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Research article

Reliability of Sprint Force-Velocity-Power Profiles Obtained with KiSprint System

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Abstract

This study aimed to assess the within- and between-session reliability of the KiSprint system for determining force-velocity-power (FVP) profiling during sprint running. Thirty (23 males, 7 females; 18.7 ± 2.6 years;) young high-level sprinters performed maximal effort sprints in two sessions separated by one week. Split times (5, 10, 20 and 30 m), which were recorded with a laser distance meter (a component of the KiSprint system), were used to determine the horizontal FVP profile using the Samozino's field-based method. This method assesses the FVP relationships through estimates of the step-averaged ground reaction forces in sagittal plane during sprint acceleration using only anthropometric and spatiotemporal (split times) data. We also calculated the maximal theoretical power, force and velocity capabilities and the slope of the FV relationship, the maximal ratio of horizontal-to-resultant force (RF), and the decrease in the RF (D_{RF}). Overall, the results showed moderate or good to excellent within- and between-session reliability for all variables (ICC > 0.75; CV < 10 %), with the exception of FV slope and D_{RF} that showed low relative reliability (ICC = 0.47-0.48 within session, 0.31-0.33 between-session) and unacceptable between-session absolute reliability values (CV = 10.9-11.1 %). Future studies are needed to optimize the protocol in order to maximize the reliability of the FVP variables, especially when practitioners are interested in the FV slope and D_{RF}. In summary, our results question the utility of the sprint-based FVP profiling for individualized training prescription, since the reliability of the FV slope and D RF variables is highly questionable.

Key words: Acceleration, horizontal force, force-velocity relationship, sprinters.

Introduction

The ability to quickly accelerate forward is a decisive factor of performance in track-and-field and is also of paramount importance in sports that require athletes to cover a given distance in the shortest possible time (Gabbett, 2012; Haugen et al., 2014). Consequently, a considerable amount of research has been dedicated to understanding the biomechanics of sprinting (Pantoja et al., 2016), to determining the most valid and feasible testing methods (Samozino et al., 2016; Cross et al., 2017), and to designing effective training methods that improve acceleration ability and sprint running (Lockie et al., 2012; Alcaraz et al., 2018). One of the aspects of acceleration and sprint running that has been receiving an increasing amount of attention in the last few years is the force-velocity-power (FVP) relationship. Novel testing procedures for assessing FVP have been developed (Samozino et al., 2016) and used for assessments of training effects (Morin and Samozino, 2016; Alcaraz et al., 2018; Cahill et al., 2020), for comparisons of subgroups within athletic populations (Morin and Samozino, 2016; Devismes et al., 2019; Jiménez-Reyes et al., 2019), and for design of individualized training programs (Morin and Samozino, 2016).

While the force-velocity (FV) relationship in isolated skeletal muscle is hyperbolic (Thorstensson et al., 1976), subsequent studies have consistently revealed linear FV relationships in several multi-joint movements (Jaric, 2015; Zivkovic et al., 2017), including sprinting (Morin and Samozino, 2016; Samozino et al., 2016; Cross et al., 2017; Jiménez-Reyes et al., 2019). The FV (or FVP) relationship is typically reported as the slope of the FV line (i.e. the ratio of maximal force and velocity qualities for a given individual), alongside theoretical maximal force (F_0), theoretical maximal velocity (V_0) and the associated maximal power output (P_{max}) (Jaric, 2015; Cross et al., 2017). These variables do not only characterize the mechanical limits of the neuromuscular system but provide useful information for the design of individualized training. Even though sprint performance is highly correlated to Pmax, it has been shown (both theoretically and experimentally) that changes in the slope of the FV relationship can improve jumping performance independently from changes in P_{max} (Samozino et al., 2012; Jiménez-Reyes et al., 2017), which supports the use of FV relationship for individualized training design. However, several studies have shown that parameters pertaining to the FV relationship, in particular the slope of the relationship, might not be sufficiently reliable to be used in practice (Valenzuela et al., 2020; Lindberg et al., 2021). Moreover, individual FV profiles are not consistent across different tasks (Valenzuela et al., 2020; Kozinc et al., 2021). Thus, the reliability of FVP relationship needs to be inspected separately for each task.

