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The Ultimate Athlete: Genetics Vs. Training

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Abstract: This paper examines what determines athletic ability between genetics and training. The papers seek to answer why some athletes perform excellently in sprinting, long-distance racing, swimming, and jumping, yet they are almost subjected to similar training in their respective sports. The paper starts by examining constituents of skeletal muscles: slow-twitch oxidative and fast-twitch glycolytic fibers, which are associated with long-distance running and sprinting, respectively. Findings indicate that the performance of these muscles is triggered by genes: *ACTN3* and *ACE.* Further, the paper brings in the science of biomechanics. Biomechanics shows that the ultimate body performance depends on specific body features that are gene-engineered. Long arms and a long torso are ideal for excellent performance due to enhanced body movement. Explanation of biomechanics is centered on Micheal Phelps, an American swimmer who has won multiple world records due to his favoring body features. Also, the article brings the case of Usain Bolt, whose composition of both slow-twitch and fast-twitch fibers transformed him into a superhuman as the world's best sprinter. Further research indicates that although genes have an authoritative role in determining athletic ability, training, which is greatly influenced by environmental factors, such as a change in altitude, ambient temperature, and humidity, must come into play. For the genes to remain active, an athlete must engage in training within an environment that supports positive outcomes. An athlete must engage in practices that support thermoregulation to enhance heat loss. One must maintain a higher surface area to mass ratio, stay hydrated, and wear woolen clothes to enable heat loss and prevent cases of hyperthermia. The overall findings indicate that although the ultimate athletic ability depends primarily on genes, training must come into play to support and sustain improved performance.

1 Introduction

What determines an ultimate athlete? Is athletic ability influenced by genes or training? Athletes compete in various sporting events, including racing, jumping, and swimming, among other competition activities. In all these events, there are winners and losers. Some athletes are known to win a competition with outstanding performance. Precisely, some have set world records consecutive times. For example, Usain Bolt, a German sprinter, is arguably the greatest sprinter of all time, breaking and setting new world records. Michael Jordan falls in the same category as the NBA's most outstanding player. What makes these players ultimate in their performance? Is it the genes or the intensity of training? Extensive research has been done to find answers to these questions. Findings indicate that both genes and training influence athletic performance. However, genes play an authoritative role in determining athletic ability. Although training is crucial, it depends on the surrounding environmental factors. Therefore, the ultimate athlete's ability primarily relies on a favorable genetic profile joint with an optimal training environment.

2 Skeletal Muscles and Science behind Biomechanics Associated with Athletic Ability

Physical traits, such as skeletal muscles strengths, and the category of fibers constituting them determine one's athletic ability [1][2]. Thus, a person with strong skeletal muscles has a high chance of producing outstanding performance. Conversely, the type of fibers that make up the muscles influences an individual's ability [3]. The two types of fiber muscles are slow-twitch oxidative and fast-twitch glycolytic fibers [1][2]. Slow-twitch fibers contract slowly, have low tension force, and are fatigue resistant. The latter fast-twitch fibers contract rapidly; they have high tension and do not experience fatigue quickly. Based on the explanation, slow-twitch oxidative fibers can remain active for an extended time without tiring easily; thus, they support endurances athletic activities, such as long-distance racing [1][3]. Fast-switch glycolytic fibers are prone to rapid tiring and are suitable for short races, especially sprinting [1]. All these are genetic traits.

The science underlying skeletal muscles and constituting muscle fibers explains why some athletes are good at sprinting while others perform in long races [2].

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This explanation means that great world sprinters like Usain Bolt have fast-twitch glycolytic fibers that constitute their skeletal muscles. It is why Usain Bolt has always remained the world's ultimate sprinter. On the other hand, athletes like Eliud Kipchoge have skeletal muscles comprised of slow-twitch oxidative fibers, making him the world's greatest marathoner of all time. Therefore, before training comes into play, the making of an ultimate athlete depends on favorable genes [2]. Further explanation of how genes influence athletic ability is reviewing the performance of an American swimmer, Michael Phelps. Michael Phelps has not only made multiple world records but remains to be the most ornamented Olympian swimmer of all time [4], having won 28 gold medals.

