GenAI Tool for Elite Athlete Performance

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A dissertation submitted in partial fulfilment
of the requirements for the degree of

Master of Science (MSc)
in
Artificial Intelligence for Biomedicine and Healthcare
of
University College London (UCL)

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February 2025

Abstract

This thesis presents original research on the development and validation of a generative AI system designed to assist sports science experts and elite athletes with the creation of real-time, personalised nutrition plans to optimise athletic performance. Motivated by the static nature and lack of real-time adaptability of existing tools, this research fine-tunes and thoroughly evaluates a GenAI model integrating Natural Language Processing (NLP) and Reinforcement Learning from Human Feedback (RLHF). It lays the groundwork for future AI agents in sports science and performance nutrition.

The core concept of this thesis is AI for performance-oriented nutrition planning using advanced transformer-based NLP models for context-aware plan generation. These models are fine-tuned using multi-modal data, engineered for extension with RAG, and validated through human-in-the-loop feedback mechanisms to ensure outputs adhere to expert dietary and performance guidelines.

This work was conducted with renowned experts, in collaboration with open-source platforms, and is being deployed in elite sport clubs via NutriElite Ltd (UK). A planned participation in EU GENIA on responsible GenAI for athlete nutrition and injury prevention.

This research comprises three investigations:

Exp 1 - Data acquisition and Preprocessing: This dissertation develops a structured data pipeline including nutrition, movement, heart rate, environmental, and wellness datasets. This multi-source approach supports structured representations for GenAI personalisation.

Exp 2 - Generative AI Model Development: This dissertation advances GenAI in Sports Nutrition by deploying a fine-tuned transformer model on athlete-specific and session-specific data, allowing the generation of highly personalised plans.

Exp 3 - System validation and expert evaluation: The generated plans are benchmarked against expert-designed regimens through statistical metrics and pilot evaluations, with iterative refinement based on domain expert feedback.

The thesis makes the following contributions to science:

1. **Introduction of GenAI for Athlete Nutrition and Performance Optimisation** – This research presents a novel, scalable and adaptive AI system for synthesising structured, goal-aligned meal plans in real time.

2. **Multi-Source Data Integration for Athlete-Specific Planning** – This system combines structured and unstructured athlete and session data, advancing decision support in sports science.

3. **Benchmarking AI Against Human Experts** – This work introduces a rigorous validation framework to ensure scientific reliability and trust in AI-generated nutrition recommendations.

A paper derived from this research has been drafted and will be submitted for publication. For code access, please contact the lead researcher at george.iliev.24@ucl.ac.uk.

Impact Statement

This research advances the field of performance nutrition by developing a GenAI system for real-time, personalised planning in elite athletes. By integrating Natural Language Processing (NLP), Reinforcement Learning from Human Feedback (RLHF), and multi-source data fusion, including meal and supplements, movement, heart rate, environmental, and wellness data, the system enhances the precision, scalability, and adaptability of athlete-specific performance nutrition plans.

The system bridges the gap between AI-generated dietary guidance and expert clinical judgement, ensuring recommendations are scientifically grounded and responsive to athletes' evolving physiological and performance needs. The work also lays the foundation for future Agentic AI systems that act as autonomous assistants to sports scientists and dietitians.

The impact of this work is structured around three core investigations:

- **Exp 1 — Data Acquisition and Preprocessing (Chapter ??):** This study establishes a robust, production-ready data pipeline that fuses nutrition, movement, heart rate, wellness and environmental data from over 1,000 athletes and 10,000 sessions
- **Exp 2 - Generative AI Model Development (Chapter ??):** This study fine-tunes transformer-based NLP models to generate personalised, evidence-based performance nutrition plans aligned with professional dietitian principles
- **Exp 3 - System Validation and Expert Evaluation (Chapter ??):** This study benchmarks AI outputs against expert-designed plans using iterative HITL (human-in-the-loop) feedback and comprehensive real-world scenario testing

This research pioneers a scientifically credible and ethically grounded AI framework that empowers sports dietitians, sport scientists, and elite athletes with adaptive, evidence-based nutrition and performance support. It establishes a new paradigm for intelligent dietary guidance: one that delivers transparent, interpretable, and actionable recommendations using real athlete data, heart rate monitoring, and multi-modal contextual analysis. The approach sets a new standard for trustworthy, professional-grade decision support in both healthcare and elite sports environments.