

The Role of Genetics in talent selection *El Papel de la Genética en la selección de talentos*

Edsnel Eugenio Daudinot-Llibre¹, Yolainis López-González², Manuel Sandes-Movilla³

¹ Ms.Sc. Instructor Professor. Guantánamo University. Guantánamo, Cuba.

² Univ. Trained Professor. Guantánamo University. Guantánamo, Cuba.

³ Ms.Sc. Auxiliary Professor. Guantánamo University. Guantánamo, Cuba.

Email:

edsnelkrt2@gmail.com

yolainislopez3@gmail.com

sandes@cug.co.cu

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ABSTRACT

This study investigates how genetic variations influence sports performance and their relationship with talent selection. Through a case analysis of prominent athletes, the ethical implications of using genetic information were evaluated. Findings indicate that genes such as ACTN3 and ACE are determinants in performance. An integrated model was created highlighting the role of genetic factor to optimize the talent selection process, allowing for a more holistic approach in athlete development.

RESUMEN

Este estudio investiga cómo las variaciones genéticas influyen en el rendimiento deportivo y su relación con la selección de talentos. A través de un análisis de casos de atletas destacados, se evaluaron las implicaciones éticas del uso de información genética. Los hallazgos indican que genes como ACTN3 y ACE son determinantes en el rendimiento. Se creó un modelo integrado que resalta el papel del factor genético para optimizar el proceso de selección de talentos, permitiendo un enfoque más holístico en el desarrollo de atletas.

Keywords

Genetic variations; Sports performance; Talent selection; Integrated model.

Palabras clave

Variaciones genéticas; Rendimiento deportivo; Selección de talentos; Modelo integrado.

INTRODUCTION

The early identification of potential sports talents is essential to maximize the potential of athletes. Talent selection is not limited to the evaluation of physical abilities; it also involves an analysis of psychological, technical and, increasingly, genetic factors. This process involves understanding and applying a multidimensional approach in the identification and development of potential.

The integration of genetics in talent selection offers significant advantages in the formation of future champions. Research has identified genetic variations associated with specific physical characteristics and athletic abilities. These findings suggest that genetics plays a significant role in sports performance, but should not be the only evaluation criterion.

Despite these advances in the genetic understanding of athletic performance, the identification and development of sports talents remains a complex process that has traditionally focused on the evaluation of physical and psychological abilities. With the study of several investigations we were able to identify different limitations on this topic, of which we point out:

- Limitations in generalizability: The findings may not be applicable to all levels of competition as they focus primarily on elite athletes, which may exclude amateur or developing athletes.
- Reliance on previous studies: This analysis is based on existing literature, which may affect the validity of the results due to variability in methodologies and approaches used in the reviewed studies.
- Incomplete interaction: How environmental factors interact with genetic factors on sports performance is not addressed, limiting a comprehensive understanding of the impact of both on talent development.

The above allowed us to declare the following **problematic situation**: there is a lack of systematic integration of knowledge on how genetic factors can impact sports performance in the current selection and development processes of potential talents.

These deficiencies allowed us to identify the following **scientific problem**: How to systematically integrate genetic factors into the selection process of sports talents and their impact on athletic performance?

Therefore, the present study establishes the following **objective**: To develop a model that systematically integrates genetic factors into the selection process of sports talents, through a literature review and case analysis, in order to optimize the selection and development of athletes.

Specific objectives

1. Identify relevant genetic variations that influence sports performance through a literature review and analysis of genetic data, in order to understand their impact on talent selection.
2. Analyze the relationship between genetic factors and sports performance through case studies of outstanding athletes, providing concrete evidence on the genetic influence on performance.
3. Evaluate the ethical implications of using genetic information in talent selection, considering aspects such as equity and discrimination, to ensure fair practices in the sports field.
4. Propose an integrated model that develops the role of the genetic factor in the selection of sports talents, based on previous findings, to optimize this process.
5. Investigate how environmental factors interact with genetic factors to influence sports performance through longitudinal studies, in order to provide a more holistic approach to talent selection and development.

In order to conduct the research process, the following **hypothesis** is formulated: If genetic factors are systematically integrated into the selection process of sports talents, then the accuracy in identifying talents with high athletic performance potential will be improved.

Methodology

This article is based on a comprehensive review of the existing literature on genetics and sports performance, as well as on case studies that illustrate the influence of genetics on sports talent. The research focuses on a theoretical approach, with the aim of developing an integrated model for the selection of sports talents that combines genetic and environmental factors.

