

Introduction/Background

Our overarching goal is to help Purdue Strength and Conditioning to train their athletes better by profiling athletes, finding correlations within the data, and helping them to understand player tendencies. In the fall semester, we worked with the softball team and set out to create a team-relative analysis of strength metrics and track player swinging tendencies to allow the coaches to have unbiased view of their players. In the spring semester, we worked with the volleyball team. We wanted to help the trainer see how fatigue plays a role in player performance and an athletes ability to stay healthy.

Research, Tools, and Methodology

Our research analyzed workload, fatigue, and performance trends using Catapult to monitor jumps and Internal Movement Analysis (IMA) metrics, while Hawkins Dynamics provided force plate data on jump performance and fatigue. Inspired by *Fatigue and Training Load Factors in Volleyball* by Pawlick and Mroczek, we brainstormed fatigue-related projects for volleyball. For softball, we used HitTrax to measure batting stats like launch angle and velocity, drawing insights from *Launch Angles & Softball* by Matt Lisle. We pitched these ideas to our mentors, shaping our approach based on their feedback.

Softball Results

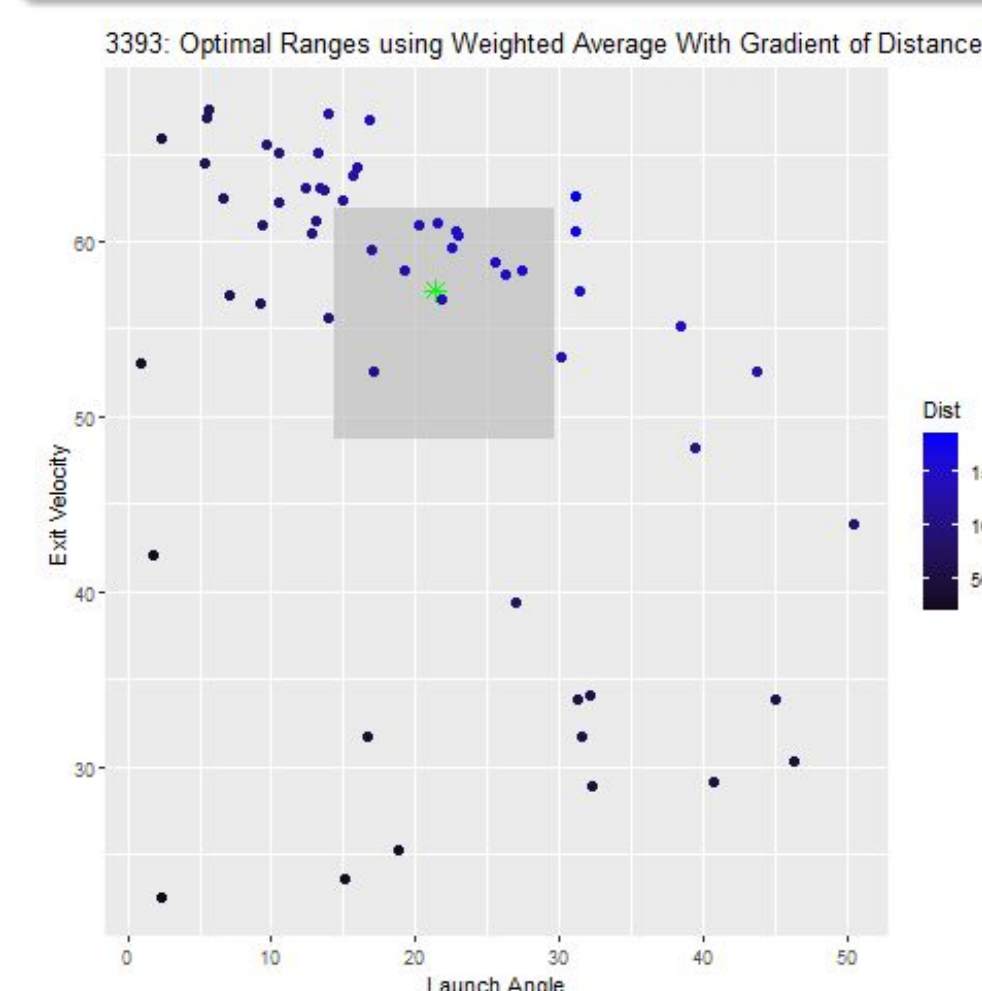


Figure 1

Figure 1 displays a player's HitTrax swinging data. The horizontal axis represents the ball's exit angle, while the vertical axis shows its initial velocity. Swing distance is color-coded from black to blue. The highlighted box encapsulates the weighted average of swings, offering a player-specific guide to optimizing hitting strategy for optimal distance and velocity.

