Validity of the Freelap system for measuring running stride parameters

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Mai 2025

Contents

1 Abstract

The aim of this study was to compare the Freelap system to the OptoJump system, considered the gold standard in the analysis of stride parameters in sprinting (frequency and length).

Forty-seven sprinters, ranging from recreational to elite level, performed two 20 m fly sprints and two 30 m block starts at maximal intensity; the block starts were performed only by advanced sprinters.

The analysis of the 30 m sprint trials was restricted to the final 20 m. OptoJump data from these trials were preprocessed using three different methods: raw data (-0), data excluding the first two steps (-2), and data excluding both the first two and the final step (-3). These preprocessing strategies aimed to replicate the automated data processing performed by the Freelap system.

During the maximal velocity phase, Freelap demonstrated excellent reliability (ICC ≥ 0.97). No significant bias was observed for stride frequency ($P = 0.95$; SEM $= 0.04\,\text{s/s}$). A small bias of $-1\,\text{cm}$ was observed for stride length, attributed to a known overestimation by the OptoJump system.

During the acceleration phase, ICC values remained high (≥ 0.91). Significant differences were observed : $+0.04\,\text{s/s}$ for stride frequency (compared to -0) and $-2\,\text{cm}$ for stride length (compared to -3), with measurement errors similar to those observed during the max velocity phase.

Conclusion: Freelap is a reliable tool for monitoring training performance, but it exhibits greater random error than OptoJump, which limits its suitability for research applications. Preprocessing OptoJump data using the -3 method is recommended—though not essential—during the acceleration phase to improve consistency with Freelap results.

2 Introduction

Stride parameter analysis is essential for understanding sprint performance. Sprinting velocity results from the product of stride frequency and stride length (Hunter & al., 2004). Significant differences in stride frequency have been reported between elite and sub-elite athletes (Coh & al., 2001), while stride length increases significantly between the acceleration and maximal velocity phases (Manzer & al., 2016). It is therefore important for coaches to assess these parameters across the different phases of sprinting.

For this reason, having access to a reliable measurement system has become essential for training purposes. Several systems have been validated for this purpose, including force plates, high-speed cameras, accelerometers, and optical systems. However, each of these presents certain limitations that prevent their use in everyday training conditions.

Force plates are generally confined to laboratory settings. High-speed cameras and optical systems require significant space, setup time, and post-processing. Although accelerometers are easier to deploy, they do not provide timing data—an essential metric for coaches and athletes. Moreover, these systems are often expensive, limiting their accessibility.

The OptoJump (Micrograte, Bolzano, Italy) as become a gold standard in the analysis of stride parameters. This modular device consist of 1-meter-long cells,each composed of 96 LED spaced at 1.04 cm. The system detect ground contact and calculates stride length and frequency accordingly. Multiple cells can be combined to cover longer distances. Initially validated for vertical jump height measurement (Glatthorn & al.,2011), the system was later validated for ground contact time, stride frequency and stride length, with a known overestimation of 0.5 ± 1.3cm (Ammann & al.,2016),(Gindre & al.,2015),(Healy & al.,2015). Despite its precision, the lack of portability and high cost remain major barriers to its use in day-to-day training.

The Freelap system (Freelap SA, Fleurier, Switzerland) offers a lighter and more portable alternative. It consists of a wearable chip (Fx Motion) and electro-magnetic transmitters (Tx Junior Pro, e-Starter), which can be deployed in field conditions without the need for post-processing. The transmitters emit an electro-magnetic field of 80 cm, and must be spaced accordingly to ensure accurate timing. Data is transmitted directly to the "myFreelap" mobile application.

Originally designed solely as a timing system, Freelap claims a timing accuracy of 0.02 s, based on comparisons with Fully Automatic Timing (FAT) systems. However, no independent study has yet confirmed this level of accuracy.

With the release of the new FxMotion chip, Freelap also provides stride frequency and stride length measurements. These data are delivered after automated preprocessing, but they have not yet undergone scientific validation. In a "Start–Finish" configuration, the first two steps are automatically excluded, as they are considered non-representative. This filtering is not applied in the "Lap–Finish" configuration. Additionally, steps identified as outliers—particularly the final step if the athlete slows down prematurely—are also excluded from the final output.

The aim of this study was to investigate the concurrent validity of running stride parameters (frequency and length) measured by the Freelap system, by comparing them to those obtained with the OptoJump system. The two systems were assessed during both the maximal velocity phase, using a 20 m flying sprint, and the acceleration phase, using the final 20 m of a 30 m sprint with block start.

3 Methods

3.1 Subjects

Forty-seven athletes, trained either in sprinting ($n = 35$) or in other track and field disciplines ($n = 12$), participated in this study. Their performance levels ranged from recreational to elite, with 20-meter flying sprint times ranging from 1.89 s to 2.89 s.

All participants were familiar with the testing protocol and provided informed consent prior to participation.

3.2 Procedures

The experiment was conducted on a standard athletics track. Athletes wore appropriate clothing and their personal sprint spikes. All participants were given sufficient time to complete their individual warm-up routine.