In terms of sprinting, the FVP relationship has been used to characterize the capability to produce horizontal external force throughout the acceleration phase (Samozino et al., 2016; Cross et al., 2017). In addition to the FVP relationship, the technical ability associated with mechanical effectiveness has been assessed as the ratio be-

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tween horizontal and resultant ground reaction forces (RF) (Morin et al., 2011). While the RF can be assessed for each step or individual sections of the sprint, a linear decrease in RF (D_{RF}) throughout the acceleration phase is used to quantify the athlete's ability to maintain horizontal orientation of the resultant force vector (Morin et al., 2011; Cross et al., 2017). Since sprint mechanical variables appear to be more individual-specific than sport-specific (Haugen et al., 2019), sprint FVP profiles represent a promising approach for more individualized assessment and training practices (Morin and Samozino, 2016).

The FVP relationship during sprinting can be quantified using different methods and associated technologies (Cross et al., 2017). While older approaches involved either specialized treadmills or sequences of force plates (Cross et al., 2017), simplified techniques that require only the use of timing gates or a radar have been recently introduced and validated (Samozino et al., 2016; Morin et al., 2019). These methods enable the assessment of mechanical variables of the sprint in realistic conditions without using force plate measurements. In addition to validation against the force plate method, several studies reported high reliability of the obtained FVP relationship (CV < 5 %) (Samozino et al., 2016; Morin et al., 2019). On the other hand, some of the subsequent studies have reported only moderate reliability of certain variables, particularly those associated with split times > 10 m and those including a horizontal force component (Simperingham et al., 2019). Nevertheless, devices that allow accurate measurement of sprinter's velocities (either continuously or in split time intervals) could represent a feasible and convenient tool for both researchers and practitioners interested in sprint running and associated FVP relationship, however, the reliability of the measurement protocols should be clarified.

This study aimed to assess the within- and between-session reliability of the sprint FVP profiling using a KiSprint system, which was recently shown to provide accurate information on mechanical patterns and technique during sprint initiation and acceleration, and can thus assist in personalization of training programs (Mirkov et al., 2020). It consists of an instrumented sprint start block, an electric trigger gun and a high quality laser distance sensor, which allows practitioners to concomitantly evaluate block start performance and the FVP relationship in sprint acceleration. The system is portable, easy to set-up and usable indoors and outdoors. However, the reliability of the FVP profiling with this system has not been explored before. Moreover, previous reports on inter-session reliability are limited to one study, which reported good reliability of all outcome variables, but it did not include D_{RF} (Simperingham et al., 2019). Previous studies used either photocells systems or radar guns with sampling rate of 47 Hz (Samozino et al., 2016; Morin et al., 2019; Simperingham et al., 2019) whereas the KiSprint laser sensor samples at 1000 Hz. For this study, we hypothesized that the outcomes will mostly show good to excellent reliability with very low within-individual error (ICC > 0.75; CV < 5 %), while later split times (i.e. 20 m and 30 m) and FV slope will exhibit at least moderate reliability (ICC > 0.6; CV < 10 %).

Methods

Participants

Thirty young track and field athletes (specializing in 100 and/or 200 m sprints), 23 males (age = 18.7 ± 2.6 years; body height = 1.81 ± 0.06 m; body mass = 74.2 ± 8.2 kg; best 100-m time = 11.34 ± 0.61 s) and 7 females (age = 18.9 ± 3.3 years; body height = 1.67 ± 0.03 m; body mass = 58.0 ± 5.1 kg; best 100-m time = 12.78 ± 0.60 s), volunteered to participate in the study. The participants were recruited through national and regional sports associations. They have been regularly competing and performing on average 6.21 ± 1.21 training sessions per week, being involved in regular training for 6.56 ± 2.02 years. While all participants completed at least one session and were considered for within-session reliability assessment, only 23 participants were considered for between-session reliability assessment, because 7 participants did not attend the second testing session. Participants reported no injuries within the last two years and were healthy at the time of testing. The study protocol was approved by the National Medical Ethics Committee (number of approval: 0120-99/2018/5) and was compliant with the latest revision of the Helsinki Declaration. Additional consent was provided by legal guardians for all underage participants.

