Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The physique of Olympic athletes as a reflection of human physical variation: Implications for the study of adaptive evolution and the mapping of global sports potential

Pavel Grasgruber (32487@mail.muni.cz)
Masaryk University Brno

Research Article

Keywords: Olympic athletes, physique, height, BMI, human physical variation

Posted Date: May 3rd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1617363/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

The physique of Olympic athletes as a reflection of human physical variation: Implications for the study of adaptive evolution and the mapping of global sports potential

Pavel Grasgruber*, Oldrich Racek, Zuzana Hlavonova, Tereza Kralova, Lenka Svobodova, Sylva Hrebickova, Jan Ondracek, Jan Cacek

Faculty of Sports Studies, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic

*Corresponding author. e-mail: 32487@mail.muni.cz. Phone number: +420 608 569 374

Abstract

In this study, we compared the basic body dimensions (height, weight, body mass index/BMI) of 19,662 male Olympians from 159 countries competing at the Summer Olympic Games 2000-2016. We hypothesized that the average physique of national Olympic teams reflects the predominant body type of their native populations, and the knowledge of such physical differences could find practical use in creating more rational programs of sports talent selection. The results demonstrate that the mean height of men's Olympic teams is highly correlated with the mean height of young men in their native countries (r = 0.83, p < 0.001), and the Olympic means of BMI characteristically cluster at the regional level. This geographical trend in the Olympic BMI values remarkably agrees with the documented body composition of human populations, and identifies Polynesians as the group with the most robust body build, followed by Micronesians and Melanesians. The biological validity of these results is further supported by their highly significant relationships with genetic and climatic factors. These findings suggest that the physique of Olympic athletes can be used for the study of human physical variation and evolutionary ecological rules. Based on these data, it is also possible to identify the global sports potential and the spectrum of sports in which each country has the greatest chance of international success.

Keywords: Olympic athletes, physique, height, BMI, human physical variation

Introduction

It is an indisputable fact that human populations differ significantly due to their physical adaptations to natural conditions. These adaptations are governed by two main ecological rules: According to Bergmann's rule [1], organisms living at higher, colder latitudes are generally larger than those living closer to the equator because a larger body size has a more advantageous volume/surface ratio and better conserves heat. According to Allen's rule [2], organisms from colder environments are characterized by shorter and thicker limbs, because they also limit heat loses. Short limbs in cold-adapted humans are further accompanied by disproportionately shorter distal segments (forearms, calves), and hence lower brachial and crural indices [3].

These differences were documented by numerous scientific studies [4-8]. Thus, at the extremes of human variation, we can find slim, long-legged East African Nilotes or Cushites adapted to the hot tropical climate, and stocky, short-legged Aleuts and Inuit adapted to the cold climate. The difference in relative sitting height between a Nilotic male and an Aleut male reaches ~6-7% body height. In other words, the average Nilotic male will have 10.5-12.3 cm longer legs than the average Aleut male, provided that both are 175 cm tall. (See Supplementary table 1).

However, these rules do not apply universally in all human groups. Whereas body weight and BMI have a significant positive relationship with latitude and a significant negative relationship with temperature, the relationship is less clear in the case of height. In fact, the environmentally driven increase in body weight is primarily associated with increasing body width (biiliac breadth), and not so much with rising height [5]. Ecological rules fail mainly in sub-Saharan Africa, where we find a very large variability in physiques – from the dwarfish Pygmies to the tall Nilotic tribes from southern Sudan, who were the tallest in the world shortly after World War II, with tribal means ranging between 178.7-184.9 cm [9-10] (Supplementary table 2). An extreme anomaly in terms of height and BMI are the inhabitants of tropical Oceania (especially Polynesians), who are relatively tall and disproportionately heavy. These irregularities probably result from other environmental factors such as humidity, precipitation, food availability, and climatic instability [5-6, 11]. Humidity intensifies the effect of heat because hot air saturated by water reduces the evaporation rate and prevents the body from cooling [12]. High precipitation is generally associated with better food availability and it can potentially weaken the role of climatic factors [11].

