

Taekwondo, height and biomechanical advantage: state of the art after the Tokyo 2020 Olympic Games

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Abstract. Taekwondo, an ancient Korean martial art based mainly on the use of kicking techniques, became an official Olympic discipline at the Sydney 2000 Games. Currently, it is possible to observe the use of protection kits equipped with electronic sensors, which totally exclude the interpretation of the score and human error. It is also evident that these variations and changes in the rules have substantially changed the whole performance model, and consequently the morphology of the typical combat athlete. The objectives of this contribution will focus on the analysis of the height trends of taekwondo athletes who have won medals at all editions of the Olympic Games, from the first Sydney 2000 Olympic Games to the recently concluded Tokyo 2020 Games. The working assumption was to check that the average height of medal-winning athletes has been increasing edition after edition, favoring the biomechanical advantage provided by longer lower levers (reach). *Material and Method.* All 174 athletes who reached the Olympic podium, namely the winners, runners-up and third-place winners of each weight category (Olympic taekwondo medalists) were taken into consideration. The sample consists of 174 athletes, all aged between 18 and 35 years and comprising 87 males and 87 females, analyzing a period of twenty years and taking into account that the most recent Tokyo2020 edition was postponed by one year to 2021, due to the Covid19 pandemic. *Results.* The trends obtained by comparing the average heights, updated with data from the most recent Tokyo 2020 Olympics, confirm with a good approximation that the average heights of athletes has been increasing edition after edition. *Conclusion.* As for the conclusions, it is clear that the starting assumption was confirmed: the average height increased considerably, determining an important advantage in terms of biomechanical reach for the lower limbs.

Keywords: *Taekwondo, Olympics, average height, biomechanical advantage, reach, Tokyo 2020.*

Introduction

Within the scientific contributions in the field of martial arts and combat sports, the concept of research of the performance model and the functional prototype of the athlete is particularly current and stimulating. More specifically, taekwondo, literally "the art of flying kicks and punches" (1), is a Korean martial art based mainly on the use of kicking techniques. Its most popular style, the WTF (2) is also an Olympic discipline: at first, it was demonstrative (1988 Seoul Olympics and 1992 Barcelona Olympics), and then became fully integrated into the Olympic circuit from 2000 Sydney edition, until the most recent Tokyo 2020 edition. The perspectives of the studies carried out on the subject seem to be quite accurate, from the research works on the anthropometric and functional profile of the elite Olympic athlete (3,4), to those on the existing relationship between the athlete's height and taekwondo performance (5). Apparently limited are the studies of the latter mentioned strand, i.e. those concerning the relationship between the athlete's height and taekwondo performance: a field in which this research project will be included. The objectives of this contribution will focus on the analysis of height trends of taekwondo athletes who have won medals in all editions of the Olympic Games, from the first Sydney 2000 Olympic Games to the recently concluded Tokyo 2020 Olympic Games. After reviewing the main scientific interventions carried out with regards to the anthropometric profile, within the research of the taekwondo performance model, the idea is to analyze the statistical indicators of the medal-winning athletes in each game edition, in each weight and gender category, observing the changes in the trend of heights according to the various changes in the competition rules. The regulations of taekwondo's "kyorugi" (combat) discipline have undergone many variations and changes since May 28, 1973 (6), i.e. the year of their first draft, with numerous variations and changes. From the very first moment, these changes have increased the spectacular power and the executive speed of the techniques.

Furthermore, in order to safeguard the safety of the competitors, body protectors, helmets and protections for the lower and upper limbs have been introduced over time; in particular, they have been integrated with measurement sensors (6). Thanks to the use of these sensors and computer applications, a fully automated scoring system has been created. It is clear that these changes in the rules have substantially modified, generation after generation, the interpretation and implementation of the combat both from the technical-tactical and physical-conditional point of view. These changes have increasingly selected the morphology of the athletes suitable for the new performance models: in particular, a competitive advantage of no small importance has been identified in the reach of the lower limbs (7). The measurement of the athlete's height, directly related to the reach of the lower limbs and included in the set of anthropometric measurements together with other parameters in literature, may therefore be the first and obvious index of a change in the evolution phase.

