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ORIGINAL INVESTIGATION

Analysis of the Kenyan Distance-Running Phenomenon

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Purpose: To investigate the ethnicity of Kenya's most successful international runners, tracking their evolution over the period of their international emergence and current dominance. ***Methods:*** The authors analyzed male track distance events from 800m upwards from all the major global athletics championships from 1964 to 2013, and the annual Top-25 world marathon performances since 1990. ***Results:*** The percentage of top-25 marathon performances and medals won by Kenyan and Kalenjin runners have increased over time with Nandi subtribe outperforming the rest of the world outside Africa ($r > .70$, large effect). However, Europe, North America, Oceania, Asia, and South America decreased over time in top marathon performances and track medals won ($r > .70$, large effect). The tribe and subtribe distribution was different in the marathon than in the track: Maasais were more likely to feature in medals won in shorter track events than in the top 25 of the world marathon rankings (risk ratio [RR] = 9.67, very large effect). This was also the case for Marakwets (RR = 6.44, very large effect) and Pokots (RR = 4.83, large effect). On the other hand, Keiyos, Kikuyus, Kipsigis, Sabaots, and Tugens were more likely to succeed in the marathon than in shorter track events (RR > 2.0, moderate effect). ***Conclusion:*** These data emphasize that the previously documented emergence of African distance runners is primarily a Kenyan phenomenon, driven by the Kalenjin tribe and in particular the Nandi subtribe. This supports the complex interaction between genotype, phenotype, and socioeconomic factors driving the remarkable dominance of Kenyan distance runners.

Keywords: evolution of performance, Olympic Games, marathon, Kalenjin, Kenya

The dominance of African nations, particularly Kenya, in distance-running events is one of the most fascinating topics in exercise performance physiology. Recently described in a demographic audit of marathon running,[1] Kenyan's emergence and dominance are illustrated by an increase in the contribution of Kenyan men in the top-20 all-time performances in the track distance events (800-m and upward) from 13.3% in 1986 to 55.8% in 2003.[2] Kenyan (by birth) men have won 43 out of a possible 108 medals (41%) in distance events at the Olympic Games since 1990 and have won the team title at 24 of the last 27 world cross-country championships dating back to 1986.

The physiological, psychological, and cultural basis for the rise and dominance of Kenyan runners has been the subject of research and opinion in both the scientific literature[3,4] and the lay media.[5] The complex physiology that underpins running performance is multifactorial, so the rise and subsequent disproportionate success of a relatively small population is unlikely to be explained by any single factor. Simplified or extreme positions that attribute success to either environment and lifestyle or genes and physiology are thus futile and incomplete.[3,6]

Of particular interest to the understanding and investigation of the Kenyan distance-running phenomenon is a specific description of the demographics of the Kenyan running population. Some previous analyses have grouped African runners together and compared them with the rest of the world, detailing their emergence and dominance from the 1990s onward.[1] Other research has investigated the ethnic and environmental backgrounds of Kenya's successful athletes compared with the general population at a specific moment in time.[2,7]

The specific composition of all of Kenya's most successful international distance athletes, as well as the evolution of the demographics of Kenyan runners over the period of their international emergence, has, however, never been described. Therefore, the aim of the current study was to characterize, in detail, the ethnicity of Kenya's most successful international male runners and to track the relative success of various ethnic groups or subtribes over time and in distance-running events (marathons compared with track). This may inform discussion and future research into both genetic and environmental factors that may contribute to observed performance trends.

Methods

Design

The design of the study was that of observational research.

Subjects

The human research ethics committee of the University of Cape Town granted permission for this study. We collected medal-winning data from all major global athletics championships in which Kenya participated, from their first medal in the 1964 Olympics to the International Association of Athletic Federations (IAAF) World Athletics Championships in 2013. We limited comparisons to championships in which Kenya had participating athletes and therefore omitted the 1976 and 1980 Olympic Games, as these were boycotted by Kenya.

We analyzed the men's distance events, comprising the 800-m, 1500-m, and 3000-m steeplechase and the 5000-m, 10000-m, and marathon. There were a total of 18 medals available per championship, for a total of 450 medals in 25 championships (11 Olympic Games and 14 world championships). The names, events, and medal

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type won by Kenyan athletes over this period were collected using the IAAF's open-access Web site (http://www.iaaf.org/, accessed March 14, 2014) and used for subsequent assignment to tribe analysis.

