STM JOURNALS

Recent Trends in
Sports

Volume 1, Issue 2, 2024
July–December
DOI (Journal): 10.37591/RTS

https://journals.stmjournals.com/rts

Review RTS

Role of Genetics in Improving Fitness and Sports Performance

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Abstract

Research indicates that variations in specific genes affects sports performance, comparing athletes with nonathletes. The genes that have been examined the most in relation to athletic performance are ACE and ACTN3. Strength and endurance have been associated with these genes, which also affect the type of fiber that makes up muscles. Sports performance factors primarily affected by genes are intrinsic motivation to exercise, power and endurance potential, training response to VO2 Max, exercise heart rate response, and exercise stroke volume. It also influences recovery and injury risk of performers. In addition to the aforementioned, genetics affects the tendency to cardio, glucose response of the body to cardio exercise, the response of the body composition to strength training, the utilization of protein, fat, and carbohydrates, the metabolism of caffeine, the response of cholesterol to dietary fat, the levels of polyunsaturated fatty acids, and the insulin response to dietary fat, HDL response to cardio, glucose response to cardio, insulin sensitivity response to cardio, testosterone levels, triglyceride response to cardio, vitamin utilization, and mineral utilization. Consequently, knowing these genetic impacts can offer athletes individualized insights for improving their diet and training plans.

Keywords: Genetics, ACTN3 gene, ACE gene, VO2Max, intrinsic motivation, insulin sensitivity, triglyceride

INTRODUCTION

Genetics is a branch of biology that examines heredity and variation in organisms or simply the biologic traits that can be passed from parents to children. Genetics is the “nature” part of the “nature versus nurture” debate. The genetic material that lies in the nucleus of each human cell is composed of a DNA code; this code consists of tightly coiled nucleic acid strands arranged into genetic units called chromosomes. Genes, the basic unit of heredity, are made up of small molecules called nucleotides and are arranged along each chromosome.

There are roughly 23,500 genes and 3.2 billion nucleotides in the human genome. Exons are the sections of each gene that code for proteins. An exome is the collective term for the approximately 180,000 exons found in the human genome. An exome is roughly 30 million nucleotides in size and makes up around 1% of the human genome. The ability to sequence every nucleotide in the human exome and even the human genome is made possible by modern technologies. A significant portion of the 13,500 single nucleotide variations (SNVs) that alter the amino acid sequence found in each exome are anticipated to be functional variants. The difficult challenge is to separate the pathogenic variations from those with negligible or no clinical impact. Although there are several algorithms, none are reliable enough [1].

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Received Date: October 22, 2024
Accepted Date: October 28, 2024
Published Date: November 05, 2024

Citation: P.P. Ranganathan. Role of Genetics in Improving Fitness and Sports Performance. Recent Trends in Sports. 2024; 1(2): 28–34p.

The study of sports genetics is a relatively new and developing topic of study. Although there is a

substantial correlation between sports and genetics, the research that is now available also reveals that genetics is only one component that influences physical fitness and athletic performance, along with a number of environmental factors. Genetics can play somewhere between 30 and 80 percent of the role in athletic performance and physical fitness [2]. Fitness and athletic performance are not solely influenced by a single characteristic or gene; rather, multiple gene combinations and permutations are crucial.

Along with environmental influences, a number of physical, physiological, and psychological elements influence athletic performance and physical fitness. The following are some aspects of physical fitness that are influenced by genetics:

- Muscular strength
- Muscular endurance
- Cardiovascular endurance
- Primary muscle fiber types
- VO2 max
- Muscle mass
- Height
- Flexibility
- Coordination and
- Intellectual ability

In India, study related to genetics are not very common. Only a few institutes to name are The Indian Academy of Medical Genetics (IAMG) is a professional organization established by qualified medical geneticists from all over India, The Indian Institute of Technology (IIT's), The Tata Institute for Genetics and Society (TIGS), Departmental Biology and Genetics, Indian Institute of Science (IISc) and a few are undertaking study specific to human genetics.

