

Differences in sprint profile, sprint completion times, and jumping performance between division I track and field sprinters, throwers, and long-distance runners

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Published online: January 31, 2023

(Accepted for publication January 15, 2023)

DOI:10.7752/jpes.2023.01002

Abstract

Problem Statement: The sport demands of differing track and field events may impact sprinting and jumping performance. Yet this remains to be explored across sprinters, throwers, and long-distance runners. **Purpose:** This study explored the differences in sprint profile measures, sprint completion times, and jump performance between track and field athletes. **Approach:** Forty-two collegiate track and field athletes (sprinters = 18; throwers = 10; long-distance runners = 14) completed broad jump (BJ) trials where distance and peak vertical and horizontal forces were obtained. Force, power, and modified reactive strength index were obtained during vertical countermovement jumps (VJ). Subjects completed 30-meter sprints with the MySprint mobile application assessing subjects' sprint profile including maximal theoretical horizontal force, maximal theoretical velocity, maximal theoretical power, maximal speed, maximal ratio of force, force-velocity slope, and decrease in ratio of force. A series of one-way ANOVAs with follow up comparisons determined group differences for each measure of interest. **Results:** Multiple sprint profile variables and sprint completion times differed between sprinters and long-distance runners ($p < 0.01$; Hedge's $g = 1.20$ to 1.50). Similarly, sprint profile variables and sprint completion times differed between sprinters and throwers ($p < 0.05$; Hedge's $g = 0.97$ to 1.37). Additionally, various jump performance variables during VJ, and BJ differed between sprinters and long-distance runners ($p < 0.05$; Hedge's $g = 1.02$ to 2.18) and between sprinters and throwers ($p < 0.05$; Hedge's $g = 1.10$ to 1.90). **Conclusions:** Sprinters apply higher horizontally-oriented forces during sprinting compared to long-distance runners and throwers contributing to a superior sprint performance. Sprinters display better force application during jump performance compared to throwers and long-distance runners. Negligible differences exist in sprint and jump performance between throwers and long-distance runners.

Key Words: Sprinting, jumping, speed, power, track and field

Introduction

Muscular power and speed are vital physical fitness characteristics of multiple track and field events (O'Connor et al., 2007). In sprinting and long-distance running, the purpose is to cover the distance in the shortest amount of time possible. Literature highlights the importance of properly oriented ground reaction forces despite increasing velocities to attain optimal running speeds across various distances (Rabita et al., 2015; Slawinski et al., 2017). For instance, Morin et al. (2015) indicated that among sprinters, horizontal impulse was associated with 40-m sprint velocity ($r = 0.868$; $p < 0.01$).

A recently developed macroscopic method permits the computation of biomechanical variables during sprint acceleration (Morin et al., 2019; Samozino et al., 2016). Variables include maximal sprint speed, maximal theoretical horizontal force (F_0), maximal theoretical velocity (V_0), maximal theoretical power (P_{max}), maximal ratio of force (RF_{max}), decrease in ratio of force (DR_F), and force-velocity slope (S_{FV}). Collectively, these variables comprise the "sprint profile" of the athlete and guide training programs of sprint reliant athletes (Dylan et al., 2019). Moreover, research suggest that the sprint force-velocity or power-velocity relationships distinguish between athletes of different sports, positions, and expertise levels (Dylan et al., 2019; Rabita et al., 2015; Stavridis et al., 2019). Similarly, kinetics and kinematics during vertical jumping and their interrelationships (force-velocity and power-velocity) differ between sports (Jiménez-Reyes et al., 2018). Not surprisingly, kinetic and kinematic metrics obtained during sprinting and jumping are associated (Loturco, D'Angelo et al., 2015). In fact, recent research indicates that broad jump distance as the main predictor of 30-meter sprint completion times across sprinters, jumpers, and pole vaulters (Dietze-Hermosa, et al., 2021; Montalvo, et al., 2021). Recently, Jiménez-Reyes et al. (2018) indicated that the force-velocity and power-velocity relationships displayed during

sprinting were associated with the force-velocity and power-velocity relationships during jumping across various sports (F_0 : $r = 0.33-0.67$; $p < 0.05$; P_{max} : $r = 0.40-0.82$; $p < 0.01$). This follows reason since jump height and sprint completion time largely depends on the ability of the athletes' neuromuscular and osteo-articular systems to generate high levels of force, apply ground reaction force effectively, and generate effective forces despite increasing velocities (Morin & Samozino, 2016).

Yet, a comparison of sprint profile components and jumping kinetics among different event-athletes in the sport of track and field has not been conducted. Specifically, athletes considered to be competing in vary contrasting events such as sprinting and long-distance running, or athletes relying primarily on their ability to accelerate an external mass (shot put, javelin, discus). Such information can better guide practitioners to design pertinent training programs when working with different track and field athletes, particularly when the training coach must oversee all track and field athletes. What outputs a coach should target based on sprint or jump kinetic and kinematic data has previously been discussed (Jiménez-Reyes et al., 2017; Morin & Samozino, 2016). Thus, exploring sprinting and jumping performance is pertinent since the biomechanical and physiological demands of track and field events vary (Thompson, 2017). For instance, the bioenergetical demands of sprinting and long-distance running differ with long distance runners producing a majority their energy from aerobic sources whereas sprinting necessitates high rate of force development and reliance on anaerobic energy pathways. Thompson (2017) reported that high horizontal and vertical ground reaction forces and impulse are paramount for sprinters to attain high velocities yet high total and net vertical impulse may be detrimental to running economy for long-distance runners. Although sprinters and long-distance runners require the effective capacity to accelerate their own mass; throwers focus on their ability to generate forces causing acceleration of their implement. Ivanovic (2009) found that faster 20-meter sprint completion time and a greater triple jump distance helped predict a greater javelin throwing distance ($r = 0.69$; $p = 0.03$). Despite differing demands, the importance of both jumping and sprinting as key indicators in track athletes remains important (Dietze-Hermosa et al., 2021; Karampatsos et al., 2017). Therefore, this study examines the differences in sprint profile components during acceleration sprints, as well as performance differences in vertical jump and broad jump between collegiate track and field sprinters and throwers, given the importance of sprinting and jumping performance for these athletes (Dietze-Hermosa et al., 2021; Ivanović, 2009; Karampatsos et al., 2017), and a group of long-distance runners for comparison. Given the physiological and biomechanical distinctions between track and field events, we hypothesized that sprinters and throwers would display superior force and power during jumping and sprinting compared to long-distance runners.