We defined an elite marathon performance as one that was ranked in the top 25 of the annual world marathon rankings based on time. The annual world rankings were obtained from the open-access official record lists, as maintained by the Association of Road Racing Statisticians Web site (http://aimsworldrunning.org/statistics/CurrentYearStatistics.htm, accessed March 6, 2014).

Marathon performances were analyzed for the period from 1990 to 2013. This period was chosen because before 1990, Kenyan athletes rarely featured in the top 25 of the world marathon rankings. This was discovered by preliminary analysis that found that in the decade from 1980 to 1989, only 11 Kenyan men ranked in the top 25 of the annual world rankings, compared with 53 in the decade from 1990 to 1999. Since we aimed to track the rise of Kenya's relative running dominance, we thus omitted the period before their emergence from 1990 onward.

Global Comparisons

To compare Kenya with the rest of the world, we determined the country and continent of birth of the medal winners and ranked marathon performances from athletes other than Kenyans. This included Europe, North America, South America, Asia, and Oceania. We also analyzed medals won and top-25 marathon performances from athletes born in Africa but excluding Kenya.

The assignment of athletes was based on place of birth, not nationality at the time of competition, which means that many athletes who were born in Africa but competed for nations on other continents were analyzed as African. In 2 instances, athletes won medals competing for their country of birth but belong to the same tribes as Kenyan runners. These 2 instances involved Ugandan medalists identified as Kalenjin. We included these athletes in their tribal group for the tribal analysis but as Ugandan for the comparison of continents and territories.

Kenyan Tribe and Subtribe Allocation

The names of Kenyan medal winners, marathon performers, and their corresponding ranking were collected and classified according to their ethnic tribes and subtribes. Ethnic assignment in Kenya is based primarily on linguistic and geographical factors.[8] The majority of the Kenyan population belongs to various Bantu subgroups, with a significant number of Nilotes and a minority of Cushitic people making up about 2% of the population.[8] In the current analysis, all medalists and top-ranked marathoners belonged to either the Nilotic or Bantu groups.

Bantus are the largest population group in Kenya and include among others the Kikuyu, Kamba, Luhya, and Kisii tribes.[7] Nilotes are the second-largest group and include, among others, the Maasai, Luo, Rendile, Borana, Turkana, and Kalenjin.[7] The Kalenjin tribe, which mainly inhabits the altitudinous Rift Valley Province, can be further divided into subtribes that include, for the purposes of this analysis, the Nandi, Marakwet, Kipsigis, Pokot, Tugen, Keiyo, and Sabaot. In the case of marriages across different subtribes, the father's tribe took prevalence over the mother's tribe.[8]

Statistical Analysis

Statistical analyses of data were performed using the Statistical Package for the Social Sciences 21.0 (StatSoft, Tulsa, OK, USA). Linear logistic regression was used to assess the rise or decrease in total track medals and top-ranked marathoners from different parts of the world across time. A slope of the curve different from zero was interpreted as a rise or decrease, and the 95% confidence intervals were also calculated. The magnitude of the effect was interpreted as trivial (<0.1), small (≥0.1 and <0.3), moderate (≥0.3 and <0.5), large (≥0.5 and <0.7), or very large (≥0.7) according to the *r* correlation value. Ethnic frequency differences between track medals and top-ranked marathon runners were calculated by logistic regression and the proportion ("risk") ratio (RR). The magnitude of the effect was interpreted as trivial (<1.2), small (≥1.2 and <1.9), moderate (≥1.9 and <3.0), large (≥3.0 and <5.7), or very large (≥5.8). Tribes and subtribes that accounted for fewer than 5% in both total track medals and top-25 marathon-ranked athletes were excluded from the analyses (Kamba and Turkana).

Results

Historical Medal and Marathon Performances

The percentages of track distance-event medals won since 1964 and the percentage of top-25 marathon performances since 1990 for Kenyan, Kalenjin, and other Kenyan subtribes are presented in Figures 1(A) and 1(B), respectively. Table 1 provides a complete summary of medals won in Olympic Games and world athletics championships, as well as top-25-ranked marathon performances for Kenya, its various tribes and subtribes, and all other continents and territories.