Study design

A repeated-measures design was used to assess the within- and between-session reliability of the horizontal FVP profile. Participants attended two sessions that were separated by one week. The two sessions for the same participant were conducted at the same time of the day, and the tests were conducted on an indoor track to avoid weather influence. At the beginning of the session, a general warm-up was performed (10 min of low intensity jogging, 8 repetitions of dynamic stretching exercises and 10 repetitions of squats, push-ups and sit-ups each), followed by a 10-15 min sprint-specific warm-up consisting of various sprint drills led by a track-and-field coach. Participants were given sufficient time to adjust the start blocks according to their preference, and they performed 2–3 submaximal familiarization trials to confirm the set-up or make additional adjustments if needed. The main part of the experiment consisted of 10 sprints (first session) or 5 sprints (second session). The trials were initiated by the examiner pressing the trigger gun, which was preceded by ''ready'' and ''set'' commands. Participants were always instructed to sprint for 30 meters with maximal effort. At least 3 min of break were provided between repetitions. The first three successful repetitions (i.e. no missing data up to 30 m) from each session were used in analyses, while the remaining repetitions were conducted for purposes that are not considered in this study. For between-session reliability, averages of the three repetitions were compared (Simperingham et al., 2019).

Data collection and processing

The data was collected with an instrumented sprint start block system (KiSprint system, Kistler Instrumente GmbH, Winterthur, Switzerland) with an embedded laser distance sensor (sampling rate = 1000 Hz) that collected split times at 5-, 10-, 20-, and 30-m distances. The FVP profiles were determined by the split-time method as introduced and described by Samozino et al. (Samozino et al., 2016), using a purpose-built Microsoft Excel spreadsheet provided by Morin & Samozino (Morin and Samozino, 2017). The trials were initiated when the examiner pressed the trigger gun, but for the analyses, the sprint initiation was determined at the instance of force rise on the start blocks (Samozino et al., 2016). Air temperature and pressure, stature and body mass of the athlete were entered into the spreadsheet in addition to the recorded split times. The calculations and the underlying macroscopic biomechanical model have been thoroughly described by Samozino et al. (Samozino et al., 2016). This method estimates the step-averaged ground reaction forces in sagittal plane during sprint acceleration using only anthropometric and spatio-temporal (split times) data. This generates the sprinter's P_{max}, F_0, V_0 and the slope of the FV relationship, as well as the mechanical effectiveness of the force applied onto the ground. Therefore, the maximal ratio of horizontal-to-resultant force (RF) and the decrease in the RF (D_{RF}) were also calculated and analyzed. Examples of key outcome variables are depicted in Figure 1 for a representative participant.