Our own, actual data on the mean body height of 152 world populations [13] do show that contemporary tropical populations are the shortest (Fig. 1), but this comparison is markedly affected by the current role of living conditions in the developing world (particularly by the quality of nutrition and excessive population growth). For example, the remarkably tall Nilotic tribes from southern Sudan were apparently negatively affected by wars and famine, and the height of Nilotic refugees in Ethiopia and Kenya reached only 171.7-

178.1 cm during the 1990s [14-15]. Indeed, even recently, the height of South Sudanese adolescents in the study by Charchuk et al. [16] „showed height distribution similar to US norms“ and the authors report a high level of malnutrition. Changes in the everyday lifestyle can also influence BMI values, especially in today's Oceania. Here, we observe a sharp increase in obesity, which further contributes to the increase in the high local BMI values [6]. For these reasons, comparing BMI values in the industrialized populations has little practical value.

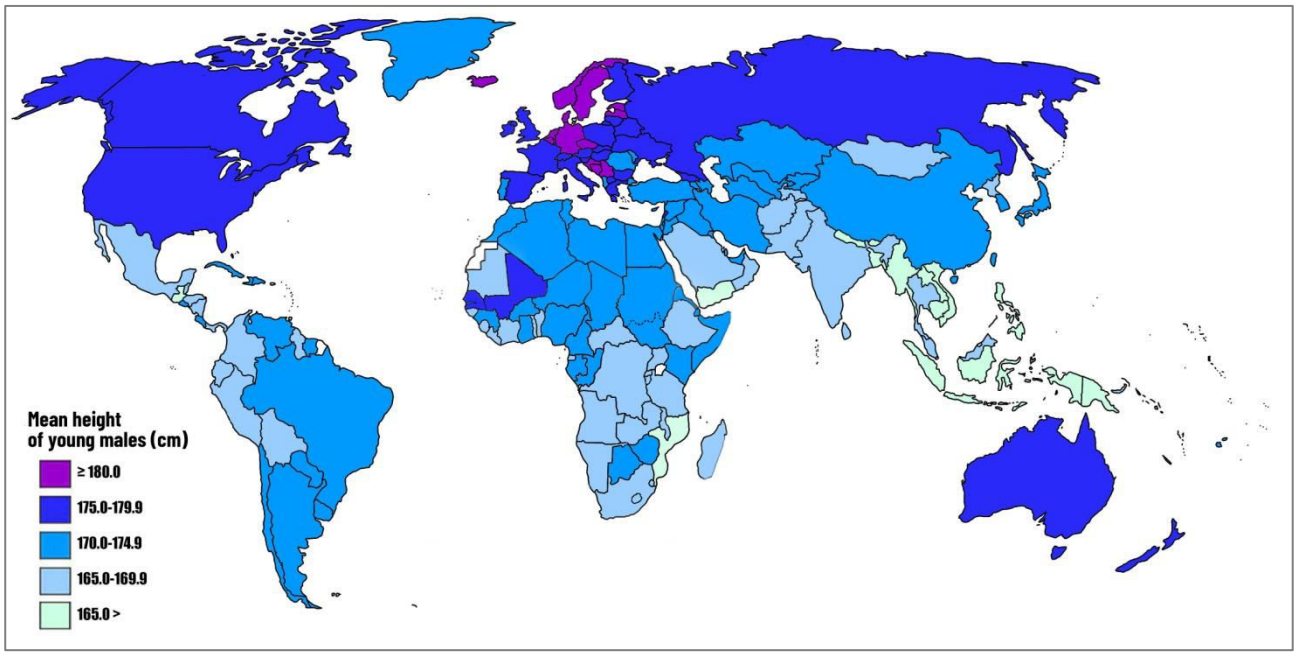


Fig. 1. Mean height of young males in the world. The data come from Grasgruber & Hrazdíra [13], except for those from sub-Saharan Africa, which were taken from the NCD Risk Factor Collaboration database (https://ncdrisc.org/height-mean-ranking.html). The mean height for "Sudan" includes South Sudan, for which no actual data are available.