The percentage of medals won by Kenyan and Kalenjin runners has increased since the first medal, won in 1964 ($r = .60$ and $r = .65$, large effect). Similarly, the percentage of top-25 marathon performances by Kenyan and Kalenjin runners has increased since 1990 ($r = .88$ and $r = .80$, very large effect) (Table 2).

Kenyan men have won 64 Olympic (32%) and 88 world-championship medals (35% of total medals, Table 1). The Kalenjin tribe have won 84% of Kenya's Olympic and world-championship medals (Table 1) and provide 79% of Kenya's top-25 marathon performances, contributing 34% of the total performances over the analyzed period (Table 1). In more recent years, Kalenjin men have sustainably produced over 40% of the best marathon performances per year, peaking above 60% in 2009, 2011, and 2013 (Figure 1[B]).

Continent-of-Birthplace Comparisons

Athletes born in Kenya have won 152 medals in all distance events, compared with 145 for other African countries (of which 61–42% have been won by Ethiopia) and 153 for the rest of the world combined. Time-series analysis revealed decreases over time in track medals won and marathon performances for Europe ($r = .50$ and $r = .88$, large effect), North America ($r = .59$ and $r = .65$, large effect), Oceania ($r = .64$ and $r = .56$, large effect), Asia ($r = .72$ in the marathon, very large effect), and South America ($r = .54$ in the marathon, large effect).

Kenyan-Subtribe Global Comparison

The Nandi subtribe have won 72 medals in Olympic and world championships, 47% of the Kenyan total (Table 2). The contribution of the Nandi to the top-25 marathon performances rose over time ($r = .87$, very large effect). The percentage of runners born in Africa excluding Kenya also increased in the top-25 marathon performances and total medals won over time ($r = .46$, moderate effect, and $r = .64$, large effect, respectively). In contrast, the rest of the world decreased over