All runs were performed at maximal intensity, with adequate rest provided between trials. Athletes were equipped with the Fx Motion chip, positioned at the waist level, with data collected via a mobile device using the myFreelap application. The running lane was fitted with OptoJump cells—96-LED optical sensors—spanning a total of 30 m.

Athletes with sprint training experience completed two 30-meter sprints from block starts. These runs were fully recorded by the OptoJump system, while Freelap recorded only the final 20 m using a "Start–Finish" configuration (Figure 1). In addition, all athletes performed two flying 20 m sprints following a 30 m run-up. Both systems recorded the final 30 m of the run. For these trials, the Freelap system was configured with three transmitters: one set to "Start" at 20.80 m, one to "Lap" at 30.80 m, and one to "Finish" at 50.80 m (Figure 1).

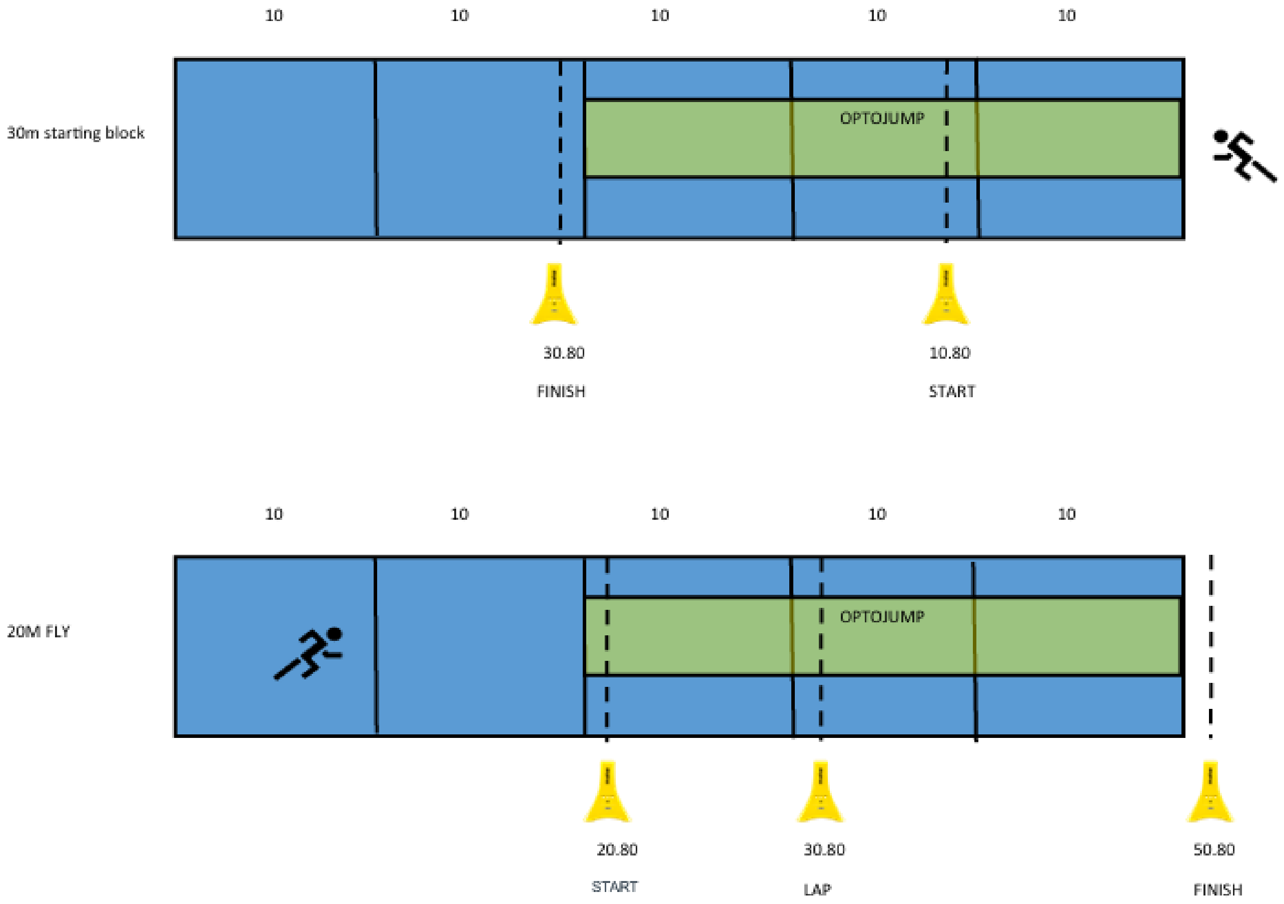

Figure 1: Experimental configuration

Following data collection, Freelap data were exported in plain text format (.csv), while OptoJump data were extracted in spreadsheet format (.xls). The files were synchronized to accurately pair each Freelap dataset with its corresponding OptoJump measurement.

In total, 16 trials were excluded from the analysis: 10 due to incorrect system setup, 3 due to execution errors, and 3 corresponding second attempts, in order to avoid potential bias. This resulted in 149 valid trials retained for analysis.