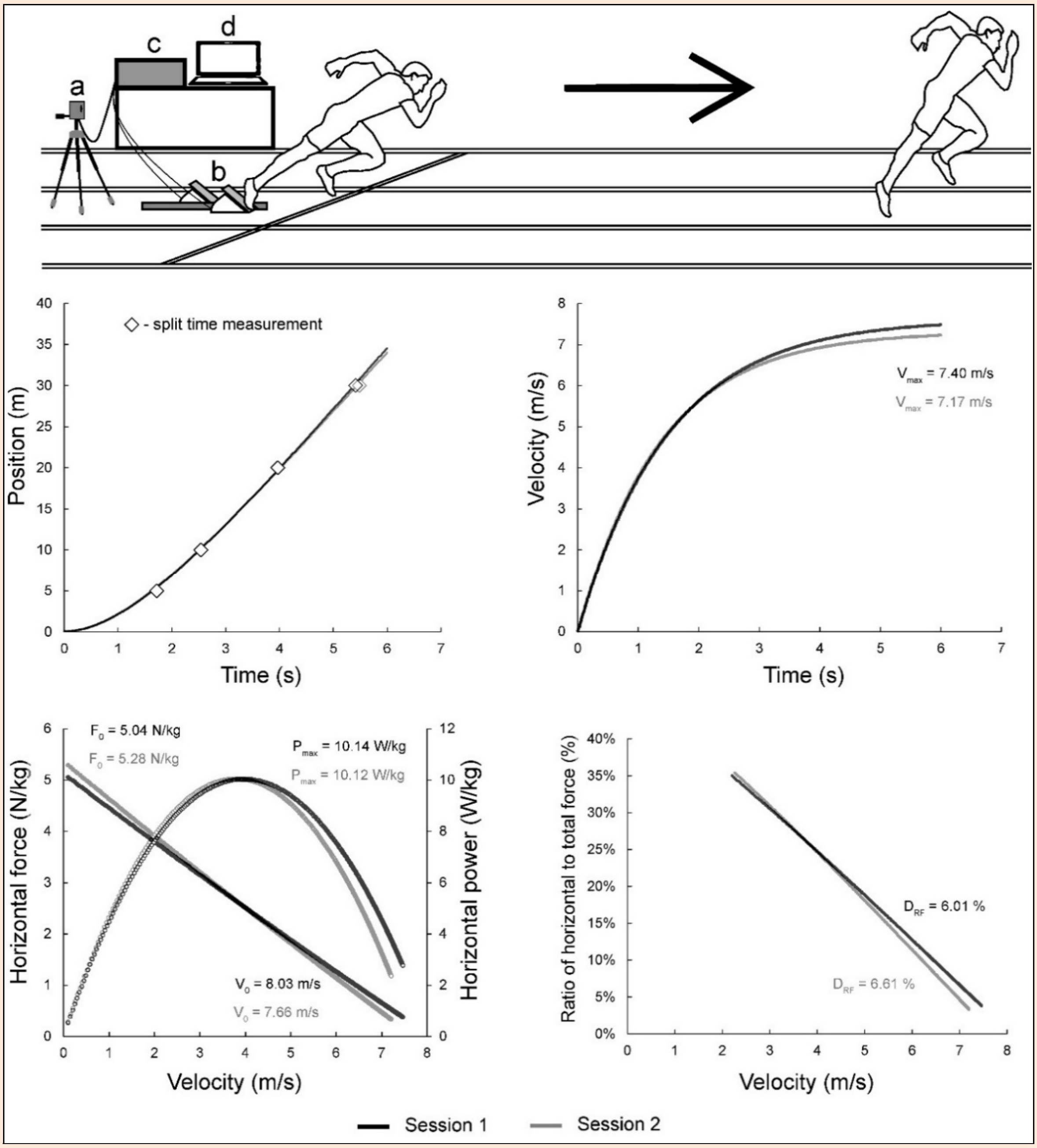

Figure 1. The split times were recorded with a laser distance meter (a). The participants started from the adjustable sprint blocks (b), and the data was stored via a data acquisition box (c) and immediately transferred to the personal computer (d) for inspection and later offline analysis. The charts depict the data of key outcome variables for a representative participant, obtained during the first (black color) and second (gray color) session.

Statistical analysis

All statistical analyses were performed using the SPSS (IBM SPSS version 25.0, Chicago, IL, USA) software with statistical significance set at an alpha level of 0.05. Normal distribution of the data was confirmed by the Shapiro–Wilk test ($p \geq 0.098$). Descriptive statistics are reported as mean ± standard deviation. Relative reliability was assessed by calculating two-way mixed intra-class correlation coefficients for single (ICCs) and average (ICCa) measures. ICC scores were interpreted as fair (ICC 0.40-0.59), moderate (ICC 0.60-0.74) and good to excellent (ICC 0.75-1.00) (Hills and Fleiss, 1987). Absolute reliability was assessed with typical error (TE; as standard deviation of the differences divided by √2) and coefficient of variation (CV; computed as TE / Mean ×100%). CV below 10 % was considered acceptable (Hopkins, 2000). Finally, the smallest worthwhile change (SWC) was calculated as TE × √2 × 0.2 (Hopkins, 2000) in order to differentiate meaningful change from trial-to-trial and session-to-session variation.

