Can we yet use genetics to determine which sports are best for our kids?

Can you choose sport based on your biology, or better yet a sport that might be good for your kids?

Typically, we hear about sports genetics in connection with elite athletes and international competition, and often the stories are based on discoveries isolated to particular genes. Are there any gene variants that foreshadow that your children will do exceptionally well if you get them training in a sport, say tennis, basketball, hockey, or gymnastics, because of their unique physiological profile? There aren't; nor are there likely to be any such genetic markers in the years to come. Instead, the overriding message of genome wide association studies (GWAS) is that the pathway from genes to traits is very complicated–much more so than many genetic diseases, where a faulty gene for a single enzyme can be enough to inflict you with the disease, or make you a carrier putting your future generations at risk.

The way that genetics plays out for talent traits, like musical performance, acting ability, humor, dance or sports is strikingly more complex than an enzyme deficiency disease, or phenomena like eye color that depend on one or at most a handful of genes. Consequently, there's no genetic test on the horizon that you could link to your children's potential for a sport any more than there's a test for their potential to be movie stars.

On the other hand, there are some important physiologic, anatomic and biochemical parameters that produce good athletes when they come together in combinations favorable to specific sports. As Genetic Literacy Project director Jon Entine presents in detail in his bestselling book, *Taboo: Why Black Athletes Dominate Sports and Why We Are Afraid to Talk About It*, evolution has shaped body types in different parts of the world and a a result athletic ability in different sports has scientifically verified associations with ethnicity.

Evolution and sports physiology

The existence of associations between ethnicity and athletic capability makes perfect sense because the physiologic, anatomic and biochemical parameters that favor athletics depend on a plethora of genes that evolution has shaped based on the environment. The associations are quite visible at the level of elite sports, and ultimately this affects which countries dominate international competition in particular events.

Having evolved along the equator, East and West Africans on average both have relatively long limbs relative to their torsos, an advantage in running. But elite athletes from different sections of Africa perform dramatically different in running events because of other factors. East Africans are shorter and have smaller upper bodies on average. And their lung capacity is naturally huge. West Africans are more muscular in their limbs and have smaller, more efficient lungs.

We can expect runners from East Africa to continue to dominate middle and long distance running, including the world's top marathons, but perform abysmally in anaerobic sprints. At the same time, athletes from West Africa (where populations are significantly different genetically from East Africans because of differing evolutionary forces) and from the West African diaspora will dominate sprinting and

other sports that depend on quick bursts of energy.

Eurasians dominate the strength events, such as hammer throw, javelin and shot put, as well as weight lifting, in part because of their body type–relative short arms and legs, which are physiological advantages in these sports.

But the mix of physical and mental characteristics that lead to success in most sports is complex and confounds easy generalizations. Gymnasts and basketball players are at opposite ends of the height spectrum, but both groups of athletes use power bursts and need to do so with more endurance than a sprinter who runs the 100-meter dash.

Nevertheless, for the recreational athlete, and for children seeking a sport, the current understanding provides some biological traits–not genes, but characteristics manifesting downstream of genetic effects–that can be assessed to help evaluate a budding athlete's potential in a sport, regardless of ethnicity.

In popular discussions, ability for particular sports or events is often discussed in connection with gross anatomic traits, like relative measurements of arms vs. legs. We see this during each Olympiad, when mainstream media highlight the enormous arm spans of swimmers like Michael Phelps, the long, slim limbs of distance runners, the much more bulky muscles of sprinters and the short stature of gymnasts. This is all perfectly sound, but the athletically relevant traits that manifest from the interaction of large numbers of genes include more than just gross anatomy.

Muscle fibers

Along with gross anatomy and lung capacity, there are other biological and physiological parameters vital to athletes. One major one, possibly the most important, is the microscopic anatomy of the muscles. Muscle cells are also called muscle fibers, because they're extremely long, but also extremely thin. You see thousands of them in cross section, if you slice through a muscle and view it under a microscope, but their diameters can grow dramatically with exercise, and thousands of fibers doing this makes growth, or hypertrophy, of the entire muscle obvious at the gross anatomic level.

Anybody training in any sport can make their muscle fibers stronger and bigger, but there are different types of fibers. One type, called slow twitch or red fibers is good for endurance. Another type, called fast twitch or white fibers, is good for power, but these cells fatigue easily. There also is a subset of fast twitch fibers that tend to start behaving more like slow twitch fibers in a person who trains in endurance activities while forgoing high power sports. On average, humans are born with roughly an equal number of fast vs. slow twitch fibers in their muscles–though there are distinct differences in proportions among some populations because of unique evolutionary forces.