Materials & Methods

Participants

A convenience sample of 42 Division I track and field athletes [18 = sprinters (male = 9; female = 9), 14 = long-distance runners (male = 7; female = 7), 10 = throwers (male = 4; female = 6)] participated in this study (Table 1). All sprinters competed in distances equal to or below 200 meters, throwers participated in shot put, discus, hammer, and javelin events, lastly long-distance runners competed in events above 5000 meters. Participants were free from any lower limb musculoskeletal injury during the three months preceding data collection and were instructed to avoid any strenuous exercise for 24 hours before testing. A priori power analysis using G*Power software (version 3.1, Universität Kiel, Germany) indicated that with a sample size of 30 (at least 10 per group) using a one-way ANOVA design with power ($1 - \beta$) set at 0.80, and $\alpha = 0.05$; yielded an effect size of 0.60 (Cohen's f). When followed by pairwise comparisons (Cohen's d) and according to Hopkins (2009), this corresponds to a moderate effect size and agrees with previously reported effect sizes (Cohen's $d = 1.15 - 2.10$) comparing sprinters and hurdlers on sprint performance (Stavridis et al., 2019). The protocol was approved by the appropriate institutional review board and conformed to the standards of the Declaration of Helsinki with participants providing signed informed consent prior to data collection.

Table 1. Descriptives of anthropometrics and all measures of interest by group

	Sprinters				Throwers				Long-Distance Runners			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Height (cm)	172	10	147	187	180	9	165	193	169	8	156	187
Weight (kg)	69.80	10.59	45.15	86.85	114.33	20.61	86.25	140.85	58.08	7.27	46.15	72.30
VJ Height (m)	0.36	0.10	0.24	0.65	0.30	0.09	0.17	0.45	0.24	0.06	0.17	0.45
VJ Max Vertical Force (N/kg)	2.48	0.18	2.03	2.74	2.44	0.45	1.88	3.41	2.28	0.44	1.81	3.57
VJ Max Vertical Power (W/kg)	5.80	0.91	4.47	7.95	5.09	1.38	3.30	7.89	4.26	0.85	3.02	5.67
VJ RSI Modified	0.54	0.17	0.25	0.88	0.48	0.23	0.16	0.91	0.35	0.24	0.05	0.90
BJ Distance (cm)	216	22	191	254	188	29	140	225	161	33	100	239

BJ Max Vertical Force (N/kg)	21.68	2.08	18.83	24.83	19.52	1.75	17.16	21.43	21.55	2.48	17.13	25.81
BJ Max Horizontal Force (N/kg)	7.33	0.82	6.16	8.83	5.62	0.56	4.90	6.42	5.75	1.11	3.72	8.16
F ₀ (N/kg)	12.12	1.93	6.58	15.20	10.17	1.36	7.43	11.95	10.13	1.10	8.34	12.04
V ₀ (m/s)	8.31	0.66	7.33	9.61	6.98	0.72	6.10	8.37	7.51	0.74	6.24	8.81
P _{max} (W/kg)	25.17	4.65	15.81	33.98	17.79	3.19	11.33	23.00	19.17	3.71	13.02	26.32
S _{FV}	-1.47	0.25	-1.81	-0.68	-1.47	0.22	-1.90	-1.15	-1.35	0.10	-1.58	-1.21
RF _{max} (%)	49.91	3.16	42.68	55.02	43.78	3.25	37.66	48.54	45.83	3.49	39.45	51.99
D _{RF} (%)	-13.51	2.27	-16.75	-6.36	-13.91	2.17	-18.18	-10.71	-12.64	0.94	-14.97	-11.12
Accel Max Speed (m/s)	8.08	0.57	7.19	9.06	6.86	0.68	6.01	8.15	7.31	0.69	6.11	8.55
Accel 5-m Time (s)	1.12	0.10	0.99	1.43	1.27	0.09	1.14	1.47	1.23	0.08	1.09	1.40
Accel 10-m Time (s)	1.87	0.12	1.68	2.19	2.12	0.14	1.93	2.43	2.05	0.14	1.83	2.33
Accel 15-m Time (s)	2.55	0.15	2.29	2.85	2.90	0.20	2.62	3.31	2.80	0.21	2.45	3.20
Accel 20-m Time (s)	3.18	0.18	2.87	3.45	3.63	0.27	3.26	4.14	3.49	0.27	3.04	4.02
Accel 25-m Time (s)	3.79	0.22	3.41	4.10	4.35	0.33	3.89	4.96	4.17	0.33	3.64	4.82
Accel 30-m Time (s)	4.38	0.26	3.93	4.77	5.07	0.40	4.49	5.78	4.83	0.40	4.19	5.61

SD = Standard Deviation; Min = Minimum; Max = Maximum; VJ = Vertical Countermovement Jump; RSI Modified = Reactive Strength Index Modified; BJ = Broad Jump; F₀ = Maximal Theoretical Force; V₀ = Maximal Theoretical Velocity; P_{max} = Maximal Theoretical Power; RF_{max} = Maximal Ratio of Force; D_{RF} = decrease in ratio of force; S_{FV} = Force-Velocity Slope; Accel = Acceleration.

Testing Procedures

All testing procedures were performed on an outdoor track. Anthropometrics were obtained first; height (m) was measured using a stadiometer to the nearest centimeter and weight (kg) was measured using a scale to the nearest hundredth of a kilogram. Following anthropometric measures, in a randomized order, participants completed two trials of 30-meter acceleration sprints, VJs, and BJs.

30-Meter Acceleration Sprints

Participants completed two 30-meter sprints with three minutes of rest between trials. Completion time was obtained using the MySprint mobile application (Dietze-Hermosa et al., 2021; Romero-Franco et al., 2017) on an Apple iPad (240 Hz; Apple, Inc., Cupertino, CA, USA). The protocol outlined in Dietze-Hermosa (2021) were strictly adhered. Participants adopted a three-point stance with their front foot on the start line. Participants instructed to maximally sprint the entire 30-meter distance with start and finish lines were clearly marked. The MySprint mobile application was used to determine split times of each five meters (5-m, 10-m, 15-m, 20-m, and 25-m), overall (30-meter) completion time, and Sprint Profile variables (Speed, F₀, V₀, P_{max}, RF_{max}, D_{RF}, S_{FV}) following the current MySprint application recommendations. The detailed review of the computational methods used by the MySprint mobile application can be found elsewhere (Morin et al., 2019; Romero-Franco et al., 2017; Samozino et al., 2016). The trial with the fastest completion time was used for analysis.

Vertical Jump

Participants performed two VJ trials with hands akimbo and a two-minute rest period between trials. Each trial began with a one-second quiet stance (motionless), after which the researcher provided an audible “go” command to signal the execution of the VJ following a prior research protocol (Montalvo et al., 2021; Tan et al., 2022). Participants were instructed to jump as high as possible. If the VJ jump protocol requirements were not met, the trial was repeated. Vertical jumps were performed on two force platforms (PASPORT-2, 1000 Hz, Pasco Scientific, Inc., Roseville, CA, USA) with force data recorded using the Pasco Capstone Software (v.2.2.0) (Dietze-Hermosa et al., 2021). Left and right force platform data were summed and filtered using a digital fourth-order low pass Butterworth filter with a cutoff at 50 Hz (Dietze-Hermosa et al., 2021; Montalvo et al., 2021). Jump height was calculated using force data with takeoff velocity (takeoff velocity² / 2*9.81) (Dietze-Hermosa, Martin et al., 2020). Maximal force, power, and modified reactive strength index (RSI_{mod}; jump height (m)/ time to take-off (s)) were calculated in a custom spreadsheet (Chavda et al., 2017; Dietze-Hermosa et al., 2020). The trial with the highest VJ height was used for analysis.

