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► To cite this version:

Andy Marc, Adrien Sedeaud, Julien Schipman, Juliana Antero, Guillaume Saulière, et al.. Geographic enrollment of the top 100 in athletics running events from 1996 to 2012. *Journal of Sports Medicine and Physical Fitness*, 2015, 57 (4), pp.418-425. 10.23736/S0022-4707.16.06019-9 . hal-01771672

HAL Id: hal-01771672

<https://insep.hal.science/hal-01771672>

Submitted on 19 Apr 2018

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J Sports Med Phys Fitness 2015 Dec 02 [Epub ahead of print]

THE JOURNAL OF SPORTS MEDICINE AND PHYSICAL FITNESS

Rivista di Medicina, Traumatologia e Psicologia dello

Sport pISSN 0022-4707 - eISSN 1827-1928

Article type: Original Article

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GEOGRAPHIC ENROLLMENT OF THE TOP 100 IN ATHLETICS RUNNING EVENTS FROM 1996 TO 2012

Andy Marc ^{1*}, Adrien Sedeaud ^{1,2}, Julien Schipman ¹, Juliana Antero Jacquemin ^{1,2}, Guillaume Saulière ^{1,2}, Katrine Okholm Kryger ^{1,3}, Jean-François Toussaint ^{1,2,4}

¹ Institute for Research in Medicine and Epidemiology of Sport (IRMES), 11 avenue du Tremblay, 75012 Paris, FRANCE, irmes@insep.fr

² Paris-Descartes University, Sorbonne Paris Cité, 12 rue de l'école de médecine, 75006 Paris, FRANCE

³ Sports Technology Institute, Loughborough University, UK

⁴ Center for Investigation in Medicine and Sport (CIMS), Hôtel-Dieu, Assistance Publique – Hôpitaux de Paris, 75004 Paris, FRANCE

*Corresponding author :

Andy MARC, 11 avenue du Tremblay 75012 Paris France,
andy.marc@insep.fr, +33141744124

Acknowledgments:

The authors thank Katrine Okholm Kryger and Scott Del Vecchio for proofreading the manuscript and providing valuable critique and advice.

ABSTRACT:

Purpose It is widely accepted in the literature that athletes of West African origins achieve the best sprint performances; while, athletes originating from East Africa are the most efficient at long distances. No epidemiological studies have measured the evolution of the contributing of each of these athlete origin groups from 100m to the marathon.

Method Speed, morphology and geographic origin of the Top 100 male and female athletes (from 100m to the marathon) were collected and analyzed over the 1996-2012 period.

Results The amount of male sprinters (100m, 200m and 400m) originating from West Africa increased from 57.7% in 1996 to 72.3% in 2012, while female sprinters from West Africa increased from 55% to 65% over the same period. This contribution has gradually increased from 400m to 100m for both sexes. For long distance events (3000m, 10000m and marathon), male athletes from East Africa represented 32% in 1996, which increased to 65.7% in 2012 and increased over the same period from 9% to 39% for women. In addition, male and female sprinters originating from West Africa have a significantly higher ($p<0.05$) BMI than athletes of other geographic origin. Conversely, long distances runners' BMI are significantly lower for runners with an East African origin ($p<0.05$).

Conclusions The best performances are dominated by a few groups including the West African ancestry for the sprint distances and East African runners for the long distances. This dominance is strengthened from 1996 to 2012 for both sexes to the detriment of Caucasian and Asian athletes.

Keywords: Track and Field, geographical origin, sprint, long distance

Heading title: Geographical domination in Track and Field

INTRODUCTION:

Culture and race in sports have always been disputed ¹. An understanding of these intertwined performance factors requires historical, psychological and biological considerations. High level performance remains multifactorial and depends on endogenous factors such as physiology, genetics, biometrics ^{2,3}, as well as exogenous parameters ⁴⁻⁶. The geographical origin of athletes is a factor affected by both endo and exogenous components, which is believed to involve components influencing the gap between the highest steps of the podium. These determining components include the athlete's genetic, physiological, morphological and cultural inheritance.