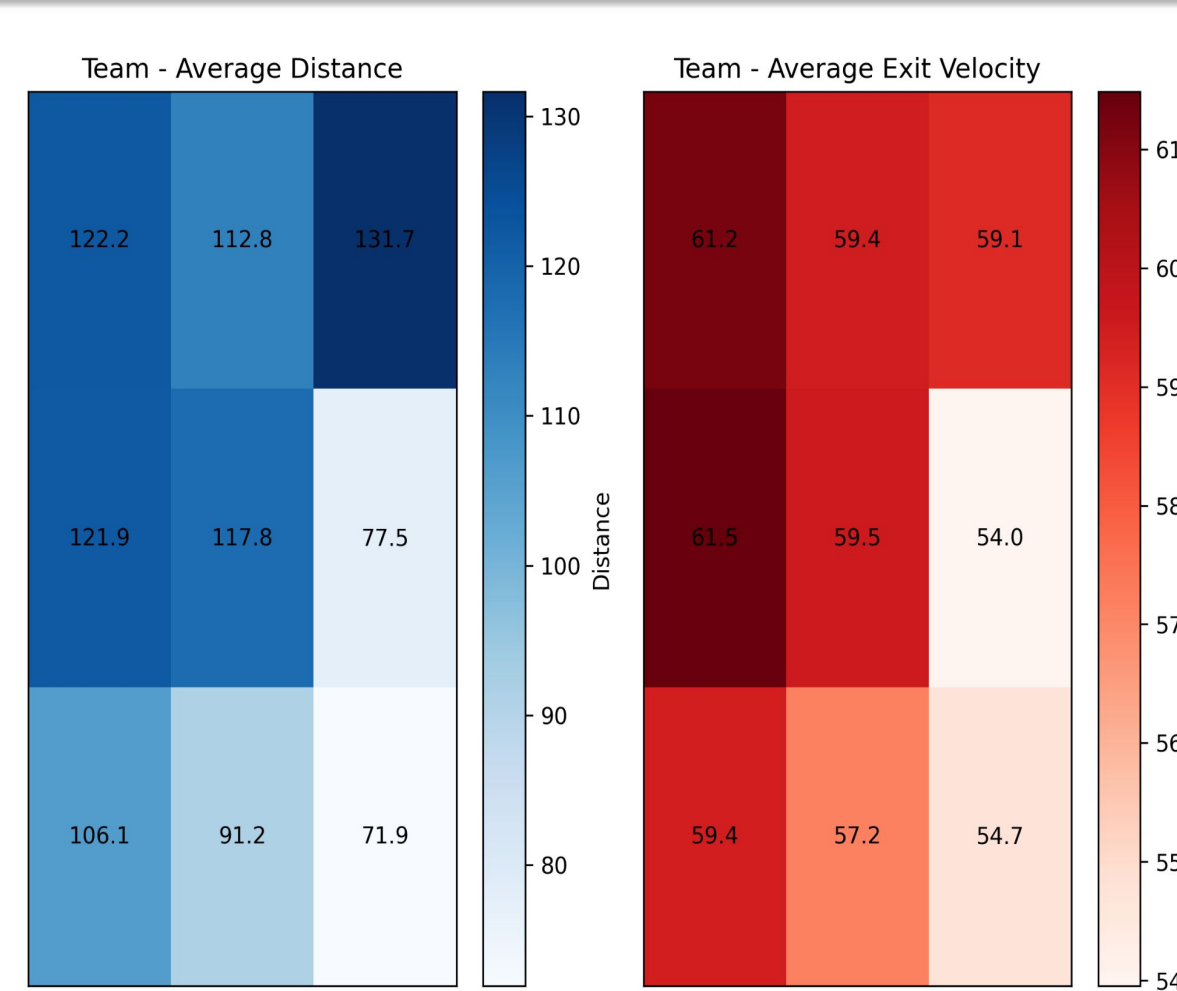


Figure 2

Figure 3

Each swing entry in the Hittrax batting practice data had a corresponding value between 1 and 9 that represented which area of the strike zone the ball was hit. In order to visualize player performance based on strike zone areas, we take the average distance and exit velocity for each zone and apply those values to two separate heat maps, one for distance and one for exit velocity. The darker the square, the higher the average distance/exit velo of the player in that specific zone.

