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Article

Understanding Gameplay Acceleration Ability, Using Static Start Assessments, Have We Got It Right?

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Abstract

Despite athletes initiating sprints from dynamic starts during gameplay, sprint performance is traditionally measured from a static position. This article aimed to determine whether static start or “pickup” acceleration are related or relatively independent motor qualities by assessing their relationship and examining how athletes’ rank order changes between static and pickup conditions. Thirty-one male athletes (20.3 ± 5.3 years) completed two 30 m sprints from a static start and two 30 m pickup accelerations following 20 m paced entries at 1.5 and 3.0 m/s, regulated by an LED system. Peak acceleration (a_{max}) was measured via a horizontal linear position encoder (1080 Sprint). The shared variance between a_{max} from the static and pickup starts was $R^2 = 11.6\text{--}39.6\%$, indicating, for the most part, a great amount of unexplained variance. The shared variance between pickup acceleration entry velocities was $R^2 = 16.8\%$. Visual analysis of an individualized rank order table confirmed that, for the most part, the fastest static start athletes differed from the fastest pickup athletes. In summary, static and pickup acceleration seem relatively distinct motor abilities, most likely requiring a paradigm shift in strength and conditioning practice in terms of acceleration assessment and development.

Keywords: sprinting; running; speed; team-sports; training

1. Introduction

Defined as the change in velocity over time ($a = \Delta v/\Delta t$), acceleration is central to decisive plays in team sports, such as contesting loose balls and creating scoring chances, and differentiates higher-performing athletes (Breddy, 2018; Faude et al., 2012; Haugen et al., 2014). In team sports, acceleration is often performed from a rolling start, termed a ‘pickup’. These accelerations are initiated from a submaximal entry velocity existing on a continuum spanning low to high velocities (e.g., walk-to-run) in relatively short bursts of effort (Duthie et al., 2006; Varley, 2013). While the frequency of non-stationary accelerations varies across sports (Gabbett, 2012), they consistently occur more often than sprints initiated from a static start (Haugen et al., 2014; Varley, 2013). In elite rugby, for instance, over half of all accelerations ($53.4 \pm 5.5\%$) begin from a walking-to-standing speed (0–1.9 m/s), with an additional $31.8 \pm 5\%$ initiated from a jogging start (>1.9 m/s) (Lacome et al., 2014). Given the common nature of pickup acceleration in gameplay, assessing acceleration capability from a rolling start would be logically valid. Practitioners however, commonly assess sprint acceleration from a static start (Cross et al., 2015; Lahti et al., 2020; Morin et al., 2019), likely due to tradition, the challenge of

standardizing the entry velocity, and a general lack of understanding of pickup acceleration. Additionally, it may be based on the contention, that both static and pickup acceleration are similar motor qualities, and therefore do not need to be assessed independently. Whether this is actually the case is unknown and provides the focus of this article.

Outside of a select few studies specific to sport (Breddy, 2018; Jakeman et al., 2023; Sonderegger et al., 2016; Young et al., 2018), most existing research on pickup acceleration stems from gait-transition studies in rehabilitation and biomechanics (De Smet et al., 2009; Segers et al., 2014; Segers et al., 2013), leaving the broader understanding of its determinants and relationship to static acceleration unclear. For example, the researchers who examine gait transitions primarily examine pickup acceleration using gradual rather than instantaneous acceleration (Segers et al., 2006; Segers et al., 2007). The select few who have examined a “spontaneous overground acceleration” or “burst transition” have limitations, including a lack of standardized entry velocity, failure to ask performers to achieve maximal acceleration, often terminating trials at a jogging pace, and, importantly, a lack of comparison with general sprint ability (Segers et al., 2014; Segers et al., 2013). Authors who have investigated pickup acceleration in sporting contexts have determined that maximal acceleration (a_{\max}) decreases with the increase in entry velocity (Breddy, 2018; Sonderegger et al., 2016) with Sonderegger finding a strong association between entry velocity and maximal acceleration ($r = 0.98$), but no researchers have investigated whether static start and pickup acceleration a_{\max} are related or independent motor skills.