In marathon, Marc et al assessed in the annual top 100 the proportion of runners in relation to their native world regions. The proportion of native runners from Kenya and Ethiopia increased from 16% in 1990 to 94% in 2011 ⁷. According to Charles and Bejan ⁸, the geographical origin is an integral part of the speed evolution phenomenon in modern athletics: runners of African origin possess the most world records in track and field. Indeed, anthropometric and biological studies ⁹ have demonstrated that systematic differences exist among athletes of different origins. The amount of published evidence is significant: anthropometrically, Africans have longer lower limbs than Caucasians ¹⁰, with smaller calf circumferences, their centre of mass is located higher in comparison to individuals of the same height ¹¹. Asians and Caucasians have longer torsos, with a lower centre of mass ⁸. These genetic, physiological, and morphological factors, partially dependant on geographical origin, could cause advantages during race events.

The purpose of this study is to analyse the effect of geographical origin and its evolution in Track and Field events on the entire spectrum of Olympics distances from 100m to the marathon.

METHODS:

Data:

This is an epidemiological cross-sectional study of the top 100 world performances in athletic running events from 1996 to 2012. Data on mass, height, body mass index (BMI), speed, birth date, citizenship, and annual ranking were collected for each international top 100 ranked male and female athlete for eight Track and Field categories: 100m, 200m, 400m, 800m, 1500m, 3000m, 10,000m and marathon during the seasons 1996 to 2012. This represented 27,200 annual-performers and 7,325 athletes worldwide: 4,003 males and 3,322 females.

Height and mass values were combined with the individual's best performance every year. All data were collected from the website <http://www.tilastopaja.org> and cross-classified by the International Association of Athletics Federations website: <http://www.iaaf.org>.

Geographical origin

The citizenship and direct ascendants of each athlete were investigated and classified into eight origin groups: West African, Afro-Americans, Caribbean, East African, North African, Euro-American, Asian, and Others origin.

“West Africans” are athletes who have West African nationality and possess at least one parent of West African nationality. “Afro-Americans” are athletes who have an American nationality and possess at least one parent who is of African origin (who could certainly be of West African descent). “Caribbean” are athletes who have a Caribbean nationality and possess at least one Caribbean parent who is of West African origin. “East Africans” are athletes who have an East African nationality and possess at least one parent of East African nationality. “North Africans” are athletes who have a North African nationality and possess at least one parent of North African nationality. “Euro-Americans” are athletes who have a European or American nationality and possess a Caucasian parent.

“Asians” are athletes who have an Asian nationality and possess an Asian parent. The group from “Others origin” include the Middle East, South America, South Africa and Oceania.

Morphology

For men and women, the mean height, mass and BMI, and standard deviation were calculated for the world regions that dominate the sprint events. BMI of Afro-American, Caribbean and West African sprint runners were compared to the other athletes (in light of their dominance in the 100, 200 and 400m). The same method was applied in long distance events for east African runners (in light of their dominance in the 3000m, 10,000m and marathon). Their biometrical characteristics were compared to those of runners from other regions.

Statistical analysis

Statistical analysis was performed in R software v2.14.0. Statistical significance was considered at $p < 0.05$. For each year and for both sexes, the contribution of each world region in the Top 100 was calculated as a percentage. Percentages of each group representation inside the top 100 between 1996 and 2012 were compared by χ^2 test. BMI was statistically compared between groups of athletes by Students t-tests.

Ethics Committee approval: We did not need any ethics committee approval because we collected all data from websites.

RESULTS:

Geographical distribution

27,200 athletes performed in running events annually between 1996 and 2012. During this period, the top 100 in the sprint events (100, 200 and 400m) were dominated by Afro-North American, Caribbean, and West African runners. Over the total period, these three groups represented 63% for men and 58.5% for women (Figure 1).

