

# How accurate are amateur soccer players when running at submaximal sprinting speeds?

Ludwig Ruf,<sup>1</sup> Sascha Härtel,<sup>2</sup> Stefan Altmann<sup>1,3</sup>

<sup>1</sup>TSG ResearchLab gGmbH, Zuzenhausen, Germany

<sup>2</sup>TSG Hoffenheim, Zuzenhausen, Germany

<sup>3</sup>Institute of Sports and Sports Science, Karlsruhe Institute of Technology, Karlsruhe, Germany

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## Headline

Submaximal sprinting speeds are commonly used in rehabilitation protocols and warm-up routines in team sports to prepare players for maximal sprinting. During rehabilitation, graded exposure to progressively higher sprinting speeds is particularly important because accelerating from a lower starting velocity (1) and higher sprinting speeds increase strain on the muscle-tendon unit (2,3). Therefore, progressively increasing the sprinting speeds during warm-ups aims to ensure players are adequately prepared for maximal sprinting and the specific demands of training or match play. In practice, these runs are often prescribed as a percentage of a player's maximal sprinting speed (MSS) and communicated via simple verbal instructions (4).

With the widespread adoption of tracking systems such as global positioning systems (GPS), global navigation satellite systems (GNSS) or local positioning systems (LPS) in professional environments, team-sport players are routinely exposed to speed-related metrics, including MSS (5). In addition, professional players commonly complete linear sprint tests in which both total sprint time and MSS are measured and fed back. These exposures, regular coaching feedback, and prescribed sprint sessions during training may improve the accuracy of self-regulated submaximal sprinting speeds of professional players. However, Darrall-Jones et al. (6) showed that professional rugby union players were not able to accurately match prescribed submaximal sprinting speeds between 60% and 90% of MSS. Players systematically ran faster than instructed at 60% (mean difference: +4.1 km/h), 70% (+2.4 km/h) and 80% (+0.6 km/h), and slower than instructed at 90% of MSS (-1.2 km/h). These findings suggest that even in professional environments, these rugby players show a systematic bias when attempting to self-regulate submaximal sprinting speeds. This might have practical implications for warm-up and rehabilitation settings, where running faster than intended could excessively load lower-limb tissues, potentially leading to acute negative responses to load by exaggerating symptoms of fatigue (7), increasing injury risk or exceeding tissue tolerance during progressive return-to-performance protocols (3).

As these findings were obtained in professional rugby players, it remains unclear whether amateur soccer players, who typically have limited access to such technology and objective feedback, show comparable accuracy when prescribed submaximal sprinting speeds.

## Aim

The aim of this study was to replicate the Darrall-Jones et al. (6) protocol in male adult amateur soccer players to assess how accurately they are able to run at prescribed submaximal sprinting speeds (70%, 80%, and 90% of MSS) without external feedback.

## Methods

### Participants

Forty-four adult male amateur soccer players (age:  $24.4 \pm 3.2$  years; body mass:  $80.7 \pm 7.3$  kg; standing height:  $181.2 \pm 5.1$  cm) volunteered to participate in this study. All players were actively participating at a recreational level and can be classified as Tier 2 athletes (trained/developmental) competing at the 6th, 7th, or 8th division within the German league system (8). Players typically participated in two to three training sessions and one official match. Written informed consent was obtained from all players before data collection.

### Study design

Cross-sectional study with repeated measures design.

### Procedures

#### Maximal Sprinting Speed Assessment

Maximal sprinting speed (MSS) was assessed using two 40-m linear sprints with approximately 3 minutes of passive recovery between trials. Single-beam error correction processing timing gates (SmartSpeed, VALD Performance, Brisbane, Australia) were positioned at 20 m, 25 m, 30 m, 35 m, and 40 m with times measured to the nearest 0.01 s. All gates were mounted at a height of 0.95 m matching approximately the hip height of the players. The starting position was set to a 2-point split-stance at the starting line. The fastest 5-m split time recorded across all timing intervals in either trial was converted to the average speed (distance divided by time) and used to determine individual MSS for each player.

