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Review Article

Your Genes Can Help You Choose a Suitable Sport

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Abstract

Genetic variations regulate vital athletic requisites like aerobic capacity, nature of energy release, predominance of slow or fast twitch muscle fibres and muscle fatigue resistance. Understanding the genetic factors that influence an individual's adaptability to different types of physical activities can help in choosing the right sport based on innate ability. Additionally, the position or role in sport can also be planned accordingly. Through personalized training and tailor-made nutritional requirements, genetic insights can aid in sport choice and enhance performance.

Keywords: Oxygen; Sustained Energy; Flexibility

We enjoy competitive physical activity that demands an organized participation. Such activities like dancing, aerobics, running, swimming, jumping on a skipping rope, football, cricket, basket ball, among others, improve our physical ability and skills, alongside keeping us entertained. Qualities like ease of breathing during a physical activity, stamina, strength, endurance, flexibility, injury propensity and recovery pace are vital in determining how well we get adapted to and perform the physical activity. Insight on genes related to such qualities brings out our innate ability to perform a physical activity. And this information can help us make best choices in physical activity. For instance, if a person struggles to do a sprinting activity like jumping on a skipping rope, then probably his body would suit him better for an endurance sport like swimming. To reemphasize, understanding genetic variations in this aspect can help in choosing the right sport based on innate ability. Additionally the position or role in sport can also be planned accordingly.

Factors that determine the suitability towards the kind of exercise/sport

- Oxygen uptake abilities or aerobic capacity
- Nature of energy release, that is, whether sustained or quick bursts
- Intensity and duration
- Predominance of slow or fast twitch muscle fibres
- Muscle fatigue resistance based on efficiency of oxygen supply to remove fatigue-causing metabolites

Categorization of exercise/sports type based on the above factors [1,2]

Genes determine the adaptability towards endurance or sprinting

In accordance with the above mentioned factors, let's understand the role of genes in determining the adaptability towards endurance or sprinting.

Endurance	Sprinting
Good aerobic capacity supports this kind of exercise/sport	This kind of sport can be carried out even with sub-optimal aerobic capacity
Sustained energy release (mainly from carbohydrates and fats) for prolonged duration	Quick bursts of energy (mainly from creatine phosphate and glycogen-lactate) for short duration
Mild to moderate intensity activities	High intensity activities
Higher % of slow twitch muscle fibres.	Higher % of fast twitch muscle fibres.
Slow twitch muscle fibres have more number of mitochondria, higher capillary density. Hence muscle fatigue resistant owing to efficient oxygen supply and removal of fatigue-causing metabolites	Fast twitch muscle fibres have less number of mitochondria, low capillary density. More prone to muscle fatigue
Examples include walking, jogging, distance running, swimming, cycling at a steady pace, aerobics, dancing, cardio machines, spinning, hiking and kickboxing	Examples include heavy weightlifting, high intensity interval training, sprinting, jumping or jumping on a skipping rope, high jump
Physical activities like basketball, football, hockey, etc, are a combination of both endurance and sprinting.	

Table 1

Genes regulate oxygen uptake abilities or aerobic capacity

Gene (SNP/Single Nucleotide Polymorphism)	Gene function	Endurance-suitable allele	Sprint-suitable allele
VEGFA (rs2010963) [3,4] Vascular Endothelial Growth Factor Alpha	Being a signalling protein, influences formation of new blood vessels in exercising muscles in response to increase in the demand for oxygen	'C' allele relates with sufficient oxygen supply to exercising muscle by new blood vessel formation and increased VO2 max. 'G' allele relates with sub-optimal oxygen supply to exercising muscle	
HIF1A (rs11549465) [3,5-9] Hypoxia-inducible factor 1 alpha	It is a major regulator of oxygen homeostasis within cells. Supports oxygenation by aiding in vascularisation and angiogenesis	'C' allele is favourable for endurance owing to good training response and increased expression of VEGFA	'T' allele increases HIF1α protein stability and transcriptional activity, hence improves glucose metabolism. Anaerobic glycolysis is one of the most important sources of energy for power performance. 'T' allele also relates with predominance of fast-twitch muscle fibers
GABPB1 (rs12594956) [10] GA-binding protein subunit beta-1	Also known as Nuclear respiratory factor 2 or NRF2. It regulates oxygen utilization in skeletal muscle	'A' allele renders greater supply-demand balance of oxygen within the exercising muscle. 'C' allele denotes oxygen supply doesn't match the demand during exercise and hence suboptimal aerobic capacity	

