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Original Research

Early Single Sport Specialization in a High-Achieving US Athlete Population: Comparing National Collegiate Athletic Association Student-Athletes and Undergraduate Students

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Context: Early single-sport specialization and the relative age effect are often cited as improving the chances of sport success. Both concepts suggest that genetics and the environment have little influence on sport success.

Objective: To compare National Collegiate Athletic Association Division I student-athletes (SAs) with their undergraduate nonathlete peers (NAs) in terms of birth month, age of sport initiation, and age of single-sport specialization. A family history of sport participation was examined as a potential marker for genetic and social influences.

Design: Cross-sectional survey.

Setting: Large urban university.

Patients or Other Participants: A total of 273 Division I SAs (138 women, 135 men) and 155 NAs (78 women, 77 men) participated. The NAs had been involved in competitive youth sports before entering the university.

Main Outcome Measure(s): Participants were asked to complete a questionnaire that addressed the age of sport initiation, birth month, age of single-sport specialization, and parental and sibling sport achievement.

Main Results: Neither birth month nor the age of sport initiation differed between groups (age of sport initiation = 7.16 ± 2.6 years for the SAs versus 7.71 ± 3.5 for the NAs; $P = .176$). A larger proportion of SAs began participating before 10 years of age (80% versus 63%; $P = .02$). The parents of SAs were more likely to have participated in collegiate (32.4% versus 8.4%; $P < .0001$) and professional (10.9% versus 1.3%; $P = .0005$) sports. The SAs specialized in a single sport at an older age (15.38 ± 2.7 years versus 14.30 ± 2.6 years; $P = .002$). Both groups participated in multiple sports in childhood (SAs = 3.9 ± 1.8 sports, NAs = 3.2 ± 1.8 sports; $P = .366$).

Conclusions: The Division I SAs did not specialize in a single sport at a younger age than the NAs. No evidence of a relative age effect was present. Importantly, higher levels of sport achievement among the parents and siblings of SAs suggest that genetic endowment and family or other environmental dynamics play a large role in athletic performance. Overall, the results are not consistent with deliberate practice theory and point toward an alternative model that includes not only sport-specific skill development but also genetic and social factors as key elements of long-term sport achievement.

Key Words: deliberate practice, relative age effect, youth athletes, genetics

Key Points

- High-achieving Division I athletes specialized in a single sport in middle adolescence, which was no earlier than their nonathlete peers who did not continue sports in college.
- Greater sport achievement by the parents of student-athletes indicated that genetic endowment and family and social dynamics played a significant role in athletic performance.
- Genetic and social factors appeared to be key elements in long-term sport achievement.

Single-sport specialization can be defined as year-round participation in training and competition in 1 sport to the exclusion of others.[1,2] Although the concept that early single-sport training is essential to long-term success has been promoted by some authors,[3,4] few scientific data support this approach for young athletes.[5–7] In fact, with the exception of early-entry sports (eg, figure skating, gymnastics), research on elite athletes showed that early single-sport specialization did not correlate with success in most sports.[6] Despite this, some parents and coaches may fear that a child who does not specialize in 1 sport at a young age will be at a competitive disadvantage.

The push toward early single-sport specialization has been driven in part by the theory of deliberate practice.[3] The central tenet of this model is that an individual's ultimate level of performance is directly related to, and constrained by, the accumulated amount of deliberate practice. Another factor consistent with the deliberate practice model is the *relative age effect* (RAE), which purports that those born earlier in a calendar year will have

an advantage in achieving sport success.[8–10] Both deliberate practice and the RAE minimize the potential role of genetic traits and environmental influences.[11] However, others[12–14] argued that although practice was essential for sport success, various individual genetic differences (both physical and psychological) and social influences combined with training to promote elite levels of athletic achievement.

Much of the more rigorous research regarding the relationship between sport-participation history and sport success has been performed among cohorts of non-US athletes.[5–7,15,16] This is noteworthy because US sport-participation and -development programs are typically different from those in Europe and the United Kingdom. Consequently, it is not clear if the development of new paradigms of youth sports will be suited to young US athletes.

With this in mind, the purpose of our study was to compare the sport-participation history of National Collegiate Athletic Association (NCAA) Division I (DI) student-athletes (SAs) and nonathlete undergraduates (NAs) with respect to age of sport initiation and age of single-sport specialization. Birth month was assessed to identify an RAE. Family history of sport participation was considered a marker for genetic and environmental influences. We hypothesized that SAs would be distinguished by having families with a history of high levels of sport achievement and that the age of single-sport specialization and birth month would not differ between groups.