Given the paucity of research in the area, the assumption is that most practitioners believe that those athletes that have good static start acceleration will have good pickup acceleration; however, this may not be the case. Drawing parallels from strength research, where static and dynamic strength measures reflect related but distinct qualities (Berger, 2013), it is plausible that these acceleration modes differ in terms of their neuromechanical determinants. A simple statistical approach to test this contention, is to test the strength of association between the a_{\max} quantified from both types of testing. The purpose of this article therefore is to examine whether sprinting initiated from static and pickup starts share similar motor qualities. We hypothesize that pickup acceleration and static start acceleration are relatively independent motor qualities, and if this is the case then a paradigm shift in how acceleration is assessed may be needed.

2. Materials and Methods

2.1. Experimental Approach to the Problem

Thirty-one team sport athletes performed two 30-m maximum-effort sprint accelerations from a static start and four 30-m maximal pickup accelerations with paced entries (2×1.5 m/s and 2×3.0 m/s). Distance and velocity-time measures were extracted for each trial using a linear position encoder (1080 Sprint, 1080 Motion AB, Lidingö, Sweden) to capture spatiotemporal data at 333 Hz. Correlation coefficients and coefficients of determination (R^2) were used to describe the strength of the association and shared variance between conditions. Finally, a rank-order analysis was performed on individualized data to compare static and pickup acceleration capabilities.

2.2. Subjects

Thirty-one injury-free male team sport athletes (age 20.3 ± 5.3 years; stature 1.82 ± 0.09 m; body mass 80.1 ± 17.1 kg) from American football, $n=10$; baseball, $n=8$; basketball, $n=4$; track and field (200 and 400m), $n=4$; soccer, $n=3$; professional ultimate frisbee (AUDL) $n=1$; Gaelic football, $n=1$ all with >1 year of training experience participated in this study. Before testing, athletes were instructed to refrain from intense exercise for 24 h prior. Written informed consent was obtained from each participant. Ethical approval for the study was granted by the AUT Ethics Committee (Approval Number 21/437).

2.3. Procedures

Athletes performed two 30 m static sprints and six randomized 30 m pickup accelerations (2 x 1.5, 2 x 3.0, and 2 x 4.5 m/s entry velocities, but only 1.5 and 3.0 m/s entries were analyzed due to the fastest entry velocity inducing greater line sway in the tether, obscuring analysis of the breakpoint by increasing the incidence of false steps on the signal. These entry speeds were selected because they aligned closely with the sprint velocity thresholds defined by GPS unit manufacturers, and similar values have been used in related pickup acceleration research (Cullen et al., 2017; Sonderegger et al., 2016; Sweeting et al., 2017), allowing for comparison with other studies. Subjects were attached to a linear position encoder via a tether and waist harness, and entries were paced by an LED system (LED Rabbit, BV Systems, LLC, Shawnee, KS). For each pickup, athletes started at the beginning of the runway and were asked to maintain a paced entry until approaching the 20 m cones, then maximally accelerate through to the end of the 30 m pickup zone. During pilot testing, a minimum distance of 13 m was established as the distance needed to ensure a consistent entry velocity. The 1080 Sprint provided displacement/time-series data at a 1 kg load (isotonic mode) to minimize impedance to the athlete and provide tension on the tether (Feser et al., 2022). The rest between trials was a minimum of 5 min. The 50 m sprint setup (see Figure 1) consisted of a 0-20 m paced zone, used for establishing the pickup entry velocity, and a 30 m pickup zone. For static start trials, athletes using the same track and tether setup, participants also performed a 30 m sprint from the same starting point as the pickup trials. The LED system was configured to “Multiple” mode, stabilizing the entry velocity over the 25 m strip. Trials were allocated randomly via an Excel spreadsheet (Microsoft Excel, Microsoft, Redmond, WA, USA). The instructions to the subjects were, “After the LED Rabbit starts, accelerate to match the speed of the light and maintain this pace until approaching the end of the first cones. After this distance, maximally accelerate through the last series of cones.” If participants failed to maintain the pace set by the LED, the trial was discarded. Trials that were removed were repeated after the appropriate rest interval. The average of each sprint condition was used for subsequent analysis. The testing procedures used to determine a_{\max} and the split times have been found to be reliable previously (Pryer et al., 2025) with coefficients of variation of less than 4.75% for all variables of interest.