ACE (rs4646994) [11] Angiotensin I converting enzyme	ensures optimum muscle performance through constant and adequate oxygen supply via blood circulation	Insertion pattern provides higher oxygenation, greater aerobic power and less strenuous breathing which ultimately improve VO2 max	deletion pattern renders the ability to work under sub-optimal oxygen state, a form of anaerobic exercise
AGT (rs699) [11] Angiotensinogen	takes part in supplying much-needed increased oxygen to exercising muscle via blood vessel dilation	'T' allele relates with optimal levels of angiotensin II and associated with good aerobic capacity and endurance	'C' allele correlates with higher levels of angiotensin II and associated with power and strength sport performance
AGTR2 (rs11091046) [12-14] Angiotensinogen Receptor	Functions as a receptor for angiotensin II. The vasoconstrictive effect of angiotensin II occurs by occupation ofAGTR2.	C allele is associated with an increased proportion of slow-twitch muscle fibres, endurance athlete status and aerobic performance	A allele is associated with a higher percentage of fast-twitch fibres and power-oriented disciplines
NOS3 (rs2070744) [15,16] Nitric Oxide Synthase 3	Produces nitric oxide (NO) which relaxes blood vessels and mediates VEGF-induced angiogenesis	In 'G' allele carriers, optimal level of nitric oxide synthesis promotes efficient mitochondrial ATP production and oxygen consumption in skeletal muscles. Favourable eNOS (endothelial Nitric Oxide Synthase) activity reduces oxidative stress and renders muscle fatigue resistance. 'T' allele carriers have sub-optimal level of nitric oxide synthesis and hence their aerobic capacity is not up-to-the-mark. Reduced eNOS activity reduces defensive antioxidant enzyme activity and makes the exercising muscle prone to fatigue due to oxidative stress	

Table 2

Genes regulate nature of energy release during body's adaptive response to exercise

Gene (SNP/Single Nucleotide Polymorphism)	Gene function	Endurance-suitable allele	Sprint-suitable allele
PPARA (rs4253778) [17,18] Peroxisome proliferator-activated receptor Alpha	This gene regulates body's adaptive response to exercise by facilitating more energy fuel provision and utilisation in exercising muscle	'G' allele improves oxygen supply and energy utilisation in the muscles during exercise and enhances performance. 'C' allele relates to sub-optimal energy utilization in exercising muscle and hence more prone to fatigue and tiredness	

PPARGC1A (rs8192678) [19] Peroxisome proliferator-activated receptor gamma, coactivator 1 alpha	regulates energy fuel provision for body's adaptive response to exercise	In 'G' allele carriers exercise-induced increase in VO_2 max is favourable. While 'A' allele relates to sub-optimal increase in VO_2 max in response to exercise	
PPARD (rs2016520) [20,21] Peroxisome proliferator-activated receptor delta	Regulates the peroxisomal beta-oxidation pathway of fatty acids. Functions as transcription activator for the acyl-CoA oxidase gene	'C' allele relates with endurance. Efficient Fatty acid oxidation strongly influences VO_2max and training response via lipid metabolism for ATP availability	'T' allele relates with sprint. Usage of fatty acids as substrates for energy production is less efficient
ADRB2 (rs1042713) [22] beta-2-adrenergic receptor	ADRB2 [26] regulates efficient mobilization of substrates to maximize performance and sustain it	'A' allele relates with good aerobic capacity and efficient mobilization of substrates to maximize endurance performance. Enhances gluconeogenesis and vasodilatation.	'G' allele is better suited for sprint type of sports

Table 3

Genes determine the Predominance of slow or fast twitch muscle fibres

Gene (SNP/Single Nucleotide Polymorphism)	Gene function	Endurance-suitable allele	Sprint-suitable allele
ACTN3 (rs1815739) [23] alpha (α)-actinin-3	encodes synthesis of ACTN3 protein, which is predominantly found in fast-twitch muscle fibres	X variant produces less alpha actinin 3 increasing suitability for endurance sports	R variant produces more alpha actinin 3 exemplifying the sprinting potential

