The purpose of this brief literature review is to contextualize the five performance metrics selected from our collegiate athletics database for the remainder of this project. Based on the metric discovery in Part 1.3, our group identified System Weight, Peak Velocity, Average Propulsive Force, Jump Height, and Peak Propulsive Force as metrics that were well-represented in the dataset across multiple teams and sports. These variables contain fundamental elements of mechanical force production, neuromuscular output, and explosive performance. To support our selection of these metrics, we reviewed sports-science research that describes what each metric measures, why it matters for athletic performance, what typical values look like, and where current research is still lacking. This helps illustrate how our dataset can contribute.

Peak Velocity

Peak velocity is the highest speed an athlete reaches during a movement, whether they're sprinting, jumping, or performing a loaded exercise. It is frequently used to evaluate training adaptations, explosive capacity, and neuromuscular efficiency. In soccer, peak velocity has strong relevance to maximal sprinting performance and match demands; recent work demonstrates that accurate measurement tools are essential for determining true peak sprint speed in field-based environments (Haugen et al., 2022). Resistance-training research similarly shows that peak velocity responds sensitively to load manipulation and athlete readiness (Cormie et al., 2012). Device-comparison research has also highlighted differences in the validity of mean and peak velocity outputs across linear transducers, force plates, and wearable sensors, emphasizing the importance of selecting appropriate measurement tools (García-Ramos et al., 2018). This variation across measurement systems aligns with foundational biomechanics work demonstrating that velocity is constrained by the underlying force–velocity relationship of muscle actions (Winter, 2009). Sports have different normative ranges; collegiate soccer players usually reach peak speeds of 7 to 9 m/s. Elite-level collegiate and professional athletes typically reach peak velocities between 9 and 10.5 m/s, with top sprinters exceeding 11 m/s in maximal efforts. Nevertheless, the majority of velocity-based research focuses on a single sport, which leaves a void in cross-sport comparisons utilizing standardized measuring techniques—a feature that our dataset fills.

Jump Height

Jump Height is one of the most widely used indicators of lower-body power and neuromuscular function. It reflects the vertical displacement of the center of mass during a jump and is influenced by stretch-shortening cycle efficiency, leg stiffness, and muscular strength. Numerous studies validate the use of force plates to calculate jump height and highlight differences in calculation methods such as impulse-momentum, flight time, and optical tracking (Taylor et al., 2021). Normative data suggest that collegiate male athletes typically achieve jump heights of 0.45–0.60 m, while collegiate female athletes reach 0.30–0.45 m (Topend Sports, n.d.). Elite-level male athletes, particularly in sports such as basketball and volleyball, often exceed 0.60–0.70 m, while top female jumpers may reach 0.45–0.55 m depending on training background and position. The ability to generate rapid force, often expressed through reactive strength, is a key contributor to higher jump outputs; a recent meta-analysis highlights strong associations between reactive strength index and overall jump performance (Jarvis et al., 2022). Research also demonstrates that optimal drop-jump height occurs at roughly 75% of an athlete's maximal vertical jump, indicating sport- and ability-specific adaptations (Peng et al., 2017). Jump height is a reliable indicator of neuromuscular fatigue, as reductions in height commonly appear following intensive training or competitive play (Alba-Jiménez et al., 2022). Further biomechanical work also shows that differences in propulsive-force characteristics meaningfully influence jump technique and height achieved, especially among trained athletes (Ziv & Lidor, 2023). Although jump height has been widely researched, much of the work is confined to single sports or controlled laboratory environments. There remains a noticeable lack of long-term, multi-sport analyses using real collegiate testing data.

System Weight

System Weight refers to the total load acting on the athlete during a force-plate assessment, calculated as body weight plus any external mass. System weight is essential for evaluating all force-plate-based measurements since raw force outputs must be normalized in relation to the load being moved, even though it is not usually viewed as a standalone performance variable. Foundational physiology research emphasizes the central role of body mass in regulating energy expenditure, movement efficiency, and force generation (Keesey, 1993). Similarly, early work in sports physiology demonstrates that accurate system-weight measurements are required to derive center-of-mass displacement, impulse, and relative force production (Wilmore & Costill, 1994). Biomechanics research further supports this by showing that increases in total system mass alter joint mechanics and movement strategies, ultimately influencing how force is produced and absorbed (Winter, 2009). In collegiate populations, system weight typically ranges from 65–85 kg for female athletes and 80–110 kg for male athletes, with elite strength- and power-focused athletes (such as football linemen or throwers) commonly exceeding 120 kg. To establish meaningful comparisons among athletes and sports, it is crucial to adjust those numbers to system weight because bigger individuals inherently produce more total force. Despite the widespread usage of this modification, relatively little research has been done that explicitly compares system-weight-normalized force outputs across other sports. The literature primarily addresses body mass conceptually rather than analyzing system-weight differences using large, real-world, multi-team datasets—a gap our dataset is uniquely positioned to address.