3.3 Parameters

Freelap data were extracted using the "myFreelap" application. Specifically, the "FQ (s/s)" column for stride frequency and the "Length (m)" column for stride length, based on the segments of interest.

OptoJump data were processed by computing the mean of the “Rhythm [s/s]” values for stride frequency and the “Step” values for stride length. First steps shorter than 50 cm were excluded from the analysis (Figure 2).

To ensure consistency between systems, OptoJump values were rounded to match the precision level of the Freelap data.

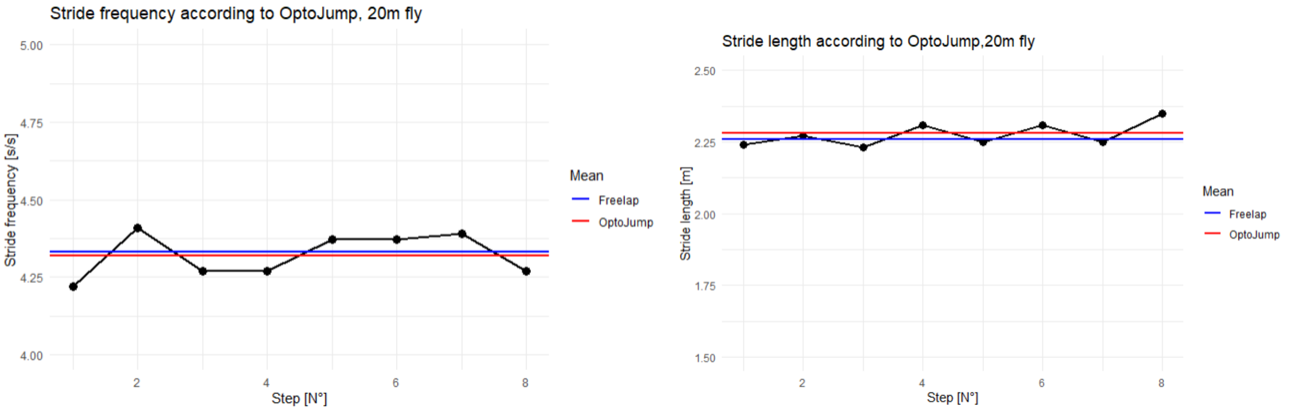

Figure 2: Comparison of OptoJump and Freelap data during maximal velocity phase

For the 30 m sprints from block start, three preprocessing methods were applied to the OptoJump data: no filtering, including all steps (denoted as “-0”), exclusion of the first two steps (“-2”), and exclusion of both the first two and the final step (“-3”). These configurations were selected to evaluate the impact of step filtering on the agreement between the two measurement systems (Figure 3)

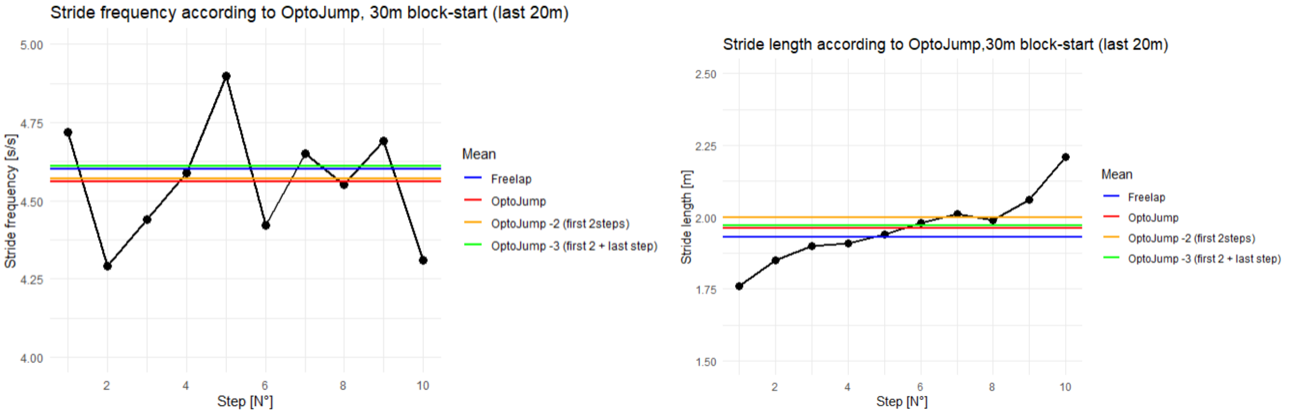

Figure 3: Comparison of OptoJump and Freelap data during the acceleration phase

4 Statistical analysis

As all runs were performed at maximal intensity, intra-individual variability was considered equivalent to inter-individual variability, whether within the same system or between systems. Consequently, each run was treated as an independent observation for statistical analysis.

Data normality was assessed using the Kolmogorov–Smirnov test. To detect potential systematic bias between measurement systems, a paired-sample Student’s t-test was applied and complemented with Bland–Altman plots.