METHODS

The participants were NCAA D1 SAs and NAs at a single institution in a large urban setting. They were administered a questionnaire that assessed personal sport-participation history, birth month, age of single-sport specialization, and parental and sibling sport-participation history. The survey was developed in consultation with statisticians at our university. The format was pilot tested with local high school students. Feedback was gathered regarding the time to complete the survey, and the pilot surveys were reviewed. The survey format and some questions were modified. No formal attempts were made to validate the survey.

Single-sport specialization was defined as the age at which the athlete stopped participation in all other sports to focus on 1 sport.[1,2] Parental and sibling sport achievements were categorized as professional, collegiate, high school, recreational or none.

For inclusion in the study, NCAA DI SAs were eligible if they were officially listed on the roster of one of 19 NCAA sports offered at the university and had competed in US youth sports. The DI SAs were recruited during annual preparticipation examinations. Undergraduate students were eligible for inclusion in the study if they endorsed participation in competitive youth sports in the US before age 18. The NAs were recruited from both athletic and nonathletic university clubs or groups. Many of these students participated in university club or recreational activities, including power lifting, martial arts, and tennis. Members of the premedical student group, as well as undergraduate members of the athletic training program, also participated. Before entering college, the NAs had participated in a variety of youth sports, including each of the NCAA sports represented in the SA group. Participation in the study was voluntary and anonymous. The study was approved by the university's Office for Protection of Research Subjects, and filling out the survey was considered informed consent. The data were collected from 2012 to 2014, and each sport or group was surveyed once.

Table 1. Study Participants From a National Collegiate Athletic Association Division I University

Characteristic[a]	Student-Athletes (n = 273)	Nonathletes (n = 155)
Women	138	78
Men	135	77
Age, y	19.0 ± 1.26	19.7 ± 1.27

[a] The distributions of sex and age were not different between the student-athletes and nonathletes.

The statistical analysis was performed by a statistician using the R statistical software system (The R Project for Statistical Computing, Vienna, Austria).[17] To analyze parental sport-participation history and the age groupings of sport initiation, we conducted 2 sample tests for equality of proportions. Welch 2-sample *t* tests were performed for all other comparisons between the SAs and NAs. The a priori level of significance used for all statistical tests was .05.

RESULTS

A total of 275 SAs agreed to participate in the study. The overall participation rate for DI SAs was 46%. A total of 164 NAs also participated (Table 1). (Rosters or membership numbers for NA club and recreational sports were not maintained by those groups; thus, the response rate cannot be provided.) Two SAs were excluded, 1 who did not complete the questionnaire and 1 who did not compete in US youth sports. Nine NAs were excluded: 8 who did not begin a sport until age 18 or older and 1 whose survey was incomplete. Thus, the data from 273 DI SAs (138 women, 135 men) representing 19 NCAA sports (Table 2) and 155 NAs (78 women, 77 men) were included in the analysis.

Individual Sport-Participation History

Overall, the average age of sport initiation was not different between the 2 groups. (7.2 ± 2.6 years for SAs versus 7.7 ± 3.5 years for NAs; $P = .176$). The vast majority of SAs and NAs began sports before age 10. However, a larger of proportion of SAs began sport participation before age 10 (80% of SAs versus 63% of NAs; $P = .02$). Both SAs and NAs participated in multiple sports during their youth (3.9 ± 1.8 sports for SAs versus 3.3 ± 1.8 sports for NAs; $P = .366$). The SAs specialized in a single sport at an older age than the NAs (15.4 ± 2.7 years versus 14.3 ± 2.6 years; $P = .002$).