Literature review. The sources used for this project were divided into preliminary, primary and secondary. Among the preliminary sources, a number of specialized sites dealing with the connections between height, weight categories and martial arts, were considered. Overall, these sources tend to question the subdivision of competitions by weight category in favor of the introduction of categories by height, like the introduction of electronic devices for assigning scores; as in the case of taekwondo, this has radically changed the performance model by leveling some conditional parameters in favor of anthropometric parameters such as height. Among the primary sources, as mentioned before, we can clearly find all studies and major research projects carried out on the relationship between taekwondo and the height and physical parameters of elite athletes. Many works deal with the relationship between the athlete's height and taekwondo performance. Some interesting contributions raise the question introduced earlier, i.e. if it is allowed to replace weight categories with height categories in martial arts (8). Other studies place the focus on the height of the taekwondo athlete for the purpose of a better performance (5), while other analyses consider the study of a height-based performance model for taekwondo to reduce the problems associated with sudden weight loss and safeguard the athletes' health (9). Another line of research concerns the investigation of the anthropometric and functional profile of the elite taekwondo athlete. Some interesting studies take into consideration the profile of the Olympic Taekwondo competitors, identifying some indexes such as weight, height, age, scored points, warnings, point deductions, number of defensive/offensive kicks and punches (15, 3,4), where the winners tended to be younger in age and with lower BMI indexes than the average of their weight category. Gaeini, who tried to determine the relationship between anthropometric, physiological and body composition characteristics of elite male taekwondo athletes with their sport success, based his contribution on the same considerations (10). Instead, other contributions aimed to determine the differences in some morphological characteristics and parameters of competitive effectiveness between winners and other competitors in Olympic competitions (11), and also between those selected and not selected for participating in the games (12).

Among the secondary sources we mainly find manuals and technical texts (13), which deal with taekwondo from the physical and performance point of view (14), as well as from the historical and philosophical perspective, and finally focusing on the competition rules and their evolution in relation to the progress of the performance model.

Material and Method

The research project is included in the experimental research category, and in this context, the methodology chosen and used was the data development study. The problem analyzed was to investigate why, as taekwondo professional practitioners and amateurs state, there has been a significant increase in the height of taekwondo athletes in the specialty of combat. The working assumption taken into consideration was therefore to verify that the average height of medal-winning athletes in the six editions of the Olympic Games, in which taekwondo has been included in a stable and regular way, has been increasing edition after edition, favoring the biomechanical advantage provided by longer lower levers, or the advantage generated by a longer reach.

In order to support and verify these assumptions, different data collection and analysis methods were used. The research was first carried out by collecting and statistically analyzing (15) the height, the weight at the time of the competition and the ages of the athletes (16) who took part in the Olympics from the Sydney 2000 edition up to the recently completed Tokyo 2020 edition.

All 174 athletes who reached the Olympic podium, namely the winners, runners-up and third-place winners of each weight category y (16) were taken into consideration. So the sample consists of 174 athletes, all aged between 18 and 35 years (senior category) divided into 87 males and 87 females, analyzing a period of twenty years and taking into account that the most recent Tokyo2020 edition was postponed by one year to 2021, due to the Covid19 pandemic.

Results

With regard to the data analysis, we tried to compare the heights of the 174 medalists for the male (-58 kg, -68 kg, -80 kg, +80 kg) and female (-49 kg, -57 kg, -67 kg, +67 kg) categories (12,17). All this by calculating, from time to time, the mathematical average for each weight category - for both men and women - and for each edition of the Olympic Games, possibly predicting an increase or decrease in each weight category first, and then based on gender differences. The objective of this data analysis was to obtain a time trend related to a specific weight category, in order to obtain an estimate in terms of height of the "prototype" suitable for each weight category (Figures 1- 10).