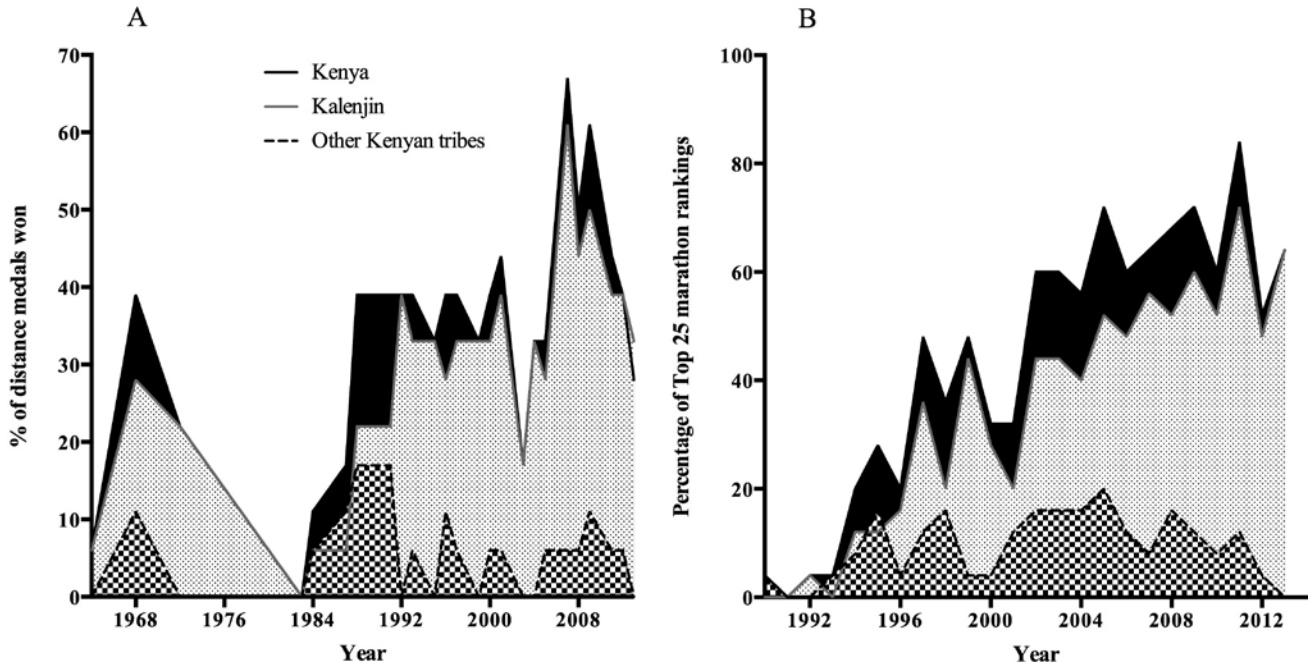

Figure 1 — (A) Percentage of track medals won and (B) percentage of top-25 marathon performances achieved by Kenya, Kalenjin, and other Kenyan tribes.

Table 1 Total Medals in 800-m, 1500-m, 3000-m Steeplechase, 5000-m, 10000-m, and Marathon in the Olympic Games Since 1964, World Championships Since 1983, and Marathon Performances in the Top 25 Since 1990 in Kenyan Runners From Each Tribe and Subtribe and the Rest of the World

	Olympic Games		World Championships		Top-25 Marathon Performances	
Runner origin	Medals	% total	Medals	% total	Total	% total
Kenya	64	32.3	88	34.9	262	43.7
Kalenjin	54	27.2	77	30.6	206	34.3
Nandi	33	16.7	39	15.5	86	15.5
Keiyo	5	2.5	10	4.0	38	4.0
Kipsigis	7	3.5	6	2.4	45	7.5
Marakwet	5	2.5	15	6.0	5	0.8
Pokot	1	0.5	3	1.2	2	0.3
Sabaot	0	0.0	1	0.4	8	1.3
Tugen	3	1.5	3	1.2	22	3.7
Kikuyu	6	3.0	3	1.2	28	4.7
Maasai	1	0.5	7	2.8	2	0.3
Kisii	3	1.5	2	0.8	16	2.7
Kamba	1	0.5	0	0.0	10	1.7
Turkana	0	0.0	1	0.4	0	0.0
Other Africa	57	28.8	88	34.9	128	21.3
Europe	46	23.2	54	21.4	102	17.0
North America	14	7.1	10	4.0	25	4.2
Oceania	8	4.0	3	1.2	8	1.3
Asia	6	3.0	4	1.6	60	10.0
South America	3	1.5	5	2.0	15	2.5

Table 2 Slopes of the Evolution of Total Medals in the Olympic Games Since 1964, World Championships Since 1983, and the Top-25 Marathon Performances Since 1990 in Kenya, Kalenjin Tribe, and Other Parts of the World

	Kenya	Kalenjin	Africa	Rest of the world	Europe	North America	South America	Oceania	Asia
Total medals									
r	.60	.65	.64	.76	.50	.59	.22	.64	.26
effect	Large	Large	Large	Very large	Moderate	Large	Small	Large	Small
slope	.12	.13	.12	–.24	–.13	–.05	–.01	–.04	–.01
95% CI	.05–.19	.06–.19	.06–.18	–.33 to –.15	–.23 to –.03	–.07 to –.02	–.02 to –.01	–.06 to –.02	–.03 to .00
P	**.002**	**.000**	**.004**	**.000**	**.009**	**.002**	.298	**.001**	.213
Top-25 marathon performances									
r	.88	.80	.46	.88	.88	.65	.54	.56	.72
effect	Very large	Very large	Moderate	Very large	Very large	Large	Large	Large	Large
slope	.78	.73	.17	–.78	–.43	–.16	–.07	–.06	–.22
95% CI	.61–.96	.60–.85	.03–.31	–.96 to –.61	–.52 to –.34	–.25 to –.08	–.11 to –.02	–.10 to –.02	–.31 to –.13
P	**.000**	**.000**	**.02**	**.000**	**.000**	**.001**	**.005**	**.004**	**.000**

Abbreviation: CI, confidence interval.

Note: Significant *P* values are shown in boldface type.

