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Effect of Entry Velocity on Pickup Acceleration Performance

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ABSTRACT

Sprint acceleration is a fundamental component of team sports and is typically measured from a static start, despite athletes frequently initiating sprints from a walking/jogging/running start on the field. The focus of this study was how the entry velocity varies within and between sessions and whether this affects subsequent sprint performance (i.e., pickup acceleration). Sixteen male athletes (age 21.9 ± 4.8 years) performed three sessions, each consisting of two sprints at each of the four pre-determined entry velocities (static start (0%), 20%, 40%, and 60% of maximum velocity), guided via an LED pacing system. Data were measured via a linear position encoder (1080 Sprint), from which maximum acceleration (a_{max}), maximum velocity (v_{max}), and split times (2, 5, 10, and 20 m) were determined following the moment of pickup. Linear mixed-effects models were used, with entry velocity, trial, and session (and their interaction) as fixed effects and participant as a random effect. Entry velocity had a large effect on all variables (η_p^2=0.22 to 0.97; p <0.001). The only variable to differ significantly across trial and session was v_{max}. However, the effect sizes were small and within trial (6.0-7.0%), and between-session (0.15 to 0.67%) coefficients of variation were less than 10%. In summary, entry velocity had minimal effect on the stability of a_{max}, v_{max}, and split times across trials and sessions, and the practitioner can be confident that these measures are reasonably stable across repeated testing occasions and, therefore, can be used to measure and monitor pickup acceleration.

Keywords: sprinting, speed, velocity, field sports, running

INTRODUCTION

Sprinting acceleration is a key factor in determining performance in many sports and disciplines. In team sports, acceleration is necessary for both attacking, defending, and evasive maneuvering, often in response to scoring opportunities [1, 2]. During these accelerations, the athlete performs a ‘pickup’ and maximally accelerates from a submaximal entry velocity on a continuum spanning low to high velocities (e.g., walk-to-run) in relatively short bursts of effort [3, 4]. The prevalence of non-stationary accelerations varies by sport [5], but typically far outnumber static-start sprints [4, 6]. To this point, there is evidence that in elite-level rugby, accelerations are initiated from a walking-standing (0-1.9 m/s) start at a frequency of 53.4 ± 5.5% or a jogging start (>1.9 m/s) 31.8 ± 5% of the total accelerations quantified [7]. Simply put, it is evident that in-situ, athlete sprint capability is defined by the ability to ‘pickup’ and maximally accelerate in non-static conditions (i.e., pickup acceleration) and across a range of entry velocities. Nonetheless, most research on the subject, and accordingly measurements in practice, involve characterizing sprinting from a static start, this potentially indicates a disconnect to what occurs commonly on-field.

Maximal acceleration is characterized by the ability of the athlete to orient force production horizontally, which enables an increase in velocity. This expression of physical and technical capacities underlying sprinting performance is situational, but ultimately changes based on the velocity of the athlete and the position of their center of mass [8-10]. Horizontal force and acceleration vary in a highly predictable fashion with movement velocity [11-13], and higher velocities are associated with lower rates of acceleration, and vice versa. This horizontal force application proportionality decreases with increased speed as the athlete's posture shifts towards vertical, and v_{max} is attained. With the highest rate of acceleration (a_{max}) occurring near the start of the sprint, it can be logically inferred that accelerative a_{max} also decreases with the addition of an entry velocity. Previous researchers investigating static start sprinting [14] have shown simple measurements such as distance-time to be consistent across testing sessions; however, reporting of how these variables change during pickup acceleration has not been undertaken.

Pickup acceleration is largely under-explored in the literature, with only a small selection of articles examining the entry velocity's impact on a_{max}, and v_{max} [15]. In studying the impact of an entry velocity on acceleration, Sonderegger et al. [15] used a pacer who received auditory cueing through a headset to pace athletes into their accelerations across three absolute entry velocities (~1.67, ~3.00, ~4.17 m/s). Once the pacer initiated their entry, they sounded a whistle at an arbitrary distance and the tested athlete then maximally accelerated through 50 m. A significant inverse correlation was observed between the entry velocity and a_{max} (r= -0.98), with a_{max} decreasing by 27-35% with each increasingly faster entry velocity [15]. This group's work shows that accelerative capacity decreases linearly with increasing entry velocity.