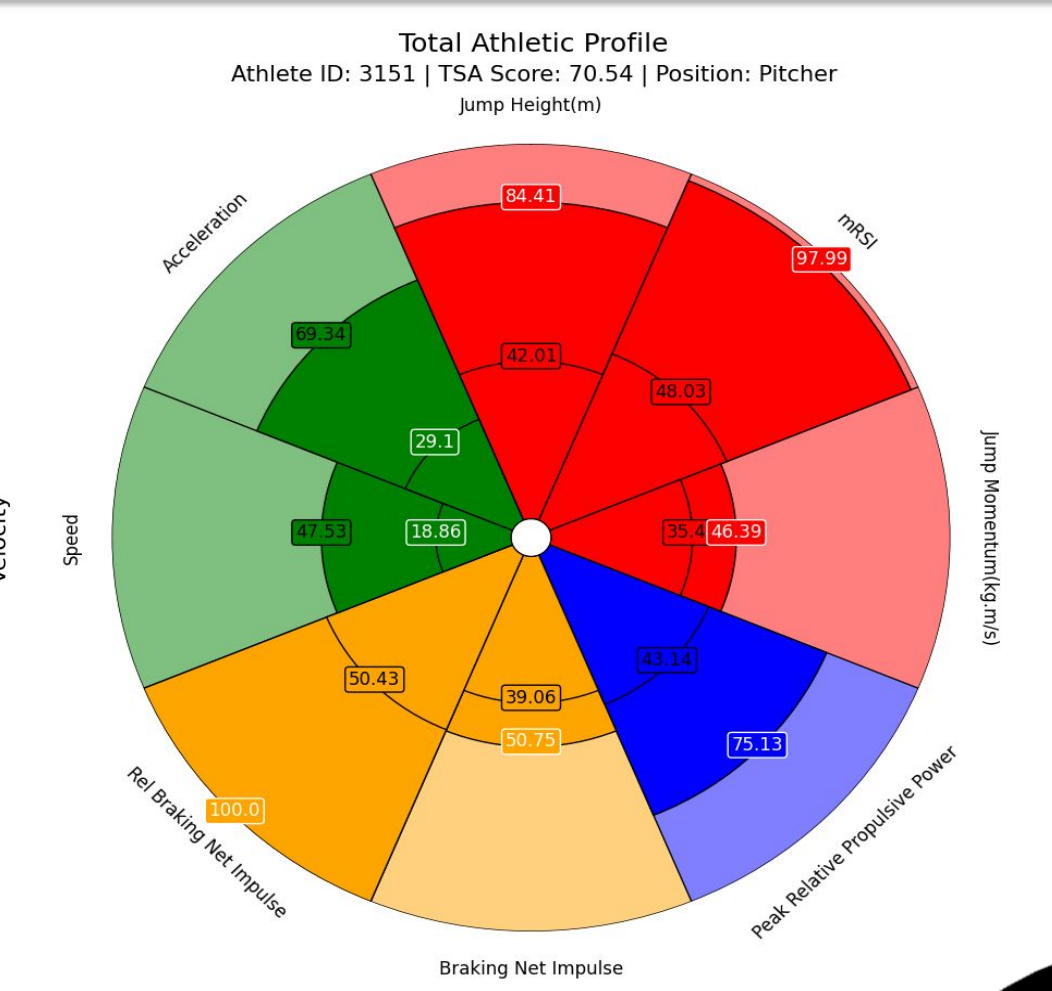


Figure 4

This spider graph is an example of a Total Score of Athleticism spider graph for an athlete. Each slice of the graph represents the scaled T-score for a specific metric, and the overall TSA is calculated as an average of all the metrics. We combined this with a multiple linear regression model to find the most important metrics in relation to batting skill. This visualization highlights individual strengths and weaknesses but also provide a clear evaluation of an athlete's performance.