Keeping the above in mind the researcher intended to pursue a study on the theme Human Genetics and Physical Fitness.

Limitations of the Study

1. As the study is about a retired player, no current objective data are available.
2. The fitness data used for the study is the subjective self-judgement of the subject himself, recollecting his past performance to compare with the current genetic test results.

Significance of the Study

Research has revealed that there is a strong relationship between genetics and physical fitness/physical performance. It also suggests that there are several different genes, and its different combinations affect the human performance.

Humans are defined by the approximately 20,000 genes that we all share. However, the genomes of different humans do differ greatly from one another. Mutations if the frequency is less than 1% and single nucleotide polymorphisms if the frequency is larger than 1% are examples of this, as are "replication" of gene sequences (copy number variation, tandem repeats) or changes to individual base pairs. Sports performance is influenced by a wide range of human characteristics, including heart and lung size, skeletal structure, tendon elasticity, and muscle strength. Each of these characteristics is the consequence of intricate interactions between numerous anatomical, biochemical, and physiological systems [3].

Being one of the pioneer studies in India of its nature, this may enlighten the roll of genetics in the physical fitness of an individual.

LITERATURE REVIEW

Even though this being one of the first studies in India, the researcher had reviewed several research articles of similar nature from western origin. A brief synopsis of those articles is included here.

Although sedentary behavior and physical activity have a moderate heritability, little is known about the mechanisms that underlie these traits. According to a multi-ancestry meta-analysis of genome-wide association studies, which merged data from 51 studies and up to 703,901 people, 99 loci are linked to sedentary behavior at work, moderate-to-vigorous intensity physical activity during leisure time (MVPA), and self-reported leisure screen time (LST). Resistance training alters the expression of genes in skeletal muscle, and these genes are more prevalent in loci associated with LST. A missense mutation in ACTN3 causes alpha-actinin-3 filaments to become more flexible, which reduces the maximal force in isolated type IIA muscle fibers and may offer protection against exercise-induced muscle damage. Lastly, Mendelian randomization analyses demonstrate that body mass index (BMI) mediates or confounds the positive effects of lower LST and higher MVPA on a number of risk variables and diseases. Our research clarifies the processes underlying physical activity and how it helps avoid illness [4].

Physical inactivity's detrimental effects on health, particularly its crucial role in fostering obesity, are widely recognized and well-documented [5]. Numerous factors influence an individual's level of physical activity, making it a multifactorial habit. In recent years, studies employing both human and animal models have unequivocally demonstrated the link between genetics and physical exercise. Additionally, a number of noteworthy and suggestive genomic quantitative trait loci linked to physical activity have been discovered by researchers. There are currently few reliable candidate genes for the causal genes underpinning the regulation of physical activity [6].

One of the most hotly contested areas of sports science study is how genetics affect physiology and athletic performance. More than 20 genetic variants may condition the position of the elite athlete, while almost 200 polymorphisms have been found to affect sports performance qualities [7, 8]. Nevertheless, given the available data, it is unquestionably too early to decide how to use genotyping as a tool to forecast exercise or sports performance or enhance existing training techniques. The lack of assessment of reliable exercise performance phenotypes is one of the methodological flaws in this research, which makes it challenging to interpret the study's findings [9].

This comprehensive review set out to evaluate the impact of genetic variants and polymorphisms on competitive athletes' muscle strength, endurance performance, and injury susceptibility. We searched the online databases PubMed and Web of Science for pertinent studies. The RoBANS tool was used to evaluate the study's quality. Studies that satisfied the following requirements were accepted: human study published between 2015 and 2019 in either German or English; examination of the relationship between genetic variations and muscle strength, endurance performance, and/or training status; participants between the ages of 18 and 60; participation in national or international competitions; and comparison with a control group [10].

