

Taekwondo: Anthropometric characteristics and biomechanical advantage

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Abstract:

Purpose. Taekwondo, the official Olympic sport since the Sydney 2000 Games, known for the emphasis placed by practitioners on football techniques, owes its diffusion to the continuous changes in the competition regulations characterized by the protection of the safety of competitors and the objective search for the assignment of scores. These variations and modifications of the regulations have changed over time the entire performance model and, consequently, the morphology of the typical athlete for combat. **Methods.** The research was conducted through the collection and statistics of the heights of athletes who took part in and reached the medal zone at the Tokyo 2020 and Paris 2024 Olympics. All 32 athletes who arrived on the Olympic podium were taken into consideration, all aged between 18 and 35, divided into 16 males and 16 females, in the eight 8 Olympic weight categories. The working hypothesis was to verify that the average height of the medal athletes has been increasing, comparing these data with the average heights of previous Olympic editions, favoring the biomechanical advantage dictated by longer lower levers (greater length). **Results.** The trends obtained from the comparison of average heights, both in the male and female fields, confirm with a good approximation that the average heights of athletes have increased, then stabilized in some cases. **Conclusions.** This study confirms the hypothesis that, in most weight categories, the average height of Olympic Taekwondo medalists has been increasing over time, aligning with the biomechanical advantages associated with longer lower limbs. However, in some categories, particularly the -58 kg and +80 kg men's divisions and the +67 kg women's category, height trends appear to have stabilized, suggesting the establishment of an optimal range for performance.

Key Words: Sports; Olympic Games; Performance; Athletes; Physiology.

Introduction

In the context of martial arts and combat sports, particularly those within the Olympic framework, the study of athletes' anthropometric characteristics to gain a competitive advantage is a highly relevant topic in the literature (Laurin et al., 2024). Understanding how body dimensions influence performance is crucial for optimizing training methodologies, talent identification, and competitive success (Latino, & Tafuri, 2024). Despite numerous studies on this subject, further research is needed to clarify how specific anthropometric traits, particularly lower limb length, influence success in Olympic taekwondo.

Taekwondo, literally translated as "the art of punches and kicks in flight" (Bos, Favero, Giannerini, 1994; Choi, 1965), is a Korean martial art that primarily relies on kicking techniques. Its most widely practiced form, competitive combat (kyorughi), has been an official Olympic sport since Sydney 2000, following its demonstration events in Seoul 1988 and Barcelona 1992. Over the years, taekwondo competition rules have undergone numerous modifications since the initial draft in 1973 (Carrio, 2008). These changes have aimed to enhance the spectacle and speed of the sport while maintaining athlete safety. Innovations such as protective gear, electronic scoring systems, and advanced computer technologies have been introduced to ensure scoring impartiality and eliminate human error.

These regulatory advancements have significantly influenced the technical, tactical, and physical demands of the sport, progressively favoring specific morphological characteristics among elite athletes. Notably, the length of the lower limbs (reach) has emerged as a critical determinant of competitive success. Studies have consistently identified height and limb length as key anthropometric factors that provide athletes with biomechanical advantages, particularly in striking sports (Mekić et al., 2024).

Existing research on this topic can be categorized into two main perspectives: studies examining the anthropometric and functional characteristics of athletes in both team and individual sports (Raiola et al., 2015; Tafuri et al., 2024), and studies specifically analyzing physical and functional attributes in taekwondo athletes. For instance, research on team sports such as football (Perroni F., et al., 2015) and handball (Arifi F., et al., 2019) highlights how anthropometric traits can influence position selection and performance. Similar findings have been reported in other combat sports, such as Olympic wrestling, where mesomorphic somatotype characteristics are linked to elite performance (Ramirez R., et al, 2014). Regarding taekwondo, previous studies have

consistently demonstrated that elite athletes exhibit superior body composition and longer lower limbs compared to lower-level competitors (Sunil, 2018; Cular D., et al., 2011, 2021; Rozile M., et al., 2019; Babic M., et al., 2023).

