Sports Pairs: Insights on Athletic Talent; Research Reviews: Twins with Leukemia; Parents and Twins

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Twin research exploring genetic and environmental influences on athletic interests and talents is reviewed. Illustrative examples of twin athletes representing a variety of sports activities are presented. This is followed by an overview of twin studies offering critical insights into the onset and progress of leukemia. In the last section, timely events involving twins and parents of twins will be described — each case provides a new look at an old question.

Sports Pairs: Insights on Athletic Talent

Superb athletic performance is mesmerizing. The upcoming 2008 Beijing Olympics will have many people wondering about the origins of the athletes' extraordinary talents. Research on monozygotic (MZ) and dizygotic (DZ) twin pairs holds some answers to these questions.

An accumulating body of work is revealing genetic influence on a broad assortment of traits associated with athletic interests and talents. The findings do not imply that practice and training are unimportant — rather, they suggest that the predispositions people bring to activities matter, and that we may be attracted to activities in which we do well (rather than the other way around). The foregoing applies to both elite and amateur athletes. Given the recent proliferation of twin studies of athletic performance, only selected articles of interest will be presented; a more comprehensive review of this topic is available in Segal (2000). Some concepts will be highlighted with reference to the life histories of twin athletes.

Olympic Sports Performance

A co-twin control study compared 40-year-old MZ twin race walkers across a variety of physical and behavioral measures (Klissouras et al., 2000). The twin brothers had participated actively in the sport between the ages of 19 and 33, at which time they stopped racing competitively. From that time onward, they engaged in only moderate amounts of exercise until age 40 when they completed an extensive research test battery. They were assessed across a series of anthropometric, echocardiographic, dynamometric, exercise and personality measures. Their training, competition and performance profiles were also compared.

The twins had competed an average of 14 times each year, between the ages of 19 and 33. One twin had placed first in one Olympic event, and second in two Olympic events, in 1980, 1984 and 1988, respectively. He had also won a world championship in 1987. In contrast, his twin brother had placed 11th in the 1980 Olympics, but had finished first in the 1983 world championship — this was the year in which his twin brother had not taken part. The twins had, however, always trained together and had followed virtually identical practice programs. This pair, therefore, offered a valuable opportunity to identify factors that might explain performance differences in two highly sports-minded and genetically identical individuals.

The physiological and echocardiographic data showed no remarkable within-pair differences. One twin showed some advantages in the dynamometric measures, but it was not the Olympic winner. The only exercise measure that yielded a meaningful difference was blood lactate concentration during metabolic cardiorespiratory response to maximal effort, which was higher for the Olympic gold medalist.

Possible clues to the twins' performance differences were found only in their contrasting personality profiles, provided by the State-Trait Anger Expression Inventory (STAXI). The Olympic medalist scored very high on both anger reaction and anger control (nearly 100% on the percentile scale), and displayed a tendency toward keeping his anger unexpressed. His

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co-twin scored very low on anger reaction and anger control (nearly zero on the percentile scale), and showed a higher than average tendency toward expressing his anger.

It was concluded that the Olympic medalist's extreme response to frustration, sensitivity to criticism and emotional control may have contributed to the twins' performance differences. That is to say, the medalist's unexpressed anger may have deepened his competitive drive and autonomic function. This explanation is worth further study - it reminds me of what 1984 Olympic gold medalist, skier Phil Mahre, told his identical twin brother, Steve, when it appeared that Phil had won the event: 'Here's what you have to do to beat me.' Perhaps slight variations in anger, drive, confidence, or all three explain the difference between these twins, as well.

Sports Participation. Twin and family studies of athletic performance outnumber studies of sports participation; see Maes et al. (1996) for an example of the former. However, several recent studies provide insights into this question, as well. A review by Beunen and Thomis (1999) cited two Dutch studies that found heritabilities ranging from .35 for female adolescents to .77 for male adolescents, based on self-reported sports participation. Another series of twin and family studies yielded heritabilities for extent of daily physical activity, ranging from .29 to .65. Methods for data collection and analysis contributed, in part, to the variation in the findings.

Research on sports participation has also found a greater likelihood of one MZ twin participating in intensive physical activities if his or her co-twin did so (as compared with less intensive activities). It was, therefore, concluded that genetic effects on regular participation in intensive activities are greater than those on more moderate activities. This makes sense if we consider that more intensive exercise requires greater effort that fewer people may be willing to expend, thus allowing for greater individual differences in expression.

Beunen and Thomis's review also provides discussion of activity as a temperamental trait. Genetic effects on activity level have been provided mostly by studies of young twins, although studies of temperament in adult twins are also available (see, for example, Spinath et al., 2002). It is likely that one's temperamental profile significantly affects the level and extent of one's physical activities and exercise, although Beunen and Thomis did not develop this line of reasoning.