Broad Jump

Participants performed two BJ trials with hands akimbo, their toes placed at a clearly marked start line, and two minutes rest provided between trials. Each trial began with a one-second quiet stance (motionless) after which the researcher provided an audible “go” command to signal the execution of the BJ into an adjacent sandbox. The BJs were performed on two force platforms (PASPORT-2, 1000 Hz, Pasco Scientific, Inc.,

Roseville, CA, USA) with force data recorded using the Pasco Capstone Software (v.2.2.0). Force platform data were summed and filtered using the same method as for the VJ. Maximal horizontal and vertical forces were calculated as the highest force (N) attained during the concentric phase of the BJ (Loturco et al., 2015). Athletes were instructed to jump horizontally as far as possible and land on both feet. Measuring tape was used to obtain jump distance to the nearest centimeter. Distance was measured as the distance from the takeoff (start line) to the back of the athlete's heel (Dietze-Hermosa et al., 2021). For the jump distance to be recorded, participants had to land with both feet grounded or else the trial was repeated. The trial with the longest jump distance was used for analysis.

Statistical Analysis

Data were exported from each respective software into a comprehensive spreadsheet (Microsoft Excel, Microsoft, Redmond, WA). Data were then imported into SPSS 26 (SPSS, Inc., IBM, Armonk, NY) where all statistical calculations were performed. Data are expressed as mean $\pm$ standard deviation and range (Table 1). Shapiro-Wilk test and Levene's test for homogeneity of variance were checked prior to data analyses. Reliability of data was assessed using two-way mixed-measures intraclass correlation coefficients ($ICC_{2,k}$) with absolute agreement and coefficient of variation (CV). Excellent reliability was determined at an $ICC \geq 0.90$ and a $CV \leq 10\%$, similar to prior research (Koo & Li, 2016). A series of one-way ANOVAs were conducted to compare differences in each measure of interest across sprinters, throwers, and long-distance runners. Moreover, partial eta squared (η_p^2) calculated from the ANOVAs were provided and interpreted as: small ($\eta_p^2 = 0.01$); medium ($\eta_p^2 = 0.09$); and large ($\eta_p^2 = 0.25$) effects (Lakens, 2013). The measures of interest were: sprint completion times, sprint profile variables (Speed, F_0 , V_0 , P_{max} , RF_{max} , D_{RF} , S_{FV}), VJ height, VJ max force, VJ max power, VJ RSI_{mod}, BJ distance, BJ max vertical force, and BJ max horizontal force. To mitigate increased family-wise error rate caused by multiple comparisons, the Holm-Bonferroni method was used when conducting follow up comparisons resulting in an adjusted p-value. Furthermore, effect sizes (Hedge's g) with 95% confidence intervals were calculated in a custom spreadsheet according to prior literature (Lakens, 2013). The effect sizes were interpreted as follows; trivial = ≤ 0.20 ; small = 0.20 to 0.60; moderate = 0.60 to 1.2; large = 1.2 to 2.0; very large = 2.0 to 4.0; very large >4.0 (Hopkins et al., 2009). Significance was set at an alpha level of 0.05 for all analyses.

Results

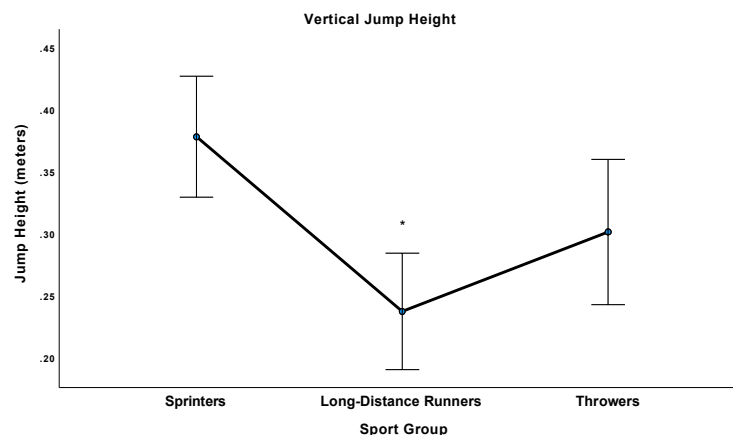
All data displayed excellent reliability ($ICC \geq 0.90$ and $CV \leq 10\%$) (Koo & Li, 2016). For the vertical jump, ANOVAs resulted in group differences in VJ height [$F(2,40) = 8.97$; $p = 0.001$; $\eta_p^2 = 0.35$; *large*], RSI_{mod} [$F(2,40) = 3.65$; $p = 0.04$; $\eta_p^2 = 0.18$; *medium*], and VJ max power [$F(2,40) = 10.29$; $p < 0.001$; $\eta_p^2 = 0.38$; *large*]. Differences between groups were observed for BJ distance [$F(2,40) = 17.48$; $p < 0.001$; $\eta_p^2 = 0.49$; *large*], BJ max vertical force [$F(2,40) = 3.34$; $p = 0.04$; $\eta_p^2 = 0.16$; *medium*], and BJ max horizontal force [$F(2,40) = 12.46$; $p < 0.001$; $\eta_p^2 = 0.42$; *large*]. Lastly, group differences were observed for several sprint profile variables to include Speed [$F(2,40) = 7.15$; $p = 0.002$; $\eta_p^2 = 0.27$; *large*], F_0 [$F(2,40) = 7.23$; $p = 0.002$; $\eta_p^2 = 0.27$; *large*], V_0 [$F(2,40) = 7.13$; $p = 0.002$; $\eta_p^2 = 0.27$; *large*], P_{max} [$F(2,40) = 10.21$; $p < 0.001$; $\eta_p^2 = 0.34$; *large*], and RF_{max} [$F(2,40) = 6.71$; $p = 0.003$; $\eta_p^2 = 0.26$; *large*]. Thus, pairwise comparisons for each measure of interest are reported.

Vertical Jump

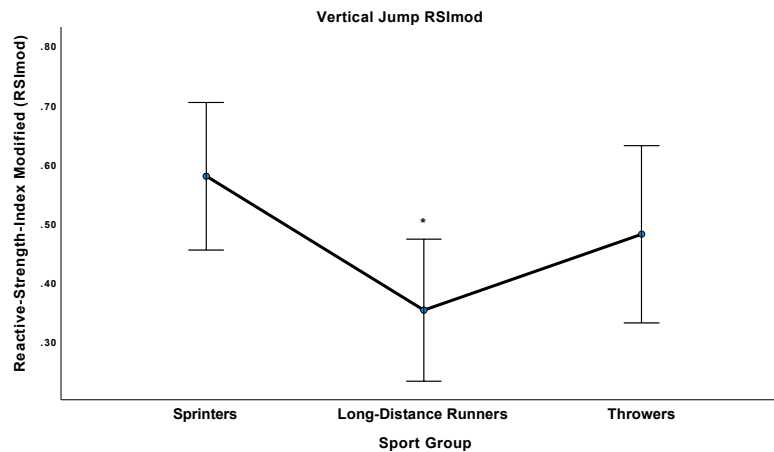
Differences in jump height ($p = 0.001$; Hedge's $g = 1.66$; *large*), maximal vertical power ($p < 0.001$; Hedge's $g = 2.00$; *very large*), and RSI modified ($p = 0.03$; Hedge's $g = 1.01$; *moderate*) were noted between sprinters and long-distance runners. No other comparison between groups were significant (Table 2) (Figure 1).