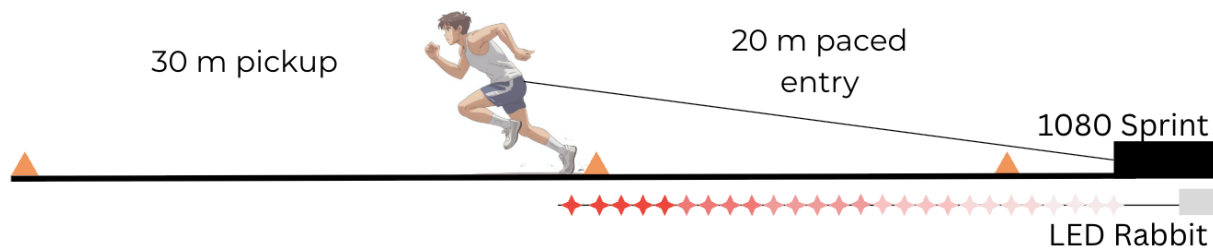


Figure 1. Sprint lane setup for pickup and static start acceleration testing.

2.4. Data Analysis

For each athlete, all static and pickup trials were extracted and used to form the average a_{\max} for static and pickup entry velocities. Each trial was extracted and processed similarly, except for the manual determination of the pickup point. Raw distance and velocity-time data were exported from the 1080 Motion web portal, unmodified, for static starts. After visual screening, each trial was analyzed in MATLAB (MATLAB R2022, MathWorks, Natick, MA, USA) using a 4th-order 0.5 Hz Butterworth lowpass filter. Two, 5, 10, and 20 m splits were extracted, v_{\max} , and a_{\max} , with only a_{\max} used in this analysis. For all trials, a_{\max} was the highest acceleration value seen on the ascending limb of the filtered velocity-time waveform. The pickup point was selected after a sudden increase in velocity between 13 and 20 m during pickup trials. Additionally, the 5 m mean entry velocity before

the pickup was collected and analyzed, compared to the prescribed entry to verify the fidelity of the trial entry velocity.

2.5. Statistical Analysis

An a priori sample size estimate was conducted to determine the number of participants required for the correlational analysis. Using G*Power, a conservative estimate was derived using the correlation-based model with an anticipated correlation of 0.70, an alpha level of 0.05, and a power of 0.80. This approach yielded a minimum requirement of 14 participants to detect a statistically significant correlation. Data were analyzed for normality, and outliers were removed. Means and standard deviations were used to quantify the centrality and spread of data. To determine the strength of the association between static and pickup acceleration, a correlational analysis using Pearson's r at an alpha level of $p < 0.05$ was conducted in JASP (Version 0.18.1, University of Amsterdam, Amsterdam, NL). Thresholds for correlations were reported as: 0.0 to 0.3 (or 0.0 to -0.3), negligible; 0.3 to 0.5 (-0.3 to -0.5), low; 0.5 to 0.7 (-0.5 to -0.7), moderate; 0.7 to 0.9 (-0.7 to -0.9), high; 0.9 to 1.0 (-0.9 to -1.0), very high (Moore, 2021). Coefficients of determination (R^2) indicated the shared variance between variables. For the rank-order analysis, athletes were manually sorted and ranked from highest to lowest by their a_{\max} values, determined from their static start, and then matched across different entry velocities in an Excel spreadsheet.

3. Results

The mean a_{\max} values were: static start = 4.52 ± 0.58 m/s²; 1.5 m/s: a_{\max} 3.21 ± 0.28 ; 3.0 m/s: a_{\max} 2.36 ± 0.24 m/s². The correlations between static and pickup acceleration for a_{\max} are detailed in Table 1. For a_{\max} , correlations between static start and pickup acceleration ranged from 0.34 to 0.63, corresponding to a shared variance of 11.6-39.6%. The shared variance between the different a_{\max} entry velocities was 16.8%.

Table 1. Pearson's correlation matrix for static-start and pickup acceleration a_{\max} .