THEORETICAL METHODS

Literature review: A critical analysis of recent research, academic articles and relevant publications in the field of genetics and sport was performed. This review allowed to identify relevant genetic variations and their impact on sports performance.

Previous studies were collected that analyze the relationship between specific genetic variations (such as ACTN3 and ACE) and athletic abilities, as well as their implications in talent selection.

Case analysis:

Iconic cases, such as the Williams sisters and the Klitschko brothers, were examined to illustrate how genetic factors can influence sports performance. These examples provide qualitative evidence on the relevance of genetic variations in specific sporting contexts.

Based on the findings obtained in the literature review and case analysis, an integrated model was developed that combines sports intelligence with genetics. This model seeks to optimize selection and training processes by considering both genetic and environmental factors.

Genetic variations and sports performance

ACTN3: encodes the alpha-actinin-3 protein, which is located in fast-twitch muscle fibers. This protein is crucial for the production of explosive force and speed. Athletes carrying the R577X variant tend to have a higher proportion of fast muscle fibers, which gives them significant advantages in sports that require explosiveness, such as sprinting and weightlifting. Studies have shown that approximately 18% of the population has this variant, which may influence their performance in high-intensity disciplines (MacArthur & North, 2007).

ACE (I/D) (angiotensin converting enzyme) has been associated with aerobic capacity and performance in endurance sports, such as cycling and swimming. Research indicates that endurance athletes tend to have a higher frequency of the I allele, suggesting a favorable genetic predisposition for activities that require a high level of cardiovascular endurance (Hoffman et al., 2014). This finding highlights the importance of the ACE gene in the natural selection of specific sports based on physiological characteristics.

BDNF (Brain-derived neurotrophic factor): is related to neuronal plasticity and can influence the ability to learn motor skills and adapt to new skills. Specific variants of BDNF have been associated with better performance in sports that require complex technical skills, such as gymnastics and basketball. The presence of certain variants can facilitate the development and improvement of motor skills essential for success in these disciplines (Rodríguez, 2021).

COL1A1: codes for type I collagen, it is linked to the structure and strength of tendons. Variations in this gene can predispose athletes to injuries or increase their physical endurance. The relationship between COL1A1 and tendon health is crucial, since adequate collagen is essential for optimal performance and injury prevention in sports that involve repetitive movements or high physical load. (Arroyo, 2024)

Results and interpretation thereof

1. **Prevalence of genetic variants:** It is essential to consider the prevalence of these genetic variants in athletic populations to understand their real impact on sports performance. For example, studies have shown that athletes with favorable variants of the ACTN3 gene perform significantly better in sprint events compared to those without this variant (Papadimitriou et al.

2024). Similarly, athletes with the I allele of the ACE gene tend to excel in endurance events, suggesting that these genetic characteristics may be naturally selected within the sports field.

2. **Analysis of specific cases:** To illustrate how genetic factors influence sports performance, two emblematic cases are presented:

Williams sisters.

The sisters Venus and Serena Williams are prominent examples in world tennis. Research suggests that their success may be related to genetic variations that favor both strength and agility. Studies of their genetic profile have indicated characteristics associated with high athletic performance, including a higher proportion of fast muscle fibers, which gives them significant competitive advantages. Hermanos Klitschko.

Brothers Vitali and Wladimir Klitschko, who have dominated heavyweight boxing for years, also illustrate how genetic factors can influence athletic performance. Their success is not only due to rigorous training, but also to their physical characteristics and favorable genetic predispositions. Research has shown that they possess variants associated with greater muscle mass and cardiovascular endurance, which has been key to their dominance in the ring.

4. Integrated model for the selection and development of potential talents.

Phase 1. Comprehensive genetic evaluation

Objective: To identify specific genetic predispositions that can influence athletic performance.

- **Genetic testing:** Conduct comprehensive genetic testing that analyzes multiple polymorphisms associated with physical performance, such as ACTN3, ACE, BDNF, COL1A1, among others. This will allow for the assessment of predisposition to characteristics such as strength, endurance, and technical skills.
- **Variant analysis:** Use genome-wide association studies (GWAS) to identify genetic variations that correlate with performance in different sports disciplines. This includes the analysis of genes related to aerobic capacity, muscle composition, and susceptibility to injury.

Phase 2. Selection methods.

Objective: Implement effective methods to identify sports talents.

- **Physical assessments:** Conduct physical tests that measure skills such as speed, agility, and endurance to identify athletes with the greatest potential.
- **Psychological assessments:** Implement psychological assessments to identify traits such as resilience and motivation that can impact performance.