METHOD

Sports genetics is a new field of study in India. The researcher could not find any study conducted in India which correlates the genetic predisposition of a person to his fitness performance. At this juncture, obtaining the genetic parameters of an individual next to impossible. Thus, the researcher decided to select this individual as the subject because obtaining a genetic report as well as a subjective fitness and performance analysis of this individual will be the most accurate and assessable task. Even though the peak performance of this subject was forty to forty-three years back, the researcher believes that the subject can re-collect his performance to most accurate level. The subject was a university/state level Volleyball player and some of his skills in the game was unmatched during his time. He used to have very good vertical jump ability and superb eye hand coordination. He used to have a vertical jump reach of about 310 CMS. and a vital capacity of 4600 mL.

DISCUSSION

Endurance Profile

Interpretation

Congratulations!! Your endurance There may be a marathon runner in you waiting to be discovered. Specific exercise interventions can help you achieve maximum potential by honing your natural skills.

Gene Tested

GABPB1, PPARA, ACTN3, PPARGC1A, NRF2.

Description

The capacity to work for extended periods of time is a component of endurance. A specific muscle, a muscle group, or the entire body can all have an impact on endurance. Cardiopulmonary endurance, which measures the heart's capacity to provide working muscles with a constant flow of oxygen, is typically referred to as whole body endurance. Muscle endurance is the capacity to repeatedly contract muscles without experiencing tiredness.

Science Behind Trait

Endurance can be divided into 2 main categories namely aerobic and anaerobic. The main energy sources for ATP synthesis are fat and carbohydrates in aerobic and carbohydrates in anaerobic processes. Aerobic metabolism provides more energy, thus the longer that aerobic metabolism lasts, the more successful an endurance athlete can be. Therefore, VO2max (amount of oxygen you breathe in while exercising as hard as you can) mainly determines endurance. Raising the anaerobic threshold is the primary objective of endurance training since it increases training effectiveness. Determining factors of VO2max react differently to different training intensity and duration along with genetic factors which determine the VO2max of an individual.

Strength Profile

Interpretation

Congratulations!! There may be a strongman in you waiting to be discovered. Specific exercise interventions can help you achieve maximum potential by honing your natural skills.

Gene Tested

AGT, NOS3, PPARA, ACTN3.

Description

The body's capacity to apply force to overcome opposition is known as strength. According to estimates, between 30% and 95% of human muscle strength is inherited, or the result of genetic influence. This range is wide since the kind, speed, and particular muscle region being tested all likely affect the genetic contributions to muscle strength. Environmental factors, including exercise training and other lifestyle choices, are responsible for the remaining variation in strength levels.

Science Behind Trait

Muscle strength is a complex trait because many factors contribute to what ultimately is expressed as muscle strength. For instance, muscle size (cross-sectional area), muscle fiber type, structure (i.e., fiber length and arrangement), and neurological control all affect muscle strength. Strength growth is greatly influenced by a number of genes that regulate the aforementioned parameters. You may achieve an ideal body composition by designing your workout in line with your genetics.

Power Levels

Interpretation

Congratulations! You may be having the speed to challenge speed racer or the punch like Hercules. Your power capacity is amazing and sports such as sprinting, throwing, powerlifting etc may suit you very well.

Gene Tested

IGF2, IL6, COL5A2, COL5A1.

Description

While strength defines the ability to overcome resistance. Power is the ability to overcome resistance in the shortest period of time. Power, then, is the amount of energy produced per unit of time. This is a crucial component for throwing, running, etc. Power output depends upon the predominant muscle fiber type along with fiber length, size and maximum contraction velocity.

Science Behind Trait

Studies indicate that type I and type II fibers are almost equal in health sedentary individuals. However, power athletes may have as much as 80% type II fibers. Muscle fiber size, length and proportion are under partial genetic control meaning that training regimes may be optimized based on the genetic propensity of an individual to achieve the most out of them.

Power and Endurance Potential

Potential for power and endurance shows how each player is likely to react favorably to aerobic endurance and/or power/strength training, which may assist identify the activities that will work best for them and yield the most results. Muscle fiber composition has a major role in determining whether an individual is more power or endurance oriented. The genes that have been studied the most in connection with athletic performance are ACE and ACTN3. These genes have been connected to power/strength and endurance, and they affect the kind of muscle fiber.