Results

Descriptive statistics for split times and FVP variables are presented in Table 1 for inter-repetition comparison within the first session and between-session comparison.

Within-session reliability statistics are summarized in Table 2. All split times showed good to excellent within-session relative reliability (ICCs = 0.77-0.89). Acceptable within-participant variability with very low CVs was shown across all split times (CV = 0.84-1.34 %). Moderate relative reliability was shown for F_0 and V_0 (ICC = 0.71-0.74), with acceptable within-participant variability (CV = 2.36-3.41 %). Good to excellent reliability was observed for P_{max} and RF_{max} (ICCs = 0.86-0.90; CV = 1.29-2.20 %), however, only fair relative reliability was shown for FV slope and D_{RF} (ICCs = 0.47-0.48), although the within-participant variability was acceptable for these two variables as well (CV = 6.98-7.25 %).

Between-session reliability statistics are summarized in Table 3. All split times showed good to excellent relative reliability (ICCs = 0.84-0.96) and slightly higher TEs (0.03-0.08 s) and acceptable within-participant variability (CV = 1.09-2.10 %). Like within-session results, good to excellent reliability was shown for P_{max} and RF_{max} (ICCs = 0.88-0.92; CV = 2.03-3.92 %). Only fair relative reliability was observed for F_0 and V_0 (ICCs = 0.55-0.60), however, the CVs were acceptable (3.68 – 6.66 %). Finally, unacceptable reliability was shown for FV slope and D_{RF} (ICCs = 0.31-0.33; CV = 10.95-11.09 %).

Table 1. **Within-session and between-session descriptive statistics. Data presented as Mean (Standard Deviation)**

Outcome variables	Within Session			Between Sessions	
	Repetition 1	Repetition 2	Repetition 3	Session 1	Session 2
5 m time (s)	1.49 (0.09)	1.45 (0.09)	1.46 (0.08)	1.47 (0.08)	1.45 (0.08)
10 m time (s)	2.20 (0.12)	2.17 (0.12)	2.17 (0.12)	2.19 (0.12)	2.17 (0.11)
20 m time (s)	3.44 (0.20)	3.40 (0.18)	3.44 (0.29)	3.43 (0.18)	3.42 (0.18)
30 m time (s)	4.70 (0.28)	4.66 (0.25)	4.67 (0.29)	4.70 (0.25)	4.77 (0.28)
F_0 (N/kg)	6.78 (0.82)	7.21 (1.00)	7.25 (0.92)	7.03 (0.89)	7.55 (0.82)
V_0 (m/s)	9.30 (0.74)	9.18 (0.72)	9.14 (0.88)	9.15 (0.63)	8.63 (0.65)
P_{max} (W/kg)	15.8 (2.47)	16.5 (2.44)	16.5 (2.30)	16.1 (2.34)	16.3 (2.09)
FV Slope	-0.73 (0.10)	-0.79 (0.13)	-0.80 (0.16)	-0.77 (0.11)	-0.88 (0.12)
RF max (%)	0.43 (0.03)	0.44 (0.03)	0.44 (0.03)	0.43 (0.03)	0.44 (0.03)
D_{RF} (%)	-0.07 (0.01)	-0.07 (0.01)	-0.07 (0.02)	-0.07 (0.01)	-0.08 (0.01)
Max. Speed (m/s)	8.55 (0.58)	8.51 (0.55)	8.48 (0.68)	8.47 (0.50)	8.13 (0.53)