All the major physical characteristics discussed above (height, BMI, body width, body proportions) play a crucial role in the selection of sports talents [17-18]. Understandably, their role is the strongest in individual sports (particularly athletics), whereas team sports rely more on psychomotor skills and psychology. It is logical to assume that due to these differences in physical requirements, certain world populations will have a larger pool of potential talents for specific sports activities than others. These predispositions will be easy to verify in the case of height, due to the availability of nationwide anthropometric studies. Data on body proportions are less numerous, and the most difficult problem will lie in the assessment of somatotype, which determines muscular development and fat accumulation. Although large differences in the somatotype of warm-adapted and cold-adapted human populations are well-known [19], the question is whether it is possible to identify meaningful somatotype differences among modern-day sedentary populations from less extreme climates, where body composition is markedly affected by obesity, the lack of physical activity, and other lifestyle factors.

Very interesting, although so far rather limited data that could shed light on this problem come from the studies of Deurenberg et al. [20-21]. The authors observed that there existed significant differences in the fat mass/fat-free mass ratio among various ethnic groups, which influence the cut-off point of obesity. Whereas Ethiopians, Indians, Indonesians, Thais, Malays, and Chinese had lower BMI (and therefore less fat-free mass) at the same proportion of body fat than Caucasians (here mainly of West European descent), the BMI of US blacks was slightly higher and the BMI of Polynesians was far higher. The magnitude of these differences was huge: The BMI of an Ethiopian male would be 4.6 kg/m^2 lower than that of a Caucasian male, which equals to -14.1 kg at the height of 175 cm. In contrast, the BMI of a Polynesian male would be 4.5 kg/m^2 higher (+13.8 kg at 175 cm). In other words, this research suggests that lean body mass (and hence muscle mass) of US blacks and Polynesians is more developed than in Caucasians, while the other human groups are more subtle. However, this finding still does not exclude the role of environmental factors [22].

The idea behind the present study was to verify these observations (and possibly further expand the amount of knowledge), using the body height and weight of top Olympic athletes. Our presumption was that Olympic athletes represent the maximal limit of trainability of their native population, and their BMI values are usually accompanied by a high proportion of skeletal muscle and little body fat. Considering that every country will mainly nominate athletes, who reflect the mean physique of their native population, a comparison of multiple Olympic teams could serve as a tool for the assessment of interethnic differences in body composition.

At first glance, this method may not seem too meaningful, because it can be influenced by too many variables: The number of nominated athletes, the population size of each country, the number of sports in which they compete, the availability of technical background, financial support from the government, specifics of the local sports culture, etc. Nevertheless, Japanese researcher Kin-Itsu Hirata already tested such a hypothesis with a sample of male and female athletes, who listed their age, height, and weight at the registration list of the Olympic Games in Tokyo 1964 [23]. Hirata observed that the average national values of height and weight plotted in a graph demonstrated obvious regional differences – and mainly in European samples that were the most representative (Fig. 2). Olympic teams from the western half of Europe (mean height 178.8±1.9 cm, BMI 23.42±0.47 kg/m^2, 11 teams) were generally less robust than those from the eastern half on the continent (178.7±1.4 cm, 23.91±0.33 kg/m^2, 8 teams), and this difference in BMI was statistically significant (p = 0.02, Mann-Whitney U test). A similar west-to-east trend could be documented even in countries from the Mediterranean, which were positioned in the height underground. Even more remarkable is the fact that the tallest European nation of that time (Norwegians) had the tallest Olympic team (cf. 24), being closely followed by the Netherlands and the former Yugoslavia, which subsequently replaced Norway at the top of the global rankings [13]. In contrast, the shortest team was nominated by Portugal, which is the shortest country in continental Europe to this day.