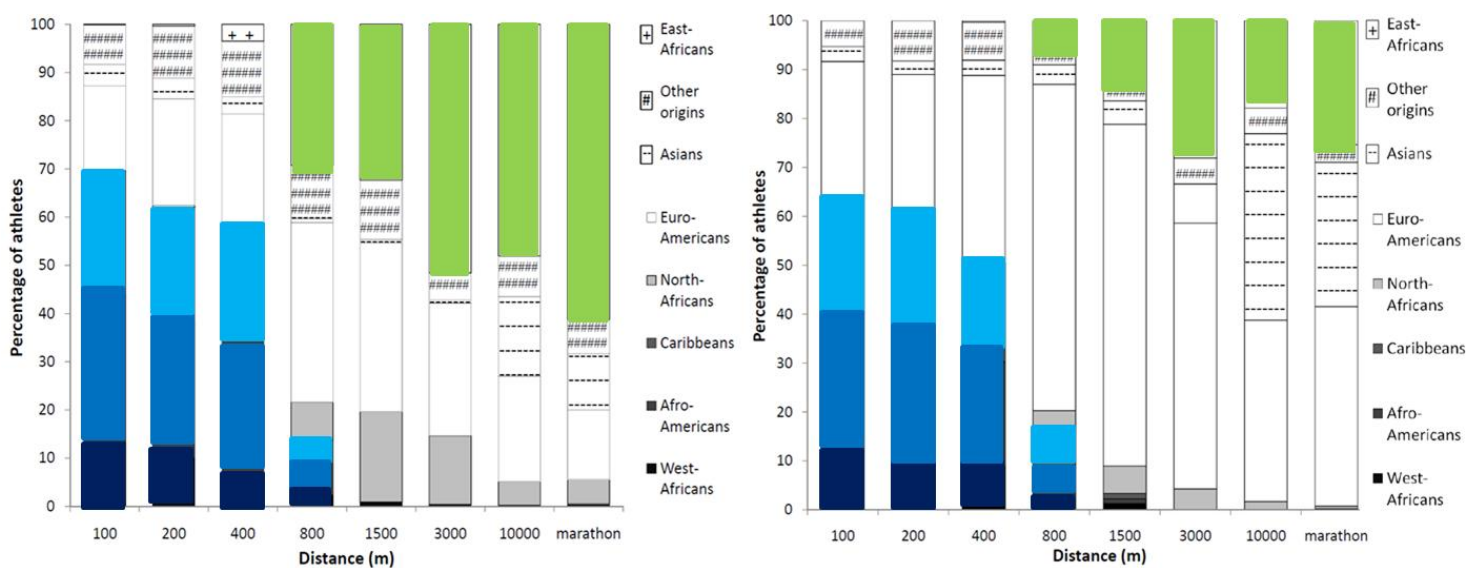


Figure 1. Percentage distribution of Top 100 athletes by Track and Field event depending on their geographical origins. (A) Men from 1996 to 2012, (B) Women from 1996 to 2012.

Men's long-distance events (3000m, 10,000m and marathon) are dominated by East African runners -representing 53.6% (Figure 1A). In women's long-distance events the contribution by world region is more heterogeneous among East African, Asian and European women; respectively 23.8%, 25.2% and 35.9% (Figure 1B). In addition, a gradient effect concerning the dominating groups is observed depending on the event.

The three dominating groups for sprint events (Afro-American, Caribbean and West African origin) are 69.5% for the 100m, 61.9% for the 200m, 57.7% for the 400m and only 13.6% for the 800m (Figure 1A). For women, the same trend is observed with a contribution of these groups representing 64% for the 100m,

60.7% for the 200m, 50.6% for the 400m and 16.1% for the 800m (Figure 1B). For both sexes, after the 800m these origin groups were almost absent from the Top 100.

Concerning long distance events, East African male runners represented 29.3% for the 800m, 32.3% for the 1500m, 51.6% for the 3000m, 48.1% for the 10,000m and 61.3% for the marathon (Figure 1A). For East African women, a similar gradient with the distance is also evident, increasing from 4.6% in the 800m to 25.4% in the marathon (Figure 1B).

For men, the comparison between 1996 and 2012 reveals a significant ($p < 0.01$) strengthening of these gradients with distance: Afro-Americans, Caribbean and West Africans' representation increase in sprint events and East African involvement increases on long distance events (Figure 2). Afro-Americans, Caribbean and West Africans' represented 61%, 53% and 59% for the 100m, 200m and 400m in 1996 (mean of 57.7%) and in 2012, 82%, 71% and 64% respectively (mean of 72.3%).