Figure 1

A)



B)



C)

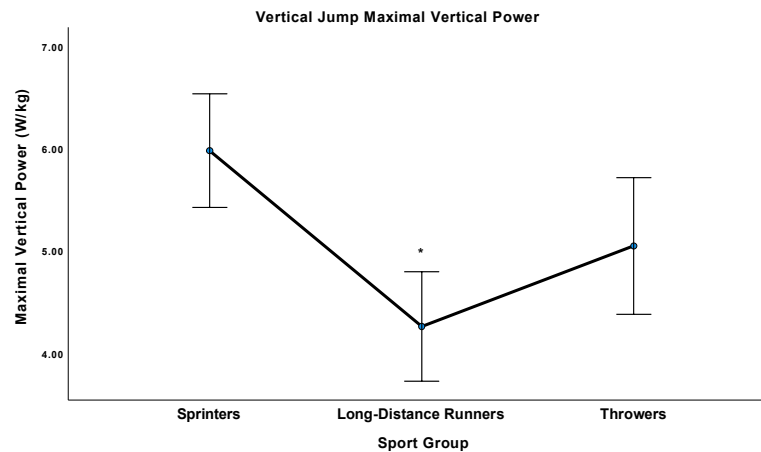


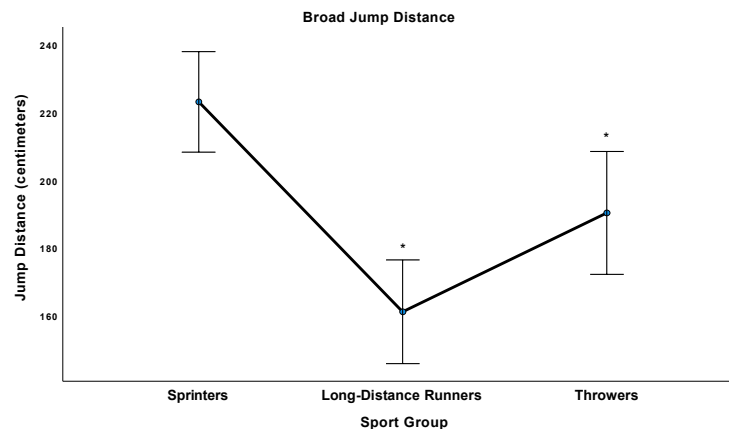
Figure 1. Differences in a) vertical jump height; b) vertical jump reactive-strength index modified; and c) vertical jump power between sprinters, long-distance runners, and throwers. “*” indicates significantly different than the sprinters.

Broad Jump

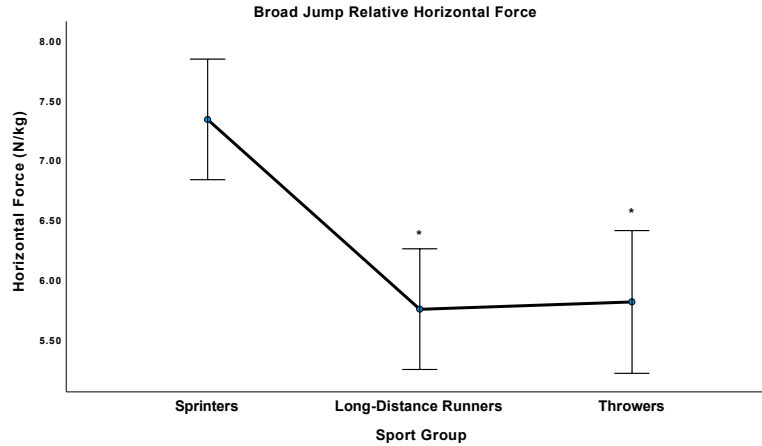
Jump distance ($p < 0.001$; Hedge’s $g = 2.18$; *very large*) and maximal horizontal force ($p < 0.001$; Hedge’s $g = 1.64$; *large*) displayed differences between sprinters and long-distance runners. A difference in jump distance ($p = 0.02$; Hedge’s $g = 1.29$; *large*), maximal vertical force ($p = 0.04$; Hedge’s $g = 1.10$; *moderate*), and maximal horizontal force ($p = 0.001$; Hedge’s $g = 1.90$; *large*) was seen between sprinters and throwers. No differences were noted between long-distance runners and throwers (Table 2) (Figure 2).

Figure 2

A)



B)



C)

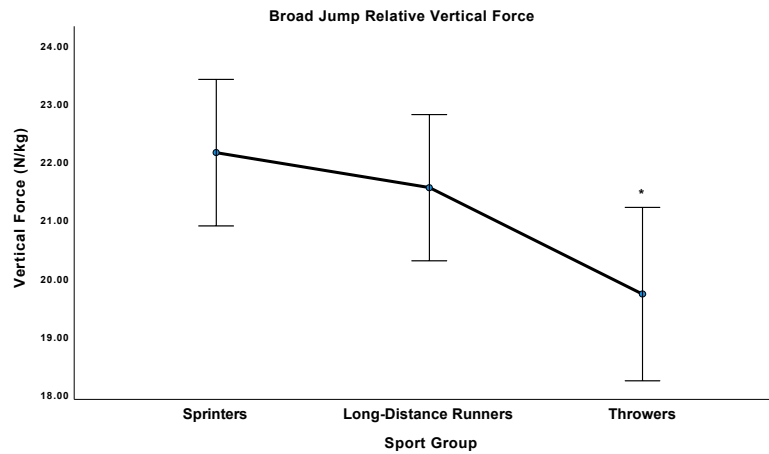


Figure 2. Differences in a) broad jump distance; b) broad jump horizontal force; and c) broad jump vertical force between sprinters, long-distance runners, and throwers. “*” indicates significantly different than the sprinters
Table 2. Jump performance outcome measures and statistics for differences and effects between groups

Jumping Performance											
Sprinter vs Long-Distance Runners				Sprinter vs Throwers				Long-Distance Runners vs Throwers			
	Difference	p-value	ES [95% CI]		Difference	p-value	ES [95% CI]		Difference	p-value	ES [95% CI]
VJ Height (m)	0.14	0.001	1.66 [0.74 - 2.48]		0.08	0.15	0.78 [0.13 - 1.63]		-0.06	0.28	-0.86 [-1.69 - 0.05]
VJ Max Vertical Force (N/kg)	0.26	0.24	0.73 [0.07 - 1.48]		0.09	1.00	0.30 [-0.57 - 1.14]		-0.16	0.94	-0.37 [-1.21 - 0.48]
VJ Max Vertical Power (W/kg)	1.72	<0.001	2.00 [1.02 - 2.85]		0.93	0.11	0.88 [0.04 - 1.73]		-0.79	0.21	-0.76 [-1.79 - 0.14]
VJ RSI Modified	0.23	0.03	1.02 [0.19 - 1.79]		0.10	0.94	0.47 [-0.41 - 1.31]		-0.13	0.55	-0.56 [-1.39 - 0.31]
BJ Distance (cm)	62.00	<0.001	2.18 [1.21 - 3.03]		32.77	0.02	1.29 [0.38 - 2.12]		-29.23	0.06	-0.95 [-1.77 - 0.07]
BJ Max Vertical Force (N/kg)	0.60	1.00	0.24 [-0.51 - 0.98]		2.43	0.04	1.10 [0.19 - 1.92]		1.83	0.20	0.82 [-0.05 - 1.64]
BJ Max Horizontal Force (N/kg)	1.59	<0.001	1.64 [0.74 - 2.44]		1.53	0.001	1.90 [0.87 - 2.79]		-0.06	1.00	-0.06 [-0.87 - 0.75]