- **Skill Identification:** Analyze athletes' previous performance in various sports activities to determine their innate abilities.

Phase 3. Interacción entre factores genéticos y ambientales

Objective: To understand how environmental factors interact with genetic predispositions to influence sports performance.

- **Environmental factors:** To assess how elements such as nutrition, psychological support and training environment affect the expression of genetic characteristics.
- **Longitudinal studies:** To conduct longitudinal studies that analyse how interactions between genetics and environment affect talent development over time.

Phase 4. Post-selection development.

Objective: To develop programmes tailored to identified talents. This integrated model provides a holistic approach to optimise selection and development processes in sport, considering not only genetic predispositions but also environmental, psychological and ethical factors.

- **Entrenamiento personalizado:** Diseñar programas de entrenamiento adaptados a las características genéticas individuales de los atletas.
- **Monitoreo del rendimiento:** Implementar un sistema de seguimiento continuo que evalúe el rendimiento del atleta en función de su programa de entrenamiento personalizado.

Phase 5. Psychological and social assessment.

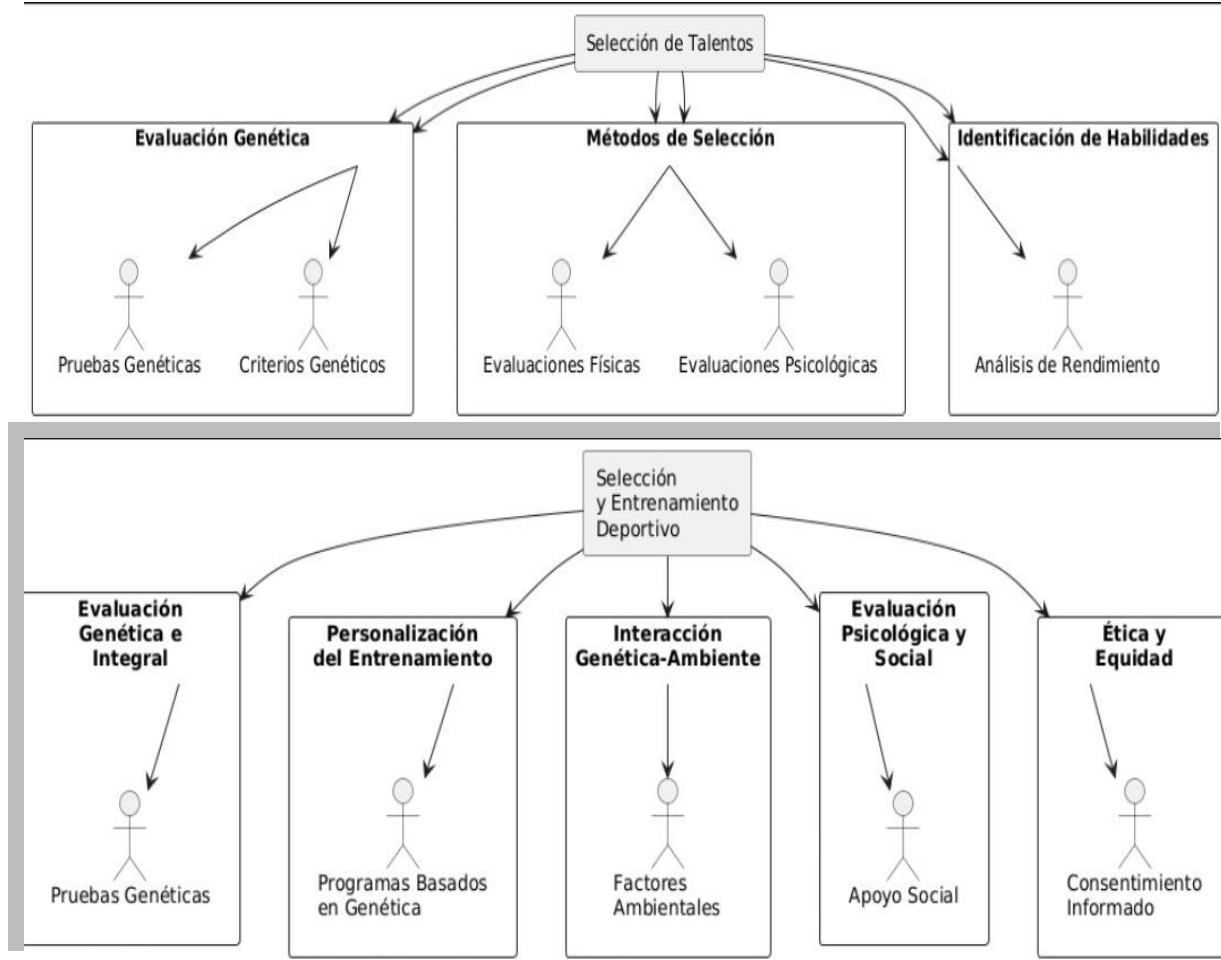
Objective: Consider psychological and social aspects that may influence sports performance.