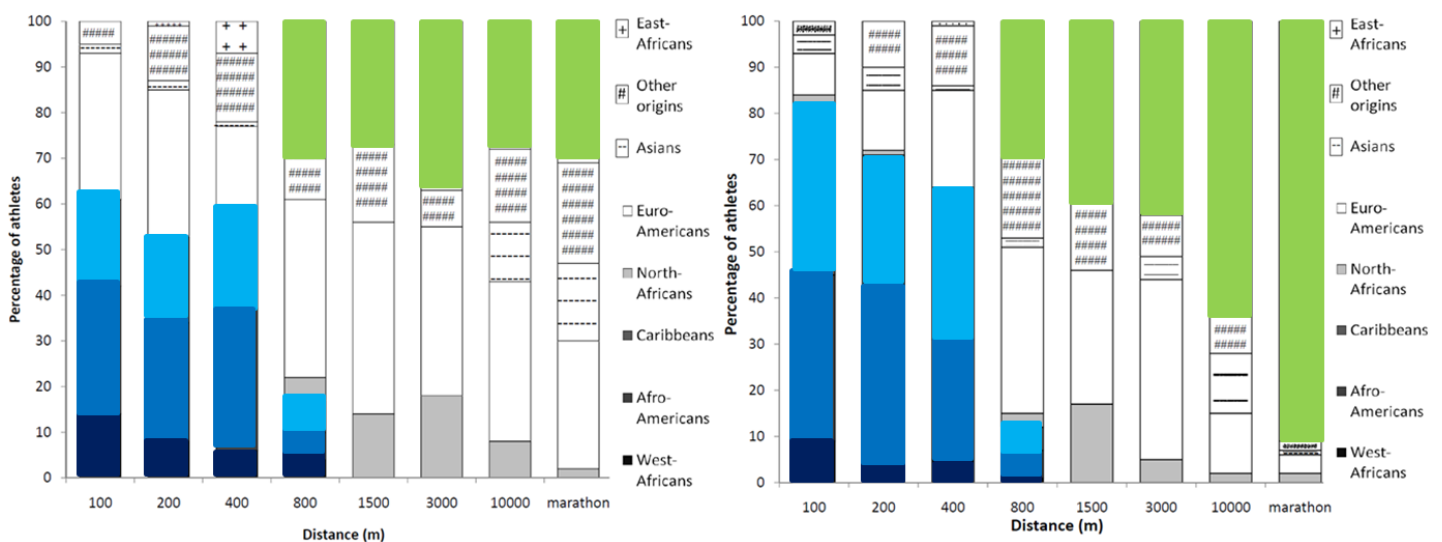


Figure 2.Percentage distribution of men athletes by Track and Field event depending on their geographical origins. (A) Top 100 in 1996, (B) Top 100 in 2012.

For the long distance events (3 000m, 10,000m and marathon), native runners from East Africa participate significantly ($p < 0.01$) more and more, 32% athletes in 1996 and 65,7% in 2012 (Figure 2). Detailed by event, these runners represented 37%, 28% and 31% for the 3000m, 10,000m and marathon in 1996 (mean of 32%) and in 2012 42%, 64% and 91% respectively (mean of 65.7%)(Figure 2).

Consequently, the share of other runners (Asians, Euro-Americans, North Africans, and the Other origins) has largely decreased from 68% in 1996 down to 34.3% in 2012.

The domination of Afro-American, Caribbean and West African women has also significantly ($p < 0.01$) increased accounting for 57%, 53% and 55% in 1996 for the 100m, 200m and 400m (mean of 55%) and in 2012 for 74%, 66% and 55% for the same events respectively (mean of 65%)(Figure 3). In contrast, Euro-Americans' share decreased from 34.7% to 28.6% during the same period.