F_0 - theoretical maximal force; V_0 - theoretical maximal velocity; P_{max} - maximal power; FV slope - slope of the force–velocity relationship; RF_{max} - maximal ratio of horizontal-to-resultant force. D_{RF} - decrease in the ratio of horizontal-to-resultant force;

Table 2. **Within-session reliability of the key outcome variables.**

Outcome variables	Relative reliability		Absolute reliability		
	ICCs (95% CI)	ICCa (95% CI)	TE (95% CI)	CV (95% CI)	SWC (95% CI)
5 m time (s)	0.81 (0.65-0.91)	0.93 (0.85-0.97)	0.02 (0.01-0.02)	1.23 (0.98-1.37)	0.01 (0.00-0.01)
10 m time (s)	0.89 (0.77-0.94)	0.96 (0.91-0.98)	0.02 (0.02-0.02)	0.90 (0.79-0.96)	0.01 (0.00-0.01)
20 m time (s)	0.77 (0.62-0.87)	0.91 (0.83-0.95)	0.03 (0.02-0.03)	0.84 (0.68-0.95)	0.01 (0.01-0.01)
30 m time (s)	0.85 (0.74-0.92)	0.94 (0.89-0.97)	0.06 (0.05-0.07)	1.34 (1.17-1.46)	0.02 (0.02-0.02)
F_0 (N/kg)	0.71 (0.49-0.85)	0.88 (0.74-0.94)	0.23 (0.16-0.28)	3.41 (2.37-4.09)	0.07 (0.05-0.08)
V_0 (m/s)	0.74 (0.58-0.86)	0.90 (0.81-0.95)	0.22 (0.17-0.26)	2.36 (1.85-2.74)	0.06 (0.05-0.07)
P_{max} (W/kg)	0.90 (0.80-0.95)	0.97 (0.92-0.98)	0.35 (0.31-0.37)	2.20 (1.95-2.32)	0.10 (0.09-0.10)
FV Slope	0.48 (0.26-0.69)	0.74 (0.51-0.87)	0.05 (0.03-0.07)	6.98 (3.70-9.96)	0.01 (0.01-0.02)
RF max (%)	0.86 (0.73-0.93)	0.95 (0.89-0.98)	0.01 (0.00-0.01)	1.29 (1.09-1.40)	0.00 (0.00–0.00)
D_{RF} (%)	0.47 (0.24-0.68)	0.72 (0.49-0.86)	0.00 (0.00-0.01)	7.25 (3.73-10.5)	0.00 (0.00–0.00)
Max. Speed (m/s)	0.77 (0.62-0.88)	0.91 (0.83-0.96)	0.16 (0.13-0.19)	1.92 (1.55-2.18)	0.03 (0.02-0.04)

ICCs – intraclass correlation coefficient (single measures); ICCa – intraclass correlation coefficient (average measures); CI – confidence interval; TE – typical error; CV – coefficient of variation (%); SWC - smallest worthwhile change; F_0 - theoretical maximal force; V_0 - theoretical maximal velocity; P_{max} - maximal power; FV slope - slope of the force–velocity relationship; RF_{max} - maximal ratio of horizontal-to-resultant force. D_{RF} - decrease in the ratio of horizontal-to-resultant force.

Table 3. Between-session reliability of the key outcome variables.