Birth Month and Family Sport-Participation History

Birth month did not differ between the SAs and NAs ($P = .927$; Table 3). The SAs were more likely to have at least 1 parent who participated in sports at the collegiate level (32.4% versus 8.4%; $P < .0001$) or professional level (10.9% versus 1.3%; $P = .005$; Figure). In contrast, 47% of the NAs did not have a parent who participated in sports at any level compared with 21% of the SAs ($P < .001$). The

Table 2. Distribution of National Collegiate Athletic Association Division I Student-Athletes (n = 273)

Sport	No.
Football	33
Women's track and field	27
Women's swimming and diving	26
Men's water polo	19
Men's track and field	18
Baseball	17
Men's soccer	17
Softball	17
Gymnastics	15
Men's volleyball	15
Women's tennis	12
Men's basketball	10
Women's volleyball	10
Women's water polo	10
Women's soccer	9
Women's golf	7
Men's golf	6
Men's tennis	4
Women's basketball	1

Table 3. Distribution of Birth Months for Study Participants, % (n)

Month[a]	Student-Athletes (n = 273)	Nonathletes (n = 155)
January	9 (25)	10 (15)
February	6 (16)	8 (12)
March	13 (35)	10 (15)
April	9 (25)	9 (14)
May	8 (21)	9 (14)
June	7 (18)	6 (9)
July	11 (31)	13 (20)
August	9 (25)	10 (16)
September	8 (22)	5 (8)
October	9 (24)	6 (10)
November	6 (16)	6 (10)
December	5 (15)	8 (12)

[a] Birth months did not differ between the groups ($P = .927$).

NAs were also more likely to have parents who participated at a recreational level only (14.8% versus 6.2%; $P = .005$). The groups did not differ with respect to parental participation at the high school level.

The same pattern was observed for sibling sport-participation history. The SAs were more likely to have had at least 1 sibling who participated in competitive sports at the collegiate (26% versus 6%; $P < .001$) or professional (3% versus 1%; $P = .04$) level. The NAs were more likely to have siblings who either did not participate in youth sports or participated at the recreational level only. Sibling sport participation in high school sports did not differ.

DISCUSSION

It is generally accepted that organized, sport-specific practice is required for skill development and long-term sport success. However, the need to implement early single-sport specialization is controversial. *Deliberate practice* is defined as highly structured activity with the explicit goal of improving performance.[3,11] This theory maintains that the level of performance an individual attains is directly related to and *constrained by* the cumulative amount of deliberate practice and, therefore, early specialized practice is essential.[11] Given this and the proliferation of independent year-round sport clubs, personal coaches and trainers, and recruiting showcase events, early single-sport specialization has become commonplace in US youth sport culture.

Most cohort studies[5–7,15,16,18,19] of the relationship between early single-sport specialization and long-term sport performance have been conducted in non-US athletes. More recently, a growing number of studies of US athletes[20–23] have generated questions about the role of early single-sport specialization. However, few authors have explored the potential role of genetic influences on exceptional US athletes and compared such findings to a peer group whose participation did not advance beyond the youth level.

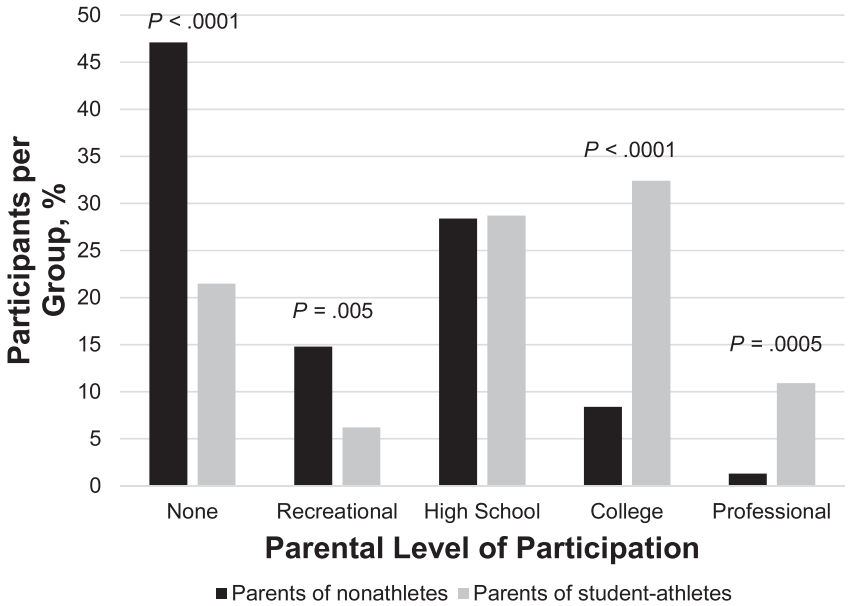

Figure. Familial levels of sport achievement among student-athletes versus nonathletes. Parents of student-athletes were more likely to have competed at the collegiate ($P < .0001$) or professional ($P < .0005$) levels.