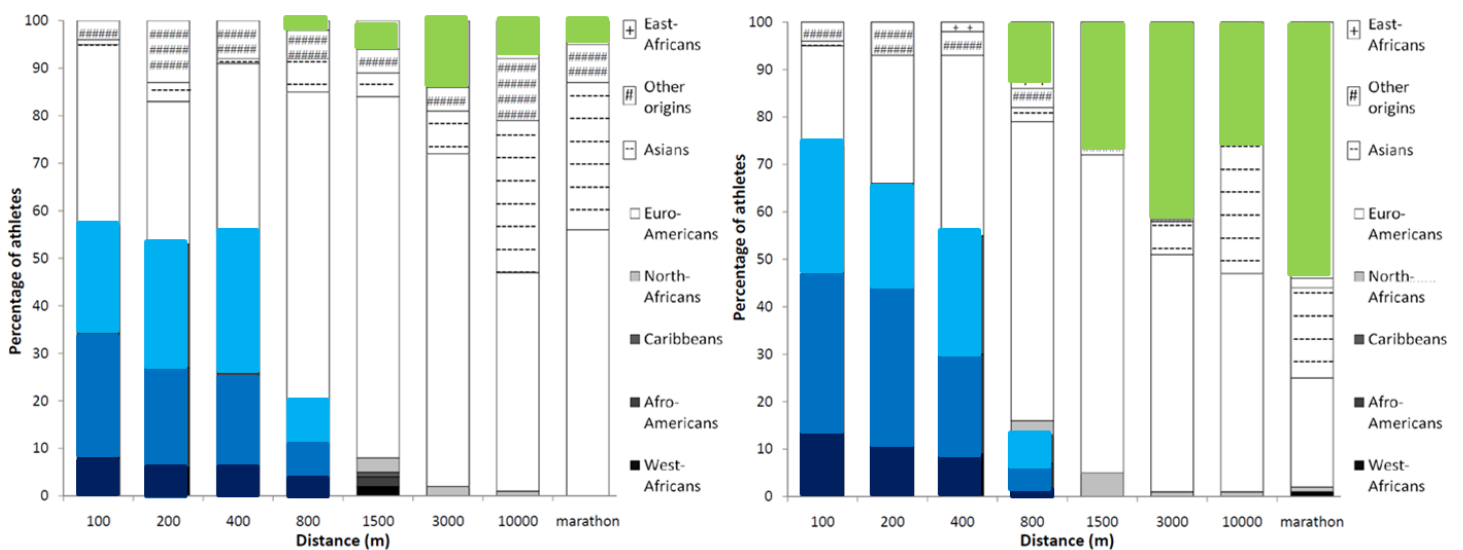


Figure 3. Percentage distribution of women athletes by Track and Field event depending on their geographical origins. (A) Top 100 in 1996, (B) Top 100 in 2012.

On long distance events, East African women runners have also significantly increased. They represented in 1996, 14%, 8% and 5% in 3000m, 10,000m and marathon respectively (mean of long distance: 9%). In 2012, East African runners represent 41%, 21% and 54% for the same events respectively (mean of 39%). Consequently, the number of Top 100 Euro-American and Asian women runners decreased. Euro-American athletes represented 57% in

1996 and 40% in 2012. At the same time, Asian runners' share decreased from 24% to 18%.

Morphological differences

During the study period, the Afro-American, Caribbean and West African athletes, who dominate sprint events, have a significantly higher BMI than all the other athletes ($p < 0.05$) and this for both sexes (Figures 4A and 4B). For men, the mean BMI of athletes of the three best regions are $23.5 \pm 1.7 \text{ kg.m}^{-2}$, $23.2 \pm 1.6 \text{ kg.m}^{-2}$ and $22.5 \pm 1.3 \text{ kg.m}^{-2}$ for the 100m, 200m and 400m respectively, compared to the other athletes who have a mean BMI of $22.9 \pm 1.6 \text{ kg.m}^{-2}$, $22.5 \pm 1.5 \text{ kg.m}^{-2}$ and $21.9 \pm 1.3 \text{ kg.m}^{-2}$ for the same distance respectively (Figure 4A).