	Static start a_{\max}	1.5 m/s a_{\max}	3.0 m/s a_{\max}
Static start a_{\max}		0.63 ($p < 0.001$)	0.34 ($p = 0.06$)
1.5 m/s a_{\max}	0.63 ($p < 0.001$)		0.41 ($p = 0.02$)
3.0 m/s a_{\max}	0.34 ($p = 0.06$)	0.41 ($p = 0.02$)	

Note: $p = p$ -value; bold denotes significant values.

The variability in the rank order of subjects from fastest to slowest for static start a_{\max} is shown in Table 2. The static start rankings appear to have little influence on an individual's pickup acceleration rankings, as no clear visual trends are observable in this table. For example, the a_{\max} ranking for athlete B43 was 3rd for the static start, 10th for the 1.5 m/s entry condition, and 30th for the 3.0 m/s entry velocity.

Table 2. Rank order of athletes across static and pickup starts.

	Static start entry	1.5 m/s entry	3.0 m/s entry
Mean entry velocity (m/s)	-	1.62 ± 0.10	3.20 ± 0.18
Athlete	rank (a_{\max} ; m/s ²)	rank (a_{\max} ; m/s ²)	rank (a_{\max} ; m/s ²)
B05	1 (6.05)	1 (3.93)	6 (2.58)
B02	2 (5.66)	13 (3.24)	4 (2.66)
B43	3 (5.28)	10 (1.93)	30 (1.93)

B14	4 (5.19)	16 (3.18)	18 (2.33)
B07	5 (5.10)	19 (3.14)	7 (2.52)
B11	6 (5.05)	14 (3.23)	12 (2.44)
B46	7 (5.04)	2 (3.67)	1 (2.82)
B16	8 (4.99)	26 (2.24)	21 (2.24)
B08	9 (4.89)	4 (3.51)	9 (2.51)
B03	10 (4.77)	6 (3.44)	5 (2.64)
B13	11 (4.76)	5 (3.49)	17 (2.35)
B10	12 (4.69)	12 (3.26)	10 (2.50)
B18	13 (4.53)	24 (3.09)	28 (2.09)
B17	14 (4.50)	3 (3.63)	24 (2.19)
B19	15 (4.47)	7 (3.40)	31 (1.92)
B42	16 (4.35)	22 (3.11)	3 (2.76)
B01	17 (4.34)	9 (3.34)	2 (2.80)
B34	18 (4.339)	11 (3.28)	13 (2.44)
B59	19 (4.32)	17 (3.16)	23 (2.21)
B12	20 (4.29)	15 (3.22)	14 (2.41)
B15	21 (4.25)	8 (3.36)	19 (2.32)
B36	22 (4.21)	18 (3.142)	11 (2.46)
B39	23 (4.15)	21 (3.13)	16 (2.36)
B40	24 (4.03)	28 (3.00)	20 (2.24)
B44	25 (4.02)	20 (3.139)	8 (2.52)
B37	26 (3.95)	25 (3.04)	26 (2.12)
B45	27 (3.93)	30 (2.75)	27 (2.11)
B60	28 (3.92)	27 (3.01)	22 (2.21)
B38	29 (3.91)	31 (2.46)	25 (2.15)
B57	30 (3.69)	23 (2.40)	15 (2.40)
B58	31 (3.52)	29 (2.06)	19 (2.06)
Mean a_{\max} (m/s²)	4.52 ± 0.58	3.21 ± 0.28	2.36 ± 0.24

Note: m/s, meters per second; m/s², meters per second squared; a_{\max} , maximal acceleration.

4. Discussion

Of primary interest was determining whether static start and pickup acceleration were similar motor qualities and therefore could be assessed and trained in the same manner. Primary findings were: 1) there was a great deal of unexplained variance between static and pickup acceleration a_{\max} $R^2 = 11.6\text{--}39.6\%$; 2) the shared variance between pickup acceleration entry velocities was 16.8%; and, 3) no systematic visual trends were observed between static start and pickup acceleration ranking of athletes.