Measurement agreement between systems was evaluated using the intraclass correlation coefficient (ICC). Absolute reliability was assessed through the calculation of the standard error of measurement (SEM), expressed in both absolute units and as a percentage. Bland–Altman plots were also used to illustrate measurement error.

Simple linear regression was used to examine the relationship between systems. For stride length, robust linear regression was preferred due to violations of the homoscedasticity assumption in certain data subsets.

All analyses were conducted using RStudio.

5 Results

	Frequency				Length			
Type of run	ICC	SEM (m)	SEM %	T-test (p-value)	ICC	SEM (m)	SEM %	T-test (p-value)
20m fly	0.98	0.035	0.79	0.000 (0.96)	0.97	0.017	0.87	-0.010 (<0.001)
30m (-0)	0.93	0.045	0.99	0.035 (<0.001)	0.93	0.021	1.16	-0.09 (0.07)
30m (-2)	0.94	0.045	0.99	0.017 (<0.001)	0.84	0.023	1.23	-0.042 (<0.001)
30m (-3)	0.94	0.047	1.02	0.003 (0.71)	0.91	0.021	1.15	-0.021 (<0.001)

Table 1: Reliability of stride frequency and stride length measurements across sprint phases

During the maximal velocity phase, ICC values indicated near-perfect reliability (≥ 0.97) (Table 1). Bland–Altman plots showed 95% limits of agreement of 0.10 s/s for stride frequency and 0.05 m for stride length (Figure 4)

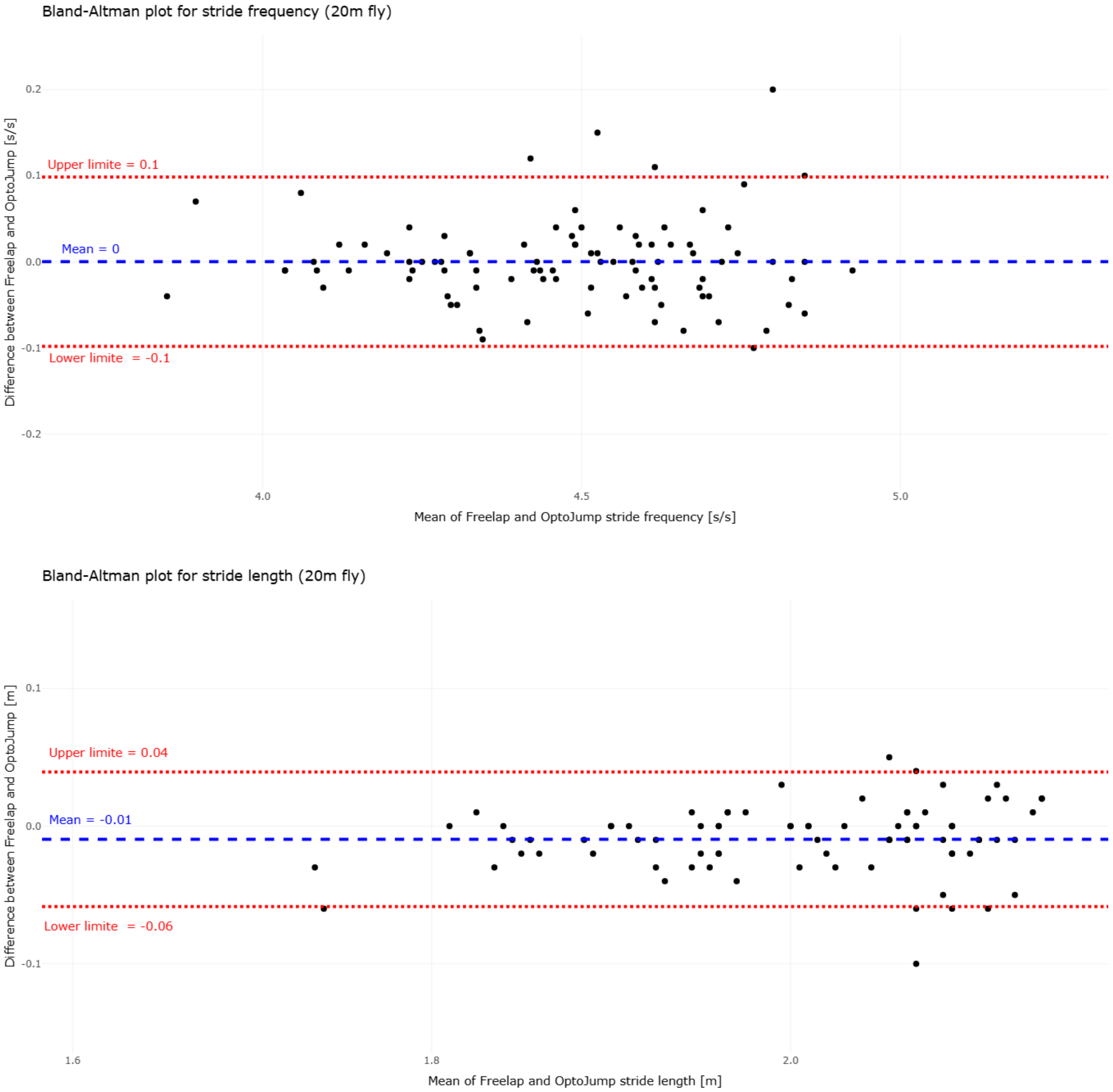

Figure 4: Bland–Altman plots for stride parameters during the maximal velocity phase

