = confidence interval; squat 1RM = 1-repetition maximum; REL SQ = relative squat strength (1RM relative to body mass); SDEF = strength deficit values from 40 to 90% 1RM.

consequently, sprint performance. Nevertheless, it is worth noting that cross-sectional studies are frequently conducted in high-performance sport settings because of the typical limitations and time constraints observed in these environments (11,13,26). Further investigations should be performed across different sports (e.g., soccer, track and field) and age categories (e.g., senior rugby players) to confirm the inferences and preliminary observations presented herein.

Practical Applications

This study sheds light and provides a more comprehensive view of the actual training effects elicited by unresisted and heavy-resisted sprint training in youth rugby players. Given that similar associations were observed between both sprint conditions, vertical and horizontal jumping abilities, and strength performance, it is plausible to hypothesize that the use of heavier sled loads (i.e., ≥50% BM) during speed-related training sessions might not be necessary. In this regard, lighter loading conditions (e.g., 20–30% BM) might also serve as a potential stimulus while avoiding the negative acute and delayed effects associated with heavy sled training (2,16,18). However, it is important to note that these considerations are based on observed relationships and should be interpreted as theoretical insights rather than conclusions drawn through direct testing. This theoretical assumption draws on several factors: (a) There seems to be no clear advantage to using heavy sled loads when the primary objective is to improve specific sprint running phases (i.e., acceleration, transition, or top-speed phases) (25); (b) The acute effects induced by heavy sled loads are mostly related to increased fatigue and disruptions in sprinting technique (2,16,18); and (c) because heavy sled training has recently demonstrated positive effects on both isometric and eccentric strength (28), we suggest that this training approach be considered a tertiary rather than a secondary sprint training method (25). Furthermore, this study indicates the potential importance of using relative strength and SDef as additional measurements of athletic performance, because these variables may assist coaches in designing more tailored training programs. By increasing relative strength and reducing (or even maintaining) the SDef, the overall performance of youth rugby players could be enhanced. In addition, practitioners might consider incorporating these strength-derived metrics (i.e., relative strength and SDef) when designing more integrated training schemes that combine traditional and ballistic strength-power exercises (e.g., squats and jump squats) across a wide range of loads (e.g., 40–80% 1RM), unresisted and resisted sprints with low-to-moderate loads (i.e., from 0% to <50% BM) (25), and plyometric drills. Nonetheless, as mentioned earlier, we acknowledge that future studies are necessary to experimentally test and validate these proposed practical applications through intervention-based research. Such studies would help confirm the efficacy of integrated training strategies in enhancing sport-specific performance among highly trained youth rugby players (13,25).

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