A recent study by Stubbe et al. (2005) showed that genetic effects on sports participation increased during adolescence, as measured at ages 13 to 16 years and again at 17 to 18 years. These data were provided by Dutch twin pairs who completed a survey including items related to their regularity of voluntary sports participation. Family factors explained 78 to 84% of the variance at the first measurement time, while genetic factors explained 36% of the variance at the second measurement time. This shift in influence is associated with the waning effects of shared family environments as children age. It was also found that younger twins participated in sports more often than older twins, and that males (in both age groups) participated in sports to a greater extent than females.

The foregoing findings await replication using other twin samples, but it likely that they will emerge. For example, in the United States, children take part in many required organized sports activities, both during school hours and beyond. Again, it is likely that genetic effects on sports participation are less pronounced at younger ages, emerging in young adulthood when sports participation becomes more voluntary in nature.

Perhaps the most persuasive evidence of genetic effects on sports participation comes from a recent study involving 37,051 twin pairs from seven countries (Australia, Denmark, Finland, Norway, the Netherlands, Sweden and the United Kingdom) comprising the GenomEUtwin project (Stubbe et al., 2006). Heritability of exercise participation ranged from 27% (Norway) to 67% (the Netherlands) for males, and from 48% (Australia) to 71% (United Kingdom) for females. The extent to which genes affected exercise participation did not differ between males and females, with the exception of Norwegian males for whom shared environmental effects played a role. The findings from this study are impressive, given that the research methods and birth cohorts varied across countries. This work also identifies topics for further study, such as the effects of personality traits and cultural attitudes on sports participation. Some studies, such as those reviewed below, have begun to use twins in analyses of physical activity and its relationships with other aspects of behavior.

Stubbe et al. (2007) found that the association between exercise participation and well-being (life satisfaction and happiness) was mediated by genetic factors that affect both measures. Furthermore, twins of all ages participating in exercise showed higher levels of life satisfaction and happiness than those who did not. Research by de Moor et al. (2007) demonstrated that common genes explain the association between exercise participation and self-rated health. However, the processes by which this occurs remain unresolved.

Life Histories and Observations

A new book, *Triumph* (Schapp, 2007), chronicles the incredible track and field career of Jesse Owens and his Olympic victories during the controversial 1936 Berlin Olympic games. Perhaps unintentionally, it supports the view that great athletic ability is a product of raw natural talent, refined by intense practice and training. Owens' powerful legs and effortless running style were mentioned often by his coaches and fans. At the same time, a change in his starting position suggested by his coach improved his performance. However, it takes twins, not

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Figure 1

Wrestling twins, taken after competition at CSU Fullerton, February 9, 2007.
From left to right: Paul Tice, Nancy L. Segal and Bryan Tice. Courtesy of the twins.

singletons, to demonstrate genetic influences on behavior and ability.

I have had opportunities to meet several MZ twin athletes on my college campus. Wrestling twins, Bryan and Paul, never compete against each other. 'I'm proud when he beats someone, but I'm also angry,' admitted Bryan. 'I'm his duplicate and I should be able to do whatever he does.' The twins participate in different weight classes — Bryan weighs 157 pounds, while Paul weighs 149. Both twins were state champions in high school — Bryan twice and Paul once, but with two second-place finishes. Bryan was one of four California State University (CSU) Fullerton team members to participate in the NCAA (National Collegiate Athletic Association) Championship, in Detroit, March 2007 (http://fullertontitans.cstv.com/sports/m-wrestl/spec-rel/022607aac.html). Tracking these twins' performance over time would be an informative addition to research on the physical and behavioral bases of sports performance and achievement.

Twins say that their intimate knowledge of one another lets them anticipate what their co-twin is doing and thinking and, ultimately, what action he or she is likely to take during a game. I have heard this from many twins, most recently from a CSU student who, along with his identical twin brother, plays on the school's soccer team.

People with certain body types are better suited to some sports than to others, so it is easy to understand why many people choose the activities that they do. Basketball requires height and speed; gymnastics requires balance and flexibility, and wrestling requires strength and stamina. These attributes are exemplified by Brook and Robin Lopez, MZ twins who play basketball for Stanford University; Paul and Morgan Hamm, DZ twins who won Olympic medals for the United States gymnastic team — the twins appear to be DZ, to this author who has met them personally; and Paul and Bryan Tice, MZ twins who are members of CSU, Fullerton's wrestling team. It is also worth noting that some sports involve competition between teams, others involve competition between individuals, while some (e.g., figure skating) involve both. Less is currently known about how personality traits interact with ability, leading one to choose a team sport over an individual sport, or one position over another. Twin studies in the future might help answer this question, offering information that coaches and players can put to good use.