A statistically significant difference of -0.01 m ($p < 0.001$) was observed for stride length (Table 1). Linear regression analyses—especially for stride frequency—revealed an excellent agreement with the line of identity ($y = x$), particularly within the observed data ranges: $[4, 5]$ for frequency and $[1.7, 2.3]$ for length (Figure 5)

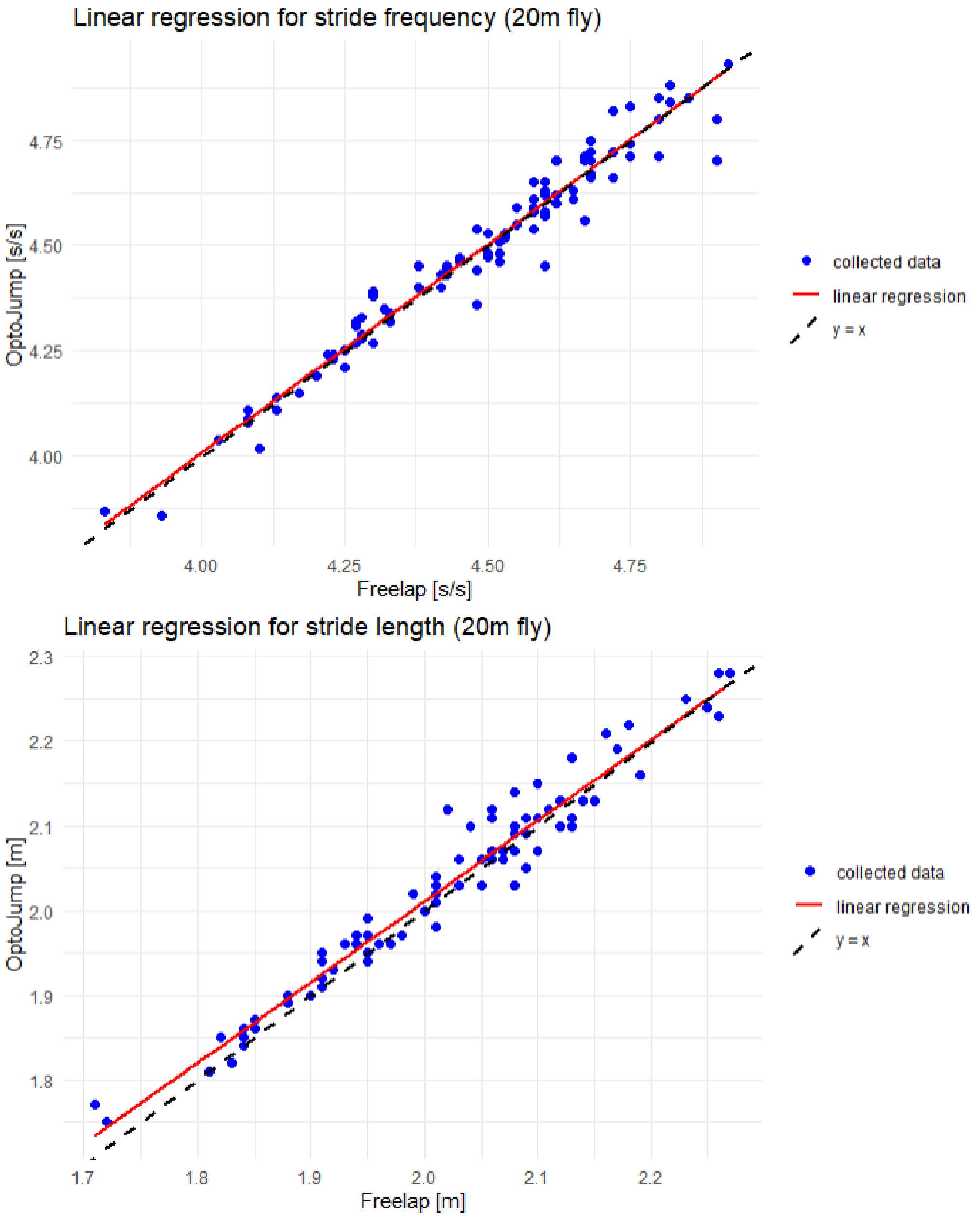

Figure 5: Linear regression plots for stride parameters during the maximal velocity phase

During the acceleration phase, ICC values remained high (≥ 0.91) for the -0 and -3 datasets, and moderately high for the -2 dataset (≥ 0.84) (Table 1). Random error was comparable to that observed in the maximal velocity phase. Bland–Altman plots showed slightly wider limits of agreement: 0.13 s/s for frequency and 0.06 m for length (Figures 6 & 7).