Outcome variables	Relative reliability ICCs (95% CI)	ICCa (95% CI)	Absolute reliability TE (95% CI)	CV (95% CI)	SWC (95% CI)
5 m time (s)	0.84 (0.67-0.93)	0.92 (0.80-0.96)	0.03 (0.02-0.03)	2.10 (1.66-2.32)	0.01 (0.01-0.01)
10 m time (s)	0.90 (0.78-0.96)	0.95 (0.88-0.98)	0.03 (0.03-0.04)	1.52 (1.31-1.61)	0.01 (0.01-0.01)
20 m time (s)	0.96 (0.90-0.98)	0.98 (0.95-0.99)	0.04 (0.04-0.04)	1.09 (1.03-1.12)	0.01 (0.01-0.01)
30 m time (s)	0.87 (0.62-0.95)	0.93 (0.76-0.98)	0.08 (0.06-0.09)	1.72 (1.21-1.87)	0.02 (0.02-0.02)
F_0 (N/kg)	0.60 (0.12-0.83)	0.75 (0.21-0.91)	0.47 (0.09-0.65)	6.66 (1.32-9.21)	0.13 (0.03-0.18)
V_0 (m/s)	0.55 (-0.04-0.82)	0.71 (-0.08-0.90)	0.34 (-0.02-0.50)	3.68 (0.25-5.50)	0.10 (0.01-0.14)
P_{max} (W/kg)	0.92 (0.82-0.96)	0.96 (0.90-0.98)	0.63 (0.56-0.66)	3.92 (3.50-4.11)	0.18 (0.16-0.19)
FV Slope	0.33 (-0.07-0.65)	0.49 (-0.16-0.79)	0.08 (-0.02-0.17)	10.9 (2.42-21.7)	0.02 (0.01-0.05)
RF max (%)	0.88 (0.70-0.95)	0.94 (0.83-0.97)	0.01 (0.01-0.01)	2.03 (1.63-2.20)	0.00 (0.00-0.00)
D_{RF} (%)	0.31 (-0.08-0.63)	0.48 (-0.17-0.78)	0.01 (0.00-0.02)	11.1 (2.73-22.5)	0.00 (0.00-0.00)
Max. Speed (m/s)	0.67 (0.04-0.88)	0.80 (0.08-0.94)	0.23 (0.01-0.30)	2.67 (0.16-3.51)	0.05 (0.00-0.07)

ICCs – intraclass correlation coefficient (single measures); ICCa – intraclass correlation coefficient (average measures); CI – confidence interval; TE – typical error; CV – coefficient of variation (%); SWC – smallest worthwhile change; F_0 - theoretical maximal force; V_0 - theoretical maximal velocity; P_{max} - maximal power; FV slope - slope of the force–velocity relationship; RF_{max} - maximal ratio of horizontal-to-resultant force. D_{RF} - decrease in the ratio of horizontal-to-resultant force.

Discussion

This study aimed to assess the within- and between-session reliability of the sprint split times measured with the KiSprint measurement system and the sprint FVP profiling obtained with the Samozino's method. Contrary to our hypothesis, all the split times showed good to excellent reliability, both within and between the sessions (ICC ≥ 0.77; CV ≤ 2.1 %). Within-session reliability was moderate or good to excellent for most of the mechanical variables, except for lower relative reliability of FV slope and D_{RF} (ICC = 0.47-0.48). Similarly, between-session reliability was moderate or good to excellent for all variables except for FV slope and D_{RF} (ICC = 0.31-0.33; CV = 10.9-11.1 %).

The Samozino's simplified method has been validated previously against the force plate measurements (Samozino et al., 2016), which was replicated in a subsequent study (Morin et al., 2019) and also by using only a smartphone with a custom-designed (MySprint) application (Romero-Franco et al., 2017). The first validation study revealed acceptable absolute bias (1.8-8.0 %) for all mechanical outcome variables, although FV slope (7.9 %) and DRF (6.0 %) had higher bias compared to F0 (3.7 %), V0 (4.8 %) and Pmax (1.8 %). Also, the reliability of the simplified method was reported, with a similar trend of higher standard errors of measurement for FV slope and DRF (4.8-4.9 %), compared to the other variables (1.4-3.5 %). However, these trends were less obvious in the replication study (Morin et al., 2019), while the reliability was similarly very high. Findings from the current study suggest that FV slope and D_{RF} are not sufficiently reliable parameters to be used in practice, although unacceptable within-participant errors have been observed only between sessions. Our results are very similar to those of Simperingham et al. (2019), who observed higher reliability for FV slope (ICC = 0.76; CV = 7.1 %) but did not assess D_{RF}. Their findings could be explained partially by the characteristics of their sample, which was likely more heterogeneous than ours (i.e., rugby players) and could have positively affected relative reliability. Presumably, averaging a higher number of repetitions would improve the reliability; however, given that individual split times already showed high reliability, it is unlikely that large improvements would be obtained.