Several articles have chronicled the impact of the entry velocity on outcome variable v_{max}. Benton et al [16] paced athletes at 3, 5, and 7 m/s using a bicycle outfitted with a digital speedometer for 25 m until reaching the start line and accelerating for 60 m. For their pickup sprints, v_{max} speeds ranged from 8.85-8.96 m/s, with the fastest v_{max} elicited by the fastest entry velocity [16]. Despite these findings, no significant differences were reported, and the intra-trial and intra-session stability of these measures was not evaluated. In the Sonderegger study, results were similar, with reported v_{max} values ranging from 8.53 to 8.69 m/s for the selected entry velocities [15], though the fastest v_{max} was observed from the standing start rather than the fastest-paced pickups. Unexplored in these investigations is the impact of the entry velocity on distance-time measures (i.e., split times); however, it can logically be surmised that similar to a_{max}, split times decrease substantially with faster entry velocities. While not explicitly tested and reported, a decrease in split o times can be inferred by previous authors showing that with the increase in entry velocity, the distance needed to attain 90 to 97.5% of v_{max} decreased [17]. Once again, these measures were not examined for consistency across repeat trials or sessions.

These articles are informative and serve as a basis for further exploration; however, there are limitations. First, in the gait transition literature, the transition from walking to running has been studied robustly; however, the bulk of it examines a steady increase in speed from a limited entry velocity bandwidth (predominantly walking, and excluding a jogging entry), with only a small portion examining a sharp increase in velocity over 3 to 4 total steps and incomplete reporting of outcome measures v_{max}, a_{max}, and split times [18-22]. The disconnect arises due to most sporting events utilizing a spontaneous transition from low to high speed, with acceleration occurring rapidly. Secondly, subjects in these gait transition studies were not asked to attain v_{max}, and a_{max} and split time numbers were not reported. Finally, the overall repeatability of these measures has yet to be examined in depth in any context, which precludes practitioners from understanding the magnitude of changes elicited and the overall reliability of measurement.

Given the aforementioned information, the aims of this study were twofold. First, we sought to understand how different standardized entry velocities (20%, 40%, and 60% of v_{max}) affected pickup acceleration outcome measures a_{max}, v_{max}, and split times; and second, how does the entry velocity affect measures of consistency across multiple repeat trials and sessions? It was hypothesized that faster entries would result in a lower a_{max} and shorter split times, a negligible impact on v_{max} would be found, and consistency across trials and sessions would be expected. The findings of this study will enable a better understanding of pickup acceleration from a sports performance and assessment perspective, as well as provide insight into measures that can be used to consistently characterize this phenomenon.

METHODS

Experimental Approach to the Problem

A repeated measures design was used to determine the effects of the entry velocity (20%, 40%, and 60% v_{max}) on pickup acceleration performance measures (a_{max}, v_{max}, and 2, 5, 10, and 20 m timed splits) across four consecutive weeks. For each trial and session, velocity- and distance-time raw data were collected by a motorized horizontal linear position encoder (1080 Sprint device), and the dependent variables of interest were extracted and compared across trial, session, and condition (entry velocity).

Athletes

Sixteen male team sport athletes (age 21.9 ± 4.80 years, stature, 1.78 ± 0.08 m; body mass, 70.9 ± 26.9 kg) from mixed sporting backgrounds (American football, N=9; American Ultimate Disc League professional ultimate frisbee N=3; soccer, N=2; Gaelic football, N=1; and basketball N=1) participated in this study. Athletes were healthy, without lower-extremity injuries in the previous six months (or any other injuries that might limit their full participation capability). They were advised to abstain from intense physical activity <24 hours before their testing session. Athletes were familiar with sprinting and sprint testing due to participation in a team sport (>1 year of sports performance training experience). Athletes provided written informed consent to participate, with ethical approval granted by the Auckland University of Technology Ethics Committee 21/437.

Procedures

Participants attended four sessions: one familiarization and three testing sessions. Athletes reported on the first testing day and were briefed on the procedures before participation. Testing was performed indoors on a 4G artificial turf, in consistent ambient conditions throughout the testing duration, and athletes wore the same footwear and sports training attire per session. All sessions, including the familiarization, took place over 60 minutes and were separated by a minimum seven-day period. Incidentally, 2 athletes missed 1 previous session due to factors outside of the control of the researchers. They subsequently performed a 'make-up' session on the Saturday after the last scheduled week of testing, at the same time of day. For each session, all athletes performed a standardized dynamic warm-up involving total-body dynamic stretches and sprint preparation movements consisting of sprint-specific joint mobility, skipping, hopping, and graded-intensity running. Familiarization primarily focused on the pacing technology used, however, it also included the measurement technology and the overall protocol. The second, third, and fourth weeks involved the athletes performing two static start accelerations followed by six pickup accelerations, two each of 20%, 40%, and 60% of peak velocity (v_{max}), extracted from the static start acceleration repetitions and rounded to the nearest 0.10 m/s. During the data collection session trials were allocated in randomized order. After completing the two static start sprints, each subject's peak velocity was calculated from the motorized horizontal linear position encoder's (LPE) tablet-based user interface. Each pickup sprint was normalized to each athlete's v_{max} as calculated on the day of testing, with each pickup condition being assigned in a randomized order. If an athlete did not properly maintain their entry velocity, the trial was discarded, and after a 5-minute rest interval, a repeat trial was commenced. Each static start trial was performed from a split stance position, and once given the 'OK,' athletes were asked to maximally sprint for a total of 32 m. For each pickup trial, athletes started from the same stance and once cleared to begin, accelerated to the pace set by the LED pacing system. A minimum of 5 minutes of passive recovery was given between each trial (static and pickup).