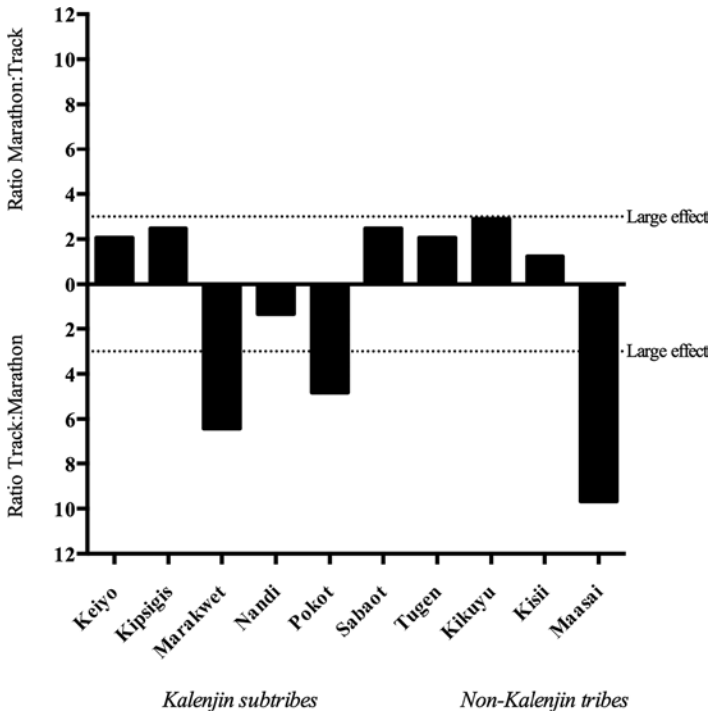

Figure 2 — Ratio of contributions to medals won in track and performances in the top-25 marathon rankings for each Kenyan tribe and subtribe.

time in both track distance-event medals won and top-25 marathon performances (r = .76 and r = .88, very large effect) (Table 2).

Figure 2 compares the RR of percentage of track medalists with the percentage of top-25-ranked marathoners from the various Kenyan tribes and Kalenjin subtribes. Where a tribe or subtribe had relatively more track medalists than marathon-ranking performers, the ratio was calculated as track:marathon. When the tribe achieved a relatively higher percentage of top-25-ranked marathon performers, the ratio was calculated as marathon:track. We excluded medals won in marathon events at major championships and performed this analysis on individual performers rather than total medals or performances, which removes multiple medalists and thus the possibility of 1 athlete biasing a tribe's performance.

The tribe and subtribe distribution was different in the marathon and in track, indicating that some ethnic groups are more prevalent in one event category or the other (Figure 2). Maasais were meaningfully more likely to feature in medals won in shorter track events than in the top 25 of the world marathon rankings (RR = –9.67, very large effect). This was also the case for Marakwets (RR = –6.44, very large effect) and Pokots (RR = –4.83, large effect). On the other hand, Keiyos, Kikuyus, Kipsigis, Sabaots, and Tugens were more likely to succeed in the marathon than in shorter track events (RR > 2.0, moderate effect).

Discussion

The current study analyzed the relative contribution of different ethnic groups and subtribes to the Kenyan distance-running phenomenon. Our novel contribution is to extend previous analyses of marathon demographics into a specific analysis of Kenyan ethnic groups over time. This may offer insights to advance understanding of the unparalleled dominance of Kenyan runners.

First, we extend previous demographic audits of marathon running by showing that the African dominance documented previously[1] is largely Kenyan and Kalenjin in nature (Figure 1 and Table 1). This reveals that the Kalenjin tribe, which consists of 5 million people, approximately 12% of the Kenyan population (Kenyan census data, 2009), account for 29% and 34% of all global track medals and elite marathon performances, respectively.

Further analysis of ethnic groups reveals that while medals and elite performances originate from 6 distinct tribes and 7 Kalenjin subtribes, the Nandis, consisting of 950,000 people (Kenyan census data, 2009), have won 72 medals (47% of Kenya's total), a number higher than the combined total of North America, South America, Asia, and Oceania (Table 1). Indeed, since 1990 the Nandi subtribe have outperformed every continent with the exception of Africa in terms of distance track medals won and elite marathon performances. Explanations for this highly concentrated endurance-running success have included physiological, environmental, cultural, and genetic factors and have been reviewed extensively elsehwere.[2–4] The disproportionate representation of a specific tribe and subtribe among a population's successful runners, as we document here, can be interpreted to support all these factors.