In closing, I want to comment further on the Lopez twins, Brook and Robin, members of Stanford University's basketball team. The twins, both seven feet, one inch tall, distinguished themselves as elite athletes at San Joaquin Memorial High School, in Fresno, California (Glionna, 2006). Today, they are making a name for themselves as freshman players on Stanford University's team.

I recently watched the twins in competition against the University of California, Los Angeles (UCLA) Bruins (UCLA won 75 to 61). Brook (number 11) is a forward and Robin (number 42) is a center. According to UCLA's junior center Lorenzo Mata, 'They're great players and they're tough to guard,' (Behniwal, 2007). The twins played together often, but there were times when each twin played alone while his brother sat on the sidelines. Brook clearly had more game time — another challenge to the question of what factors may enhance or depress performance in genetically matched individuals. It will be informative, and entertaining, to follow these twins' careers over the next 4 years.

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Research Reviews: Twins with Leukemia

Literature searches sometimes turn up unexpected treasures — sources of timely findings, historical anecdotes and new ideas. A review article, *Leukemia in twins: Lessons in natural history* (Greaves et al., 2003), presents a compelling survey of research on this disorder in twin infants and children. Most significantly, the authors draw important insights from this accumulating body of work.

The article traces the developmental events and molecular genetic features of leukemia, using a twin-based perspective. Concordance for leukemia in MZ twin infants was first described in 1882 by H. Senator, a German investigator. Subsequent to that report, over 70 such cases of leukemia in infant MZ twins have been documented in the medical literature. In contrast, concordance for leukemia in DZ twins is extremely rare, consistent with genetic, prenatal and/or postnatal etiologies. In fact, all three sources of influence are important, given the vital distinction between cases involving onset in infancy and in childhood. This concept is underlined by the observation that concordance approaches 100% for MZ twin infants, but falls to 10% for older MZ twin children. In fact, concordance in MZ twins rarely occurs if the disease emerges after age six 6 years.

Current thinking about leukemia implicates 'prezygotic genetic influence' (Greaves et al., 2003, p. 2322), although this theory was first suspected in the early 1960s. It was reasoned that the disease originates prenatally in one MZ twin and is transmitted to the co-twin via common circulation. This idea was largely ignored for nearly a decade, but since then supportive evidence has grown. Support for this theory (intraplacental transfer hypothesis) is provided partly by the fact that approximately two thirds of MZ twins have a monochorial placenta, while (with very rare exception; see Souter et al., 2003), DZ twins develop in separate fetal membranes. This idea was considered 'radical' at the time, 'implicating as it did a prenatal clonal origin in one twin followed by what was in effect a metastasis to another individual' (Greaves et al., 2003, p. 2324). In the years that followed, reports of shared chromosomal markers in twins with leukemia appeared, consistent with clonal origin; however, cytogenetic methods were less sophisticated than they are today. Furthermore, the same chromosomal markers could occur in individuals with independent leukemias of a common subtype. Therefore, it became important to identify chromosomal markers that were highly unique; definitive evidence eventually came from 'clonal markers, of leukemia fusion genes generated by chromosome translocation' (Greaves et al., 2003, p. 2324) in MZ co-twins. (Fusion genes form when breaks occur in DNA and undergo normal, error-prone repair. The break point and fusion sequence is unique in each individual except in concordant MZ twins.)

In summary, tracking the origin of leukemia in MZ twins has provided persuasive evidence of a clonal origin. This finding also applies to nontwin individuals. However, some MZ twin pairs do not show concordance in infancy. This suggests that postnatal events are necessary to trigger the disorder in one or both predisposed twins, or that some forms of leukemia originate after birth. Deciding between these alternative explanations requires identifying the same unique clonal markers in the unaffected MZ co-twin of an affected twin. This has not yet been accomplished; however, inspection of archived neonatal blood spots of nontwin children (taken for purposes of genetic screening) has shown relevant clonal sequences. According to the investigators, this finding (1) confirms the prenatal origin of leukemia in concordant MZ twins, (2) supports the early developmental origin of leukemia in most pediatric leukemias, and (3) demonstrates that differential exposure to critical environmental triggers may be associated with discordance in older twin children.

The investigators concluded with the thought that 'much can be learned from studying rare conditions' (p. 230). In fact, they show that studying twins with rare conditions can offer new information about health and health risks that would be unavailable from nontwin samples.