#### Submaximal Sprinting Speed Protocol

Following MSS assessment, participants performed submaximal sprinting trials at three target speeds: 70%, 80%, and 90% of individual MSS. Target speeds were individually calculated from each player's MSS (e.g., for an MSS of 30.0 km/h, target speeds were 21.0 km/h at 70%, 24.0 km/h at 80%, and 27.0 km/h at 90%). Each player completed two trials per submaximal sprinting speed in randomised order, with approximately 2 to 3 minutes of passive recovery between trials. Timing gates were positioned at 30 m and 40 m. Players were instructed use a self-selected acceleration strategy from the starting line to reach the specified target speed (70%, 80%, or 90% of MSS) by the 30 m mark, maintaining that speed through the 40 m mark, relying on their perceived effort without external pacing or real-time feedback.

The difference between observed and target speed (i.e., observed minus target) was computed for each player and submaximal sprinting trial. For each submaximal sprinting condi-

tion (70%, 80%, 90% MSS), the trial with the smallest absolute difference was selected for analysis.

**Statistical analyses**

Data are presented as mean with standard deviation (SD) or confidence interval (CI) unless otherwise stated.

**Statistical approach**

To evaluate whether observed submaximal sprinting speeds were practically equivalent to target speeds, we adopted an equivalence testing approach (9). Equivalence bounds were defined as the smallest effect size of interest (SESOI), representing the threshold below which differences are considered practically negligible. The region of practical equivalence was defined as the interval between the lower and upper equivalence bounds (i.e., -SESOI to +SESOI).

**Determination of the equivalence bounds**

Given the lack of a sound theoretical or practical foundation for what constitutes a SESOI for submaximal sprinting speeds, we based our equivalence bounds on the minimal statistically detectable effect (MSDE) derived from a previous study (6) that we aimed to replicate. The MSDE represents the smallest mean difference that would achieve statistical significance ( $p = 0.05$ ) at 50% power, given a specific sample size and measurement variability.

We calculated the MSDE using the data provided by Darrall-Jones et al. (6), who assessed the accuracy of submaximal sprinting speeds in professional male rugby union players. Specifically, we extracted their sample size, SDs of target and observed speeds, the correlation between paired measurements, and the corresponding critical t-value for  $\alpha = 0.05$ . This approach yielded equivalence bounds of  $\pm 1.0$  km/h for 70% MSS,  $\pm 0.7$  km/h for 80% MSS, and  $\pm 0.6$  km/h for 90% MSS.

**Equivalence testing**

We performed two one-sided t-tests (TOST) for paired data for each submaximal sprinting condition using a custom R

script. A 90% CI for the mean difference (observed minus target) was computed, corresponding to  $\alpha = 0.05$  for the two one-sided tests. The TOST p-value (pTOST) was defined as the maximum of the two one-sided p-values. Practical equivalence was concluded when  $pTOST < 0.05$ , i.e., the 90% CI was entirely within the region of practical equivalence. A comparison was declared inconclusive, when the 90% CI crossed one or both equivalence bounds. Practical superiority or inferiority was declared when the 90% CI was entirely above or below the region of practical equivalence, respectively. No adjustments of pTOST were applied.

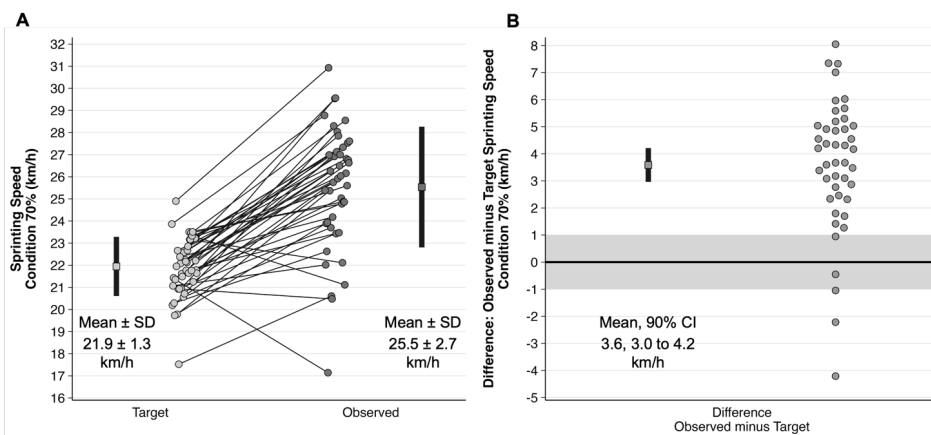
**Software**

All statistical analyses were conducted in R (version 4.5.0) using RStudio (version 1.2.5033). Primary packages included dplyr (version 1.1.4) for data manipulation, tidyr (version 1.3.1) for data reshaping, and ggplot2 (version 3.5.2) for visualisation.