In support of genetic and physiological factors, genotypical and phenotypical characteristics that may predispose a person or group of people to running success would be expected to be highly preserved within given subtribes. For instance, it has been reported that there is a strong relationship between performance-mediated attractiveness and reproductive success, which suggests that human endurance capacity has been subject to sexual selection in our evolutionary past.[9]

Similarly, although attributing Kenyan running success to a genetic explanation seems premature,[2] it is noteworthy that Kenyans present high frequencies of desirable genotypes of certain performance-linked genes. A typical example is ACTN3, which encodes the protein alpha-actinin-3 and is almost exclusively expressed in sarcomeres of fast glycolytic type II fibers responsible for the generation of rapid forceful contractions.[10] Two variants in this gene, R and X, have been identified, with the RR variant polymorphism strongly associated with sprint-running performance.[10] In this regard, Yang et al[11] have found that the XX genotype, which is nondesirable for elite sprint-running performance, is almost nonexistent in Kenyans. While single gene associations with performance are oversimplified for numerous reasons,[2] we nevertheless cannot exclude a role for genetics in our findings.

In contrast, social, environmental, lifestyle, and cultural factors would be expected to exert effects on tribes that are, by definition, tightly geographically and linguistically bound. Research has yet to reveal a gene or even a combination of genes that is conclusively linked to performance, though given complex physiology, the extremely small sample of elite athletes, the limited scope of single-gene-association studies, and the difficulty of finding appropriate controls,[3] this is unsurprising. The complex, multifactorial interaction of physiology and environmental factors remains the most accurate current explanation for the observed success.

A further novel contribution of this study is the insight regarding the performance of ethnic groups other than the Nandi, who have been described previously.[7] This novel analysis shows that certain groups are more likely to win medals in the shorter track distance events than in the marathon (Figure 2). The Maasai tribe and the Marakwet and Pokot subtribes provided meaningfully more track medalists than elite marathon runners (Table 2), whereas the Kikuyu tribe and the Kipsigis, Sabaot, Tugen, and Keiyo subtribes provided more marathon runners (moderate effect) (Table 1 and Table 2).

Specific explanations for the relative overrepresentation of a tribe or subtribe in marathon events compared with shorter track distance events are unclear. Indeed, given the complexity and previously discussed multifactorial nature of the East African running phenomenon,[2,3] the nuances that contribute to the success of ethnic groups in specific categories are perhaps conservatively attributable to similar factors. These include genetic factors[12]; environmental factors such as altitude, lifestyle, training characteristics, and early-life factors[4,13–15]; and socioeconomic factors.[7]

For example, Onywera et al[7] compared elite athletes with the general Kenyan population and found that international Kenyan athletes have a distinct environmental and ethnic background, which included origins in the altitudinous Rift Valley and running longer distances to get to school. Our data support the ethnic finding, which we extend to include not only the Kalenjin and the Nandi but also other tribes such as the Maasai and Kikuyu and subtribes including the Marakwet, Kipsigis, and Keiyo. While our method and analysis does not allow discussion of possible factors contributing to success in certain groups, we speculate that environment and lifestyle factors similar to those discussed previously[2,7] may contribute to greater relative success of ethnic groups in either track or marathon events.

The importance of social and cultural factors has also been proposed as a key driver of the disproportionate Kalenjin success, where the achievements of Kipchoge Keino, a Nandi, is said to have driven interest, participation, and dedicated recruitment of runners.[7,16] The subsequent success of Nandi runners may have inspired further success, driven by economic incentives described previously. Indeed, Onywera et al[7] found that one-third of Kenyan international runners became athletes for economic empowerment. It is not inconceivable that similar success in subtribes documented in the current study may have inspired a form of imitation leading to subsequent success and the observed increased likelihood of certain groups' success in shorter track distance events (Figure 2).