Bolded denotes significant at <0.05 or <0.01; ES = Hedge’s g effect size
VJ = Vertical Countermovement Jump; RSI Modified = Reactive Strength Index Modified; BJ = Broad Jump.
30-Meter Acceleration Sprints

There were significant differences in multiple sprint profile variables between sprinters and long-distance runners ($p < 0.01$; Hedge's $g = 1.20$ to 1.50 ; *large*). Similarly, differences in sprint profile variables were observed between sprinters and throwers ($p < 0.05$; Hedge's $g = 0.97$ to 1.37 ; *moderate to large*). No differences were seen between long-distance runners and throwers (Table 3) (Figure 3). Substantial differences in 5, 10, 15, 20, 25, and 30-meter completion times were noted between sprinters and long-distance runners ($p < 0.01$; Hedge's $g = -1.21$ to -1.41 ; *large*) and sprinters compared to throwers ($p < 0.01$; Hedge's $g = -1.01$ to -1.36 ; *moderate to large*) (Table 3) (Figure 4).

Table 3. Sprint performance outcome measures and statistics for differences and effects between groups

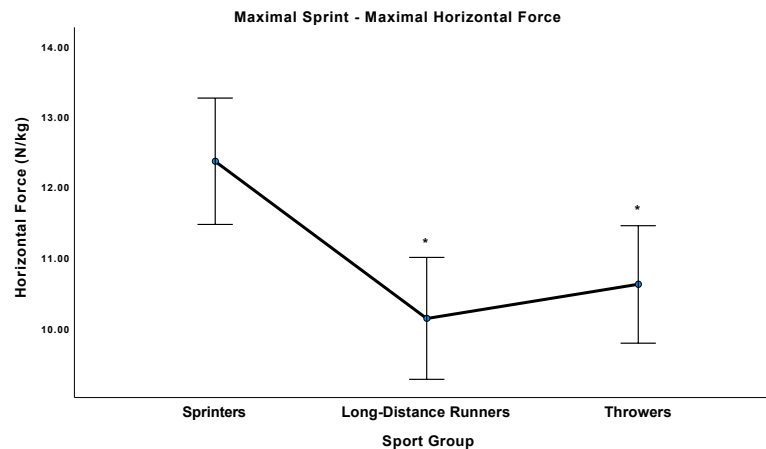
	Sprinter vs Long-Distance Runners			Sprinter vs Throwers			Long-Distance Runners vs Throwers		
	Difference	p-value	ES [95% CI]	Difference	p-value	ES [95% CI]	Difference	p-value	ES [95% CI]
F_0 (N/kg)	2.23	<0.001	1.44 [0.44 - 2.10]	1.75	0.02	0.97 [0.16 - 1.73]	-0.48	1.00	-0.37 [-1.11 - 0.36]
V_0 (m/s)	0.88	0.01	1.20 [0.34 - 1.98]	1.03	<0.01	1.32 [0.47 - 2.10]	0.16	1.00	0.20 [-0.54 - 0.92]
P_{max} (W/kg)	6.70	<0.001	1.50 [0.61 - 2.31]	6.22	0.001	1.37 [0.51 - 2.15]	-0.47	1.00	-0.12 [-0.85 - 0.61]
S_{FV}	-0.14	0.27	-0.65 [-1.40 - 0.14]	-0.04	1.00	-0.15 [-0.89 - 0.60]	0.10	0.57	0.65 [-0.11 - 1.38]
RF_{max} (%)	4.34	<0.01	1.23 [0.38 - 2.01]	4.57	<0.01	1.23 [0.38 - 2.00]	0.23	1.00	0.06 [-0.67 - 0.79]
DRF (%)	-1.02	0.53	-0.53 [-1.28 - 0.25]	0.01	1.00	0.00 [-0.75 - 0.74]	1.01	0.49	0.67 [-0.10 - 1.40]
Accel Max Speed (m/s)	0.83	<0.01	1.25 [0.39 - 2.04]	0.94	<0.01	1.31 [0.46 - 2.09]	0.10	1.00	0.14 [-0.60 - 0.86]
Accel 5-m Time (s)	-0.12	<0.01	-1.21 [-1.99 - -0.35]	-0.11	0.02	-1.01 [-1.76 - -0.19]	0.01	1.00	0.12 [-0.61 - 0.85]
Accel 10-m Time (s)	-0.19	<0.01	-1.36 [-2.15 - -0.48]	-0.19	<0.01	-1.21 [-2.02 - -0.41]	0.00	1.00	0.02 [-0.71 - 0.75]
Accel 15-m Time (s)	-0.26	<0.01	-1.40 [-2.19 - 0.52]	-0.27	<0.01	-1.34 [-2.12 - -0.49]	0.00	1.00	-0.01 [-0.74 - 0.72]
Accel 20-m Time (s)	-0.33	<0.01	-1.41 [-2.21 - -0.53]	-0.34	<0.01	-1.34 [-2.12 - -0.48]	-0.01	1.00	-0.03 [-0.76 - 0.70]
Accel 25-m Time (s)	-0.40	<0.01	-1.27 [-2.06 - -0.41]	-0.42	<0.01	-1.24 [-2.01 - -0.40]	-0.02	1.00	-0.05 [-0.78 - 0.68]
Accel 30-m Time (s)	-0.48	<0.01	-1.38 [-2.18 - -0.51]	-0.52	<0.01	-1.36 [-2.14 - -0.50]	-0.04	1.00	-0.09 [-0.82 - 0.64]

Bolded denotes significant at <0.05 or <0.01 ; ES = Hedge's g effect size

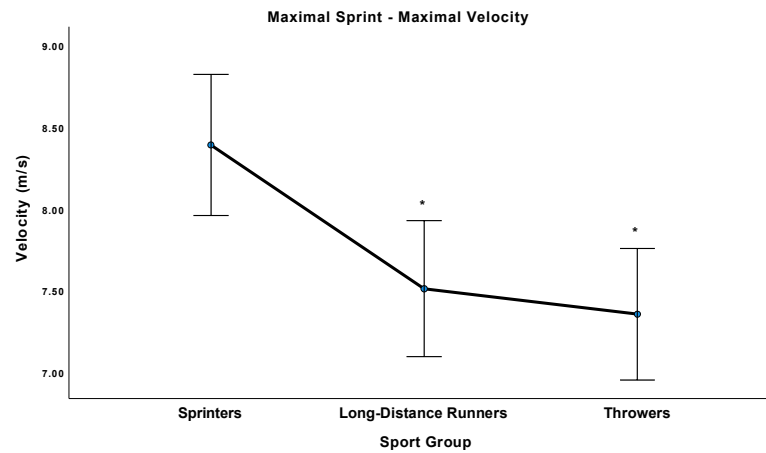
F_0 = Maximal Theoretical Force; V_0 = Maximal Theoretical Velocity; P_{max} = Maximal Theoretical Power; RF_{max} = Maximal Ratio of Force; DRF = decrease in ratio of force; S_{FV} = Force-Velocity Slope; Accel = Acceleration.