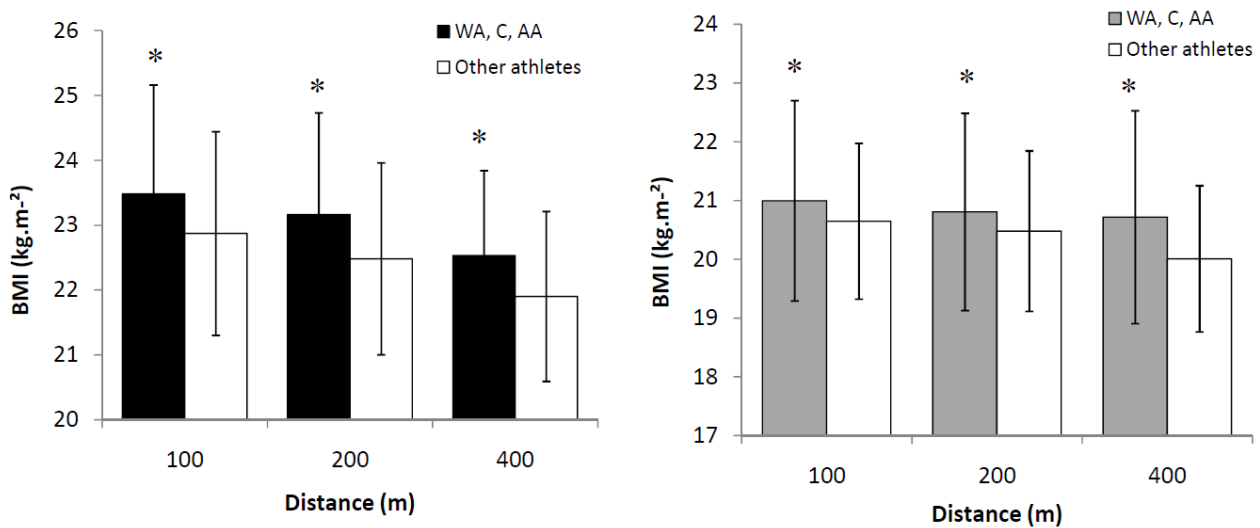


Figure 4. Mean BMI and standard deviation for the three best represented regions in sprint (West African, Caribbean and Afro-American) compared to the mean BMI and standard deviation of all the others athletes coming from the Top 100 from 1996 to 2012. (A) Men (B) Women, * $P < 0.05$ for group Other athletes.

For women, the mean BMI of athletes from the three highest represented regions are $21 \pm 1.7 \text{ kg.m}^{-2}$, $20.8 \pm 1.7 \text{ kg.m}^{-2}$ and $20.7 \pm 1.2 \text{ kg.m}^{-2}$ for the 100m, 200m and 400m respectively, compared to the other athletes who have a mean BMI of $20.6 \pm 1.3 \text{ kg.m}^{-2}$, $20.5 \pm 1.4 \text{ kg.m}^{-2}$ and $20 \pm 1.2 \text{ kg.m}^{-2}$ for the same distance respectively (Figure 4B).

For long distance events (3000m, 10,000m and marathon) the BMI of East African men is significantly lower than other runners. Their mean BMI are $19.6 \pm 1.1 \text{ kg.m}^{-2}$, $19.3 \pm 1.1 \text{ kg.m}^{-2}$ and $19.5 \pm 1.3 \text{ kg.m}^{-2}$ for 3000m, 10,000m and marathon respectively, compared to the rest of the athletes who have a mean BMI of $19.9 \pm 1.1 \text{ kg.m}^{-2}$, $19.7 \pm 1.2 \text{ kg.m}^{-2}$ and $19.6 \pm 1.2 \text{ kg.m}^{-2}$ for the same distance respectively (Figure 5A).