The sprint lane setup for the experimentation consisted of two distinct sections (see Figure 1): 1) an 18.2 m initial acceleration zone and 2) a 27.4 m pickup acceleration zone (45.6 m total). Distances were determined through pilot testing to be sufficient to stabilize cued entry velocities. Each zone was delineated by cones of a different color at the initiation and termination of the respective zone. To target and monitor entry velocity, a 25 m

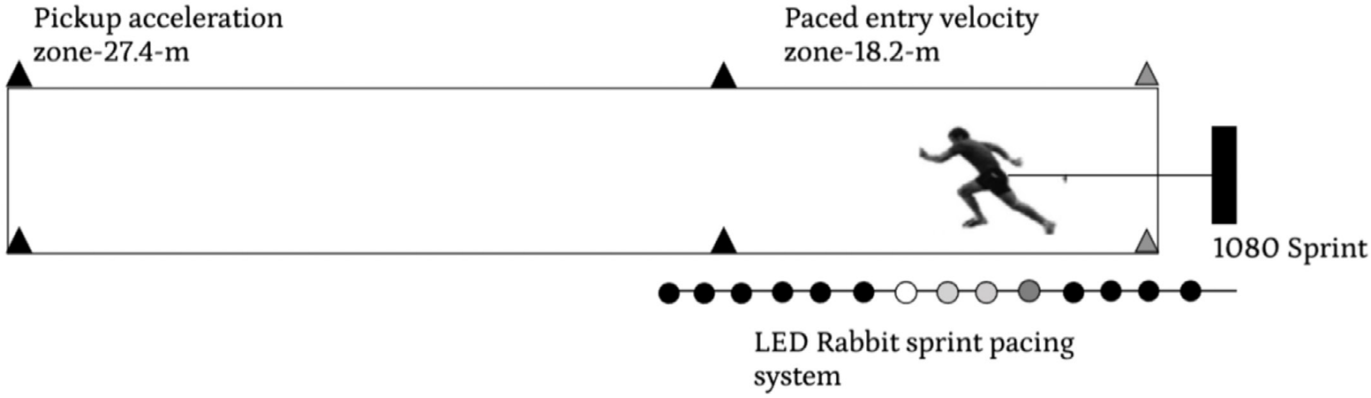

Figure 1. Methodological setup for pickup acceleration assessment.

LED pacing system (LED Rabbit, BV Systems, LLC, Shawnee, KS) was placed parallel to the sprint lane, starting ~5 m behind the start of the entry zone. The pacing system was programmed to 'Run' mode, which, when selected, elicited a gradual acceleration over the length of the 25 m strip. Entry velocities were randomized using an Excel spreadsheet (Microsoft Excel, Microsoft, Redmond, WA, USA). A motorized LPE (1080 Sprint, 1080 Motion AB, Lidingö, Sweden) was used to measure distance-time data during sprint trials. The device was set at ground level behind the sprint lane, with the retractable tether set to 2 m in distance from the motorized horizontal linear position encoder and attached to a belt around the athlete's waist. The portable linear position encoder measured position, velocity, and acceleration via a retractable cable, communicated via Bluetooth to a tablet or laptop, with raw data saved to a cloud-based server via manufacturer software. While traditionally used to provide external resistance via braking the rotating drum on which the cable is spooled, the LPE was used on the lowest resistance setting (~1 kg of horizontal braking, to simulate unresisted running). Distance- and velocity-time data were sampled at 333 Hz, thus feasibly improving the process of detecting distinct events within the data stream.

During trials, athletes were instructed to approach the starting line once the belt attached to the LPE was connected to their waist. A split stance with the athlete's preferred foot in front was used, and any slack in the tether before the initiation of the movement was removed. For the pickup trials, athletes were instructed to accelerate to the LED pacing system's speed and after 13 m from the start maximally accelerate through the sprint lane end.