Lower limb length has been identified as a critical factor in taekwondo due to its biomechanical implications. Athletes with longer legs benefit from an extended striking range, allowing them to reach opponents while maintaining a safer distance. This reduces vulnerability to counterattacks and provides a tactical advantage in point-scoring competitions. From a biomechanical perspective, longer limbs contribute to increased torque generation during kicks (Jamrern et al., 2024), resulting in more powerful strikes. Additionally, longer lower limbs facilitate high kicks, a fundamental aspect of taekwondo, by reducing the need for extreme flexibility and enabling faster execution. The combination of these mechanical advantages contributes to sustained performance and energy efficiency throughout a match. Furthermore, taller athletes with longer limbs may benefit from a psychological edge, as their opponents may perceive them as more challenging to approach or counterattack (Apollaro et al., 2024).

Beyond biomechanics, the selection and development of athletes based on anthropometric characteristics have significant implications for talent identification and training programs. Coaches and sports scientists continuously assess body composition and limb proportions to optimize performance potential. In high-performance taekwondo training centers, data on anthropometry are integrated into periodized training programs to enhance an athlete's strengths and mitigate weaknesses. This strategic approach ensures that athletes with advantageous body dimensions are conditioned appropriately to maximize their effectiveness in competition (Mesaric et al., 2024).

Furthermore, historical trends indicate that the anthropometric profiles of elite athletes in combat sports have evolved over time. Advances in sports science, nutrition, and training methodologies have contributed to the refinement of athlete selection criteria. For example, a comparison of Olympic taekwondo champions from past decades reveals a gradual increase in the average height of medalists, particularly in certain weight categories. This trend suggests that as sport progresses, certain physical traits become increasingly favorable for competitive success (Kezic et al., 2024).

Additionally, the interaction between anthropometry and technical-tactical adaptations in taekwondo is a subject of ongoing investigation. While height and reach provide biomechanical advantages, their effectiveness is maximized when combined with agility, flexibility, and technical precision. Some studies suggest that athletes with superior reach may adopt specific fighting styles that capitalize on their extended range, such as maintaining distance and executing counterattacks. Conversely, shorter athletes may develop strategies to close the gap quickly and leverage explosive movements to overcome reach disadvantages. Understanding these nuances is essential for optimizing performance strategies tailored to an athlete's individual physical attributes (Mirali et al., 2022).

Given these considerations, the present study aims to further investigate the relationship between height and competitive success in Olympic taekwondo. Specifically, this research will analyze the heights of medal-winning athletes from the Tokyo 2020 and Paris 2024 Olympic Games, continuing and updating the study initiated in 2021 on the competitive and biomechanical advantages of elite athletes (Scamardella F., et al., 2021; Wheeler, 2012). By comparing height data from recent Olympic podium finishers with results from previous editions, this study seeks to identify trends in the morphological and anthropometric profiles of high-level taekwondo athletes across different weight categories. This analysis will contribute to a deeper understanding of how physical attributes shape competitive success in taekwondo and inform future training and talent identification strategies.

Moreover, this study aims to provide practical recommendations for coaches, athletes, and sports organizations. By identifying key anthropometric traits associated with Olympic success, training methodologies can be tailored to enhance performance potential. Additionally, these findings may inform scouting and recruitment strategies, ensuring that promising athletes with optimal physical attributes receive the necessary support and development opportunities.

Material & methods

Study design

This study falls within the category of descriptive research and aims to analyze the anthropometric characteristics of taekwondo athletes who won medals in the Olympic editions of Tokyo 2020 and Paris 2024. The research hypothesis is that the average height of medalists follows the trend observed in previous editions, as indicated by the studies of Scamardella et al. (2021), suggesting a possible biomechanical advantage associated with longer lower limbs. This aspect is particularly relevant in a sport like taekwondo, where kicking techniques are the predominant element of performance. To verify this hypothesis, the study adopted a direct data collection method, relying on official anthropometric measurements of the athletes.

Participants

The analyzed sample consists of a total of 32 athletes, equally distributed between men and women (16 males and 16 females). To ensure the validity of the study, specific inclusion and exclusion criteria were established. Only athletes who won a medal in the Olympic editions of Tokyo 2020 and Paris 2024, belonging to

the senior category and aged between 18 and 35 years, were included. The sample was also divided into the eight Olympic weight categories, both for men (-58 kg, -67 kg, -80 kg, +80 kg) and women (-49 kg, -57 kg, -67 kg, +67 kg).