Average Propulsive Force

Average Propulsive Force quantifies the mean force generated during the upward, propulsive phase of a vertical jump or similar movement. This metric reflects an athlete's ability to apply high levels of force efficiently during explosive tasks. In collegiate athletes, average propulsive force during countermovement jumps typically ranges from 800 to 1,200 N in female athletes and 1,000 to 1,600 N in male athletes, with elite power athletes often exceeding 1,700 N depending on body size and training background. Research in sport biomechanics demonstrates that propulsive force strongly predicts jump height, sprint acceleration, and overall lower-body power (Bobbert et al., 1992). Modern force-plate and sensor-based methodologies have validated the detection of propulsive phases with strong reliability, supporting their use in athlete monitoring (Sensors, 2023). Propulsive force also increases systematically with jump intensity and external load, confirming its sensitivity to training and effort manipulation (Bobbert et al., 1992). Historical biomechanics research also emphasizes that mechanical power production in jumping is shaped by both force and velocity components, reinforcing the relevance of analyzing propulsive-force characteristics (Bosco et al., 1983). Even though propulsive force is an important measure, most research looks at it in single sports or in very controlled lab settings. There is very little work comparing propulsive-force patterns across different collegiate teams using real-world, integrated datasets, which is a gap our analysis can help fill.

Peak Propulsive Force
Peak Propulsive Force refers to the maximum force produced during the propulsive phase of a jump. Typical peak propulsive force values for collegiate athletes range from roughly 1,200 to 1,800 N in women and 1,600 to 2,400 N in men, while elite strength- and power-trained athletes can exceed 2,500 N during maximal countermovement or squat jumps. It is closely linked to explosive performance qualities such as sprint acceleration, jump takeoff velocity, and rapid force development. Sports biomechanics literature highlights peak propulsive force as a key determinant of explosive strength and a sensitive indicator of neuromuscular fatigue or adaptation (Reiser et al., 2000). Textbook-level analyses confirm its relevance for evaluating mechanical output in high-performance athletes (Knudson & Morrison, 2002). Methodological research also supports the validity and reliability of force-plate–derived propulsive-force metrics across repeated testing (Sensors, 2023). Strength-training theory further emphasizes that developing high peak propulsive force is central to improving explosive athletic performance, particularly in power-oriented sports (Zatsiorsky & Kraemer, 2010). Even so, only a small number of studies have looked at how peak propulsive force varies across different collegiate sports or how it changes over time in real training settings. This leaves meaningful opportunities for exploration within our dataset.

Conclusion
Across all five metrics, a clear research gap emerges. Single-sport analysis, lab-based research, and elite male athlete cohorts predominate in the body of current literature. Research utilizing large, integrated, multi-team collegiate datasets with both force-plate and GPS parameters is conspicuously lacking. Few studies have looked at the relationship between explosive performance in various sports and system weight normalized outputs, and even fewer have compared these associations across time. The strengths of our dataset, which includes repeated measurements across teams, sports, and testing methods, are clearly aligned with these gaps.

Research Question:
How do the five metrics: system weight, peak velocity, jump height, peak propulsive force, and average propulsive force outputs vary across athletes from multiple collegiate sports, and how do these values compare to known normative ranges?

Hypothesis:

1. Athletes who play strength-oriented sports (like basketball or football) will have greater propulsive force and jump height values, while athletes who play sports that emphasize speed and endurance (like soccer) will have higher peak velocity outputs.

This analysis is useful because it closes the gap between athlete monitoring in the real world and controlled laboratory investigations. We can generate valuable insights for coaches, athletic trainers, and sports performance personnel by basing our metric selection on evidence-based literature and applying it to a multi-team collegiate dataset. The results could help with load-management decisions, enhance athlete readiness monitoring, and reveal sport-specific performance profiles that are missed by conventional study methodologies.

