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Reaching the baseline: A comparative case study of anthropometric extremes in Division I female tennis players

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ABSTRACT

The purpose of this case report was to contrast the biomechanical and physiological characteristics of two Division I female tennis players representing opposite ends of the anthropometric spectrum to determine how diverse somatic types achieve elite performance. Subject A (Height-Dominant) is a 188 cm server relying on lever length. Subject B (Power-Dominant) is a 157 cm all-court player relying on neuromuscular power. Both underwent comprehensive physical profiling (range of motion, isometric strength, countermovement jump) and match performance analysis using computer vision technology (SwingVision) during one competitive set. Outcomes revealed that Subject A generated substantially higher peak serve velocity (74 mph vs. 67 mph) and utilized sharp placement angles, leveraging her height. Subject B compensated for a 31 cm height deficit with superior neuromuscular output (CMJ: 34.9 cm) and a 100% deep return rate on second serves. The conclusion is that elite performance in collegiate tennis is not homologous. While anthropometric height provides a distinct advantage in serving velocity and geometry, shorter athletes can compete effectively through superior ground force production and rotational maneuverability. Training programs must be individualized: stability-focused for taller athletes to control long levers, and power-focused for shorter athletes to maintain kinetic chain efficiency. As this is a case study of two athletes, these findings highlight the need for individualized analysis rather than broad generalization.

Key words: Tennis, Anthropometry, Biomechanics, Performance, Somatotype

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INTRODUCTION

The physiological landscape of tennis has undergone a radical transformation over the last three decades. The transition from wood to graphite racquets, accompanied by changes in court surfaces and ball technology, has shifted the sport from a game of finesse and tactical patience to one of explosive power and high-velocity collisions. In this modern era, anthropometry—specifically height and limb length—has emerged as a critical variable in talent identification and performance modeling (Germic et al., 2025). Historical analysis of professional rankings indicates a steady increase in the average height of elite female players, supporting the hypothesis that taller athletes possess distinct biomechanical advantages that are increasingly necessary for success at the highest levels (Fernandez-Fernandez et al., 2014).



The primary argument for the "taller is better" paradigm centers on the mechanics of the service motion. Recent research confirms that anthropometric parameters, particularly body height, are strongly correlated with service velocity in elite competition (Baiget et al., 2023; Sanchez-Pay et al., 2021). The serve is the only closed-skill shot in tennis, where the athlete has complete control over the ball's placement and velocity. From a physics perspective, a higher release point provides two distinct advantages: trajectory and velocity. A taller player can strike the ball at a steeper angle of incidence relative to the court surface. This geometric advantage allows the ball to clear the net with a greater margin for error while still landing within the service box.

Roetert et al. (2009) suggest that for every inch of added height, the "serve window"—the theoretical area above the net

through which a ball must pass to land in—expands significantly. Conversely, shorter athletes must rely on spin (the Magnus effect) to bring the ball down into the court, which often requires a sacrifice in linear velocity (Fett et al., 2020). Therefore, the prevailing biomechanical model suggests that taller athletes can generate higher velocities with less effort, utilizing their long levers to create racquet head speed through a wider arc of motion.

Despite the theoretical advantages of height, the collegiate landscape remains phenotypically diverse. Division I rosters are not populated exclusively by athletes over 180 cm; rather, they feature a wide distribution of body types. This persistence suggests that height is not the sole determinant of success and that alternative motor characteristics must exist (Luna-Villouta et al., 2021). Kovacs (2007) highlights the importance of the kinetic chain—the sequential transfer of energy from the ground up through the body segments—as a great equalizer.

Shorter athletes, who possess a lower center of mass, often exhibit superior agility, balance, and change-of-direction speed (Scamardella et al., 2025). Furthermore, they may compensate for their lack of lever length by generating superior ground reaction forces (GRF). By loading the legs more aggressively and utilizing a more explosive extension sequence, a shorter player can generate vertical and rotational forces that rival those of their taller counterparts. This "summation of speed" principle suggests that while the taller player relies on the radius of the swing arc, the shorter player relies on the angular velocity of the rotation.