With respect to the time-series analysis of medals and elite marathon performances, it is clear the current dominance of Kenyan athletes began at distinct time periods, with marathon dominance delayed by 2 decades compared with Olympic and world-championship distance success (Figure 1). Also notable in track and field athletics is the successful Olympic performance at altitude in Mexico City 1968, where Kenya won 7 medals. This was followed by a decline and a period of relatively modest success in the early 1980s, before Kenya won 7 medals in the 1988 Olympic Games and have since won 40% of the available distance medals, peaking at over 60% (Figure 1[A]).

A possible catalyst for this shift in the latter half of the 1980s may have been the appointment of Mike Boit to the role of Kenya's sports commissioner. Boit, a Kenyan Olympic medalist in 1972 and now professor of sports science at Kenyatta University, gave the athletes their passports and invited agents into the country. These changes facilitated increased exposure to competition and the resultant dominance of Kenya in international events.[17] In the case of the marathon, commercial factors associated with runner agency, including sponsorship, prize money, and bonus payments, would have created a large economic incentive to succeed, particularly considering the documented economic incentive reported by the very best Kenyan athletes.[7]

This supports the contribution of cultural factors to success within a relatively small population, where early generations of successful athletes inspire subsequent generations to adopt distance running for economic rewards.[7,18] Increased opportunity, improved coaching, and economic incentives have been hypothesized to increase the likelihood of success. This may partly explain the observed lag between the early success and the sustained dominance from the 1990s onwards. Indeed, Kenya's women have not yet achieved the same success as the men, but this may be partly attributable to sociocultural factors that historically hindered their participation in distance running. The first female Kenyan Olympic medal was won as recently as 1996, and future championships may reveal dominance similar to that of the men, although the data set is too small to draw meaningful insights at present.

The assignment of athletes to tribes and subtribes is an important consideration. As described, this was performed according to the Kenyan tradition of ethnic inheritance, which is primarily based on the place of birth and the spoken or related language.[7] The assignment is paternal, meaning that in the case of a mixed marriage across tribal lines, a child inherits the tribe belonging to his or her father. An example of this is the Olympic champion and world-record holder David Rudisha, who is classified in this study as Maasai (his father's tribe) despite his mother's being Kalenjin.

This, along with other examples, has implications for a discussion of the heritability of athletic predispositions, since it has previously been reported that the Kenyan athletic status is closely related to the mitochondrial DNA (mtDNA) haplogroup distribution.[12] According to Scott et al,[12] Kenyan international athletes display an excess of L0 haplogroups and a lower frequency of L3 haplogroups relative to Kenyan controls. Notably, despite the increased likelihood of elite athletes' displaying distinct geographical and linguistic heritage relative to the general Kenyan population (a finding confirmed in the current study), this did not appear to be the source of the differences between athletes and controls according to the mtDNA.[12] This has implications for the link between tribe affiliation and genotypical predisposition for endurance performance, since mtDNA comes from matrilineal inheritance.

Given that the method of tribe assignment is based on the ethnicity of the father, possible influences of the mother's genetic background can be overlooked, as may be the case for athletes from mixed tribe origins, such as David Rudisha. Therefore, results shown in this study have to be interpreted cautiously, as matrilineal inheritance is excluded from the ethnic classification despite its previously reported influence in Kenyan athletic ability.

Practical Applications

The specific investigation of time-course changes and event-specific dominance of certain tribes and subtribes reveals interesting insights on the Kenyan distance-running phenomenon. It may also guide future research, since the current hypothesis involves multifactorial contributions from genetic, physiological, and environmental factors. The fact that certain tribes are more represented in shorter track events, and others in the marathon, allows for targeted investigations into these the cultural, environmental, and physiological drivers of success. Finally, this detailed analysis may reveal previously underrealized pools of talent that may yet to be tapped to expand the Kenyan running phenomenon further.

Conclusion

We have provided novel data on the specific ethnic groups that have contributed to the emergence and dominance of Kenyan distance runners. We show that the Kalenjin tribe and the Nandi subtribe contribute a disproportionate number of medals and elite marathon performances, often outperforming the rest of the world combined.

We also show that certain subtribes are more represented in track distance events, while others are more likely to succeed in marathon. These data support the complex and intriguing multifactorial nature of Kenya's unique dominance in distance running, suggesting the interaction between genotype, phenotype, environment, and socioeconomic factors.

Acknowledgments

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