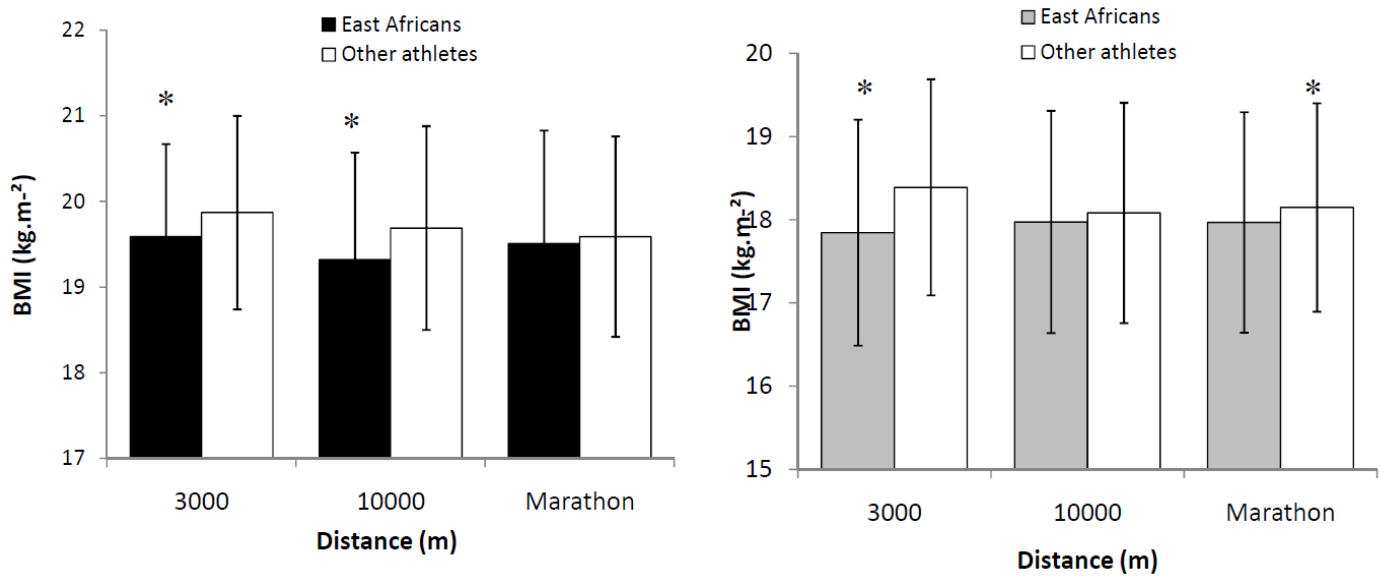


Figure 5. Mean BMI and standard deviation for the most represented long distance athletes (East African) compared to the mean BMI and standard deviation of all the others athletes coming from the Top 100 from 1996 to 2012. (A) Men (B) Women, *P<0.05 for group Other athletes.

For women, the trend is the same for East African women runners with a mean BMI of $17.8 \pm 1.4 \text{ kg.m}^{-2}$, $18 \pm 1.3 \text{ kg.m}^{-2}$ and $18 \pm 1.3 \text{ kg.m}^{-2}$ for 3000m, 10,000m and marathon respectively, compared to the rest of the runners (all the others), who have a mean BMI of $18.4 \pm 1.3 \text{ kg.m}^{-2}$, $18.1 \pm 1.3 \text{ kg.m}^{-2}$ and $18.2 \pm 1.3 \text{ kg.m}^{-2}$ for the same distance respectively (Figure 5B).

DISCUSSION

Our study is the first to describe the geographical origin of the Top 100 male and female Track and Field athletes, and to characterize its evolution over the past two decades.

This study shows that race events are increasingly being dominated by a specific geographical group of origin and this phenomenon appears to strengthen with time. In fact, these genetic, physiological, cultural, and morphological factors, which partially depend on geographical origins, could be advantageous in accordance with the race type, and consequently, for the effort characteristics and constraints.

West Africans and sprint performance

Concerning sprint distances (100m, 200m and 400m), runners with Afro-American, Caribbean and West African origins dominate, and this tendency has strengthened over time. From a genetic perspective, a previous study¹² showed that specific genes, such as *ACTN3* (α -Actinin-3), could be associated with elite athletic performance, demonstrating that male and female elite sprint athletes have significantly higher frequencies of the 577R allele than the general population. The *ACTN3* gene, specifically expressed in fast twitch myofibers, allows for the generation of force at a higher velocity.

Furthermore, our study shows that there are also morphological differences between the West African descendant sprinters, and the other Top 100 runners. For both sexes, mean BMI is significantly higher for sprinters with West African origins. Sedeaud et al.¹³ demonstrated that, physiological, physical and biomechanical constraints generated morphologies adapted to the event and that BMI appeared as a useful indicator of “embedded energy” for elite athletes’ running capabilities. It was shown that elite sprinters are heavier and that higher

BMI and mass are associated with their need of higher energy outputs. This corresponds to a maximisation of the anaerobic metabolism, the main mechanism involved in total energy

requirements for 100m sprints ¹⁴. Indeed, ATP concentration is dependent on muscle mass, and athletes' BMI represents an indication of the power reserve related to lean mass ^{15,16}. Thus the possible progression in speed would be present in muscle mass increments ¹⁷ and BMI optimisation ¹³. Furthermore, in 2005, Babel et al. ¹⁸ demonstrated that the stride number/body height ratio could be used to predict sprint performance in Afro-Caribbean children and consequently showed that the fastest runners were those with this lowest ratio. In addition, many authors have also demonstrated the relationships between stride length, ground contact time, and sprint performance ^{19,20}. Moreover, to run faster, the key is not to move quicker, but to applying greater support forces on the ground ²¹. The greater BMI of the top sprinters (with Afro-American, Caribbean and West African origins) demonstrated in this study is consistent with the trend of BMI and speed increase observed in the top 100 for all the spectrum of track and field distances ¹³.