The choice of physical activity influences how muscle fibers develop. Training for long distance running promotes growth of the slow twitch fibers and conversion of that subset of fast twitch fibers into slow twitch-like fibers. Power training, like weightlifting and sprinting, do the opposite: they prevent that subset of fast twitch fibers from learning to act like slow twitch fibers and cause both groups of fast twitch

fibers to grow and get stronger.

By affecting the slow/red and fast/white fibers differently, training has an enormous influence of sport ability, because fiber characteristics are very different. Fast twitch fibers contain relatively few mitochondria (energy organelles needed particularly for endurance), but a lot of an energy chemical compound called creatine phosphate. This, in turn, allows rapid regeneration of another energy compound called ATP–the universal energy currency in all cells, and the fuel needed immediately and constantly to make the muscle contract and relax.

With power training, the fast twitch fibers not only grow, but they get really big, and so power athletes' muscles bulk up. In contrast, slow twitch fibers have a lot of mitochondria, which allows them to burn fuel aerobically, using oxygen to get more efficiency from sugar and other body fuels. These cells get stronger and grow with training, but they do not bulk up like their fast twitch counterparts. Instead, endurance training produces long, defined, but slender muscles. Combined with long bones of the limbs, this stretched out anatomy helps distance runners to radiate heat from the limbs efficiently during the long runs.

Some muscles are more equal than other muscles

We said that on average people are born with close to equal amounts of both types of muscle fibers, but this is not universal. Instead, evolution has created differences along a spectrum in the innate ratio of fast to slow twitch fibers. It should be no surprise that people born with an extreme predominance of either muscle fiber type should have an advantage in one competition category or the other. Training is vital to an individual taking full advantage of his or her biology, but there are differences in the starting point, and these differences are key to the ethnicity factor in sports.

In the case of muscle fiber type, a muscle biopsy study by Jamaican researchers of runners from West Africa and the West African diaspora reveals particularly high ratios of fast twitch muscle fibers vs. slow twitch muscle fibers. Runners from this background developed their fast twitch fibers through training, but they also started out with more fast twitch fibers to develop in the first place.

The consensus belief is that West Africans evolved a higher proportion of fast twist muscles because of the demands of hunting during the thousands of years of evolution in their premodern state. But there are other theories. A preponderance of fast twitch fibers may be a trait that evolved to compensate for low oxygen levels in muscle, because of a gene that is not good for an athlete. I'm referring to the sickle cell gene, which is a big issue in college and even high school sports, because approximately 1 in 12 African Americans have the gene. They are carriers for sickle cell *disease*, and have what's called sickle cell *trait*. Unlike the disease, sickle cell trait normally does not produce any symptoms, but that can change under extreme physical stress, dehydration, and high altitude. Consequently, the NCAA requires sickle cell trait screening for all Division I and Division II athletes.

In terms of long distance running, while East Africans and Kenyans in particular dominate long distance running, a specific tribe, the Kalenjin, enjoy a combination of anatomic and physiologic traits that include long limbs and superior lung capacity, and also a huge preponderance of slow twitch muscle fibers that

make them the best of the best. As suggested above, the underlying genetics is so complicated that there are no specific genes that can be pinned down for this, but the evolutionary forces that shaped the outcome are thought to include high altitude combined with various other environmental factors.

In contrast with people of West African origin, East Africans were not part of the American slave trade so are not populous in most areas of North America, so most high schools will be challenged trying to recruit Kalenjin students for their cross-country teams. But, as with the opposite extreme, anyone who wants to be tested and proves to have a high ratio of slow vs. fast fibers should seriously consider long distance running, especially if they also have long, slender limbs.

What this all means

Although genes circumscribe athletic possibility in all sports, training and opportunity are key for the most talented athletes to develop their genetic gifts. A range of sports require such a series of progressive skills that early training is arguably as important as innate athletic ability. Look at gymnastics, skiing, diving and figure skating–for these and some other sports that require training, facilities and advanced equipment, the learning curve is so long and the progression of skills so systematic to reach high competition levels that nurture is key. At high levels, everybody is a top “natural” athlete, but in these sports, often getting trained by a particular coach is what puts the athlete at the very top. But the training phenomenon carries over to the lower levels too. Start a child early in an equipment sport and biology will be less of a major factor.

The extremes of muscle fiber ratios or body types manifesting in the differences between West African descended athletes, East Africans and Eurasian whites, can help shape expectations of becoming an Olympic level or professional athlete. It also underscores the importance of body type and physiology, which are important at increasingly competitive levels of various sports. But it makes relative difference on recreational athletes choosing whether to run marathons or join a basketball league. This mindset provides flexibility as parents guide their children into endurance or sprint/jump dependent sports.

Rather than seeing these ethnic associations and innate body type differences as ways to separate people based on ancestry, let’s use it as a lesson to learn more about the body and the biology of kaleidoscope of human performance. In doing so, we can also help children to stay in shape while having fun in a way that’s helpful to their self-esteem.

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