Figure 3

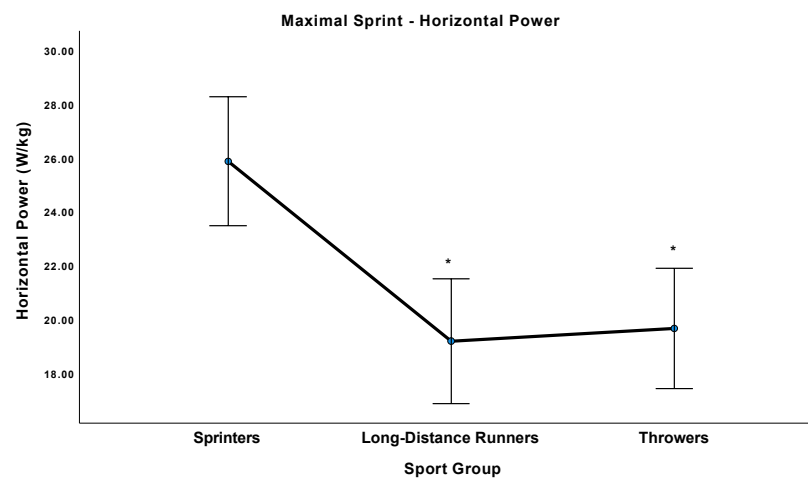
A)



B)



C)



D)

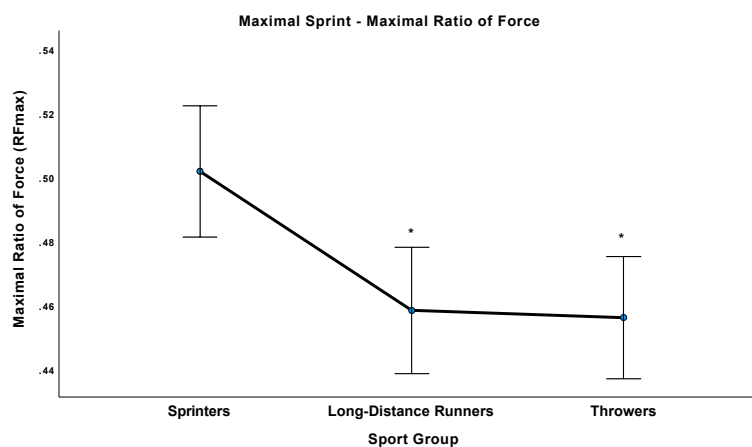
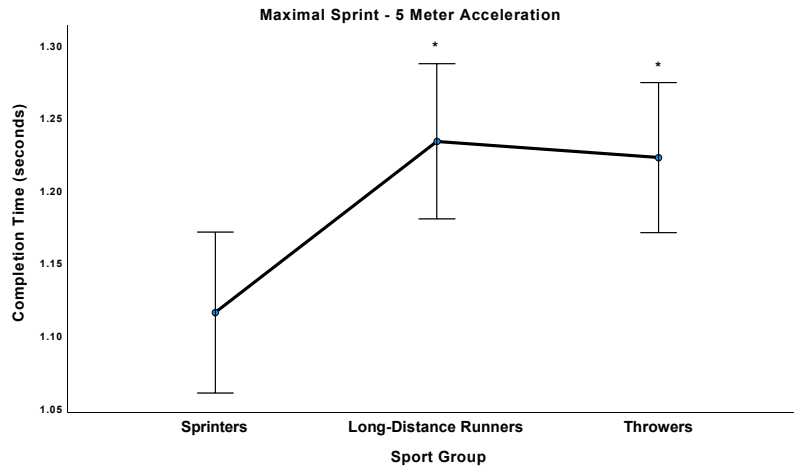


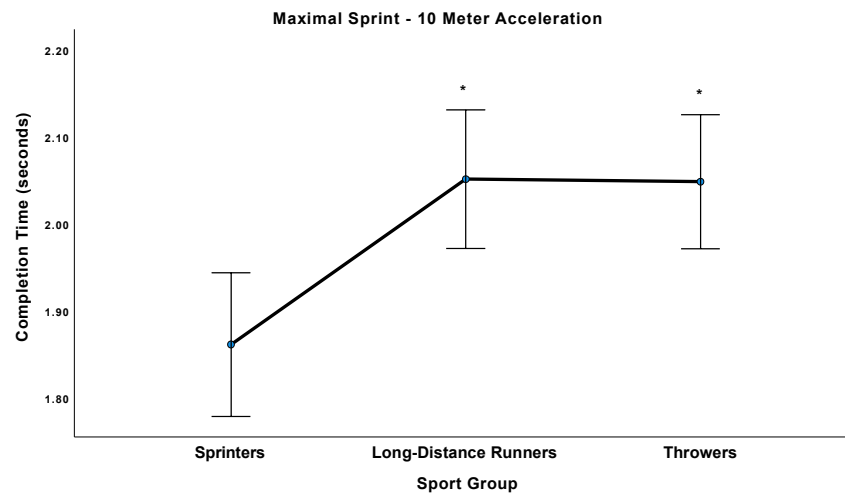
Figure 3. Differences in a) maximal sprint horizontal force; b) maximal sprint velocity; c) maximal sprint horizontal power, and d) maximal sprint ratio of force between sprinters, long-distance runners, and throwers. “*” indicates significantly different than the sprinters.