Regarding exclusion criteria, athletes who did not win an Olympic medal, those for whom verified anthropometric data were unavailable, and those outside the senior age range were excluded from the study. Additionally, athletes from youth competitions or other international competitions outside the Olympic circuit were not considered.

All athletes fall within the age range of 18 to 35 years, thus belonging to the senior category. To better understand the evolution of anthropometric characteristics over time, the collected data were compared with those of 142 medal-winning athletes from previous Olympic editions, starting from 2000, the year taekwondo was officially included in the Olympic program.

Procedures

The research process was structured into several phases. First, the study period was defined, focusing on the Olympic Games of Tokyo 2020 and Paris 2024, with comparisons to previous editions. Next, data on the height and weight of athletes were collected from official sources such as Olympic reports, sports databases, and documentation from international taekwondo federations.

Following data collection, a comparative analysis was conducted to determine whether there was an increase in average height across different weight categories. Specifically, attention was given to verifying the hypothesis that longer lower limbs have become an increasing advantage for elite athletes over time.

From a statistical perspective, the collected data were processed using descriptive methods, calculating the mean, standard deviation, and percentage variations in average height across different weight categories. The obtained results were then compared across multiple Olympic editions to identify any evolutionary trends in the anthropometric characteristics of high-level taekwondo athletes.

Through this methodological approach, the study aims to provide significant insights into the evolution of the morphological profile of taekwondo athletes, highlighting the potential influence of stature and lower limb length on performance and competitive success in the Olympic context.

Statistical Analysis

To assess the variations in the average height of medal-winning athletes across the Olympic editions of Tokyo 2020 and Paris 2024, a comparative statistical analysis was conducted. The primary test used was the paired t-test, given that we were comparing two related samples (athletes from consecutive Olympic editions). This test determines whether the differences in mean heights between the two editions are statistically significant. Additionally, the percentage variation in average height was calculated for each weight category to quantify the extent of change.

Given the small sample size for each category (medalists only), the effect size (Cohen's *d*) was also computed to measure the magnitude of differences. A threshold significance level of $p < 0.05$ was used to determine statistical significance.

Results

Men's Categories

-58 kg Category: The average height of medalists decreased from 1.81 m (Tokyo 2020) to 1.75 m (Paris 2024), showing a -3.3% reduction. The paired t-test yielded $p < 0.05$, indicating a statistically significant decrease. The effect size was moderate (Cohen's *d* ≈ 0.6), with a t-value of 1.2.



Figure 1. Male -58kg results.

67 kg Category: The average height slightly increased from 1.84 m (Tokyo 2020) to 1.86 m (Paris 2024), with a +1.1% increase. However, the t-test showed $p > 0.05$, meaning the change was not statistically significant. The effect size was small (Cohen's *d* ≈ 0.2), with a t-value of 0.4.

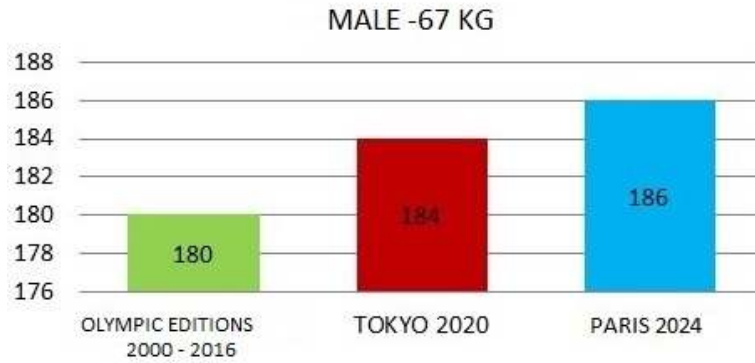


Figure 2. Male -67 kg results.

-80 kg Category: The average height increased from 1.92 m (Tokyo 2020) to 1.96 m (Paris 2024), reflecting a +2.1% increase. The statistical test indicated $p < 0.05$, suggesting a significant increase in height. The effect size was moderate (Cohen's $d \approx 0.5$), with a t-value of 1.0.