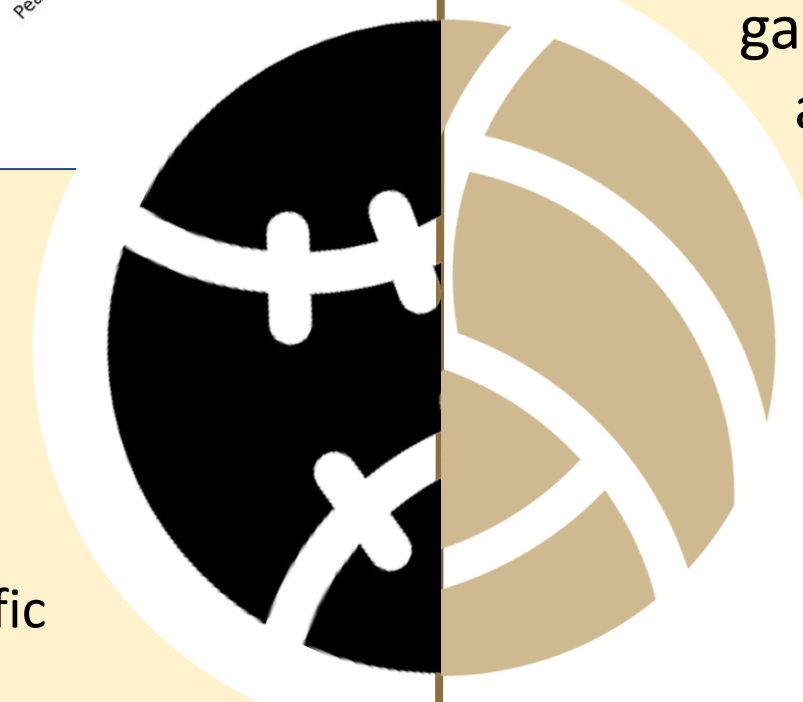


Figure 5 is used to organize and adjust volleyball practice intensity based on Catapult data by analyzing total player load, calculating exertion percentiles by position, and comparing planned intensity levels with actual exertion, ultimately supporting more informed training decisions that enhance individual performance, promote recovery, and ensure that both practices and games are appropriately aligned with the team's overall physical readiness.

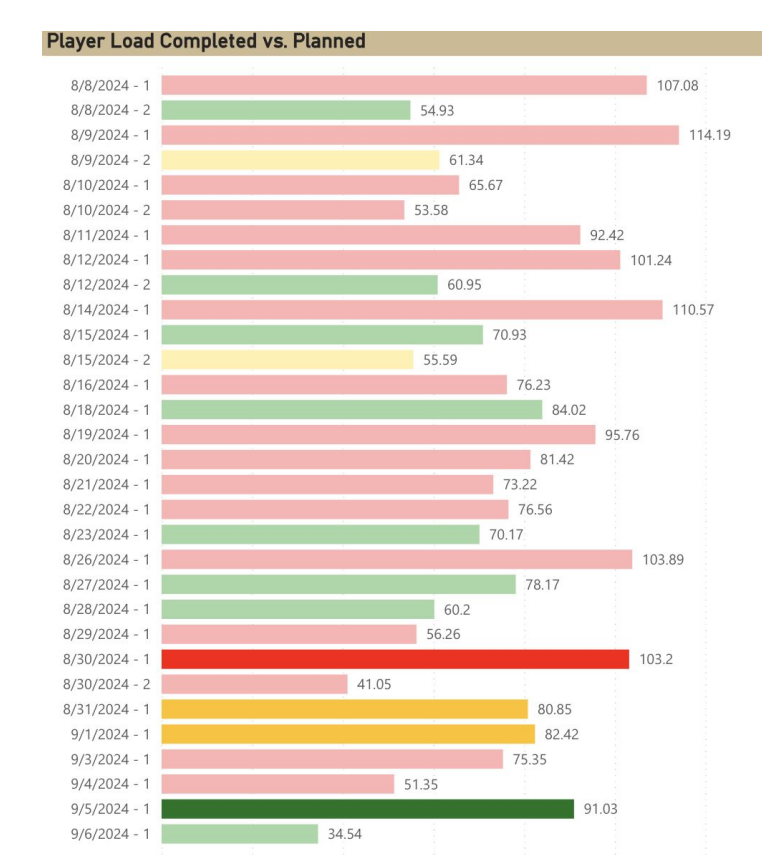


Figure 5

Volleyball Results

Figure 6 combines Hawkins force plate metrics with movement distribution data to provide a comprehensive and nuanced athlete assessment. Linking force production with movement tendencies offers valuable context for more targeted and effective training. Visualizing these relationships in a single, accessible format allows coaches to quickly identify specific areas for improvement instead of relying on generalized protocols. This integration significantly advances athletic development and strengthens injury prevention strategies.