- **Social support:** Foster a positive social environment that includes family support, coach and teammates. Social interaction can be crucial for talent development.

Ethics and equity in sports practice

Objective: Ensure that the implementation of the model is ethical and equitable.

- **Informed consent:** Ensure that all athletes give informed consent before undergoing genetic testing, protecting their privacy.
- **Clear policies:** Establish clear policies on how genetic data will be used in selection and training processes to avoid any form of discrimination or inequality between athletes.



5. Interaction between genetic and environmental factors

The interaction between environmental and genetic factors is crucial to understanding sports performance:

- **Training:** An athlete may have a favorable genetic predisposition; however, without adequate training he will not reach his full potential.
- **Nutrition:** Diet plays an important role; certain dietary regimes can enhance or limit physical capabilities based on the athlete's genetic characteristics.
- **Psychological and social support:** Factors such as family and social support can significantly influence the development of sports talent.

By addressing these points, this study offers a richer view on how to integrate genetic and environmental factors in the selection and development of sports talent.

6. Examples of genetic influence on specific skills. Endurance: Genes such as ADRB2, BDKBR2, HIF-1 α and VEGF are associated with endurance ability.

Example: An athlete with the 79C/G variant in ADRB2 might have a higher tolerance to fatigue during long races.

Karate-do: A karateka with the same variant might have a higher tolerance to fatigue during intense training sessions, allowing him to perform fast and precise movements for long periods, especially in prolonged combats.

Muscle strength and power: Genes such as ACE, ACTN3, CK-MM and IGF1 influence the development of strength.

Example: A weightlifter with R577X in ACTN3 might have a higher percentage of fast-twitch muscle fibers, improving his performance in explosive movements.

Example 2: A soccer player who has this variant can execute fast and powerful movements during a match, allowing him to improve his performance on the field, especially in high-intensity situations

Injury susceptibility: Polymorphisms in genes such as COL1A1, COL5A1, MMP3, and TNC can increase the predisposition to sports-related injuries.

Example: An athlete with variants in COL1A1 might have higher bone density, which reduces the risk of fractures.

Example 2: A karate fighter with variants in COL1A1 might experience fewer bone injuries during intense training. On the other hand, a karateka with variants in the MMP3 gene could have greater activity of metalloproteinases, which increases the risk of joint injuries

Psychological responses: Genes such as 5HTT and BDNF are related to psychological responses that can influence performance.

Example: A tennis player with variants in BDNF might have a better ability to learn and adapt to new motor skills (Gould et al., 2002).

Example 2: A cyclist with variants in the BDNF gene might have a better ability to learn and adapt to new motor skills, allowing him to improve his aerobic capacity and endurance.

Personalized training and continuous evaluation:

These genetic factors can help coaches customize training programs for each athlete. For example, an athlete with genetic predispositions for endurance might benefit from longer training sessions, while an athlete with genetic predispositions for muscular power might benefit from specific strength and explosive exercises.

Continuous evaluation of sports performance is crucial. Coaches can use genetic testing to adjust training programs and maximize the potential of each athlete. This includes monitoring performance and adapting training routines according to the individual genetic characteristics of each athlete.

CONCLUSIONS

This research has allowed us to identify relevant genetic variations that influence sports performance, highlighting the importance of genes such as ACTN3, ACE and BDNF. Through the analysis of case studies, a significant relationship has been shown between these genetic factors and the performance of outstanding athletes, which highlights the need to consider these variations in the selection of talents.

Likewise, the ethical implications related to the use of genetic information in sport have been evaluated, addressing critical aspects such as equity and discrimination. This analysis is essential to ensure a fair approach in the use of genetic data.

The proposal of an integrated model that combines sports and genetic intelligence offers a valuable framework to optimize selection and training processes, allowing for more effective personalization in the development of athletes. Finally, we have investigated how environmental factors interact with genetic predispositions, providing a more holistic approach in the selection of sports talents. This writing connects directly with the objectives of the article and presents the conclusions in a coherent and well-founded manner.

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