Figure 4

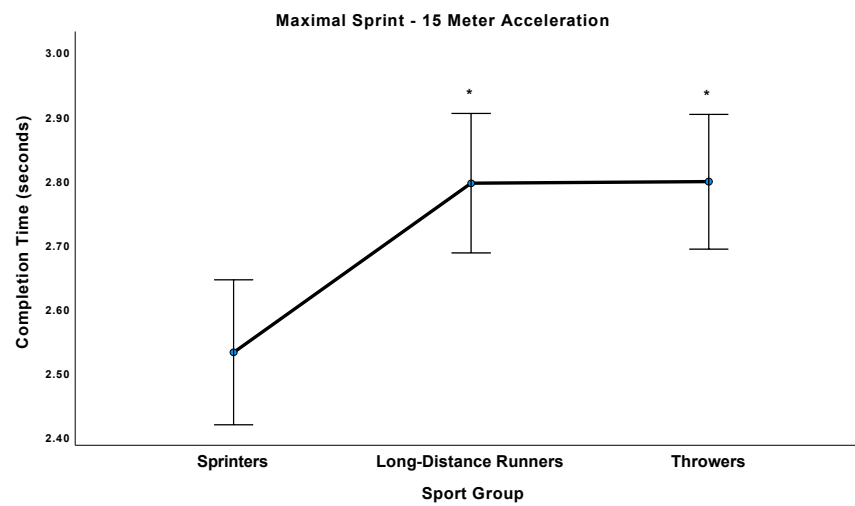
A)



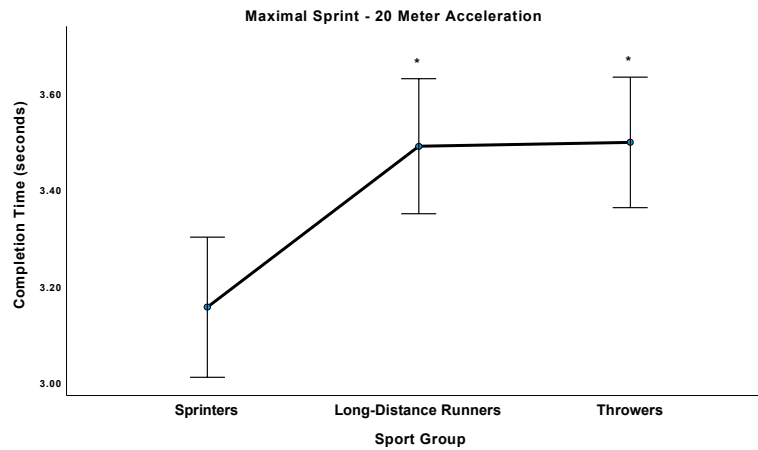
B)



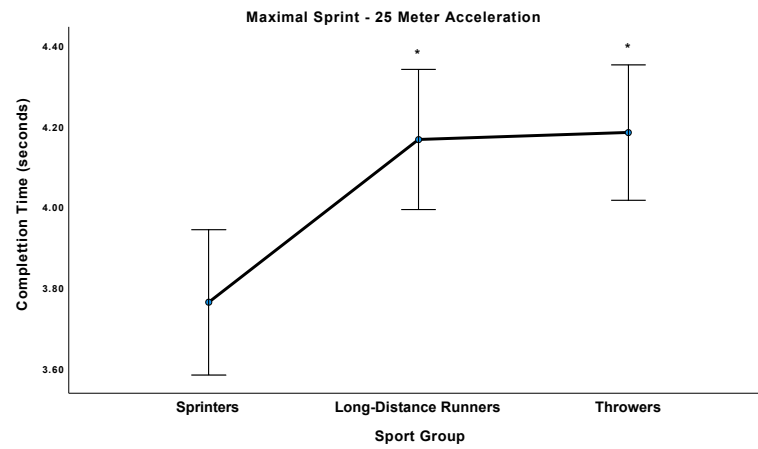
C)



D)



E)



F)

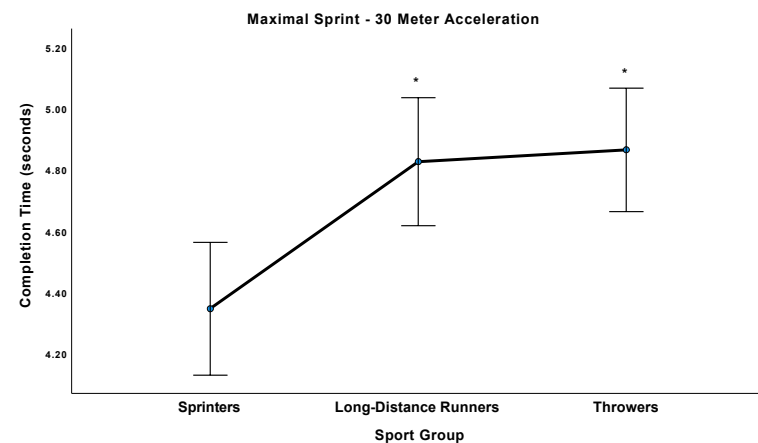


Figure 4. Differences in a) maximal sprint 5m completion time; b) maximal sprint 10m completion time; c) maximal sprint 15m completion time, d) maximal sprint 20m completion time; e) maximal sprint 25m completion time; f) maximal sprint 30m completion time between sprinters, long-distance runners, and throwers. “*” indicates significantly different than the sprinters.

Discussion

This study explored the differences in sprint profile variables during 30-meter acceleration sprints, as well as VJ and BJ performance between collegiate track and field sprinters, throwers, and long-distance runners.

It was hypothesized that sprinters and throwers would display superior force and power during jumping and sprinting compared to long-distance runners. The study hypothesis is partially supported as sprinters exhibited superior performance across most sprinting and jumping measures compared to long-distance runners. Yet, the unique finding of the current study is that no substantial differences were found comparing throwers and long-distance runners for most measures.

During the VJ, differences between sprinters and long-distance runners in VJ height (difference = 14 cm), VJ max power (difference = 1.72 W/kg), and RSImod (difference = 0.23) were noted (Table 2). One potential explanation may be the generally distinct muscle fiber composition between sprinters and other athletes, with sprinters exhibiting a high percentage of type II muscle fibers compared to more endurance-based athletes such as long-distance runners (Montalvo & Dorgo, 2019; Trappe et al., 2015). Prior research highlights that the physiological properties within type II muscle fibers enable greater power production during activities requiring high rate of force development compared to type I fibers (Cormie et al., 2011). Lastly, jumping necessitates the optimal use of the stretch-shortening cycle (SSC), athletes exposed to more power-based training may develop superior SSC ability leading to better jump performance (Loturco et al., 2015). Throwers focus on their ability to generate forces causing acceleration their implement, with needed force generation primarily in the horizontal over vertical direction (Ivanović, 2009). Ultimately, in combination, these physiological and biomechanical differences may partially explain the differences in jump performance comparing sprinters with throwers and long-distance runners. Therefore, coaches can focus on monitoring and improving certain variables derived from the vertical jump force-time curve. Interestingly, vertical forces generated during the jump did not significantly differ between groups, although the rate of force development did (VJ max power). Coaches may desire to monitor vertical jump performance and implement jump training across various track and field athletes. In fact, a recent meta-analysis indicated that jump training improved the athletic performance of endurance runners; a moderate improvement in time-trial over distances up to 5 km (Hedges $g = 0.88$) (Ramirez-Campillo et al., 2021).