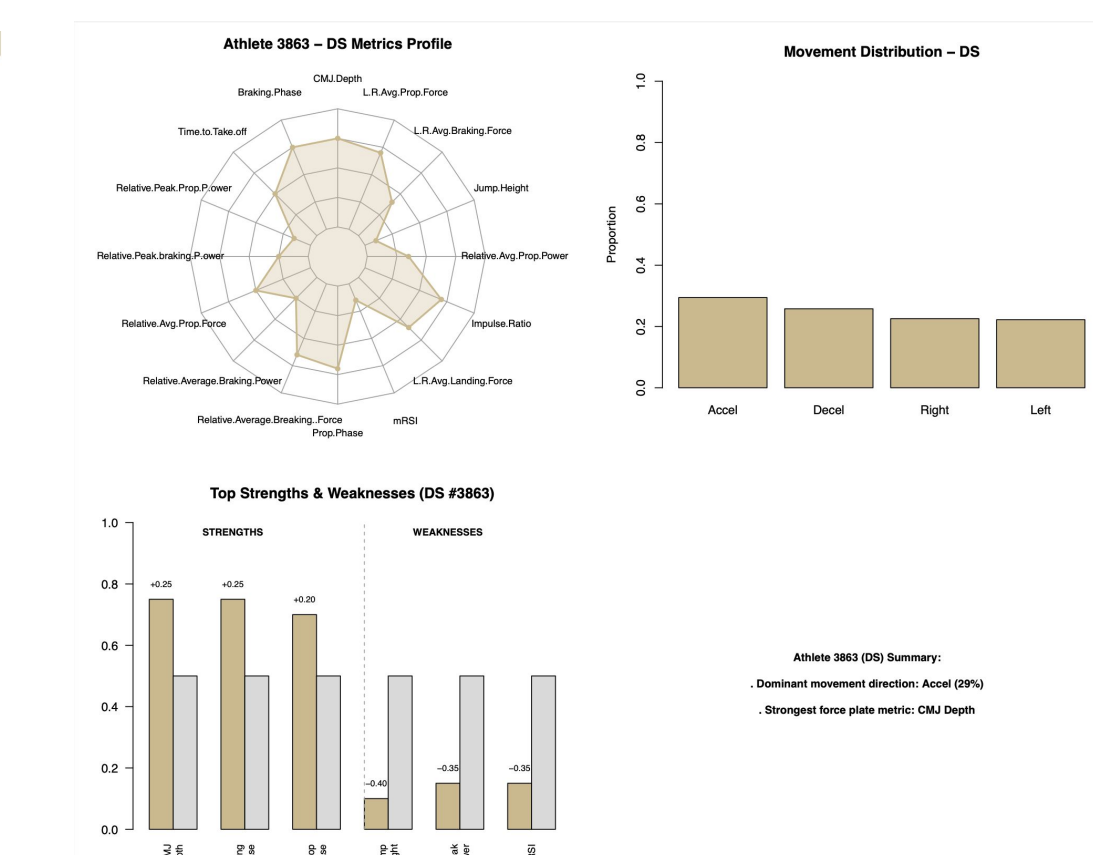


Figure 6

Clustering athletes by force plate metrics revealed distinct strength profiles that may relate to injury risk. One consistently identified group of three athletes showed similar strength patterns and reported no injuries, suggesting a potential "low-risk" profile. To explore this further, we used bootstrapping to compare metrics like mRSI between groups. The resulting confidence interval shown in Figure 7 suggests a meaningful difference, suggesting the "low-risk" group does have some significant differences in CMJ metrics, possibly reducing injuries.