Parents and Twins

Older Mother of Twins

Carmela Bousada delivered DZ twin boys, Christian and Paul, on December 29, 2006 (Reuters, 2007). The birth would have gone unnoticed except for the fact that Ms. Brousada was 67 years of age, making her the oldest multiple birth mother in medical history. Earlier, she had convinced the Pacific Fertility Clinic in Los Angeles that she was only 55 years old in order to receive artificial reproductive assistance. The clinic had reported pregnancy success rates of 2% for women older than age 43 and 56% for women younger than age 34.

Ms Bousada, originally from Cadiz, Spain, sold her house to

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raise $59,000 to pay for the treatment (CBS News, 2007). Having children had been her lifelong dream. However, the pregnancy was not easy — she was hospitalized at one point after collapsing in a supermarket. Fortunately, her health has been good since the premature delivery of her sons.

The birth of the twins has triggered considerable debate over the safety of conception at older maternal ages, as well as the advisability of becoming a mother at age 67. Currently, there are no rules in place to regulate who can and cannot receive fertility treatment, although some nations have created guidelines. For example, Great Britain will generally not assist women over the age of 45, but will make exceptions for some women who are several years older. Ms. Bousada expects to live a long time (her own mother lived until the age of 101 years), and she hopes to marry a younger man (Caton, 2007) — presumably to care for the twins in the event that her health fails.

Edut Twins: 'Astro Twins'

Identical twin sisters, Tali and Ophira Edut, enjoy dispensing advice (Ryzik, 2006). To that end, they have created a website (astrostyle.com) that offers information on fashion, pets and other topics. The twins claim to have been in business together since they were 9 years of age, and they say that they rarely disagree.

It is curious that the twins place such confidence in astrological guidance. That is because MZ–DZ twin comparisons challenge reasoning that links time of birth to personality and other behavioral predispositions. How would the twins explain why MZ twins born 10 minutes apart could be more behaviorally alike than DZ twins separated by just 1 minute? I am not the first person to raise such questions. St. Augustine devoted several pages to this topic in the fifth book of his volume, *The City of God*, written in 415 after the fall of the Roman Empire: '... how comes it that they [philosophers] have never been able to assign any cause why, in the life of twins, in their actions, in the events which befall them, in their professions, arts, honours, and other things pertaining to human life, also in their very death, there is often a great difference, that, as far as these things are concerned, many entire strangers are more like them then they are like each other, though separated at birth by the smallest interval of time, but at conception generated by the same act of copulation, and at the same moment' (p. 144).

It is true that some marked behavioral and physical differences can emerge between MZ co-twins, but it is unlikely that many strangers are more alike than they. Of course, knowledge of the biological bases of twinning was unavailable at the time this passage was written. St. Augustine's work reveals recognition of same-sex and opposite-sex twins, but does not (and cannot) distinguish between same-sex MZ and DZ pairs; instead, reference is made to pairs that are similar and different in selected ways. In general, however, his reasoning is sensible — for example, he states that (1) twins could show matched medical difficulties because of their parents' health, exposure to the same geographical conditions, and/or consumption of the same foods, rather than because of the alignment of the stars, and (2) many different people can be born at the same time in different locations, yet show highly divergent life histories. Both of these arguments pose strong challenges to astrological interpretations.

St. Augustine continues his argument by stating that if twin births occurred so close in time — such that a change in the position of the stars would be impossible — then nothing less than perfect similarity is to be expected from twins, an event that never happens. On the other hand, if the birth interval between twins were long enough allowing the stars to shift, he would 'demand different parents, which twins can never have' (p. 145).

Separated, But Not at Birth.

Behavioral differences between MZ twins are as compelling as their similarities, perhaps more so. This is because such observations challenge researchers to develop explanations for why genetically identical individuals sometimes develop differently in profound ways. The life paths of identical twins, Michael and Richard Adams, are exemplary of the kinds of occupational differences that identical twins can display, even despite their similarities in other areas (Muther, 2007).

Richard Adams works on his family's livestock farm in north-central Massachusetts, while his identical twin brother Michael is an interior designer and a contestant on Bravo's reality television show *Top Design*. The twins' contrasting life styles are not so surprising when we learn that they evolved naturally out of the twins' early predispositions. For example, when one twin played soccer, the other twin picked flowers and asked for a sewing machine. When one twin tended the farm animals, the other twin sang to them. The twins claim that these differences strengthened their relationship — they never fought, and when one twin needed style advice and the other twin needed protection, each knew where to turn.

Explaining these co-twin differences requires research attention to both prenatal and postnatal sources of influence. Parents may explain their twins' diverging lifestyles with references to their rearing differences — but they forget that children's behaviors are largely responsible for the ways they are treated by their parents. Most likely, prenatal events (e.g., hormonal exposure, epigenetic processes) are implicated in the differences between identical twins. Close study of Richard and Michael, and other pairs like them, can provide greater insight into why children develop as they do.

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