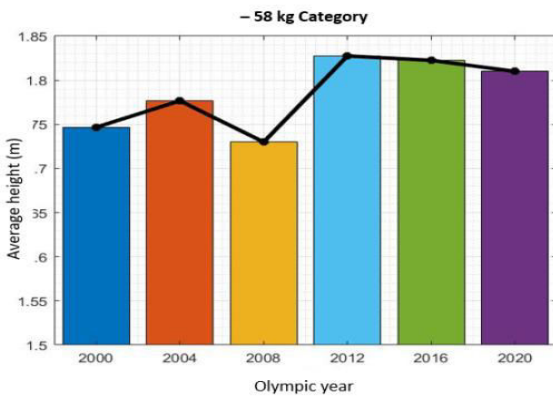


Figure 1. Average Heights, Cat. - 58kg.
Source: Our Processing

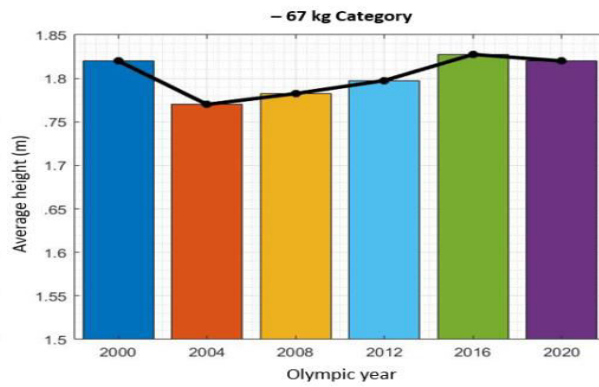


Figure 2. Average Heights, Cat. -68kg.
Source: Our Processing

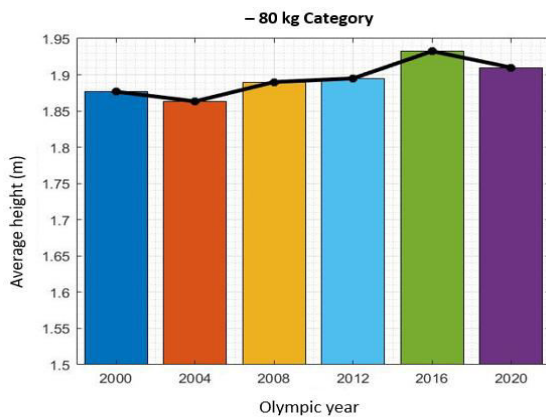


Figure 3. Average Heights, Cat.- 80kg
Source: Our Processing

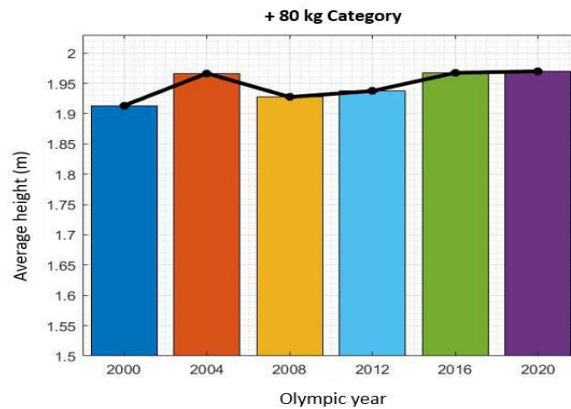


Figure 4. Average Heights, Cat.+80kg.
Source: Our Processing

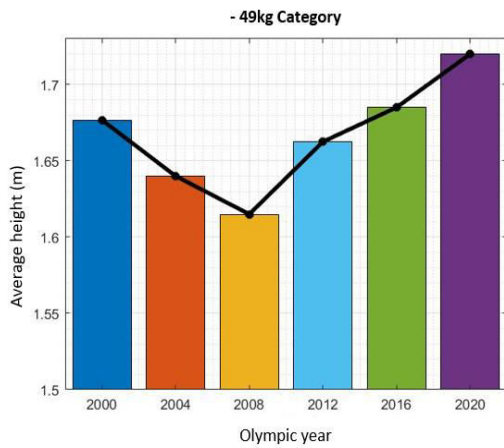


Figure 6. Average Heights, Cat. -49kg.
 Source: Our processing

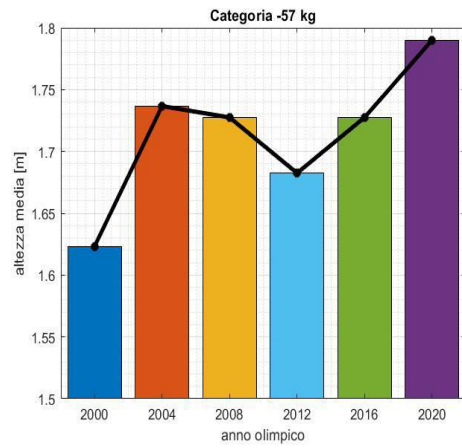


Figure 7. Average Heights, Cat. -57kg.
 Source: Our processing

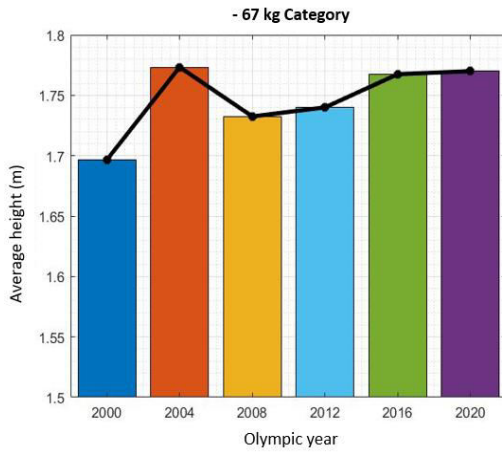


Figure 8. Average Heights, Cat. -67kg.
 Source: Our processing

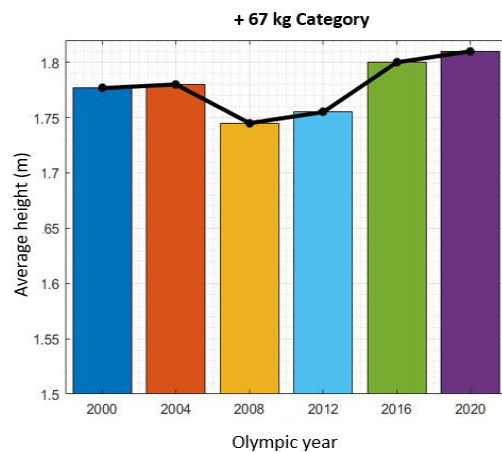


Figure 9. Average Heights, Cat. +67kg.
 Source: Our processing

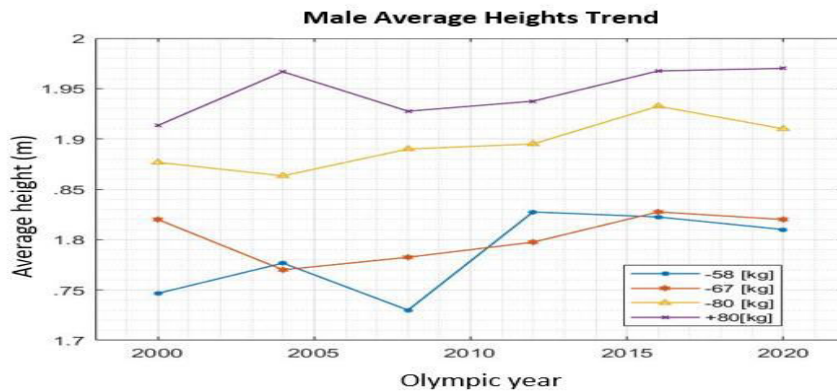


Figure 6. Variation of Male Average Heights
 Source: Our Processing

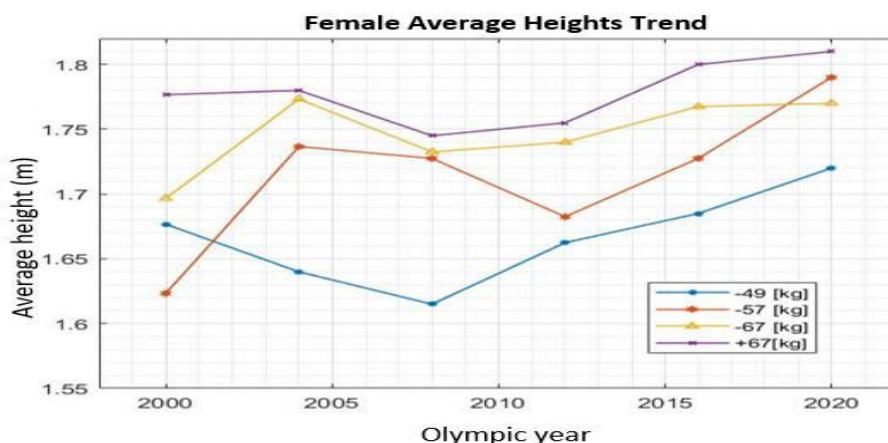


Figure 10. Variation of Female Average Heights