Data analysis

Raw data was extracted from the manufacturer-provided web-based software. Static start trials were collected and extracted to tabulate the relative individual entry velocities; however, these trials were not used in the analysis as the primary focus was on the change in performance of the pickup acceleration variables. Before processing, each data point underwent a visual inspection to identify and remove erroneous data points for each entry velocity. Manual selection of the pickup location was conducted, and its corresponding time and distance points were screened per the protocol. Six trials where the athlete's pace was incorrect or where they decelerated before the end of their 30 m acceleration were repeated with the errored trials not extracted. For extracted trials, the moment of pickup onset and trial termination were manually determined via graphical examination and subsequent manual selection. Following data extraction and inspection, each raw distance-time and velocity-time trial was individually analyzed through a custom script in MATLAB (R2022a, The MathWorks, Inc., Natick, Massachusetts, USA). Within the MATLAB script, each trial was low pass filtered with a 4th order Butterworth filter at 0.5 Hz cutoff frequency before the pertinent metrics were extracted.

Previously, researchers have established that gait touchdown lies in the trough, and toe-off slightly past the peak for each point along the raw linear position encoder waveform [23]. Pickup onset along the raw velocity waveform was determined to occur when the following researcher-defined criteria were met. The criteria employed for breakpoint selection for each pickup trial were as follows: a visible rise in velocity for each pickup condition was defined using the raw velocity-time stream, with confirmation coming through analysis of the raw acceleration-distance graph for a corresponding spike in velocity. For trials with no sudden spike in velocity or acceleration, a disruption in the homogenous nature of foot strikes was used in conjunction with analysis for a rise in acceleration on the raw acceleration-distance waveform. Pickup trials were split into pre- and post-pickup just past the waveform peak for the foot strike immediately prior, between 13 and 18.2 m. This signified that propulsion of the center of mass had occurred. From the pre-pickup data, the mean pickup velocity was determined by extracting the mean 5 m entry velocity before the selected pickup point and normalizing it to the maximal velocity attained. Post-pickup metrics extracted were time splits at 2, 5, 10, and 20 m, v_{max} and a_{max}. Finally, intra-operator reliability for the pickup conditions was assessed by analyzing all trials twice, with a minimum of two days between, with the repeatability dependent on the pickup point detection sufficient for further data processing.

Statistical analysis

Where applicable, descriptive statistics are presented as mean ± standard deviation. To assess the effects of entry velocity on pickup acceleration performance (a_{max}, v_{max}, 2, 5, 10, and 20 m split time), linear mixed-effects models were used, specifically the *lmerTest* [24] package in R language and environment for statistical computing (version 4.2.0, The R Foundation for Statistical

Computing, Vienna, Austria). Further, *geffects* [25] were used to estimate marginal means, and various packages from the *easystats* [26] framework (e.g., *performance, parameters*, and *effect size*). Linear mixed-effects models were used in favor of more classical approaches due to: 1) flexibility for data to be considered within a single model (i.e., all trials, all sessions across all conditions), without violating the assumption of independence of observations; and, 2) allowing entry velocity to be included within each model, and thus variation tested and controlled for when exploring the effects of session and trial. To this end, models were created, which first included fixed effects of the trial (representing intra-session), session (representing inter-session), and condition (representing variation in entry velocity), with the target being each performance variable. A second level of modeling included interaction effects (condition × trial, and condition × session) to explore whether intra- and inter-session measures varied by entry velocity. In both models, athletes were included as random effects.

The goodness of fit of the models was interpreted using conditional R^2. Standardized effects were extracted from running an analysis of variance on each model and reported as partial eta-squared (η_p^2) and their associated 95% confidence intervals. Finally, estimated marginal means and pairwise comparisons were determined to explore further the effects between sessions in raw change and confidence intervals, using Holm's correction for multiple comparisons. For η_p^2 effect sizes, thresholds were set as trivial < 0.01, small 0.01-0.05, medium 0.06-0.13, and large > 0.14, respectively [27]. Within-trial and between-session coefficients of variation (CV) were calculated to reflect the typical error in the measurements, CVs <10% were deemed acceptable [28]. For all analyses, the alpha value was set at $p<0.05$.

RESULTS

Descriptive statistics of the relevant dependent variables for each condition can be observed in Table 1. The mean pickup breakpoint distance was 14.75 ± 1.39 m. For breakpoint distance and breakpoint sample, inter-operator reliability was high with ICC>0.99. Eighteen of the twenty-one dependent variables analyzed had CVs <5% and all but one variable (mean entry velocity 40% v_{max}) had CVs less than 10%. Mean entry velocities are listed in Table 1. A_{max} decreased, and split times shortened with the faster entry velocities. V_{max} increased slightly between 20% and 40%, with larger increases seen at the 60% entry.