Only two research groups (Breddy, 2018; Sonderegger et al., 2016) have investigated pickup acceleration, using a methodology similar to that employed in this study. Sonderegger et al. (2016) reported values of 6.01 ± 0.55 , 4.33 ± 0.40 , 3.20 ± 0.49 , and 2.29 ± 0.34 m/s² for entry velocities of 0 m/s (static start), 1.6, 3.0, and 4.1 m/s. The entry velocities were similar across studies; however, the a_{\max} values in this study were lower (~26%) than those reported by Sonderegger et al. (2016). Breddy et al. used a wider range of entry velocities (3–7 m/s, excluding the 1.5 m/s condition used here); however, their athletes did not maintain target entry velocities, the authors reporting a mean entry of 4.29 ± 0.52 m/s for the 3 m/s trial, whereas the mean entry velocity in this study was 3.20 ± 0.18 m/s, making direct comparison problematic given the effect of entry velocity in flow on metrics. Despite the increased entry velocity, they reported a mean a_{\max} comparable to that in this study (2.34 ± 0.35 m/s vs 2.36 ± 0.24 m/s). The differences between studies in terms of the variables of interest, can be likely explained by a) subjects' training status, Sonderegger's subjects were highly trained junior male soccer players, whereas Breddy used elite developmental Premier League soccer players; and/or, b) the different technologies used for data collection (linear position encoder vs. local position measurement system and GPS).

This study aimed to ascertain if static and pickup acceleration were relatively similar motor qualities; the findings suggested this was not the case, given the low shared variance, 11.6-39.6% for a_{max} . This is the first study to explore the relationships between static and pickup acceleration across different velocities, which limits the ability to compare findings with other research. Furthermore, it was thought that those with good pickup acceleration ability would rank highly across all entry velocities. Once more, such a contention was unfounded; the shared variance was low (16.8%) between the 1.5 m/s and 3.0 m/s entries for a_{max} . Again, no other researchers have investigated the relationship between pickup acceleration entry velocities, making comparisons problematic. Nonetheless, practitioners must consider assessing and training pickup acceleration differently from static start acceleration. It is quite likely that pickup acceleration has a set of physical and technical demands that differ from the static start acceleration, which have yet to be identified and could provide direction for future research.

When viewed as a group, a_{max} values were significantly different and decreased with faster entries. However, on an individual level, a_{max} values varied substantially across different entry velocities, with some athletes performing better than their counterparts from a static start and worse at a walking or jogging start. A visual analysis of Table 2 confirms the relative independence of static and pickup acceleration across the different entry velocities, the static start ranking had little influence on the pickup acceleration ranking. For example, the a_{max} ranking for athlete B43 was 3rd for the static start, 10th for the 1.5 m/s entry condition, and 30th for the 3.0 m/s entry velocity. The low shared variance and variability in ranking indicate that performance in static starts should not be used to predict pickup acceleration ability.

Practical Applications

In summary, static start and pickup acceleration performance are relatively distinct motor abilities, given the minimum shared variance. Practitioners must be cognizant that excelling at static start acceleration does not guarantee proficiency across non-static starts and vice versa. Consequently, the assessment and training methods need to differ to understand and develop the two motor qualities optimally. For example, an assessment for deriving pickup acceleration metrics has been outlined in this paper; however, the information remains rudimentary, and a deeper understanding of step kinematics and kinetics, particularly during the approach, transition, and pickup steps, is needed. Technology, such as that used in this study, combined with videography, can provide a deeper understanding of the step-by-step mechanical determinants of pickup acceleration, if such assessments are found to be reliable. In that case, understanding what distinguishes athletes with good pickup acceleration from those with less skill is the natural next step for researchers and coaches seeking to understand and develop this motor quality. Armed with this information, the coach will have a greater appreciation of the technical and physical factors important to optimizing pickup acceleration performance. This deeper level of mechanical understanding regarding pickup acceleration is currently in its infancy, and there appears to be a plethora of research opportunities to add value to the knowledge base of pickup acceleration.

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MP and JN.; writing—original draft preparation, MP.; writing—review and editing, MP, JC, AU, NM, CS, SB.; visualization, MP, JN, and AU.; supervision, JC, JN, and AU.; project administration, MP, JC, and AU; All authors have read and agreed to the published version of the manuscript.

Informed Consent: Written informed consent has been obtained from the patient(s) to publish this paper.

IRB Approval: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of AUT 21/437 on 18/2/2022.

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