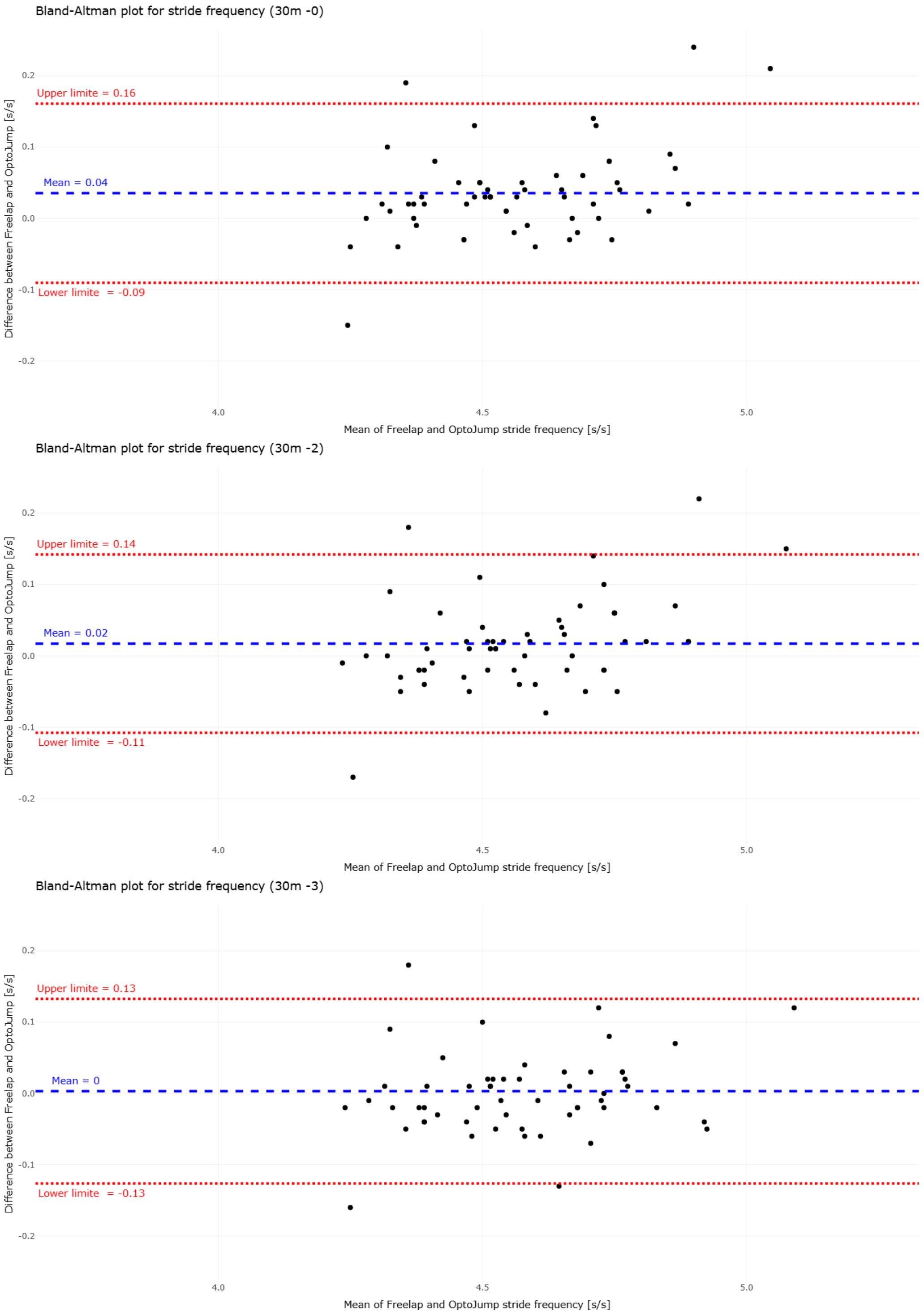

Figure 6: Bland-Altman plots for stride frequency during the acceleration phase

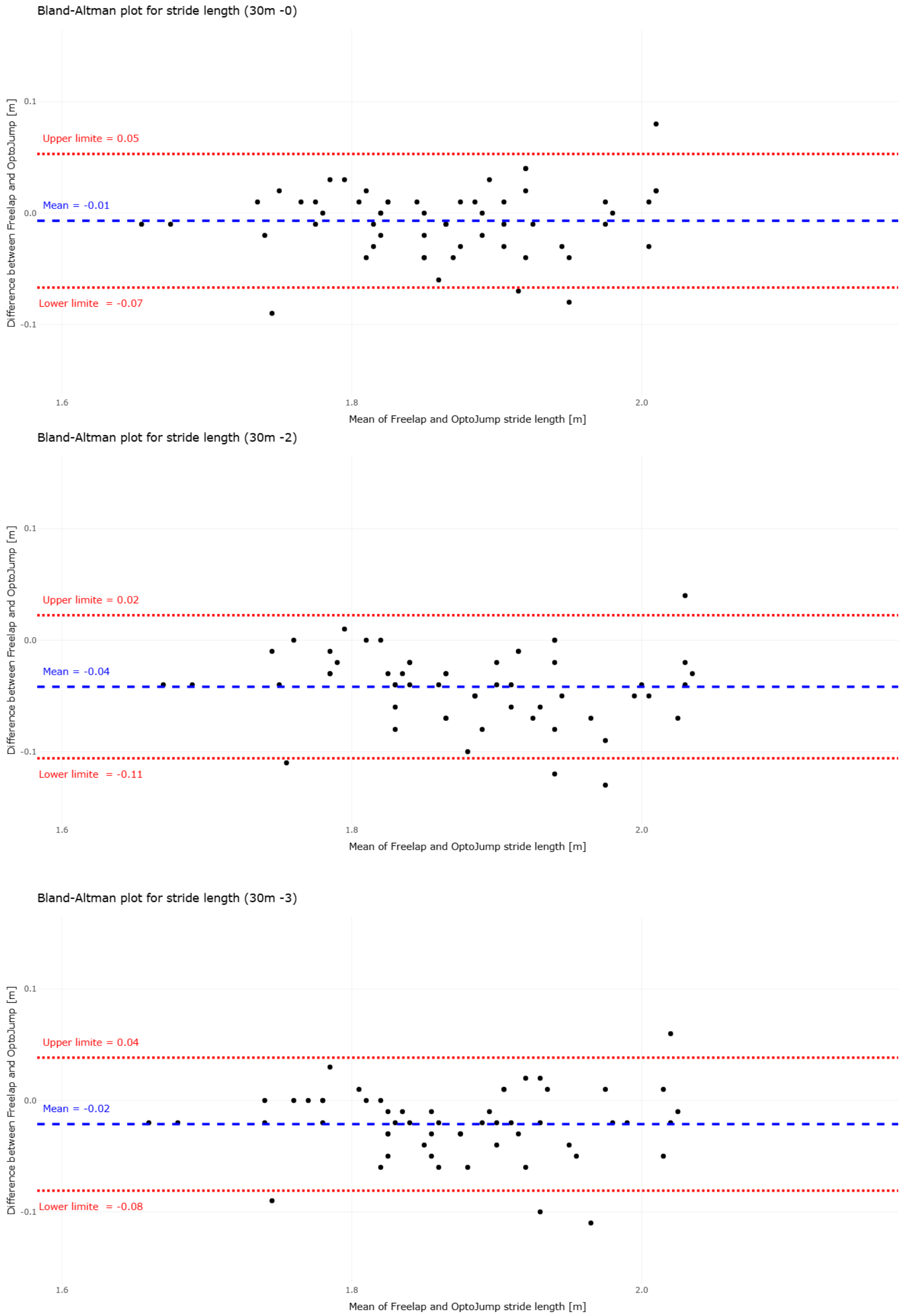

Figure 7: Bland-Altman plots for stride length during the acceleration phase

Significant differences between Freelap and OptoJump were observed for stride frequency in the -0 and -2 datasets (0.035 s/s and 0.017 s/s, respectively). For stride