Sprinters displayed higher BJ distance and max horizontal forces compared to both long-distance runners (BJ distance: difference = 62 cm; BJ horizontal force: difference = 1.59 N/kg) and throwers (BJ distance: difference = 33 cm; BJ horizontal force: difference = 1.53 N/kg) (Table 2). These findings support one another as higher horizontal forces during BJ allows the athletes to achieve longer jump distances (Robertson & Fleming, 1987). Hudgins et al. (2013) reported differences in the triple BJ distance between sprinters and distance runners (sprinters = 8.24 m; distance runners = 6.08 m). Additionally, authors suggest that sprinting requires the highest levels of muscle power compared to distance events. Authors further report that the strength of the correlations between BJ distance and running completion time decreased with increasing event distance (60 m: $r = 0.97$ and 5,000 m: $r = 0.71$) (Hudgins et al., 2013). Similar physiological rationale previously provided for VJ differences (SSC, muscle fiber type composition, training specificity) is noted in the literature to explain superior BJ performance for power-based athletes. This follows reason since these physiological and biomechanical characteristics are also important to attain high sprint speeds. For instance, the BJ distance among track and field sprinters and jumpers is also correlated to sprint completion time at 5 m ($r = -0.720$), 10 m ($r = -0.798$), 20 m ($r = -0.807$), and 30 m ($r = -0.791$) (Dietze-Hermosa et al., 2021). For instance, in the present study, BJ max horizontal forces for sprinters exceeded those of both throwers (Hedge's $g = 1.90$; $p = 0.001$) and long-distance runners (Hedge's $g = 1.64$; $p < 0.001$). Therefore, coaches may desire to monitor BJ performance and implement horizontal jump training specifically for sprinters in their track and field team (Dietze-Hermosa et al., 2021). One meta-analysis suggested the use of training programs that incorporate greater horizontal acceleration, such as broad jump, to optimize sprint performance (Sáez de Villarreal et al., 2012). Given the relationship between BJ and sprinting, differences observed in BJ distance and horizontal forces in the present study support the dissimilar values in mechanical variables of the sprint profile between sprinters and the two other event groups.

Multiple sprint profile variables were dissimilar among sprinters and long-distance runners. Specifically, F_0 , V_0 , P_{max} , and RF_{max} , displayed large effect sizes (Hedge's $g \geq 1.20$). This corroborates with prior literature observing that sprinters have greater efficiency at orienting ground reaction forces in a more optimal direction resulting in higher velocities (Morin et al., 2015; Rabita et al., 2015). Moreover, high total vertical impulse is associated with decreased running economy; an important determinant of performance for long-distance runners (Heise & Martin, 2001). Moreover, physiological distinction between sprinters and endurance-based athletes may account for differences in sprint profile components. Muscle architecture differences exist between sprinters and distance runners (Abe et al., 2000). Abe et al. (2000) indicated longer muscle fascicle lengths for the vastus lateralis (VL) and gastrocnemius (GL) for sprinters compared to both long-distance runners (VL: 8.83 cm vs. 6.15 cm; $p < 0.01$) and controls (VL: 8.83 cm vs. 7.13 cm; $p < 0.01$). Additionally, the same group of authors purported that greater muscle fascicle length relates to superior sprint completion times among sprinters (VL: $r = -0.51$; $p < 0.05$; GL: $r = -0.44$; $p < 0.05$) (Abe et al., 2001). Similarly, F_0 , V_0 , P_{max} , and RF_{max} differed between throwers and sprinters (Hedge's $g = 0.97$ to 1.37) with sprinters demonstrating greater F_0 , V_0 , P_{max} , and RF_{max} . Present study findings also agree with a recent study noting differences between hurdlers and sprinters. Authors indicated that sprinters attained greater P_{max} (2.46 ± 0.67 , Cohen's $d = 2.1$, $p = 0.004$), V_0 (0.45 ± 0.18 , Cohen's $d = 1.4$, $p = 0.03$), and RF_{max} ($2.9 \pm 0.9\%$, Cohen's d

= 1.8, $p = 0.01$) than hurdlers suggesting improved mechanical efficiency of force application of sprinters, similar to the present study (Stavridis et al., 2019). Hence, training implemented for the specific demands of the sport event may result in the disparities observed in mechanical effectiveness of force application, such as F_0 and RF_{max} during sprinting between sprinters and these two groups of athletes. Research indicates that training typically undertaken by sprinters and other field-based sports relying on acceleration over short distances improve their force application properties (Lahti et al., 2019; Lahti et al., 2020; Morin et al., 2017; Morin et al., 2020). For instance, Morin et al. (2017) suggested that an 8-week very heavy resisted sled training at 80% of bodyweight moderately improved F_0 , P_{max} , and RF_{max} in soccer players (F_0 : Cohen's $d = 0.80$; P_{max} : Cohen's $d = 0.60$; RF_{max} : Cohen's $d = 0.95$). Likewise, Lahti et al. (2019) report that F_0 and the force-velocity sprint profile properties showed a significant moderate relationship with F_0 adaptation potential after an 8-week sled resisted program with 50 or 60% velocity decrement (50%: Cohen's $d = 1.04$; $p = 0.01$; 60%: Cohen's $d = 1.00$; $p = 0.003$). These are important considerations when seeking to develop track and field athletes that may not have selected their sport event.

Interestingly differences in measures of interest between throwers and long-distance runners were not observed. This was contrary to the proposed hypothesis. However, the lack of differences in sprint performance between these two event groups may be attributed to the athlete's mass. Generally, throwers were heavier than long-distance runners and therefore, despite both groups displaying comparable sprint completion times, underlying mechanisms driving the cause could differ. For instance, the metabolic pathway, muscle fiber type composition, and prior training experience likely contributed to slower sprint times and lower jump performances for long-distance runners (Thompson, 2017). Studies indicate that throwers must exert vertical forces rapidly to overcome an external load to effectively transfer forces and attain high projectile velocities and distances (Błażkiewicz et al., 2016; Schofield et al., 2019). The inexperience with optimal orientation of ground forces in the horizontal direction may have impeded performance during BJ and sprinting for throwers (Dietze-Hermosa et al., 2021; Dylan et al., 2019). Moreover, despite regular power-based training for throwers, their body composition may have resulted in comparable relative force and power outcomes as long-distance runners. Collectively, although distinct mechanisms, these may have resulted in similar sprint and jump performances despite differing underlying mechanisms.

For limitations, the present study is unable to directly attribute differences between athletes to any potential physiological mechanisms. Hence, future research may desire to incorporate physiological assessments to obtain insight into mechanisms that underpin differences observed in the present study. Furthermore, the study included sprinters, throwers, and long-distance runners, however, other track and field foci were omitted. Consequently, differences cannot be generalized to athletes competing in events such as pole vaulting and high jumping. Additionally, caution must be taken when making inference to athletes outside the collegiate setting. Moreover, it should be noted that the sprint profile variables are derived from equations using the inverse dynamics model, which has limitations such as estimating the horizontal drag force from only stature, body mass, and a fixed drag force coefficient and having the assumption of a quasi-null center of mass vertical acceleration over the acceleration sprint; although, literature supports the method's validity and reliability (Morin et al., 2019; Romero-Franco et al., 2017; Samozino et al., 2016).

Conclusion

Sprinters in the current study applied higher horizontally-oriented forces during sprinting compared to throwers and long-distance runners contributing to a superior sprint performance. Sprinters also displayed better force application during jump performance compared to both throwers and long-distance runners. There were negligible differences in sprint and jump performance between throwers and long-distance runners, although the exact underlying mechanisms have yet to be identified. Coaches and researchers must be aware of these key differences that may stem from the sport-specific biomechanical and physiological demands. Moreover, coaches may administer tests to gain insight and tailor training programs depending on the focus within the sport of track and field.

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