East Africans and long distance performance

In contrast, East African runners dominate the long distance events, which showed to be an annually reinforced gradient. An epidemiological study ⁷ identified factors that influence best performances in the marathon, considering historical, demographic, anthropometrical and seasonal characteristics for the 100 yearly best performers from 1990 to 2011. This study confirmed the East African domination and showed that body mass, height and BMI have decreased since 1990 to reach optimal values in 2012 of 56.4 kg, 170.4 cm and BMI of 19.42 kg.m⁻².

One explanatory factor for this dominance could be physiological characteristics. Despite comparable maximum oxygen uptake, Africans tend to run at a higher running economy than

Europeans ^{22,23}. Kenyan runners also have greater β -oxidative enzyme HAD activity (3-hydroxyacyl- Co A-dehydrogenase activity) in the muscles ^{24,25}. Furthermore, Onywera et al ²⁶ reported that Kenyan runners differed from the general population due to greater physical activity during childhood and adolescence on their travels to school. A higher proportion of athletes ran to school every day (controls 22 %, national athletes 73 % and international athletes 81 %) and covered greater distances than other groups. It has been shown that Kenyan boys who travelled to school by walking and running had 30 % greater VO₂ max than those who did not ²⁷. Similar results are seen for Ethiopian runners ²⁸. Also, high altitude exposure, as experienced by many young East African runners, combined synergistically with endurance training to induce haematological adaptations, also account for greater physiological capabilities ²⁹.

However, East African female runners' superiority is not as strongly established as for men (in 2012, 54 % for women as opposed to 91% in men). This difference can be explained by their later arrival in this event; their first appearance in the marathon occurred in 1984 in the Los Angeles Olympic Games ³⁰.

Our study highlighted the presence of geographical gradients depending on the race distance. The West African ancestry (Afro-American, Caribbean and West African) sprinters dominate sprint events with a negative gradient from 100 m to 400 m, and are totally absent after the 800 m for both sexes. In contrast, the male and female East African runners dominate the long distances with a positive gradient from 800 m to the marathon. Such a gradient has already been observed in other domains such as morphology ¹³ and energetic contribution ¹⁴.

In addition, Sedeaud and al ¹³ have demonstrated that gradient of physiques such as body mass, height and body mass index are ordered and decrease progressively with distance from 100 m to the marathon. These authors highlighted the importance of the biometrics in Track

and Field performance by identifying performance organisation through optimal morphological intervals. Moreover, links between performance and morphology are strengthened by gradient of size within each discipline. For example, sprinters are not only heavier than their long and middle distances counterparts but within their distance, the fastest athletes are also the heaviest ones. In contrast, the best long distance runners have a lower mass and BMI compared to less rapid athletes ¹³. In their study ¹⁴ Ward and Smith show the existence of gradient contribution from the anaerobic and aerobic mechanisms to the total energy requirements from 100 m to 10,000 m. This mathematical model affirmed a gradual decrease of anaerobic measurements with race distance and a gradual increase of aerobic contribution from the 100 m (7 %) to the 10,000 m (96 %).

What Does This Article Add?

This study intends to reach sports scientists, and sports staff who may find support to select and optimize the morphological parameters of athletes to reach their best level.

A significant morphological gap ($p < 0.05$) is visible between the athletes dominating the sprint or the long distances events in relation to the other nationalities in the Top 100 for both sexes.

Running events such as the 800m, 1,500m and 3,000m are demographically more heterogeneous, with more nationalities represented as opposed to sprint or long distance events.

Thus, the middle distances appear to be the most accessible events to a greater range of nationalities.

However, these demographic and morphological results may be restrained only to the highest level in Track and Field events.

CONCLUSION

This study reveals the distribution of Top 100 athletes depending on their geographical origins. On the whole race events spectrum, the best performances are dominated by a few groups of West African ancestry for the sprint distances and East African runners for the long distance. This dominance has strengthened from 1996 to 2012 for both sexes to the detriment of Caucasian and Asian athletes who are less present on international podiums. The expression of multiple optimum values of biometrical, energetic parameters depending on the events is visible on the gradual contribution of these athletes with distance.

Conflicts of Interest and Source of Funding: all authors declare having no conflict of interest. The authors have not received funding for this work specifically; the Institute receives yearly funding from the French Ministry of Health, Youth, and Sports.

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