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Conference Abstract

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Integrating Pedal Power Variables as Predictors of Iliac Artery Flow Limitation in Cycling: A Pilot Study

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Abstract

Flow Limitation of Iliac Artery (FLIA) is a complex pathology that leads to reduced performance and even withdrawal from cycling. The identification of FLIA through performance loss has been studied by analyzing Power Output (PO) data, providing positive discriminatory markers. In the current era of data availability and the integration of predictive performance models in cycling, the study of discriminatory variables for the potential presence of FLIA is emerging as a useful process for integration and evaluation by performance staff. A 33-year-old male cyclist participated in the study, where external PO developed on the pedals was measured second by second during a Graded Exercise Test (GXT), along with the variables Left-Right Balance (L-R Balance) and Pedal Smoothness (PS). Using the second by second (SBS) data, Effect size test between variables was estimated and a predictive capacity analysis of FLIA were conducted via a Receiver Operating Characteristic (ROC) curve. Small effects were found in PO (d= -0.38, small, 95% CI [-0.52, -0.23] and large effects in L-R Balance (d= -1.97, large, 95% CI [-2.15, -1.79]) and PS (d= 0.82, large, 95% CI [0.67, 0.97]) between the affected and unaffected limb. The ROC analysis showed Areas Under the Curve (AUC) ranging from 0.928 to 0.959, with sensitivity values between 0.88-0.92 and specificity between 0.80-0.84, indicating a high predictive capacity for the studied variables. The logistic model combination of variables showed higher sensitivity and specificity values of 0.90 and 0.92 respectively. The implementation of SBS PO analysis models in cycling could be useful for decision making in the possible presence of FLIA, allowing for the setting of individual thresholds using the discriminatory variables in the study to detect the potential presence of FLIA at an early stage.

Keywords

cycling; iliac artery endofibrosis; FLIA; power output; performance

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1 Introduction

The Flow Limitation of the Iliac Artery (FLIA) causes performance loss and claudication in the lower limbs during cycling (Rousselet et al., 1990). There is considerable complexity in identifying the vascular pathophysiologies responsible for FLIA through the analysis of performance loss, which in some cases leads to delayed detection of up to 24 months (Mansour et al., 2016).

Previous studies have reported bilateral differences in Power Output (PO) between lower limbs (LwLs) due FLIA (Bilman et al., 2021; Kleinloog et al., 2019; van Hooff et al., 2021), and some have proposed cut-off points using PO as a predictor for FLIA detection (Kleinloog et al., 2019). Despite these findings, the "real-world" and data treatment in 3.0 cycling (Zabala, 2025) allows for the integration of predictive algorithms (and artificial intelligence use) at the individual level, enabling the definition of personalized cut-off points that may predict the potential presence of pathology through continuous performance monitoring by coaches and cyclists.

Therefore, prior to the integration of predictive algorithms, it is necessary to establish a statistical approach to the use of variables in FLIA, enabling their subsequent incorporation into instantaneous metrics to be recorded and monitored during training and competition in cycling, based on this, the objectives of the study were: 1) to present the performance data of a cyclist with FLIA that may aid in selecting discriminatory variables for the identification of FLIA; and 2) to analyse the sensitivity and specificity of the variables selected in the study for detecting FLIA.

2 Material and Methods

One 33-year-old male participant in the study, diagnosed with external iliac artery endofibrosis, consented to participate in the study. A Graded Exercise Test (GXT) was conducted on a roller trainer, recording second by second (SBS) bilateral Power Output (PO) using Favero Assioma DUO powermeters, (Favero Electronics SRL, Arcade TV, Italy Favero Electronics) (Rodríguez-Rielves et al., 2021). Left-Right Balance (L-R Balance) was calculated as the difference in PO contribution between the lower limbs to total PO SBS expressed in percentage (%), Pedal Smoothness (PS) was measured SBS to quantify the consistency and fluidity of force application throughout the pedalling cycle (mean vs. peak applied force) expressed in percentage (%). Effect size was calculated using Cohen's d to quantify the magnitude of the observed differences (Cohen 1988) and a Receiver Operating Characteristic (ROC) curve analysis was performed from the GXT (ROCGXT) using L-R Balance and Delta (Δ) of PS between LwLs, separately and combined (logistic ROC). Finally, ROC analysis using data collected in the field in a 65-minute activity (ROCFIELD) was performed to assess the agreement of the results from the ROC in a GXT and stochastics results obtained from the field.

The study was approved by the Ethics Committee for Research with Human Beings (CEISH) of the University of the Basque Country (UPV/EHU) (NoRefCEid: M10_2025_304). The present study followed the ethical standards set out in the Declaration of Helsinki in 2013.

3 Results

The ROC_{GXT} of L-R Balance resulted in a threshold (cut-off point) of -2%, with a sensitivity of 0.92 and specificity of 0.84. For PS, the threshold was 0.25, with a sensitivity of 0.88 and specificity of 0.80. The highest threshold (probability) in the logistic model was 0.55, with a sensitivity of 0.90 and specificity of 0.92.

The ROC_{FIELD} result for L-R Balance was a threshold of -4%, with a sensitivity of 0.79 and specificity of 0.66. For PS, the threshold was 0.5, with a sensitivity of 0.60 and specificity of 0.73. The highest probability result of the logistic model in the ROC_{FIELD} was 0.55 with a sensitivity of 0.90 and specificity of 0.92.