length, significant differences were identified in the -2 (-0.042 m) and -3 (-0.021 m) datasets (Table 1).
Finally, linear regression showed the closest fit to the identity line ($y = x$) with the -3 dataset, followed by the -0 dataset, and finally the -2 dataset (Figure 8 & 9)

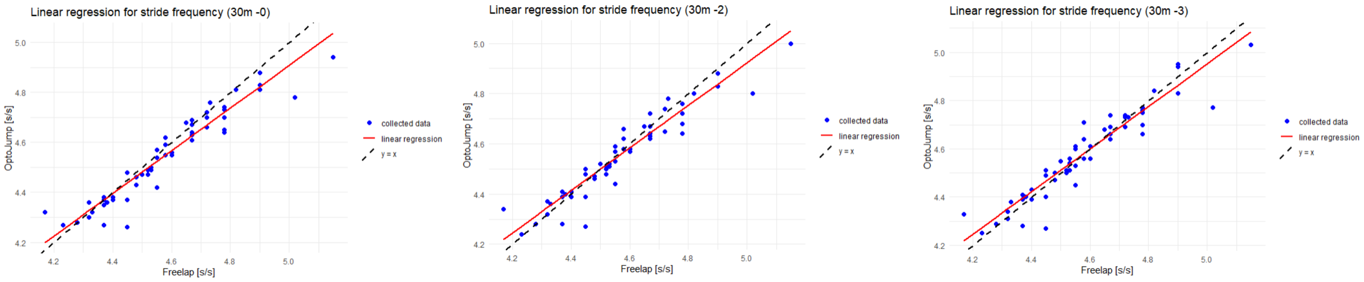

Figure 8: Linear regression plots for stride frequency during the acceleration phase