 Source: Our processing

Male categories

✓ 58 Kg.

In the first Sydney 2000 edition, for this weight category, the average height of the medalists was 1.75 m; it increased to 1.78 m in the Athens 2004 edition and decreased to 1.73 m in the Beijing 2008 edition. The average height rose considerably to 1.83 m in the London 2012 edition and settled at 1.82 m in the Rio 2016 edition. The Tokyo 2020 games saw an average height of 1.81m for the medal-winners. The average height over the course of all Olympic events is 1.78.6 m.

✓ 68 Kg.

In the Sydney 2000 edition, for this weight category, the average height of the medalists was 1.82m; it then decreased to 1.77 m in the Athens 2004 edition and slightly increased to 1.78m in the Beijing 2008 edition. The average height underwent an increase to 1.80 m in the London 2012 edition and settled at 1.83 m in the Rio 2016 edition. In the most recent Tokyo 2020 edition, the average height of the medal-winners was 1.82 m. Therefore, the average height during all Olympic events is 1.80,3 m.

✓ 80 Kg.

In the first Sydney 2000 edition, for this weight category, the average height of the medalists was 1.88 m; it decreased to 1.86 m in the Athens 2004 edition but then increased to 1.89 m in the Beijing 2008 edition. The average height of the medalists was around 1.89 m in the London 2012 edition, and rose to 1.93 m in the Rio 2016 edition. In the most recent Tokyo 2020 edition, the average height of medalists was 1.91 m. The average height during all Olympic events is updated to 1.89.3 m.

✓ +80 Kg.

In the Sydney 2000 edition, for this weight category, the average height of the medalists was 1.91 m and increased to 1.97 m in the Athens 2004 edition. This is followed by a decrease to 1.93 m in the Beijing 2008 edition and a slight increase to 1.94 m in the London 2012 edition; the value settled at 1.97 m in the Rio 2016 edition, and remained at 1.97 m in the Tokyo 2020 edition. The average height, during all Olympic events, turns out to be 1.94.8 m.

Female categories

✓ 49 Kg.