Table 1. Results of participant's PO, L-R Balance and PS in the GXT.

Variable	Right Lower Limb (Mean ± SD)	Left Lower Limb (Mean ± SD)	Effect Size
PO (Watts)	125.0 ± 22.8	134.1 ± 24.4	*d*= -0.38 (small); 95% CI [-0.52, -0.23]
L-R Balance (%)	-6.9 ± 7.0	6.9 ± 7.0	*d*= -1.97 (large); 95% CI [-2.15, -1.79]
PS (%)	23.7 ± 1.0	23.3 ± 0.9	*d*= 0.82 (large); 95% CI [0.67, 0.97]

PO: Power Output; L-R Balance: Left-Right Balance. PS: Pedal Smoothness; d: Cohen's d; 95% CI: confidence interval at 95%.

Figure 1. ROC$_{GXT}$ curve analysis results of L-R Balance, PS and logistic combination of both variables.

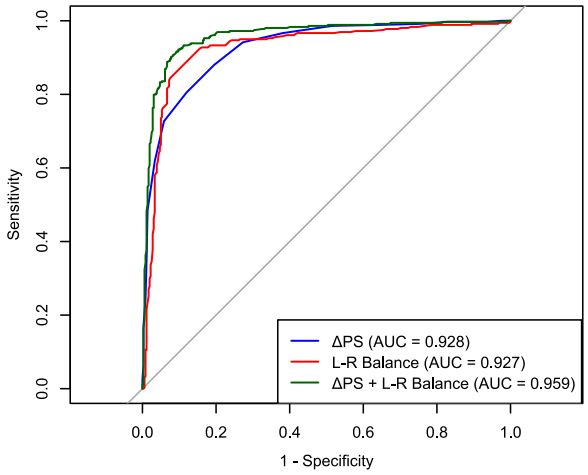
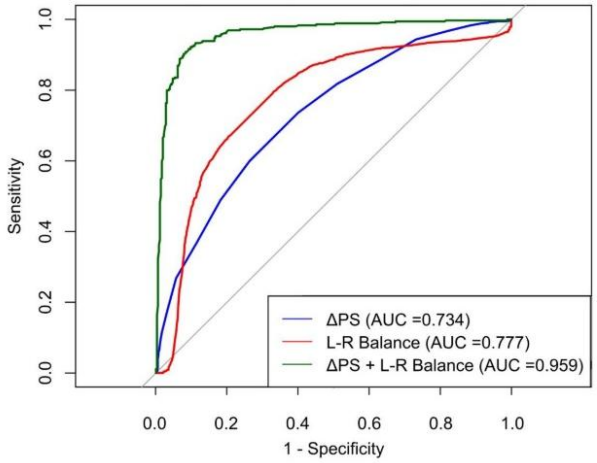


Figure 2. ROC$_{FIELD}$ curve analysis results of L-R Balance, PS and logistic combination of variables.



4 Discussion

Differences in PO between LwLs were found, with a small effect size, despite the slightly statistical differences, PO between LwLs differed by 9.1 W, suggesting that continuous SBS analysis of PO data could be useful for detecting intra-session changes in PO contribution from LwLs.

The PS variable showed large differences, reflecting alterations in the sinusoidal pedaling pattern between LwLs, with a higher PS value observed in the affected lower limb. This may be due to a lower peak force developed during the pedal stroke and a mean force value closer to this peak, as has been observed in previous studies (Kleinloog et al., 2019).

Based on ROC$_{GXT}$ analysis, the predictive capacity of PO using L-R Balance detecting the possible presence of FLIA was high with an individual threshold of -2%, which, in the case of this study was lower than the previously proposed threshold of 5.1% of difference between mean PO developed between LwLs at 95% of maximum PO in a cycling population during a GXT (Kleinloog et al., 2019). On the other hand, in ROC$_{FIELD}$, the threshold was higher (−4%) than ROC$_{GXT}$, closer to results reported of the aforementioned study. PS showed strong predictivity in the ROC$_{GXT}$ results, being less strong in the ROC$_{FIELD}$, with a threshold of 0.25 and 0.5%, respectively. L-R Balance and PS logistic model prediction showed slightly discriminatory capacity in GXT and field ROC analysis (probability 0.55%), with same results of sensitivity and specificity between ROC$_{GXT}$ and ROC$_{FIELD}$. Despite logistic model results from the field demonstrated same predicted probabilities compared to those obtained from GXT, considering the statistical limitations inherent to the GXT protocol, where SBS variables derived from PO data exhibit strong autocorrelation, the use of field-collected data may provide a more practical approach for analyzing PO variables in real-world, potentially overcoming the limitations and facilitating the detection of FLIA. These findings should be further investigated in future studies.

5 Practical Applications

The integration of analysed variables, as well as the estimation of individualized cut-off points based on thresholds to monitor performance fluctuations during training and competition, may be useful for identifying the potential presence of FLIA. Nevertheless, it should be acknowledged that the sample size does not allow for definitive conclusions and that this study represents a starting point for this line of research. Future studies should focus on validating individual predictive thresholds in a larger cyclists' population using the variables presented in this study.

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Conflicts of Interest: The authors declare no conflict of interest.

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