The linear mixed effects model outputs for all variables across trial, session, and condition are detailed in Table 2. V_{max} was the only variable to significantly differ across trial and session, while all variables differed by the entry velocity. As can be observed from Table 2, entry velocity significantly influenced all dependent variables, with the smallest effects noted on v_{max} (0.22) and similar larger effect sizes (> 0.90) found for all other variables. In contrast, v_{max}, was the only variable affected by trial or session, however, the effects were small (η_p^2 0.02).

Pairwise comparisons for trial and session are detailed in Table 3. The only variable to differ significantly was v_{max} between trial 1 and trial 2 (0.08 s CI: 0.03- 0.13 s). All other variables did not vary intra- or inter-session and the goodness of fit (R^2) for all models were > 0.82.

DISCUSSION

Implicit in improving qualities such as pickup acceleration is understanding the effects of different

Table 1. Descriptive statistics for pickup acceleration variables across three different entry velocities and between session coefficients of variation (CV).

Variable	20% v_{max} x̄ ± SD (CV)	40% v_{max} x̄ ± SD (CV)	60% v_{max} x̄ ± SD (CV)
Entry velocity mean (m/s)	1.87 ± 0.16 (8.50%)	4.43 ± 0.75 (17.0%)	6.71 ± 0.65 (9.60%)
a_{max} (m/s^2)	3.20 ± 0.32 (1.85%)	1.84 ± 0.31 (1.37%)	0.91 ± 0.21 (4.75%)
v_{max} (m/s)	7.73 ± 0.50 (0.67%)	7.80 ± 0.53 (0.15%)	8.05 ± 0.56 (0.36%)
2 m (s)	1.00 ± 0.10 (3.57%)	0.45 ± 0.09 (0.00%)	0.29 ± 0.03 (2.01%)
5 m (s)	1.73 ± 0.14 (2.94%)	1.07 ± 0.16 (1.63%)	0.71 ± 0.72 (0.82%)
10 m (s)	2.57 ± 0.18 (1.95%)	1.87 ± 0.22 (0.00%)	1.36 ± 0.12 (0.42%)
20 m (s)	3.95 ± 0.22 (1.40%)	3.24 ± 0.29 (0.18%)	2.62 ± 0.20 (0.79%)

Note: maximal acceleration (a_{max}); maximal velocity(v_{max}); standard deviation (SD); 2 m (2 m split time)

Table 2. Linear mixed-effects model outputs on pickup acceleration dependent variables and ηp2 effect sizes (95% CI) for trial, session, and entry velocity.

Dependent Variable	Trial			Session			Condition		
	F	***P***	**η_p^2 (CI)**	***F***	***P***	**η_p^2 (CI)**	***F***	***P***	**η_p^2 (CI)**
a_{max}	3.81	0.05	0.01 (0.00, 0.05)	0.23	0.80	0.00 (0.00, 0.02)	9627	<0.001	0.97 (0.97, .98)
v_{max}	9.00	0.00	0.03 (0.00, 0.08)	3.20	0.04	0.02 (0.00, 0.06)	76.3	<0.001	0.22 (0.14, 0.30)
2 m split	0.19	0.66	0.00 (0.00, 0.02)	0.73	0.48	0.00 (0.00, 0.03)	2917	<0.001	0.91 (0.90, 0.93)
5 m split	0.00	0.95	0.00 (0.00, 0.00)	0.61	0.54	0.00 (0.00, 0.03)	6497	<0.001	0.96 (0.95, 0.97)
10 m split	0.28	0.60	0.00 (0.00, 0.02)	0.45	0.64	0.00 (0.00, 0.02)	8961	<0.001	0.97 (0.96, 0.97)
20 m split	1.98	0.16	0.00 (0.00, 0.04)	0.66	0.52	0.00 (0.00, 0.03)	7532	<0.001	0.97 (0.96, 0.97)

Note: maximal acceleration (a_{max}); maximal velocity (v_{max}); standard error (SE); model fit (R2); F ratio (F); p-value (p); partial eta squared effect size (ηp2); 95% confidence interval (CI); Intra-session pickup acceleration outcome (Trial); Inter-session pickup acceleration outcome (Session)