In the first Sydney 2000 edition, for this weight category, the average height of the medalists was about 1.68 m; then it changed from 1.64 m in the Athens 2004 edition to 1.62 m in the Beijing 2008 edition. The average height increased significantly to 1.66 m in the London 2012 edition and settled at 1.68 m in the Rio 2016 edition. In the most recent Tokyo 2020 edition, the average height of the medal-winning athletes was 1.71 m, determining the average height over the course of all Olympic events at 1.66,6 m.

✓ 57 Kg.

In the Sydney 2000 edition, as for the -57 kg category, the average height of the medalists was about 1.62 m; then there was a sharp increase in height up to 1.74 m in the Athens 2004 edition, and a settling

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at 1.73 m in the Beijing 2008 edition. After that, a decrease in average height to 1.69 m in the London 2012 edition and a further increase to 1.73 m in the Rio 2016 edition were observed. The most recent Tokyo 2020 edition saw an average medal-winners' height of 1.79 m. The average height over the course of all Olympic events is 1.71.6 m.

✓ 67 Kg.

In the first Sydney 2000 edition, the average height of the medalists was about 1.70 m and increased to 1.77 m in the Athens 2004 edition; in the Beijing 2008 edition, the average height decreased to 1.73 m and settled at 1.74 m in the London 2012 edition. The Rio 2016 edition showed a slight increase up to 1.77 m, which was confirmed exactly in the Tokyo 2020 edition. The average height over the course of all Olympic events is 1.74,6 m.

✓ +67 Kg.

In the first Sydney 2000 edition, for this weight category, the average height of the medalists was about 1.78 m, and this value remained constant even in the Athens 2004 edition; then a decrease to 1.75 m in the Beijing 2008 edition and a slight increase to 1.76 m in the London 2012 edition were observed. In the Rio 2016 edition there was a further increase to 1.80 m, which persisted in the Tokyo 2020 edition, thus determining the average height of the medalists at 1.81m. The average height, during all Olympic events, turns out to be 1.78 m.

Discussion and Conclusion

First of all, from the results obtained, it can be observed that the average heights of the medalists in the most recent Tokyo 2020 Games relatively decreased compared to the previous Rio 2016 edition.

Male data. Three categories out of four showed a decrease in the average, and respectively the -58kg, -68kg and -80kg categories, and only in the +80kg category the height remained constant and unchanged compared to Rio 2016. However, it is also true that the average height of the medalists, taking into account all editions of the games, has been statistically increasing and the gap is very small in terms of millimeters. All this could be apparently explained by a stagnation in the athletes' height, which is a standstill due to the right compromise and the search for the right height for each weight category, in the light of the anthropometric changes occurred after the Beijing 2008 edition. It could be interesting to increase the data by including those of the entire pool of participants for each category, in order to understand if the tip of the iceberg of the Olympic podium corresponds to the entire weight category considered from time to time. This could represent the future direction of this work too. In any case, the decrease in average heights would seem to be an unexpected result for the male categories, thus only partially confirming the starting assumptions.

Female data. The trend analysis for female Olympic podiums is different from the male one. The results show that the average heights of female medalists in the most recent Tokyo 2020 games were increasing compared to the previous Rio 2016 edition. Three categories out of four showed an increase in the height average, respectively the categories: -49kg (+4cm), -57kg (+6cm), +67kg (+1cm); only in the -67kg category the height remained constant and unchanged compared to the Rio 2016 edition. Also in this case, as for the male trend, the average height of the medal-winning athletes, by taking into account all the game editions, is statistically in an increasing trend with a very small gap in terms of millimeters for all weight categories, except for the -57kg one; here the average height of all editions increases by 1.6 cm, changing from 170 cm to 171.6 cm. Unlike the male trend, in the female category the search for the typical height is still in progress, with a marked tendency to increase in the lightweight categories (-49kg, -57kg).

It would be interesting, once again, to increase the data by including those of the entire pool of participants for each category, in order to understand if the tip of the iceberg of the Olympic podium corresponds to the entire weight category considered from time to time. Again, it appears possible to draw the future direction of this work. In any case, the increase in average heights would seem to be an expected result for the female categories, which would apparently confirm the starting assumptions.