While numerous studies have profiled the physical characteristics of tennis players (Sánchez-Muñoz et al., 2007), most utilize group-based means that obscure individual variances. There is a paucity of literature that directly compares how two athletes of vastly different somatic types achieve similar competitive outcomes. How does the shorter athlete survive in a game increasingly dominated by serving power? What is the physiological cost of their compensation strategies?

The purpose of this case report was to contrast the biomechanical, physiological, and tactical characteristics of two Division I female tennis players representing opposite ends of the anthropometric spectrum (99th vs. 5th percentile). By integrating clinical physical profiling with match-play data derived from computer vision analysis, we aim to define the distinct "Leverage" versus "Power" signatures that allow these contrasting archetypes to achieve elite performance. This analysis seeks to challenge the "one-size-fits-all" approach to coaching and provide evidence for individualized training interventions based on somatic type.

METHODS AND PROCEDURES

Experimental Design

This study utilized a comparative case study design to analyze the distinct physiological and biomechanical profiles of two collegiate athletes. This approach was selected to allow for a granular analysis of how contrasting anthropometric phenotypes navigate the demands of Division I tennis, providing specific insights that are often lost in large-cohort aggregate data.

Subjects

Two female NCAA Division I tennis players from the same university team were selected for this case study. The selection criteria were based on maximizing the anthropometric contrast between teammates who compete at the same level of play.

- Subject A (Height-Dominant): Age 22, 188 cm (6'2") tall, weight 79.4 kg (175 lbs). Subject A represents the ectomorphic/mesomorphic blend typical of the modern "power server." Her playing style is characterized by aggressive first-strike tennis.

- Subject B (Power-Dominant): Age 20, 157 cm (5'2") tall, weight 60 kg (132 lbs). Subject B represents a mesomorphic, compact build. Her playing style is characterized as an "all-court counter-puncher," relying on movement and consistency.

Ethical Considerations

Written informed consent was obtained from both subjects for the publication of this case report and accompanying data. The study protocol adhered to the Declaration of Helsinki and was approved by the university's institutional review board (IRB) for exempt research involving standard athletic performance monitoring.

Physical Examination

A comprehensive battery of physical tests was administered to establish a baseline musculoskeletal profile. Test selection was based on established protocols in tennis medicine literature for assessing risk factors and performance indicators (Ellenbecker & Roetert, 2003; Sanchez-Pay et al., 2021).

- Isometric Strength: Strength was assessed using a Jamar digital handheld dynamometer (Patterson Medical, Warrenville, IL). The "make test" protocol was used, where the examiner holds the dynamometer stationary while the athlete exerts maximal force against it for 3-5 seconds. Three trials were averaged for each position. Key muscle groups tested included the shoulder external rotators (posterior cuff), internal rotators (anterior cuff/pecs), hip abductors (gluteus medius), and hip extensors (gluteus maximus).

- Range of Motion (ROM): Passive ROM was measured using a standard double-arm goniometer. Particular attention was paid to the glenohumeral joint (total arc of motion) and hip internal/external rotation, as these are common sites of adaptation in rotational athletes (Moreno-Pérez et al., 2016).

- Neuromuscular Power: Lower body explosive power was quantified via Countermovement Jump (CMJ) height. Data was collected using the MyJump app (iOS), which utilizes high-speed camera footage to calculate jump height based on flight time. This tool has been validated against force platforms in scientific literature as a reliable field-based measure of vertical power.

Match Analysis

To bridge the gap between clinical metrics and on-court performance, one competitive set of singles match play was analyzed for each subject. The match data was captured using SwingVision (Cupertino, CA), a mobile artificial intelligence platform that utilizes a single camera mounted on the back fence. The software uses computer vision algorithms to track ball trajectories, player positioning, and shot outcomes in real-time.

Key Performance Indicators (KPIs) extracted included:

- Serve Velocity: Peak speed for 1st and 2nd serves (mph).

- Serve Placement: Heat maps distinguishing between "T" (center), Body, and Wide serves.