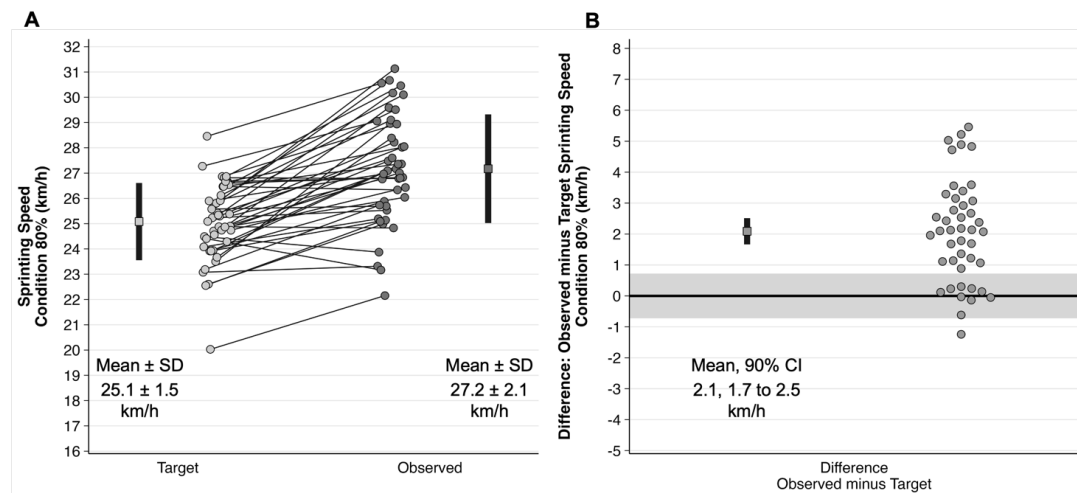
**Results**

Across all three submaximal conditions, observed speeds exceeded target speeds. The mean difference (observed minus target) was  $4.0 \pm 2.3$  km/h at 70% MSS,  $2.5 \pm 1.7$  km/h at 80% MSS, and  $0.8 \pm 1.3$  km/h at 90% MSS (Figures 1 to 3). On an individual level, differences (observed minus target) ranged from -4.2 to 8.1 km/h at 70% MSS, -1.2 to 5.5 km/h at 80% MSS, and -3.6 to 3.3 km/h at 90% MSS (Figures 1 to 3).

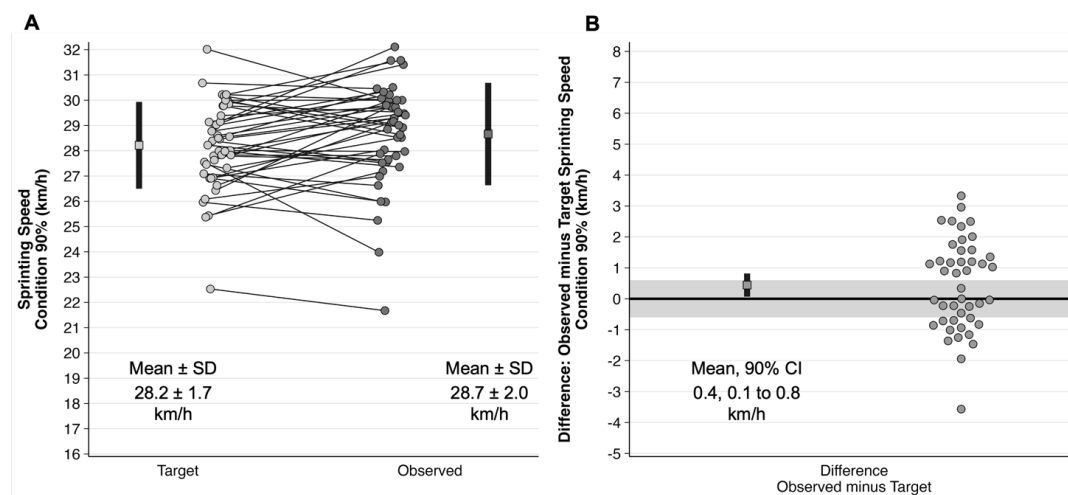
Equivalence testing confirmed this intensity-dependent pattern. At 70% MSS, the 90% CI for the mean difference (3.0 to 4.2 km/h) lay entirely above the upper equivalence bound of +1.0 km/h ( $pTOST = >0.99$ ). Similarly, at 80% MSS, the 90% CI (1.7 to 2.5 km/h) exceeded the upper equivalence bound of +0.7 km/h ( $pTOST = >0.99$ ). In both conditions, equivalence to the prescribed speed was rejected. At 90% MSS, the 90% CI (0.1 to 0.8 km/h) overlapped the upper equivalence bound of +0.6 km/h ( $pTOST = 0.73$ ), and equivalence could neither be confirmed nor rejected.