Biomechanics researchers have found that the ultimate body performance depends on gene-triggered specific body features. Biomechanics is the science of studying body movement and how bones, muscles, ligaments, and tendons collaborate to enhance movement [4]. According to these researchers, a long arm and long torso are the ideal features for excellent performance body movement [4]. Thus, a person with these body features will most probably be a great swimmer. Long arms help a swimmer to make a powerful stroke, and the long torso lessens the drag on the swimmer. Michael Phelps, with a height of 6'4", has a torso that is proportional to an individual who is 6'8" [4]. Also, Michael's legs are proportionate to someone 5'9" [4]. These features give him an exceptionally high torso-to-leg ratio. Additionally, his feet offer him an added advantage while swimming. Michael's feet size was 14, which allows him to place more thrust into the water while kicking [4]. It is an added advantage since swimmers rely on their feet to create force. Further biomechanics shows that Michael's ankles hyperextend by 15 degrees while kicking, generating more thrust [4]. Based on these body features, biomechanics research considers Michael as a walking fish.

As noted earlier, Usain Bolt's outstanding sprinting record is associated with fast-twitch glycolytic fibers, which are genetic [5]. The sciences behind his superhuman legs indicate that his ultimate performance depends on muscle composition. Usain Bolt's muscle composition is more of fast-twitch fibers [5]. Bolt's proportion of fast-twitch to slow-twitch fibers stands at 80 percent and 50 percent, respectively [5]. It means that his genes favor both fast-twitch and slow-twitch fibers, compared to an average man. This muscle composition gives him a remarkable thrust than the common people. Bolt's muscle composition explains why he engages in 100m and 200m races [5]. Fast-twitch glycolytic fibers enable him to move rapidly in a 100-meter sprint, and a combination with slow-twitch fibers helps him overcome the tension and fatigue while running for a 200-meter race [5]. The explanations of these great athletes' body movement and muscle composition illuminate that favorable genes play a vital role in influencing athletic ability.

One may wonder about the competition outcome when an individual with favorable genes races against a person who has trained for a long time. In this case, the assumption is that the genetically-gifted athlete started to train months before the competition while the other individual has trained throughout life. Who will emerge as the winner in this case? Borrowing explanations from Davis Epstein's book, *The sports gene: Inside the science of extraordinary athletic performance (2014)*, the analysis will be based on two jumpers, Donald Thomas and Stefan Holm. Stefan Holm was 5'10" tall and recorded his best jump of 7'10.5", which was only two inches off the world record, and he won the gold medal. Holm has been training since he was a teenager [6]. On the other hand, Donald Thomas recorded a personal best of 7'8.5," and he was 6'3" tall [6]. However, Thomas was training a little over the year and even started high jumping while betting with his peers. In this example, Thomas's height acted as an advantage. He had a higher center of gravity, allowing him to travel less distance to jump over the bar [6]. Being taller meant that he had long legs. Longer legs mean much muscle energy within the Achilles tendons [6], generating more thrust while jumping.

3 Genes Associated with Athlete Performance

Research on genes indicates that *ACTN3* and *ACE* are the most common genes that influence athletic performance [7]. They are responsible for influencing the type of fiber that make up muscles. Also, they are linked with endurance and strength [8]. The *ACTN3* gene directs the making of alpha (α)-actinin-3 proteins, mainly located in fast-twitch skeletal muscle fibers [9]. The *ACTN3* gene has a variant called R577X, which supports the making of an oddly short α-actinin-3 protein; this protein is easily broken down [8]. Some athletes carry this variant in their gene copies, creating a genetic pattern referred to as the 577XX [8]. People with this genotype lack the α-actinin-3 protein [7]. As a result, they tend to have reduced fast-twitch muscle fibers but own a high amount of slow-twitch fibers [7]. Research indicates that the 577XX variant is normally found in endurance athletes, especially long-distance runners and cyclists [9]. On the other hand, the 577RR is linked with an increased share of fast-twitch fibers [7]; thus, it is usually evidenced among short-distance sprinters, especially 100-meters runners.

On the other hand, the *ACE* gene is responsible for giving instructions for the making of angiotensin-converting enzyme protein [7]. This protein then converts the angiotensin I hormone into the angiotensin II hormone. The latter helps in controlling blood pressure and influences the functionality of the skeletal muscles [8]. A variation in the *ACE* gene, ACE I/D polymorphism, alters the gene's activity [7]. As a result of the variation, a person can own a version of two replicas referred to as the D allele, typically stated as the DD pattern [9]. Also, one can have a version known as the I Allele, referred to as the II pattern [8]. At the same time, a person can have a replica of each version, referred to as the ID pattern. However, the DD pattern is linked with increased angiotensin-converting enzyme levels [7]. Therefore, it is linked with an increased fraction of fast-twitch fibers; hence, usually present among short-distance sprinters.