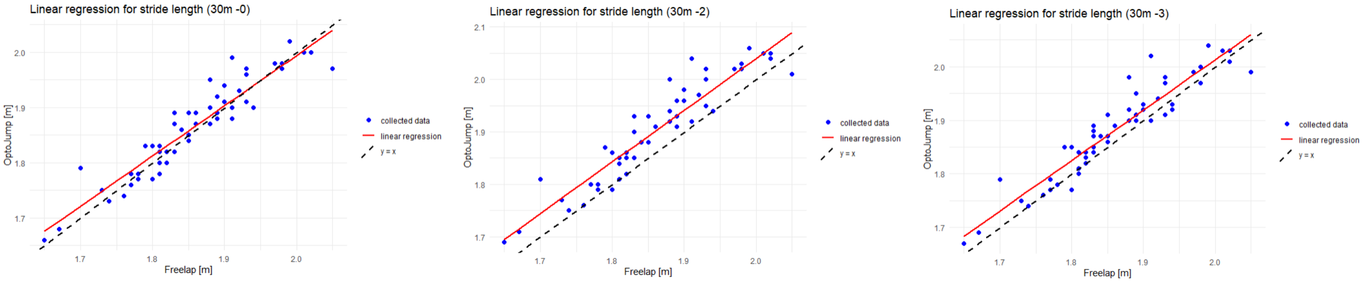

Figure 9: Linear regression for stride length during the acceleration phase

6 Discussion

This study confirmed the validity of the Freelap system for measuring running stride parameters during the maximal velocity phase. The observed underestimation of 1 cm in stride length does not pose a significant issue for accurate measurement, especially considering the known overestimation of 0.5 ± 1.3 cm from the OptoJump system, which was rounded to 1 cm in the present study

Freelap can therefore be considered a viable alternative to OptoJump for field-based applications. However, despite being small, the random error remains too high for precise scientific measurements.

During the acceleration phase, Freelap data were comparable to the raw OptoJump data (-0), acknowledging a systematic overestimation of stride frequency by 0.04 s/s by the Freelap system.

It is recommended to compare Freelap and OptoJump data after a preprocessing excluding both the first two step and the last step(-3). This subset more accurately reflects the automatic data treatment performed by Freelap in a “Start-Finish” configuration.

This preprocessing results in improved agreement between the two systems, as demonstrated by the linear regression equations ($OptoJump = 0.88 \times Freelap + 0.54$ for stride frequency and $OptoJump = 0.94 \times Freelap + 0.13$ for stride length). The observed overestimation of 2 cm in stride length by Freelap is statistically significant. However, when taking into account the OptoJump measurement error (rounded to 1 cm), the discrepancy relative to the true value may still be significant, but could be reduced to a practical error of around 1 cm. This margin would not represent a major limitation in a training context.

The automatic preprocessing performed by Freelap in a "Start-Finish" configuration warrants discussion. This type of processing is unlikely to affect results during maximal velocity runs, as running parameters remain relatively stable at constant speed. Thus, over a 20 m segment—as recommended by the manufacturer—excluding the first two steps still provides sufficient data to compute a reliable average.

In the context of a stationary start, the exclusion of the first two steps also appears justified. These early strides often present as outliers relative to the rest of the run and would distort the representativeness of the final measurement.

While improvements in the initial two steps would be detected by OptoJump, they would not be reflected in Freelap data due to the automatic exclusion. However, it is worth noting that improvements in the initial strides generally lead to subsequent improvements across following steps, making such progress indirectly visible in the Freelap output.

The comparison using a "-2" preprocessing (excluding only the first two steps) did not yield the expected results.

This is likely due to the test setup: athletes tended to prematurely reduce effort in the final step of the segment. In such cases, an intermediate timing configuration might have eliminated the need for "-3" processing, and a "-2" configuration may actually be more suitable—especially in a “Start-Lap” setup during the acceleration phase.

Freelap computes mean values for each parameter. However, the relevance of these averaged values can be debated, particularly during acceleration phases when stride parameters change rapidly from step to step (Figure 3). This may lead some users to attempt measurements over shorter distances (e.g., 10 m). Such practices are not recommended by the manufacturer, as they could lead to erroneous data—likely due to insufficient stride measurements after automatic preprocessing.

Bland-Altman analysis revealed no evidence of proportional bias, despite regression coefficients differing from 1. This discrepancy could be attributed to the limited range of data observed, with stride frequency ranging from 3.6 p/s to 5.1 p/s and stride length from 1.60 m to 2.30 m. A dedicated study focusing on these extreme values would be necessary to further explore potential biases.

7 Conclusion

This study is the first to analyze the new data collected by the Freelap system using the Fx Motion. The results confirm its relevance and practicality for training applications. Freelap demonstrates very good relative and absolute reliability, particularly during maximal velocity phases. However, the observed random error—although relatively small—remains too high for the system to be considered a gold standard for scientific use.

For more accurate comparisons, it is recommended to harmonize preprocessing methods between Freelap and OptoJump, especially during the acceleration phase. A preprocessing strategy that excludes both the first two steps and the final step (in a "Start-Finish" configuration) yields more comparable results.

In conclusion, Freelap appears to be an accessible and reliable tool for field-based training monitoring, but it cannot yet replace OptoJump as a reference system for scientific research.

8 Acknowledgements

The author would like to thank Freelap SA for its hospitality and support throughout the duration of the study.

9 Declaration of Conflict of Interest

The author was employed by Freelap SA during the course of the study.

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