**Fig. 1.** Submaximal sprinting speeds at 70% of maximal sprinting speed. Panel A displays target and observed sprinting speeds with mean  $\pm$  standard deviation and individual data points connected by lines. Panel B displays the mean difference (observed minus target) with 90% confidence interval and individual differences. The grey shaded area represents the region of practical equivalence (SESOI =  $\pm 1.0$  km/h).



**Fig. 2.** Submaximal sprinting speeds at 80% of maximal sprinting speed. Panel A displays target and observed sprinting speeds with mean  $\pm$  standard deviation and individual data points connected by lines. Panel B displays the mean difference (observed minus target) with 90% confidence interval and individual differences. The grey shaded area represents the region of practical equivalence (SESOI =  $\pm 0.7$  km/h).



**Fig. 3.** Submaximal sprinting speeds at 90% of maximal sprinting speed. Panel A displays target and observed sprinting speeds with mean  $\pm$  standard deviation and individual data points connected by lines. Panel B displays the mean difference (observed minus target) with 90% confidence interval and individual differences. The grey shaded area represents the region of practical equivalence (SESOI =  $\pm 0.6$  km/h).

### Discussion

In this study, we investigated how accurately male adult amateur soccer players are able to run at prescribed submaximal sprinting speeds (70%, 80%, and 90% MSS) without receiving external feedback. The main findings were as follows: (i) players ran faster than prescribed across all submaximal conditions, with practical equivalence rejected at 70% and 80% MSS and remaining inconclusive at 90% MSS; (ii) accuracy was sprinting speed-dependent and improved as submaximal sprinting speeds increased; and (iii) there was substantial individual variability in individual differences between target and observed speeds across all three conditions. These findings highlight the need for caution when prescribing relative submaximal sprinting speeds during warm-ups or rehabilitation

sessions without access to objective feedback, given the systematic bias toward faster sprinting speeds, particularly at lower sprinting speeds (70% and 80% MSS).

Players ran faster than prescribed across all three conditions (70% MSS: +3.6 km/h, 90% CI: 3.0 to 4.2 km/h; 80% MSS: +2.1 km/h, 90% CI: 1.7 to 2.5 km/h; 90% MSS: +0.4 km/h, 90% CI: 0.1 to 0.8 km/h). These findings align with previous research in professional rugby union players (6) and team-sport players (10), both demonstrating systematic overestimation at lower submaximal sprinting speeds with improved accuracy as prescribed sprinting speeds increased. At 70% MSS, the magnitude of overestimation (mean difference: +3.6 km/h) closely matched that observed at 60% MSS in professional rugby players (+4.1 km/h) (6). At 80% MSS, our find-

ings (+2.1 km/h) showed greater overestimation compared to professional rugby players at the same sprinting speed (+0.6 km/h) (6) and team-sport players (+1.0 km/h) (10), suggesting that amateur players may have more difficulty regulating mid-range submaximal sprinting speeds. At 90% MSS, the smaller mean difference (+0.4 km/h) resembled in absolute magnitude that observed at 80% MSS in professional rugby players (+0.6 km/h) (6) and at 90% MSS in team-sport players (-0.4 km/h) (10). Despite the smallest mean difference, practical equivalence could not be established given the narrower region of practical equivalence for this sprinting condition.