Table 3. Pickup acceleration intra- and inter-session pairwise comparisons

Dependent Variable	Trial 1-Trial 2			Session 1-2			Session 1-3			Session 2-3		
	***Delta* (CI)**	***SE***	***p***	***Delta* (CI)**	***SE***	***p***	***Delta* (CI)**	***SE***	***p***	***Delta* (CI)**	***SE***	***p***
a_{max}	0.04 (0.00, 0.08)	0.02	0.05	0.01 (-0.04, 0.07)	0.02	>0.99	0.01 (-0.04, 0.07)	0.02	>0.99	0.00 (-0.06, 0.06)	0.02	> 0.99
v_{max}	0.08 (0.03, 0.13)	0.03	0.00	0.00 (-0.08, 0.07)	0.03	0.92	0.07 (-0.01, 0.15)	0.03	0.08	0.07 (-0.01, 0.15)	0.03	0.08
2-m split	0.00 (-0.02, 0.03)	0.01	0.66	0.00 (-0.02, 0.04)	0.01	>0.99	0.00 (-0.04, 0.02)	0.01	>0.99	-0.02 (-0.05, 0.02)	0.01	0.68
5 m split	0.00 (-0.02, 0.02)	0.01	0.95	0.00 (-0.02, 0.04)	0.01	>0.99	0.00 (-0.04, 0.02)	0.01	>0.99	-0.01 (-0.05, 0.02)	0.01	0.81
10 m split	0.00 (-0.03, 0.02)	0.01	0.60	0.00 (-0.02, 0.04)	0.01	>0.99	0.00 (-0.03, 0.03)	0.01	>0.99	-0.01 (-0.04, 0.02)	0.01	>0.99
20 m split	0.02 (-0.04, 0.01)	0.01	0.16	0.01 (-0.03, 0.05)	0.01	0.93	0.00 (-0.04, 0.03)	0.01	0.93	-0.02 (-0.06, 0.02)	0.01	0.77

Note: maximal acceleration (a_{max}); maximal velocity(v_{max}); standard error (SE), p-value (p); intra-session pickup acceleration outcome (Trial); inter-session pickup acceleration outcome (Session)

entry velocities and whether these effects can be measured consistently across multiple trials and testing sessions. With this in mind, the dual foci of the study were to 1) quantify the effects of various running velocities on pickup acceleration measures and 2) determine if these effects could be consistently measured across testing occasions. The main findings were: 1) as expected, entry velocity affected all variables; 2) v_{max} was the only variable to differ significantly across trials, but within a trial (6 to 7 %) and between sessions (0.15 to 0.67%), CVs were less than 10%.

The v_{max} of the subjects in this study were (7.73 to 8.05 m/s), which was less than the subjects in the Sonderegger et al. (8.52 to 8.69 m/s), Young et al. (8.18 to 8.30 m/s) and Benton et al. (8.85 to 8.96 m/s). These differences in v_{max} are most likely explained by the variation in subjects' sporting backgrounds (AFL senior players, junior male soccer players, and young field sport athletes) and the varying technology used (radar and position transducers). For example, the 1 kg resistance setting used with the motorized horizontal linear position encoder in this study, could explain the slower velocities as compared to unresisted methods e.g. radar.

Unsurprisingly, entry velocity exerted significant effects on all performance variables, with large effect sizes (η_p^2=0.22 to 0.97). Faster entry velocities resulted in lower a_{max} values (20% entry = 1.87 ± 0.16 m/s, a_{max} = 3.3 ± 0.32 m/s^2; 40% entry= 4.43 ± 0.75 m/s, a_{max}=1.84 ± 0.31 m/s^2; 60% entry= 6.71 ± 0.21 m/s, a_{max}= 0.91 ± 0.21 m/s^2) and larger changes (17 to 55%) in split times (see Table 1). It is difficult to compare our results to other researchers given the disparate entry velocities of Benton et al. (3 m/s, 5 m/s, and 7 m/s) and Young et al. (unstandardized gradual entry). Sonderegger et al. used 1.61 m/s, 3.0 m/s and 4.1 m/s entry velocities and reported decreases in a_{max} of 4.3 m/s^2, 3.20 m/s^2, and 2.29 m/s^2. Sonderegger [15] reported the reliability of a_{max}, the CVs ranging from 5.4 to 10.9%, which were higher than those of this study (1.85 to 4.75%). Nonetheless, even with the different methodological approaches, the effects of entry velocity in all studies had a clear effect on the a_{max} attained for the trial.

The fastest splits and v_{max} values were achieved with the faster entry velocities (v_{max} values were 7.73, 7.80, 8.05 m/s for 20%, 40%, and 60% entries respectively). Additionally, significant split time differences were found between the 20% and 60% entry velocities, with the 60% entry velocity being ~122% faster at 2m, ~62% faster at 5 m, ~37% faster at 10 m, and ~22% faster at 20 m. Each 1% increase in entry velocity decreased split times by 0.01 to 0.02 s (CI -0.1, -0.1; -0.2, 0.2) and a_{max} by 0.04 m/s (CI -0.4, -0.4). No other researchers have detailed changes in this manner.