We compared high-achieving US SAs at the NCAA DI level with their NA peers and found that the average age of single-sport specialization for the former occurred in middle adolescence and was 1 year older than for the latter (15.4 versus 14.3 years; $P = .002$). A recent survey[20] of DI athletes that did not include a comparison group demonstrated an age of specialization of 14.9 years. In addition, 88% of the SAs in our study participated in more than 1 sport in youth, and the average was 3.9 sports. Taken together, these findings are consistent with data from outside the United States indicating that long-term sport success was associated with multisport participation in youth and that single-sport specialization occurred in middle adolescence rather than childhood or early adolescence.[15,16,18,24–28] It is also interesting to note that although the average age of sport initiation was similar between the groups, the SAs were more likely to have begun sport participation before age 10. This result supports the model of sampling and skill transfer rather than starting early in only 1 sport.[29] Furthermore, these data are consistent with those from studies of other athletes, chess players, and dart throwers that refuted the claim that individual differences in performance were largely accounted for by differences in accumulated deliberate practice.[30]

Deliberate practice research has not assessed the effects of genetic endowment and the family environment on the development of expertise.[3,11] We used parental sport-participation history as a marker for genetic influences and family dynamics. The parents and siblings of SAs were more likely to have been high-achieving athletes, which was in striking contrast to the NAs. Although these observations cannot be directly attributed to genetic factors, they suggest that both genetics and being in a family or social setting that values sport participation play significant roles in long-term sport success. Such findings are consistent with other investigations[13,31] of genetic factors and sport success. Furthermore, the recognition of genetic and environmental influences in sport performance could indicate that youth who are genetically endowed and in a setting that encourages sport participation are more likely to be successful in a number of different sports and do not feel compelled to focus on a single sport until much later in adolescence. This would be a unifying concept consistent with our results and those from non-US athletes.

Another factor that has been observed in many published studies of youth sports is the RAE.[8–10] This refers to the overrepresentation of athletes born earlier in a chronologic age grouping. Such age groupings aim to provide a more equal opportunity for participation but do not account for variations in physical and cognitive development within an age group that tend to favor those born earlier in that cycle. Thus, the RAE reflects the general advantage early-maturing youth have in size, strength, and potentially skill development compared with those who matured later in the same chronologic age grouping. Interestingly, we did not identify an RAE, as birth months did not differ between the SAs and NAs. The reasons for this are unclear. It is possible that birth month within the calendar year may not be a useful comparator in the United States. For schools and scholastic sports, the age of entry can vary among public school districts and private schools. With respect to nonscholastic youth sports, because the athletes in this study came from many areas of the United States, they may reflect differences in sport age groupings (soccer being a notable exception). We were unable to analyze such differences in age segmentation among different sports or within a single sport. In addition, some US children born in the summer and fall months may not enter school in the same calendar year as those born earlier in the same year. This can occur when parents delay school entry for a year due to concerns such as school readiness or because they seek to gain an athletic or academic advantage for their child—in some cases, perhaps because of awareness of the RAE.[32–34]

Study Limitations

This was a cross-sectional survey and subject to recall bias. It was performed at a single NCAA DI institution and had a relatively small sample size and a limited response rate. As such, the findings may not represent other DI athlete populations or athletes at the Division II or III levels. In addition, the data may not apply to US athletes competing at the national or international level outside the collegiate system. Also, although the SAs competed in 19 sports, the sample in each sport was small and not evenly represented. Therefore, variations in youth participation by sport cannot be assessed. It is also possible that the NA group included at least some higher-level athletes who chose to not pursue collegiate sports. Finally, it is important to note that we did not assess the volume of training in youth sport. Thus, the effect of any differences in cumulative training cannot be determined.

CONCLUSIONS

Our findings add to the building evidence that deliberate practice alone is insufficient to achieve long-term athletic success. Specifically, high-achieving NCAA athletes specialized in a single sport in middle adolescence, and they did not specialize earlier than their peers who did not continue sport at the DI level. Furthermore, the higher levels of sport achievement among the parents and siblings of the SAs suggested that genetic endowment and family and social dynamics played a large role in athletic performance. Overall, the results point toward an alternative model that includes not only sport-specific skill development but also genetic and social factors as key elements of long-term sport achievement. More research assessing these factors among larger athlete populations within specific sports and comparisons between women and men is needed.

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