The similar pattern across different sports (i.e., rugby (6); soccer, hockey and Australian football (10)) and competitive levels (i.e., professional (6); regional-level (10)) may suggest that the inability to accurately self-regulate submaximal sprinting speeds is not sport-specific but may reflect the lack of familiar reference benchmarks for self-regulating submaximal sprinting speeds.

Beyond the systematic bias observed at the group level, substantial variability in individual differences between observed and target speeds was evident across all three conditions, decreasing as submaximal sprinting speeds increased. At 70% MSS, differences between observed and target speeds ranged from approximately -2.0 to +8.0 km/h, indicating that some players were sprinting close to their individual MSS when instructed to run at 70% MSS. At 80% MSS, the range narrowed to approximately -1.0 to +5.5 km/h, while at 90% MSS it decreased further but remained substantial (when contextualised against the region of practical equivalence of  $\pm 0.6$  km/h) at approximately -3.5 to +3.5 km/h.

This sprinting speed-dependent variability aligns again with previous findings from both professional rugby union players (6) and regional-level team-sport players (10). For example, when team-sport players were asked to run at 75% of their MSS, achieved speeds ranged from 68% to 92% MSS, whereas the inter-individual variability decreased to 83% to 97% MSS at the 90% MSS condition (10). The consistent observation of decreasing variability at higher submaximal sprinting speeds suggests that self-regulation improves as the prescribed speed approaches individual MSS, potentially because players have a more familiar internal reference point when running closer to their MSS.

To reduce the large differences between target and observed sprinting speeds, previous research demonstrated that objective feedback can substantially improve the accuracy of submaximal sprinting speeds. Providing feedback through timing gates (11) or single familiarization sessions (12) has been shown to improve self-regulation of submaximal sprinting speeds, suggesting the systematic bias and variability observed in the present study may be modifiable through relatively simple interventions.

### Strengths, limitations and further research

This study employed a robust methodological approach, combining equivalence testing with a sample size ( $n = 44$ ) adequate for precise estimation of mean differences and confidence intervals. The findings are directly relevant to a large population of amateur soccer players who typically have limited access to qualified coaching personnel and tracking technologies such as GNSS, GPS or LPS to receive objective feedback on individual sprinting speeds during submaximal and maximal runs. Therefore, these results have broad practical implications for this substantial population.

However, several limitations should be acknowledged.

- Our findings represent a status quo assessment without providing any form of feedback to the players regarding

whether and by how much they were sprinting too fast or too slow at a given submaximal sprinting speed. Future research should investigate whether accuracy in submaximal sprinting speeds improves after receiving acute feedback following individual runs or cumulative feedback across repeated training sessions.

- We prescribed only relative target speeds (i.e., percentages of MSS); it remains unclear whether absolute speed targets (e.g., "run at 25 km/h") would be more intuitive for players and yield better accuracy.
- These findings are specific to amateur players with limited exposure to tracking systems and may not be generalized to high-performance settings, where players have been routinely exposed to speed-related metrics via tracking systems for many years. Greater familiarity with such feedback may fundamentally alter their self-regulation abilities to run at relative submaximal sprinting speeds.

### Practical Applications

- Adult male amateur soccer players with limited exposure to tracking systems systematically run faster when asked to run at 70% and 80% of their individual MSS; caution is needed when prescribing these submaximal speeds during rehabilitation or warm-ups, as actual speeds may substantially exceed intended sprinting speeds and thus increase strain on the musculotendinous system.
- At 90% MSS, players are closer to target speeds on average, yet substantial between-player variability remains (range: approximately -2.0 to +4.0 km/h), requiring individual attention to avoid over- or underloading.
- Objective feedback via tracking systems (e.g., GNSS, GPS, LPS), timing gates, or radar guns immediately after each run may improve accuracy at the player level and ensure intended training loads during rehabilitation sessions or warm-up.

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### Disclosure statement

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