Table 4

Genes determine the propensity for muscle fatigue

Gene (SNP/Single Nucleotide Polymorphism)	Gene function	Endurance-suitable allele	The other allele
AMPD1 (rs17602729) [24] Adenosine monophosphate (AMP) Deaminase	When muscles use up energy during exercise, the energy molecule AMP needs to be converted to IMP (Inosine monophosphate). Accumulation of AMP in muscle causes muscle pain and weakness, a sign of fatigue. AMPD1 enzyme actively participates in catabolism of AMP.	'C' allele relates to sufficient AMPD1 enzyme activity implying favourable clearance of AMP from exercising muscle and hence fatigue resistance. This gives scope for longer duration endurance sports. While the 'T' allele relates to sub-optimal activity of AMPD1 enzyme, thus posing a risk for AMP accumulation in exercising muscle and consequently spasms, tiredness and muscle pain after training sessions	'T' allele relates to sub-optimal activity of AMPD1 enzyme, thus posing a risk for AMP accumulation in exercising muscle and consequently spasms, tiredness and muscle pain after training sessions

MCT1 (rs1049434) [25-27] monocarboxylate (lactate/pyruvate) transporter 1	This gene encodes MCT1 enzyme, which is required for lactate to enter the myocytes for oxidation	'A' allele is associated with favourable lactate transport rate and optimal clearance of lactate. Hence promotes fatigue resistance	'T' allele denotes reduction of lactate transport rate and elevation of blood lactate levels. More prone to muscle fatigue
GSTP1 (rs1695) [3,28,29] Glutathione S-transferase P1	GSTP1 is a phase II conjugating enzyme that protects the cell against oxidative stress. This enzyme mediates VO_{2max} in response to training	G allele may improve exercise performance by improvement in VO_2max and other cardiorespiratory fitness measurements. Also renders better elimination of exercise-induced ROS/Reactive Oxygen species	A allele relates with suboptimal change in VO_2max and is associated with an impaired ability to remove excess reactive oxygen species

Table 5

Practical application and future perspectives

Exercise genomics is occupying the centre stage as a practical tool for assessing elite sports performance. Physiological adaptations to acute bouts of exercise and the responsiveness to sustained sports training rely on crucial aspects like cardiorespiratory fitness, erythropoiesis, angiogenesis, skeletal muscle energy metabolism, mitochondrial biogenesis, muscle fiber type composition and inflammatory homeostasis. The adaptation to exercise training and physical performance traits result from an interplay of intrinsic and extrinsic factors. The sportsperson/athlete status is a remarkably heritable trait, with a majority of variance (nearly 66-70%) explained by additive genetic factors and the remaining arising from environmental influencers like motivation, training and nutrition. A number of sports' performance-related parameters hail a substantial genetic component. For instance, genetic factors explain inter-individual variations in baseline aerobic capacity by 60%, in anaerobic power by 70-90% and muscular strength by 50-70%. Citing a practical application, the myostatin/MSTN gene regulates muscle mass and its polymorphism, rs1805086 (MSTN K153R), located in exon 2 of the gene explains a change from A to G in the codon encoding the 153rd amino acid of myostatin (the protein arginine/R is displaced with lysine/K at position 153). This genetic variation significantly influences muscle strength in response to power-oriented physical training by affecting proteolytic processing, inducing myoblast proliferation and muscle mass differentiation. Its 'R' variant can be considered as a genetic marker associated with increased skeletal muscle strength and muscle mass (OR = 2.02, P = 0.05). The RR genotype gene is more common in top-class weightlifting athletes [30-33].

The choice of a sport should convincingly be supported by innate abilities to enhance performance. Physiological adaptations to exercise, as ascertained through genes, can guide in planning training regimens and help in choosing the best nutrients to suit innate tendencies. For instance, endurance runners have superior aerobic capacity, while sprinters are exceptional in their anaerobic power. Hence dietary practices are crucial in shaping their body composition to align to align with their chosen sport. Nutrition for endurance running highlights carbohydrates for sustained energy, while sprinters focus is mainly on protein for muscle recovery and strength [34].

Conclusion

The genetic variations discussed in this review highlight the importance of choosing the right sport based on innate ability. Which kind of exercise/sport one can comfortably carry out is a million dollar question. And a clue to its answer lies in our genes. Genetic variations regulate vital athletic requisites like aerobic capacity, nature of energy release, predominance of slow or fast twitch muscle fibres and muscle fatigue resistance. Understanding the genetic factors that influence an individual's adaptability to different types of physical activities can help in choosing the right sport based on innate ability. Additionally, the position or role in sport can also be planned accordingly. By considering these genetic factors, individuals can optimize their physical performance and reduce the risk of sports-related injury.

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