The above explanation implies that favoring genes comes first before training when determining athlete ability. In response to the investigated question, in a competition outcome between an individual with favorable genes against a person who has trained for a long time, an athlete with favorable genes will probably emerge as the winner. However, training must come in to enhance endurance. A combination of genetic factors and training must come into play [5]. Endurance training alters muscle fibers [3]. Muscular activity and endurance training change the percentage of both slow-twitch and fast-twitch fibers [1][2]. Also, aging alters their distribution inside the skeletal muscles. It implies that, even if a person has favorable genes, failure to engage in muscular activity may compromise their distribution and performance [1][2]. This interpretation explains why outstanding athletes flop once they reach a certain age. For example, Usain Bolt has already retired from sprinting after losing against other upcoming sprinters. However, the decline in performance is explained by aging since the skeletal muscles become weak and undergo detraining [2][1], leading to slower contraction.

4 Environmental Factors and Individual Features Influencing Athlete Performance

4.1 Change in Altitude

Although genes dominate in determining athletic ability, training is fundamental. Physical training can help one attain a superhuman quality like most of the known world athletes. It is the reason best athletes keep on training despite their favoring genes. However, successful training that would trigger a positive gene response depends on various environmental factors. It implies that one's genes and the training environment influence each other. Change in altitude is one of the physical factors that would influence one's performance. Air is colder and less dense at a high altitude due to fewer gas molecules [10]. Also, the air is drier, with less moisture, and usually cleaner, with insignificance particle matter. With air being less dense at altitude, performance is usually excellent. Less dense air means matters move more quickly due to reduced air resistance [11]. As a result, sporting activities, such as running, cycling, and javelin, among others happens faster and at ease [11]. Indeed, less dense air at a high altitude is why planes fly at high altitudes since air resistance is insignificant.

What do high altitude and reduced air resistance mean for athletes? It means that they will be running in an environment that supports and pushes them forward. In other words, unlike at sea level, where an athlete has to race or jump against air resistance and gravity, one will run faster or jump high at altitude since the resistance is reduced [12]. A good illustration of how high altitude can help athletes achieve excellent performance is the 1968 Mexico City Olympics, where the altitude ranged between 7000 to 10,000 feet [13]. This is when world's records for the 100-meters, 200-meters, and men's long jump were set [13], records that existed for more than a decade. These world's records imply that a merge between reduced air resistance and favorable genes supports outstanding performance. In this case, athletes with favorable genes, such as the *ACTN3* and *ACE,* will set high world records while sporting in environments with such altitudes. It also implies that people living in high altitudes will perform better since they acclimate to the environment.

Altitude also influences an individual's aerobic performance. At high altitudes, a person's aerobic capacity (V.O2max) reduces [12]. As a result, PO2 remains at its reduced level, resulting in a lower saturation of arterial oxygen. Therefore, any activity that makes ATP from Aerobic breakdown will be harmfully affected. Therefore, when a person living at sea level is subjected to a higher altitude, at first, the Hemoglobin level will be the same [12]. However, the difference will be on saturation [12]. The effect triggers the secretion of Erythropoietin (EPO) by the kidney in twenty-four hours after exposure. As a result, IT mounts in the blood after forty-eight hours [14]. At the same time, EPO triggers the bone marrow to generate more red blood cells (RBCs). Depending on altitude, an individual's iron status will increase within three or more weeks. The level of RBC will also increase, raising the Hemoglobin level [11]. These changes result in the acclimatization of the new altitude. Once one has acclimatized to the new altitude, they have a higher chance of winning.

Before the commencement of the Mexico City Olympics, researchers investigated the effect altitude would have on athletes' performance [12]. They found that athletes who resided at or adapted to high altitude would have an added advantage in sporting events [12]. It implies that high-altitude training can improve athlete endurance while engaging in intense exercise. High altitude increases one's aerobic activity, oxygen flow in the blood, and tolerance to lactic acid [15]. Therefore, if athletes with favoring genes train in such an environment, they become superfine and improve endurance to tiredness.

4.2 Ambient Temperature and Humidity

Also, ambient temperature is another factor that influences athletic ability. Ambient temperature explains the temperature in the adjacent environment. Sporting activities generate much heat as a result of vigorous metabolic processes. During exercise, calories can increase to 10 or 20 from one calorie/minute while resting [16]. An athlete can also gain heat from the environment, for example, when the weather is hot. Therefore, an athlete must lose excess heat while running to avoid an accumulation of excessive body temperature, resulting in hyperthermia. Hyperthermia explains an elevated body temperature and occurs when heat production exceeds heat loss [17]. If this condition continues, an individual may suffer from heat prostration or heat stroke [18]. At this point, the significance of a higher surface area to mass ratio comes into play. For an athlete to lose excess heat, one must have a higher surface area to mass area [18]. Therefore, athletes are expected to maintain an average body size to endure exercising in high ambient temperatures. A lower surface area to mass ratio means one cannot dissipate heat as expected [16]. As a result, it becomes risky to develop hyperthermia.