Of secondary interest was determining if the effects of different entry velocities could be consistently measured across multiple testing occasions. In terms of consistency, v_{max} was the only variable that differed significantly across trials and sessions. The session 3 v_{max} was faster than sessions 1 and 2, which could point to a learning effect by the athletes. When pairwise comparisons were computed, between trial v_{max} data was the only comparison to differ significantly. It needs to be noted, however, that between trials, CVs for v_{max} ranged from 6.0 to 7.0% across the three entry velocities, indicating acceptable reliability. The between-session CVs for the variables of interest were, for the most part, (18/21) less than 5%, indicating adequate consistency across sessions. Furthermore, there appeared to be no change in variability with increasing entry velocity. V_{max} has been reported to be reliable and valid, with a CV of 1.1 ± 0.5% [30], the CVs slightly more than those of this study (0.15 to 0.67%). Benton [16], Young [17], and Sonderegger (25) did not report v_{max} or split time reliability, and Benton et al. [16] and Young et al. [17] reported within trial reliability only given their single session methodology.

This study was the first to comprehensively investigate the reliability of a_{max}, v_{max}, and split times in conjunction with varying entry velocity conditions. In summary, despite our entry velocities being distinct from those seen in other literature, they substantiate that increasing entry velocity decreases a_{max} and increases v_{max}. Furthermore, the entry velocities we used had minimal effect on the stability of a_{max}, v_{max}, and split times across trials and sessions. Although statistically significant differences were noted between trial v_{max}, effect sizes, and CVs were small, reflecting trivial practical changes between trials 1 and 2. In tandem with small standard errors (range 0.01-0.03 s), these metrics exhibit acceptable consistency across trials and sessions. The high consistency observed in this study aligns with previous literature demonstrating the reliability of the performance measures examined.

PRACTICAL APPLICATIONS AND FUTURE RECOMMENDATIONS

During sporting accelerations, the athlete typically performs a ‘pickup’ and maximally accelerates from a submaximal entry velocity on a continuum spanning low to high velocities (e.g., walk-to-run) in relatively short bursts of effort. Though common in sports, pickup acceleration is not well researched and, therefore, understood. The first step in understanding any motor quality is to determine measures that enhance the practitioner’s understanding of the motor quality and, secondly, ensure that these variables can be measured consistently, i.e., reliability. Maximal velocity and acceleration, as well as split times, were thought to be the best kinematic variables to initially quantify to enhance the understanding of pickup acceleration. As expected, maximal acceleration capacity and split times were closely linked to the entry velocity of the athlete during pickup acceleration testing. The practitioner needs to understand this relationship within the context of their sport i.e. pickup assessments should take place within the entry velocity band common in the sport. Additionally, in similar cohorts, the coach would expect entry velocity to have a measured effect on a_{max} (0.04 m/s^2 decrease per 1% increase in entry velocity) and split times (0.01 to 0.02 s decrease per 1% increase in entry velocity). Also, if using similar testing procedures as outlined in this paper, the practitioner can be confident that the outcome measures are reasonably stable across repeated testing occasions and, therefore, can be used to measure and monitor pickup acceleration.

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CONFLICTS OF INTEREST

The authors have no reported conflicts of interest to report.

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ETHICAL APPROVAL

Athletes provided written informed consent to participate, with ethical approval granted by the Auckland University of Technology Ethics Committee 21/437.