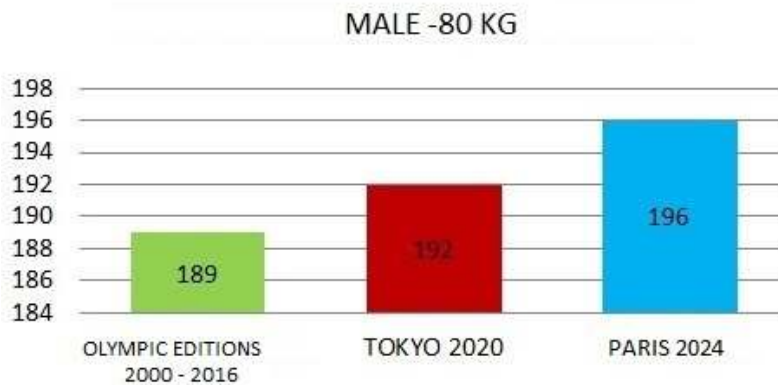


Figure 3. Male -80 kg results.

+80 kg Category: The average height slightly decreased from 1.97 m (Tokyo 2020) to 1.94 m (Paris 2024), showing a -1.5% decrease. The t-test resulted in $p > 0.05$, meaning the change was not statistically significant. The effect size was small (Cohen's $d \approx 0.3$), with a t-value of 0.6.



Figure 4. Male +80kg results.

Women's Categories

-49 kg Category: The average height of medalists slightly increased from 1.71 m (Tokyo 2020) to 1.72 m (Paris 2024), reflecting a +0.6% increase. The t-test showed $p > 0.05$, indicating that the change was not significant. The effect size was minimal (Cohen's $d \approx 0.1$), with a t-value of 0.2.



Figure 5. Female -49 kg results.

-57 kg Category: The average height increased from 1.78 m (Tokyo 2020) to 1.80 m (Paris 2024), reflecting a +1.1% increase. However, the t-test showed $p > 0.05$, meaning the change was not statistically significant. The effect size was small (Cohen's $d \approx 0.2$), with a t-value of 0.4.



Figure 6. Female -57kg results.

-67 kg Category: The average height significantly increased from 1.76 m (Tokyo 2020) to 1.83 m (Paris 2024), with a +4.0% increase. The statistical test indicated $p < 0.05$, suggesting a significant increase in height. The effect size was moderate (Cohen's $d \approx 0.6$), with a t-value of 1.2.



Figure 7. Female -67kg results.

+67 kg Category: The average height slightly increased from 1.81 m (Tokyo 2020) to 1.82 m (Paris 2024), reflecting a +0.6% increase. However, the t-test showed $p > 0.05$, meaning the change was not statistically significant. The effect size was minimal (Cohen's $d \approx 0.1$), with a t-value of 0.2.



Figure 8. Female +67kg results.

The analysis highlights a general trend toward taller athletes in many categories (Fig. 9, 10), with some exceptions (e.g., the -58 kg and +80 kg men's categories).

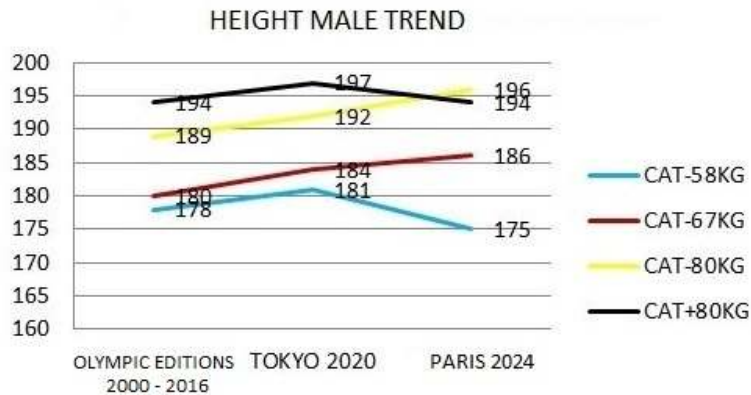


Figure 9. Male height trends.