The variables related to the FVP relationship and RF provide key information about neuromuscular and technique-related capabilities, which can serve in optimizing sprint performance by individualized assessment and training. Among the mechanical determinants, sprint running performance is predominantly dependent on P_{max}, V_0, and D_{RF} (Morin et al., 2011, 2012). Sprint-specific exercises, such as sled pushing (Cahill et al., 2020) and sled towing (Kawamori et al., 2014), have been used to improve these capacities. It has been suggested that training loads could be optimized for superior results based on an individual's FVP profile (Morin and Samozino, 2016). However, while current field-based methods for assessing mechanical characteristics of sprint acceleration generally show good reliability, FV profile and D_{RF} showed unacceptable reliability in this study, reflected in larger errors than observed in F_0, V_0, P_{max}, and RF_{max}. Future studies should aim at providing optimal assessment protocol for maximizing the within- and between-session reliability of sprint FVP profiling.

Previous studies have used FVP profiling to assess the effects of different training methods on sprint performance (Carlos-Vivas et al., 2019; Macadam et al., 2019; Cahill et al., 2020). Collectively, it seems that smaller acute- and long-term changes in sprint FVP profile followed by training programs or other interventions should mostly be detectable despite the suboptimal reliability of the FVP profiling, as the changes observed in these studies were larger than SWCs that we observed. However, as mentioned above, our results question the utility of the sprint-based FVP profiling for individualized training prescription. Importantly, FV slope and D_{RF}, which are considered the most important variables in sprint FVP profiling, both showed unacceptable reliability. This is in accordance with the recent studies that showed unacceptable reliability of FV slope in vertical jumps (Valenzuela et al., 2020; Lindberg et al., 2021). Another study that assessed FV profile during ice hockey sprint acceleration also showed low to moderate reliability of FV slope, while the remaining variables showed acceptable reliability (Perez et al., 2019). Since FV slope is influenced by variation in both F_0 and V_0, it is expected to show lower reliability than the other two variables. Future studies should explore methodological approaches to maximize the reliability of FVP profiling. In terms of sprint, a promising approach is to use the average value of multiple trials (Simperingham et al., 2019).

Some limitations of the study need to be acknowledged. We collected the data from the sample of younger high-level sprinters. Thus, the results cannot be generalized to all track-and-field populations. Moreover, the sample consisted of 23 males and seven females. Therefore, future studies should explore whether differences exist between genders in terms of the reliability of sprint FVP profiling. Also, although high reliability has been reported previously for distances similar to ours (Samozino et al., 2016), it is presumable that sprint running recorded across a longer running distance (e.g., 60 m) would provide higher reliability (Morin et al., 2019). Clearly, further studies need to confirm our results in different athlete-populations and explore whether using longer sprint distances or other protocol modifications could improve reliability.

Conclusion

The present study confirmed the reliability of the KiSprint system for assessing split times and most of the FVP profile variables based on the Samozino's simplified method. However, the FV slope and D_{RF} variables were prone to error and showed unacceptable reliability. Thus, FVP profiling for individualized sprint assessment and training should be implemented cautiously. Future studies are needed to optimize the protocol to maximize the reliability, before the simplified method for field-based sprint FVP profiling can be used in practice.

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Key points

- This study showed moderate to excellent within- and between-session reliability for sprint split times (5, 10, 20 and 30 m) and most variables related to force-velocity profiling in sprint running (F_0, V_0, P_{max}).
- Unacceptable lower reliability was shown for force-velocity profile (i.e. the slope of the profile) and the coefficient of decrease in the ratio between horizontal and total force throughout the trial.
- Future studies are needed to optimize the protocol in order to maximize the reliability of the force-velocity variables.

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