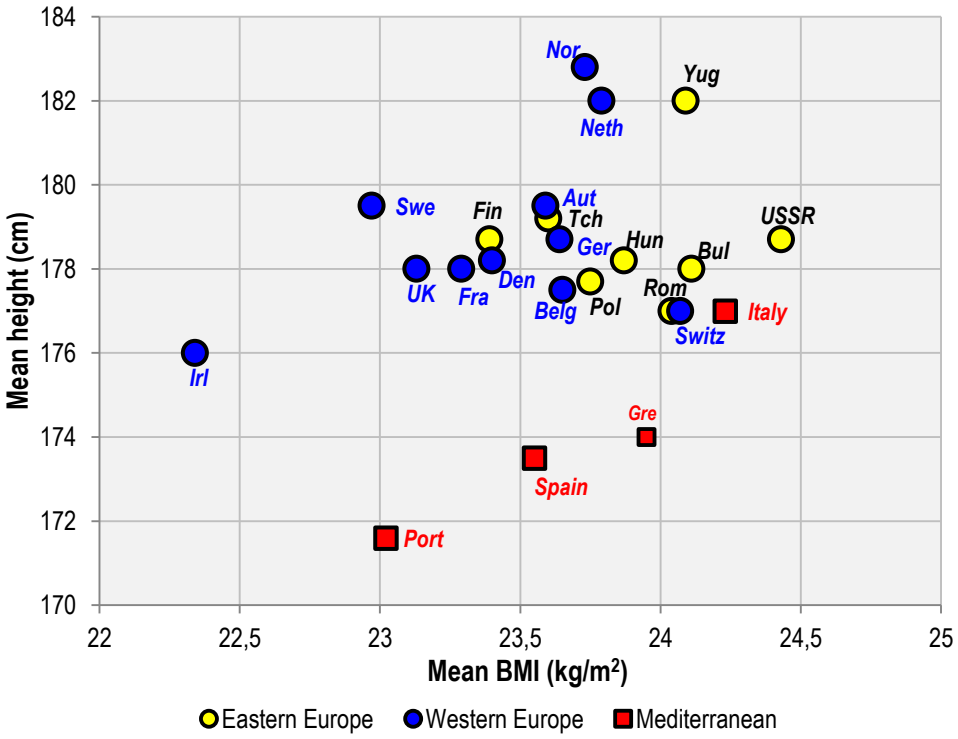


Fig. 2. Mean height and BMI of men's Olympic teams from Europe in Tokyo 1964 (23 countries). After the data by Hirata [23]. All countries (except Greece) were represented by at least 20 male Olympians. The teams of Western Germany (FRG) and Eastern Germany (GDR) competed under a single flag.

This result confirms the assumption that the mean height of Olympians reflects the mean height of their native population. Therefore, the key research question of the present study was whether the BMI of Olympic athletes could also reflect the mean somatotype of their native population. In case that this hypothesis was confirmed, the findings could potentially reveal somatotype differences even in the highly industrialized, sedentary populations. Although the physique of Olympians in Tokyo was obviously influenced by the physical requirements in Olympic sports and their height was substantially higher than in young men from their native countries, even the relative comparison of national Olympic teams could well serve our purpose. The obtained results could subsequently have important practical implications for the national programs of sports selection because they would enable a more economical funding of sports activities in which the respective country has the best chance of international success.

Results

Olympic height and population height

Actual data on the height of young males were available for 148 out of 149 samples examined (except for the US Virgin Islands). The comparison of male population height with Olympic height shows a very high mutual

correlation (r = 0.83, p < 0.001) (Fig. 3), although the Olympic height is 6.0 cm above the population mean (172.8 cm vs. 178.8 cm). The correlation was slightly weaker (r = 0.79, p < 0.001), when we considered only 83 teams with a moderate number of Olympians (20-199). This is contrary to our expectations but the lower correlation in this subsample must be ascribed mainly to the outlier position of Angola and North Korea. The Olympic team of Angola exceeded the population mean of Angola by +18 cm, whereas Libya (-1.8 cm) North Korea (-1.0 cm), and Seychelles (-0.8 cm) were the only countries, whose Olympic heights were shorter than population heights. The difference between male population height and Olympic height was the highest in short populations (~7 cm) and decreased in tall populations (~5 cm). This illustrates that the teams of short-statured nations must be better selected in order to be internationally competitive.