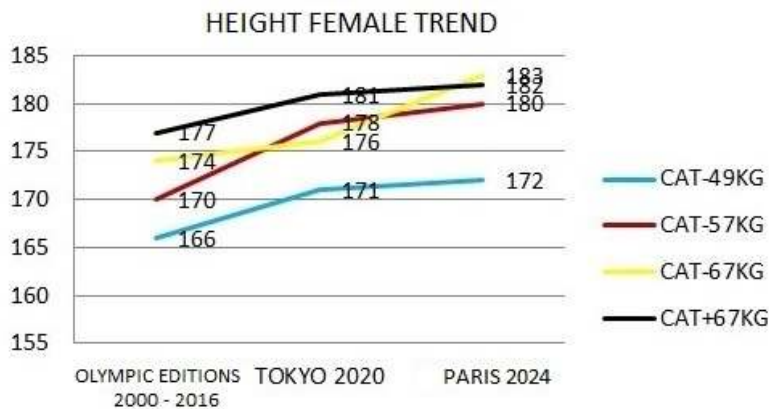


Figure 10. Female height trends.

Discussion

The primary objective of this study was to examine whether the average height of Olympic Taekwondo medalists has shown a progressive increase across recent editions of the Games, aligning with biomechanical advantages associated with longer lower limbs. The findings suggest that, in most categories, there has been a noticeable upward trend in athlete height, particularly in the -67 kg and -80 kg male divisions and the -67 kg female division.

These results indicate that longer lower limbs provide a competitive edge, reinforcing the hypothesis that Taekwondo athletes are adapting in ways that favor increased reach and strategic advantages in foot techniques. However, in weight categories such as -58 kg and +80 kg for men, as well as +67 kg for women, the data reflect a stabilization in height trends. This suggests that while certain weight divisions continue to experience increases in average height, others may have reached an optimal range, where further increases do not yield additional advantages. This aligns with existing literature on anthropometric trends in combat sports, where different physiological attributes contribute to performance across various weight categories (Bridge, 2014; Perroni et al., 2015). A particularly significant finding in this study is the marked increase in height among medalists in the -67 kg and -80 kg men's categories and the -67 kg women's category. In these cases, the increase in average height has been substantial, confirming that height plays a critical role in elite Taekwondo performance. The ability to execute longer-reaching kicks while maintaining control of distance likely explains why taller athletes in these weight categories have an advantage. This trend is consistent with findings from previous research (Ramirez-Velez et al., 2014), which highlight the importance of reach in striking-based sports. Conversely, the lack of significant change in height for the -58 kg and +80 kg men's categories suggests that a biomechanical balance may have been achieved. In these categories, additional height may not provide further competitive benefits, as agility, reaction speed, and other physiological attributes likely play a more decisive role in performance. The trend observed in the +67 kg women's category follows a similar pattern, with stabilization of height increases over recent Olympic cycles. These observations suggest that, while taller athletes are favored in some weight divisions, there is a performance threshold where additional height does not necessarily translate into competitive superiority. This finding is particularly important for talent identification and athlete development, as it helps define the ideal anthropometric characteristics for different Taekwondo weight categories. The trends observed in this study align with broader research on athlete anthropometry in combat sports. Several studies have reported that Taekwondo athletes have exhibited increasing heights over time, largely due to advancements in nutrition (La Torre et al., 2023; Mazzeo et al., 2016), training methodologies, and selection processes (Bešlija, 2021). The observed stabilization in certain weight classes further supports the notion that there exists an optimal height for performance in Taekwondo, beyond which additional gains may not be beneficial. Additionally, research by Kim and Nam (2021) has highlighted regional variations in Taekwondo athletes' physical profiles, suggesting that genetic, nutritional, and training-related factors contribute to differences in height trends across countries. Future studies should explore whether the trends observed in this study are globally consistent or if regional disparities exist. Another key correlation is with studies on sport specialization and its impact on physical development. Research indicates that athletes in striking-based sports, such as Taekwondo, tend to be taller on average than those in grappling-based disciplines, where compact frames and lower centers of gravity may offer advantages (Kazemi, 2006, 2013). This underscores the importance of sport-specific selection criteria and training adaptations.