In determining the power/strength and endurance potential, the type of muscle fibers in an individual's body accounts for about 40%. The other 60% is determined by the environment which include how the individual trains, the nutrition one obtains and other facilities available.

Type I (slow twitch) and type II (rapid twitch) are the two categories of muscle fibers. Type I use oxygen for fuel, fire slowly, supply energy continuously, and possess a high level of endurance. Type II are more prone to fatigue, fire quickly, and rely on anaerobic metabolism for energy. Purely anaerobic, type IIb fast twitch fibers have the fastest contraction rate during brief activity bursts and fatigue rapidly. Intermediate or hybrid rapid twitch fibers, known as type IIa fibers, use anaerobic and aerobic metabolism almost equally.

Research indicates that genetic predisposition accounts for over 60% of potential, with just roughly a third being altered by training and nutrition, even though people can train and adapt to changes in muscle fiber size, shape, and, to a lesser extent, type.

A person's power and endurance potential can be divided into three categories based on their genetic makeup: higher endurance genotype, equal endurance/power genotype, and higher power genotype.

"Higher Endurance" Genotype

When exercising in endurance-focused sports like cycling, running, and swimming, a person with the genotype "Higher endurance" is more likely to experience increases in VO2 Max and other endurance metrics. These people are less likely to succeed at a high level in sports that reward power-oriented athletes because they may have more type I muscle fibers. This group can exploit their genetics by maximizing endurance training. These folks may not have the genes to be elite sprinters or throwers, but that doesn't mean they should completely give up strength training. Even for endurance sports, they can and should include specialized training to build muscle, strength, and power.

"Equal Endurance/Power" Genotype

The customer is likely to experience increases in VO2 Max and other endurance markers as a result of cardiovascular fitness exercise if they have the genotype "Equal endurance and power." Strength

training is likely to help them gain more power, which will enable them to succeed in power-based sports. This is the most prevalent genotype found.

Successful endurance Athletes' capacity to consume oxygen gives them a strong aerobic base. In contrast, sports involving power require shorter bursts of action that are faster and more forceful. Power sports include mixed martial arts, baseball, football, hockey, volleyball, and so forth.

A player with this genotype may perform better in sports where having equivalent amounts of strength and endurance can be advantageous. People can take advantage of their genotype by engaging in a combination of strength and endurance exercise aimed at enhancing fitness on both ends of the range. The intersection of endurance and power may also be advantageous for these clients. A 100-meter dash runner, for example, is primarily a power athlete but also need a foundation of endurance to build upon. Similarly, road cycling is typically an endurance sport, but the best riders are able to sprint for the finish line after a hard day in the saddle and produce the maximum power for their weight. In order to sprint up and down the field, kick, and pass for a whole game, soccer players need to have equal amounts of strength and stamina. Sports like rowing are frequently referred to as "power endurance" sports since they need muscles to produce power repeatedly with little recovery.

"Higher Power" Genotype

A player with the genotype "Higher power" is probably going to have notable power increases as a result of strength training. These individuals possess genes that could enable them to perform better in sports like track racing, competitive lifting, sprinting, throwing, jumping, and others where power is essential. They can take advantage of this genotype by making strength and power training a priority in their fitness routine.

CONCLUSION

The individual under study falls in the genetic category of "Equal Power/Endurance Potential". He can excel in sports where both power and endurance play good role. The information gathered from the person speaks for itself. It also holds true in this case that about 40% contribution comes from genetics and the remaining 60% potential is contributed by environment. Enen though the individual's nutritional status was fairly good during the days he was playing at his optimal, he lacked the high-quality training. This was evident in his potential.

RECOMMENDATIONS

1. Similar study may be conducted on current national players as a case study as well as group study.
2. Similar study may be conducted on players from different sports which are purely endurance based or purely power based.

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