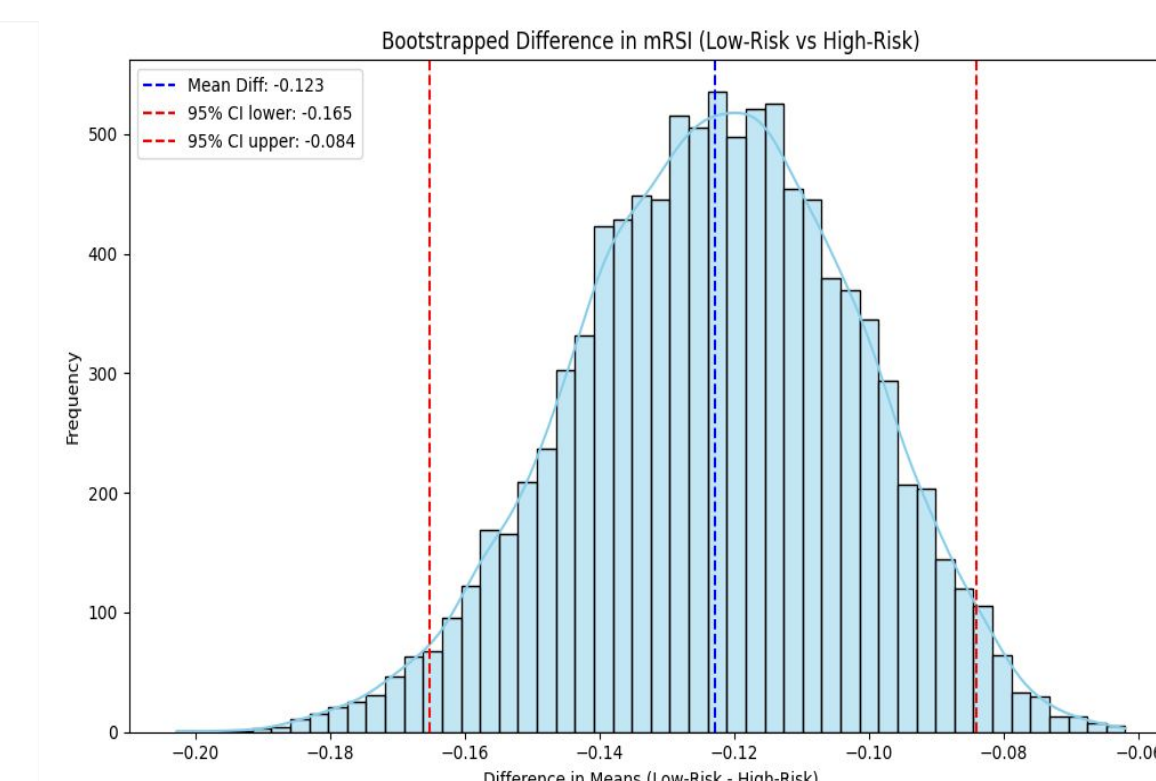


Figure 7

Softball Conclusions

Our main result from our analysis was player categorization, with the TSA graphs offering Purdue Strength and Conditioning an efficient and clear method to quickly assess how each player's Hawkins strength metrics compare to the rest of the team, while also tracking their improvement over time, providing valuable insights into player development; in addition, the analysis of correlations revealed that each player's swing is uniquely different, which led us to create optimal performance ranges that account for individual tendencies, rather than applying a uniform swing style across all players; the heat maps further enhance this by pinpointing where each player feels most comfortable hitting the ball and identifying areas of struggle, empowering coaches to develop tailored, data-driven training programs that address specific needs and improve overall performance on the field.

Future Goals

For the future, we would like to use WHOOP, an internal load tracker, to combine internal and external load metrics. Using these in tandem allows staff to better profile their players and provide them the optimal training. The injury model is also looking to be expanded upon. Being able to predict when an athlete is going to be injured is very valuable. This would require more data about each individual athlete.

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Volleyball Conclusions

Our volleyball analysis provided key insights into the relationship between player workload, fatigue, and performance. By integrating data from Catapult and Hawkins Dynamics, we identified trends in jump load, internal movement, and force output that can inform training decisions. The use of position-specific exertion percentiles and individualized performance baselines allows Purdue Strength and Conditioning to better manage practice intensity, reduce fatigue-related risks, and tailor athlete development plans. These insights contribute to a more data-informed approach to optimizing volleyball performance and reducing injury risk moving forward. As data collection continues, these tools will further enhance personalized training and long-term athlete monitoring strategies.