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REFERENCES

1. Taylor, J.B., et al., Activity demands during multi-directional team sports: a systematic review. Sports Med, 2017. 47(12): p. 2533-2551.
2. Harper, D.J., C. Carling, and J. Kiely, High-intensity acceleration and deceleration demands in elite team sports competitive match play: A systematic review and meta-analysis of observational studies. Sports Med, 2019. 49(12): p. 1923-1947.
3. Duthie, G.M., et al., Sprint patterns in rugby union players during competition. J Strength Cond Res, 2006. 20(1): p. 208-14.
4. Varley, M., Acceleration and fatigue in soccer-thesis, in College of Sport and Exercise Science. 2013, Institute of Sport, Exercise and Active Living (ISEAL), Victoria University, Melbourne, Australia.
5. Gabbett, T.J., Sprinting patterns of National Rugby League competition. J Strength Cond Res, 2012. 26(1): p. 121-30.
6. Haugen, T., et al., The role and development of sprinting speed in soccer. Int J Sports Physiol Perform, 2014. 9(3): p. 432-41.
7. Lacome, M., et al., A new approach to quantifying physical demand in rugby union. J Sports Sci, 2014. 32(3): p. 290-300.
8. Nagahara, R., et al., Association of acceleration with spatiotemporal variables in maximal sprinting. Int J Sports Med, 2014. 35(9): p. 755-61.
9. Colyer, S.L., R. Nagahara, and A.I.T. Salo, Kinetic demands of sprinting shift across the acceleration phase: Novel analysis of entire force waveforms. Scand J Med Sci Sports, 2018. 28(7): p. 1784-1792.
10. Nagahara, R., et al., Association of sprint performance with ground reaction forces during acceleration and maximal speed phases in a single sprint. J Appl Biomech, 2018. 34(2): p. 104-110.
11. Cormier, P., et al., Comparison of acceleration-speed profiles from training and competition to individual maximal sprint efforts. J Biomech, 2023. 157: p. 111724.
12. Morin, J.B., et al., Individual acceleration-speed profile in-situ: A proof of concept in professional football players. J Biomech, 2021. 123: p. 110524.
13. Miguens, N., et al., Individual in-situ GPS-derived acceleration-speed profiling: towards automatization and refinement. Pre-print, 2023.
14. Rakovic, E., et al., Validity and reliability of a motorized sprint resistance device. J Strength Cond Res, 2022. 36(8): p. 2335-2338.
15. Sonderegger, K., M. Tschopp, and W. Taube, The challenge of evaluating the intensity of short actions in soccer: A new methodological approach using percentage acceleration. PLoS One, 2016. 11(11): p. e0166534.
16. Benton, D., An analysis of sprint running patterns in australian rules football: The effect of different starting velocities on the velocity profile, in Sch of Human Move & Sport Sci. 2000, University of Ballarat. p. 150.
17. Young, W.B., et al., Gradual vs. maximal acceleration: Their influence on the prescription of maximal speed sprinting in team sport athletes. Sports (Basel), 2018. 6(3).
18. Segers, V.A., P.; Lenoir, M.; De Clercq, D., Dynamics of the body centre of mass during actual acceleration across transition speed. J Exp Biol, 2007. 210(Pt 4): p. 578-85.
19. Segers, V.A., P.; Lenoir, M.; De Clercq, D., Spatiotemporal characteristics of the walk-to-run and run-to-walk transition when gradually changing speed. Gait Post, 2006. 24(2): p. 247-54.
20. Segers, V.L., M.; Aerts, P.; De Clercq, D., Kinematics of the transition between walking and running when gradually changing speed. Gait Post, 2007. 26(3): p. 349-61.
21. Segers, V., et al., External forces during actual acceleration across transition speed. J Appl Biomech, 2008. 24(4): p. 340-50.
22. Segers, V.D.S., K.; Van Caekenberghe, I; .Aerts, P.; De Clercq, D., Biomechanics of spontaneous overground walk-to-run transition. J Exp Biol, 2013. 216(Pt 16): p. 3047-54.
23. Røkke, O., Validation of force-, velocity-, and acceleration-time curves and temporal characteristics as output data from the 1080 Sprint, in Dept of Phys Perf. 2018, Norwegian School of Sports Sciences. p. 63.
24. Kuznetsova, A., P.B. Brockhoff, and R.H.B. Christensen, lmerTest package: tests in linear mixed effects models.

Jour of Stat Soft, 2017. 82(13).

25. Lüdecke, D., ggeffects: Tidy data frames of marginal effects from regression models. Jour of Open Source Soft, 2018. 3(26).
26. Lüdecke, P., Ben-Shachar, Wiernik, Bacher, Thériault, & Makowski. easystats: Framework for easy statistical modeling, visualization, and reporting. 2022 [cited 2023 07/12/2023]; Available from: https://easystats.github.io/easystats/.
27. Richardson, J.T.E., Eta squared and partial eta squared as measures of effect size in educational research. Edu Res Rev, 2011. 6(2): p. 135-147.
28. Atkinson, G. and A.M. Nevill, Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. Sports Medicine, 1998. 26(4): p. 217-238.
29. Feser, E.L., K; Clark, K.P; Bezodis, N; Korfist, C; Cronin, J, Comparison of two measurement devices for obtaining horizontal force-velocity profile variables during sprint running. Intl J of Sports Sci & Coach, 2022.
30. Komino, P.L.M., Y; Zadro, I; Osgnach, C; Morin, J.B., Sprint acceleration mechanical outputs: direct comparison between GPEXE Pro2 and 1080 Sprint devices. Sport Perf Sci, 2022. 163(v1): p. 1-4.