Excessive sweat heat loss leads to dehydration. Dehydration affects more than just aerobic and anaerobic parameters [19]. Dehydration diminishes mental responses and reduces ambient temperature endurance while exercising [19]. Also, it reduces muscle strength, resulting in heat cramps and heat prostration. As dehydration reaches six percent, a person becomes vulnerable to heat exhaustion, heat stroke, coma, and death [19] Research indicates that a 4% dehydration level drops isotonic and isometric strength by 29% and 31%, respectively [20]. Further, mental responses are diminished. Rifle accuracy drops by 15-20% over control scores, and visual and auditory alertness during hot and humid conditions is also adversely affected [21]. Therefore, despite having favoring genes that trigger athletes' performance, managing body temperature also counts in their exercise.

4.3 Skin Pigment and Body Size

Athletes' skin pigment influences their strategy to maintain a higher surface area to mass ratio. Solar radiation, expressly short wavelengths, can reflect off of light-colored objects but be absorbed by darker objects [22]. Therefore, a darkly pigmented person will become evidently more heated by direct radiation than would one with lighter skin [22]. It implies that athletes, especially from African countries, generate much heat from their surroundings during exercises. In addition to body temperature generated metabolically due to intense activity, heat dissipation becomes crucial. As explained earlier, one's body size influences heat loss [22]. A person with a low surface area to mass ratio will lose less heat as expected, becoming vulnerable to hyperthermia [23]. One may be talented with genes responsible for sprinting or long-distance racing. However, a low surface area to mass ratio will lead to poor performance since the chances of heat exhaustion or heat stroke are high.

5 Maintaining Thermoregulation and Heat Loss

5.1 Woolen Clothing

In order to support heat loss, athletes are expected to wear woolen clothes to enhance sweating. Heat loss by sweating is a major heat dissipation method, especially in sports, where individuals expend a large amount of calories [24]. However, in order for heat to dissipate, the sweat must evaporate. However, athletes must wear woolen attires that enhance sweat loss [24]. For example, wearing plastic or rubber clothing basically prevents sweat from evaporating. Therefore, one is expected to wear clothes made of porous fibers, such as cotton or wool [24]. Wearing plastic clothing translates to a suicide mission.

5.2 Adequate Hydration

Keeping hydrated is another way towards thermoregulation and balancing the body temperature due to sweating. A person must drink about two liters of water daily [25]. This water is meant to cater to fluid lost either through sweating. When exercising, one loses a lot of water through sweat [25]. Thus, water intake is required. For a person exercising in a warm environment, ACSM recommends consuming about 250 ml of fluid/15 minutes, which translates to 1 liter/hour [25]. However, if one sweats excessively, taking more water is recommended.

6 Conclusion

Research findings indicate that genes play an authoritative role in determining athlete ability. Despite engaging in similar physical exercises simultaneously, some athletes' performance stands out as superhuman. A review of various studies shows that genes, such as *ACTN3* and *ACE, are* responsible for athletic performance. These genes influence the formation and distribution of slow-twitch and fast-twitch fibers within the skeletal muscles, determining whether an athlete is a long-distance runner or a sprinter. Also, biomechanical science shows that genes trigger the development of ideal body features, such as long arms and a long torso, giving a person an advantage for excellent performance in body movement. Therefore, the emergence of an ultimate athlete is highly influenced by genes.

However, triggering the best performance out of these genes requires training. Research findings show that training influences little changes in both slow-twitch and fast-twitch fibers. That is the reason the world's best sportspeople train regularly. Without training, these muscles will be inactive, and the favoring genes will be useless. At the same time, excellent performance for these genes during exercise depends on various subjected environmental conditions and athletic physical features. For example, change in altitude, where training at high altitude improves performance due to reduced air resistance. Also, training at high altitudes increases the hemoglobin level, which is responsible for improved oxygen saturation during exercise.

Other environmental factors that influence performance include ambient temperature and humidity. An athlete must engage in practices that support thermoregulation to enhance heat loss. For example, they must maintain a higher surface area to mass ratio, stay hydrated, and wear woolen clothes to enable heat loss and prevent cases of hyperthermia. Overall, although the ultimate athlete depends primarily on genes, training must come into play to support and sustain improved performance.

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