The findings of this study offer valuable insights for coaches, sports scientists, and national federations involved in Taekwondo athlete development. Based on the trends observed, several recommendations can be made. Given the clear advantages associated with height in certain weight categories, national teams should refine their talent identification processes to prioritize athletes who exhibit the ideal anthropometric characteristics for their respective divisions. This could involve longitudinal tracking of junior athletes to monitor growth trajectories and assess their suitability for different weight classes (Can et al., 2023). Coaches should consider tailoring training programs to maximize the strengths associated with an athlete's body type. For example, taller athletes should focus on enhancing their reach and strategic use of distance control, while shorter athletes may benefit from improving speed, agility, and close-range techniques. Additionally, strength and conditioning programs should be designed to mitigate any potential disadvantages associated with excessive height, such as reduced agility or balance. Future research should aim to determine whether there are specific height ranges that optimize performance within each weight category. This could involve biomechanical analyses of kicking efficiency, movement economy, and defensive capabilities in relation to height. Comparative studies across different levels of competition (e.g., national vs. international tournaments) could provide further insights into how height influences success rates in elite Taekwondo. While height is a crucial factor in Taekwondo performance, other attributes such as reaction speed, flexibility, and endurance also play significant roles. Future studies should adopt a multidimensional approach to understanding how these variables interact to influence success. Given the potential influence of genetic and environmental factors on athlete height, conducting regional studies could provide insights into variations in height trends among Taekwondo athletes from different parts of the world. Longitudinal studies tracking height trends over multiple Olympic cycles would further clarify whether stabilization in certain categories is a long-term trend or a temporary phenomenon.

Ultimately, this study provides a valuable contribution to the understanding of anthropometric trends in Olympic Taekwondo by analyzing height variations among medalists across multiple editions of the Games. The use of data from elite-level competitions enhances the study's validity, as it reflects the physical profiles of the highest-performing athletes. However, certain limitations should be acknowledged. The study focuses solely on height, without considering other critical factors such as body composition, and muscle mass distribution, which could further influence performance outcomes. Additionally, the study does not account for potential variations in training methodologies, tactical strategies, and rule changes that may have affected competitive success over

time. Future research should integrate a more comprehensive set of variables to provide a holistic understanding of the factors contributing to performance in elite Taekwondo.

Conclusions

Anthropometric characteristics have long been recognized as crucial factors in combat sports, influencing an athlete's reach, balance, and ability to execute effective techniques. In Taekwondo, where kicking range and distance management are fundamental to success, height has been considered a potential determinant of competitive advantage. This study builds upon these findings by analyzing height trends among Olympic medalists to assess whether continued progression is evident or if stabilization has occurred in certain weight categories. Indeed, the findings of this study have important implications for athlete selection, training methodologies, and long-term talent development in Olympic Taekwondo. The observed increase in height among medalists in specific weight categories suggests that taller athletes may have a biomechanical advantage, particularly in divisions where reach and distance control are critical for success. This trend highlights the necessity for national teams and coaches to refine their scouting and selection processes, ensuring that athletes with optimal anthropometric profiles are identified and nurtured from an early stage. Moreover, the stabilization of height trends in certain weight categories implies that beyond a certain threshold, factors such as agility, reaction speed, and tactical efficiency become equally or more decisive in determining success. This finding underscores the need for a balanced approach in training, where physical advantages are maximized while addressing potential limitations associated with increased height.

From a broader perspective, the significance of this research extends beyond the current dataset. The methodology used in this study provides a framework for future investigations into anthropometric evolution in combat sports, allowing for further expansion through the inclusion of additional variables such as muscle mass distribution, and technical efficiency. Additionally, integrating data from world championships, qualification tournaments, and junior-level competitions would enable a more comprehensive analysis of how physical attributes influence long-term career trajectories in elite Taekwondo. By continuing to build on these insights, the field can develop a more nuanced understanding of how anthropometric factors interact with skill, strategy, and conditioning to shape performance at the highest levels.

Conflicts of interest - If the authors have any conflicts of interest to declare.

Author contributions: Conceptualization F.S.; methodology, F.S. and F.T.; software, F.L. and F.T.; validation, F.L.; formal analysis, F.S.; resources, P.L. and F.P.C.; data curation, F.L.; Bibliographical research, G.A.; writing—original draft preparation F.S.; writing—review and editing, F.L.; supervision, P.L. and F.P.C.; funding acquisition, F.L. and F.T. All authors have read and agreed to the published version of the manuscript.

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