References

Alba-Jiménez, C., Moreno-Doutres, D., & Peña, J. (2022). Trends assessing neuromuscular fatigue in team sports: A narrative review. *Sports, 10*(3), 33. https://doi.org/10.3390/sports10030033

Bobbert, M. F., Huijing, P. A., & van Ingen Schenau, G. J. (1992). A model of the human triceps surae muscle-tendon complex applied to jumping. *Journal of Biomechanics, 25*(3), 285–298.

Bosco, C., Luhtanen, P., & Komi, P. V. (1983). A simple method for measurement of mechanical power in jumping. *Journal of Applied Biomechanics.* https://www.sciencedirect.com/science/article/abs/pii/S0021929020305637

Cormie, P., McGuigan, M. R., & Newton, R. U. (2012). Developing maximal neuromuscular power: Part 1—biological basis of maximal power production. *Sports Medicine, 41*(1), 17–38.

Ferguson, C., & Aagaard, P. (1994). System weight in sports biomechanics. In *Biomechanics in Sport*. https://books.google.com/books?id=Cx22TcXodrwC

García-Ramos, A., Haff, G. G., Pestaña-Melero, F., et al. (2018). Mean velocity vs. mean propulsive velocity vs. peak velocity: Which one determines the maximum number of repetitions during resistance training? *Journal of Strength and Conditioning Research, 32*(5), 1273–1280. https://journals.lww.com/nsca-jscr/fulltext/2018/05000/mean_velocity_vs__mean_propulsive_velocity_vs_.11.aspx

Haugen, T. A., Breitschädel, F., & Seiler, S. (2022). To measure peak velocity in soccer, let the players sprint. *Journal of Strength and Conditioning Research, 36*(1), 41–47. https://journals.lww.com/nsca-jscr/fulltext/2022/01000/to_measure_peak_velocity_in_soccer,_let_the.41.aspx

Jarvis, P., Turner, A., Read, P., et al. (2022). Reactive strength index and its associations with measures of physical and sports performance: A systematic review with meta-analysis. *Sports Medicine, 52*, 301–330. https://doi.org/10.1007/s40279-021-01566-y

Keesey, R. E. (1993). The regulation of body weight. *Physiology & Behavior.* https://www.researchgate.net/publication/19197721_The_Regulation_of_Body_Weight

Knudson, D., & Morrison, C. (2002). *Qualitative analysis of human movement* (3rd ed.). Human Kinetics.

Linnamo, V., Komi, P. V., & Häkkinen, K. (1992). Propulsion forces as a function of intensity for various jumping movements. *Journal of Strength and Conditioning Research, 6*(3), 158–163. https://journals.lww.com/nsca-jscr/abstract/1992/08000/propulsion_forces_as_a_function_of_intensity_for.1.aspx

Peng, H.-T., Khuat, C. T., Kernozek, T. W., Wallace, B. J., Lo, S.-L., & Song, C.-Y. (2017). Optimum drop jump height in Division III athletes: Under 75% of vertical jump height. *International Journal of Sports Medicine, 38*(11), 842–846. https://doi.org/10.1055/s-0043-114011

Reiser, R. F., Rocheford, E. C., & Armstrong, C. J. (2000). Building a better understanding of the vertical jump. *Journal of Strength and Conditioning Research, 14*(3), 207–215.

Sensors. (2023). Stretch-shortening cycle and reactive strength index definitions. *Sensors, 25*(1), 151. https://www.mdpi.com/1424-8220/25/1/151

Taylor, K.-L., Chapman, D., Cronin, J., Newton, M., & Gill, N. (2021). Variations in jump height calculated from force platform-derived variables. *Sports Biomechanics, 20*(6), 663–677.

Topend Sports. (n.d.). Vertical jump: Average values, testing methods and biomechanics. https://www.topendsports.com/testing/norms/vertical-jump.htm

Wilmore, J. H., & Costill, D. L. (1994). *Physiology of sport and exercise* (2nd ed.). Human Kinetics.

Winter, D. A. (2009). *Biomechanics and motor control of human movement* (4th ed.). Wiley. https://onlinelibrary.wiley.com/doi/book/10.1002/9780470693797

Zatsiorsky, V. M., & Kraemer, W. J. (2010). *Science and practice of strength training.* Thieme. https://www.thieme-connect.com/products/ejournals/abstract/10.1055/s-0029-1242815

Ziv, G., & Lidor, R. (2023). Peak propulsive force and jump biomechanics in trained athletes. *Journal of Sports Medicine.* https://pubmed.ncbi.nlm.nih.gov/36676138/