- Shot Consistency: The percentage of returns landing in the court and the depth of those shots (past the service line).

- Groundstroke Velocity: Average ball speed for forehand and backhand groundstrokes.

RESULTS

The anthropometric disparity between the subjects was substantial. Subject A possesses a 31 cm (12.2 inch) height advantage and a 19.4 kg (43 lb) mass advantage. Despite the mass disadvantage, Subject B demonstrated superior neuromuscular explosive capabilities.

Table 1
Anthropometric and Neuromuscular Profile Comparison.

Variable	Subject A (Height-Dominant)	Subject B (Power-Dominant)	Difference
Anthropometry			
Height	188 cm (6'2")	157 cm (5'2")	+31 cm (Subject A)
Weight	79.4 kg	60.0 kg	+19.4 kg
Experience	3 Years (D1)	2 Years (D1)	+1 Year
Neuromuscular Power			
CMJ Height	26.7 cm	34.9 cm	+8.2 cm (Subject B)

Note: CMJ = Countermovement Jump; D1 = Division 1 collegiate level.

Subject B's CMJ of 34.9 cm was 30% higher than Subject A's 26.7 cm, indicating a reliance on vertical force production to overcome stature limitations.

The match analysis revealed how these physical traits translated into ball mechanics. Subject A dominated the serve velocity metrics, hitting a peak of 74 mph compared to Subject B's 67 mph. However, the return game favored the shorter, more agile athlete.

Table 2
Match Performance and Tactical Analysis (SwingVision Data).

Metric	Subject A (Height-Dominant)	Subject B (Power-Dominant)	Analysis
Serve Velocity			
Peak 1st Serve Speed	74 mph	67 mph	+7 mph (Subject A)
Peak 2nd Serve Speed	69 mph	62 mph	+7 mph (Subject A)
Serve Placement (Deuce)			
"T" / Center	47%	10%	Subject A targets lines.
Body	15%	50%	Subject B jams opponent.
Wide	38%	40%	Comparable usage.
Return Game			
1st Return Consistency	76% In	100% In	Subject B superior consistency.
2nd Return Depth	83% Deep	100% Deep	Subject B superior depth.
Groundstrokes			
Forehand Speed (Avg)	52 mph	52 mph	Equal.
Backhand Speed (Avg)	54 mph	44 mph	Subject A superior drive.

Marked differences were observed in shoulder mechanics and hip strength. Subject B exhibited classic signs of overhead adaptation, including Glenohumeral Internal Rotation Deficit (GIRD), but compensated with superior absolute rotator cuff strength.

Table 3
Musculoskeletal Profile (Dominant Side).

Variable	Subject A (Height-Dominant)	Subject B (Power-Dominant)	Interpretation
Shoulder ROM			
Internal Rotation	77°	47°	Subject B exhibits GIRD.
External Rotation	80°	92°	Subject B has ER Gain.
Total Arc of Motion	157°	139°	Subject A is hypermobile.
Isometric Strength			
Shoulder Internal Rotation	32.5 lbs	37.0 lbs	Subject B is stronger.
Hip Extension	58.3 lbs	66.3 lbs	Subject B stronger deceleration.
Hip Abduction	30.6 lbs	30.0 lbs	Subject B stronger relatively.

DISCUSSION

This case study elucidates two distinct biomechanical pathways to Division I tennis. Subject A utilizes a "Leverage Strategy." Her height provides a high moment of inertia, allowing her to create racquet-head speed through a long swing radius rather than maximal muscular effort. This aligns with findings by Baiget et al. (2023), who identified that height and anthropometry are primary drivers of service velocity in elite populations. Subject A's relatively lower CMJ (26.7 cm) suggests she does not need to generate maximal ground reaction forces to achieve a 74 mph serve because her release point height naturally optimizes the throw. However, this efficiency may lead to a de-emphasis on lower-body loading, potentially limiting her ceiling if she were to integrate more explosive mechanics.