Generally speaking, the studies on the biomechanical advantage in taekwondo would seem to deserve further investigation; therefore, in the light of the data updated with the Tokyo 2020 Olympics, the starting assumptions appear to be partially fulfilled, albeit with some limitations. The limits highlighted in terms of quantity of data, and therefore referable to the sample analyzed, clearly hinder the process of knowledge of the area in question. Therefore, some research gaps in terms of biomechanical advantage in taekwondo clearly emerge; gaps that, as mentioned before, can become an opportunity for further development and investigation, starting from the same methodological basis.

Expanding the research sample not only to the medal winners, but also to the entire pool of a specific weight category (i.e. even athletes participating in the editions, but not reaching the podium) is an example of how, by starting from this contribution, it is possible to further develop the starting assumptions, adding a further contribution to the link between taekwondo, height and biomechanical advantage.

References

1. Bos W., Favero S., Giannerini P. (1993) *Taekwondo Tecniche di base e combattimento*. Ed. Mediterranee.
2. Kazemi M, Waalen J, Morgan C, White AR (2006). A profile of olympic taekwondo competitors. *J Sports Sci Med*;5 (CSSI):114-21.
3. Kazemi M, De Ciantis MG, Rahman A (2013). A profile of the Youth Olympic Taekwondo Athlete. *J Can Chiropr Assoc.*; 57(4):293-300.
4. Sang HK (2004). *Ultimate Flexibility*. Turtle Press, Rockville (USA).
5. Wheeler K., Emily N, Ball N (2012). Can anthropometric and physiological performance measures differentiate between Olympic selected and non - selected Taekwondo athletes? *International Journal of Sports Science and Engineering*; VI(3): 175-183
6. World Taekwondo, World Taekwondo Competition Rules and Interpretation, Available from URL: <http://www.worldtaekwondo.org/rules/>.
7. Taekwondo Data, Olympic taekwondo medalists, Available from: <http://www.taekwondodata.com/pers onsearch>.
8. Dubnov-Raz G, Mashiach-Arazi Y, Nouriel A, Raz R, Constantini NW (2015). Can height categories replace weight categories in striking martial arts competitions? A pilot study. *Journal of Human Kinetics*; volume 47: 91-98.
9. Bešlija T., Čular D., Kezić A., Tomljanović M., Ardigò LP., Dhabhi W., Padulo J. (2021). Height-based model for the categorization of athletes in combat sports, *European Journal of Sport Science*; 21:4, 471-480
10. Gaeini, A., Mahmoudi, Y., Moradyan, K., Fallahi, A. (2010). The relationship between anthropometric, physiological and body composition characteristics of male elite taekwondo athletes with their success. *Journal of Sport Biosciences*; 2(4): 5-20.
11. Cular D, Krstulovic S, Janovic M (2011). The Differences Between Medalists and Non-Medalists at the 2008 Olympic Games Taekwondo Tournament. *Human Movement Quarterly*; 12(2): 165-170.
12. Taekwondo Data, Olympic taekwondo medalists, Available from URL: <http://www.taekwondodata.com/pers onsearch>.
13. Jung K and Pak CK (2014). *The Science of Taekwondo*. Tkdsanga, Seul (Korea).
14. Stecchi A (2004). *Biomeccanica degli esercizi fisici*. ErikaEditions, Forlì-Cesena.
15. Pasquale E (2008). *Probabilità e statistica per le scienze e l'ingegneria*. McGraw-Hill Editor, Milan.
16. Sunil Singh (2018). Performance Of National Level Taekwondo Players In Relation To Their Body Height. *International Journal of Emerging Technologies and Innovative Research*;5(11): 1066-1070.
17. World Taekwondo, World Taekwondo Competition Rules and Interpretation, Available from URL: <http://www.worldtaekwondo.org/rules/>.

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