In stark contrast, Subject B employs a "Power Strategy." Every shot requires a near-maximal recruitment of the kinetic chain. Her 34.9 cm vertical jump indicates she uses the ground aggressively to transfer energy up through the trunk and into the racquet. Notably, she matches Subject A's average forehand speed (52 mph) and exceeds it cross-court (54 mph) despite a significant disadvantage in arm length. This finding validates the "summation of speed" principle and correlates with research by Scamardella et al. (2025), which highlights how anthropometric disadvantages in tennis can be offset by superior neuromuscular qualities. She effectively muscles the racquet through the zone, evidenced by her superior shoulder internal rotation strength (37.0 lbs vs. 32.5 lbs).

The serve placement data provides a fascinating window into how anthropometry dictates tactics. Subject A heavily favored

the "T" serve on the Deuce side (47%). Because of her height, she can view the service box with a steeper angle, allowing her to target the lines with a flat trajectory (Roetert et al., 2009). Subject B, limited by a flatter release height relative to the net, adopts a "Body Serve Strategy," directing 50% of her Deuce serves into the opponent's body. This is a tactical compensation for a biomechanical limitation, consistent with Fett et al. (2020), who noted that shorter players must often rely on varying location and spin rather than pure velocity.

While Subject A dominates the serve, Subject B dominates the return, posting a 100% consistency rate on 2nd serve returns and a 100% depth rate. This reversal of fortune can be explained by the physics of rotational inertia. Long levers (Subject A) require more torque to initiate movement and more time to change direction. Subject B, with shorter limbs, possesses a lower moment of inertia. She can adjust her racquet face and body position rapidly. This agility advantage makes her significantly more effective at neutralizing the server's advantage.

The most critical finding for sports medicine practitioners is the divergence in physiological "cost" and injury risk. Subject A must stabilize a long spinal column, and her hypermobility suggests a reliance on passive structures. In contrast, Subject B pays a "tax" for her power, exhibiting Glenohumeral Internal Rotation Deficit (GIRD) with a 30-degree deficit compared to Subject A. This adaptation is common in high-velocity overhead athletes (Ellenbecker et al., 2002; Rose & Noonan, 2018). Because Subject B must generate more arm speed to match Subject A's ball velocity, her posterior shoulder musculature and capsule are under higher chronic tension.

Limitations

It is important to acknowledge the limitations of this study to contextualize the findings. First and foremost, this is a case study of only two athletes (n=2). While this allows for deep individual analysis, the results cannot be statistically generalized to the broader tennis population. The findings represent specific phenotypic adaptations rather than universal rules. Second, match analysis was limited to a single competitive set per player. While this provides a snapshot of performance, longitudinal data across a full season would provide a more robust understanding of consistency and fatigue profiles. Finally, while SwingVision is a powerful tool for tactical analysis, it does not offer the same biomechanical precision as 3D motion capture systems regarding joint kinematics. Future research should utilize larger sample sizes stratified by somatotype to validate these observational trends.

Practical Applications

Based on the findings that elite tennis performance is reached through divergent physical pathways, strength and conditioning programs cannot be uniform.

1. Interventions for the Height-Dominant Athlete: Focus on core stability, deceleration control, and end-range strength to protect the long spinal lever.
2. Interventions for the Power-Dominant Athlete: Focus on posterior capsule mobility (GIRD management), power maintenance, and pelvic stability to manage high internal tissue loads.
3. Tactical Coaching: Taller players should leverage "Serve + 1" patterns, while shorter players should utilize body serves to jam opponents and rely on superior conditioning.

CONCLUSION

The comparison of these two athletes demonstrates that there is no single phenotype for Division I tennis success. While anthropometric height provides a distinct advantage in serving velocity and geometry, elite neuromuscular power can bridge the gap. The Height-Dominant athlete succeeds through efficiency and geometry, while the Power-Dominant athlete succeeds through work rate, ground force production, and rotational agility. However, these strategies come with distinct physiological costs. Clinicians and coaches must recognize that the shorter, explosive athlete often bears higher internal tissue loads to produce equivalent external results. Therefore, training and recovery protocols must be individualized based on the athlete's somatic type and specific biomechanical demands.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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