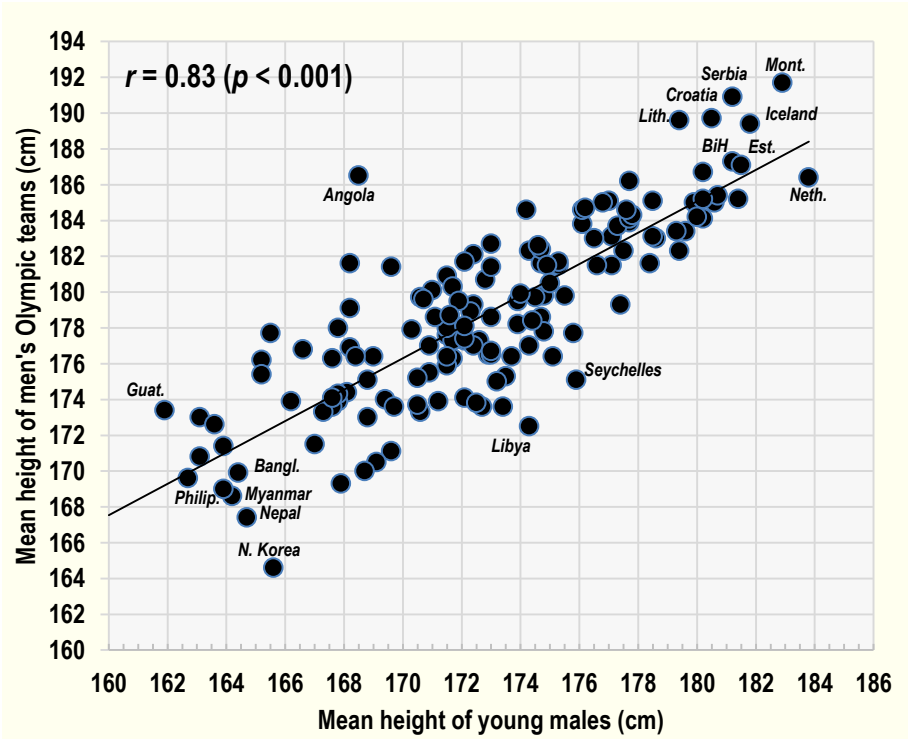


Fig. 3. Correlation between the mean height of young males and the mean height of 148 men's Olympic samples (r = 0.83, p < 0.001). The mean height of young males in Melanesia, Micronesia, and Polynesia was calculated from the mean height of young males in countries that were represented at the Olympics.

The close relationship between men's population height and Olympic height confirms the assumption that the physique of Olympic teams mirrors the physical potential of their home populations. At the same time, the fact that the height of Olympic teams is markedly higher than the height of young men in their home countries again shows that Olympic height is influenced by the spectrum of Olympic sports that mostly place high demands on tall stature. Because nations with larger populations can better compensate for these height shortcomings, it is inevitable that the height of men's Olympic teams increases with their size, from 176.4±5.0 cm in ‚small' teams through 178.5±5.2 cm in ‚medium-sized' teams to 182.8±2.6 cm in ‚large' teams. Large

teams reach an average height that is relatively closest to the “ideal” height requirements in Olympic sports, and this observation is further confirmed by the small standard deviation.

The tallest country at the Olympics, Montenegro (191.7 cm), is probably the tallest in the world at this moment with 182.9 cm, surpassing even the Netherlands among 18-year-olds (182.4 cm) [13]. In contrast, the shortest Olympic teams mostly come from the tropical belt of Asia, reaching only 167-174 cm. This also agrees with the current situation because young men from this region are only ca. 165 cm tall. Still, the absolutely shortest Olympic team is that of North Korea (164.6 cm) – not very distant from the documented height of North Korean male refugees (165.6 cm).

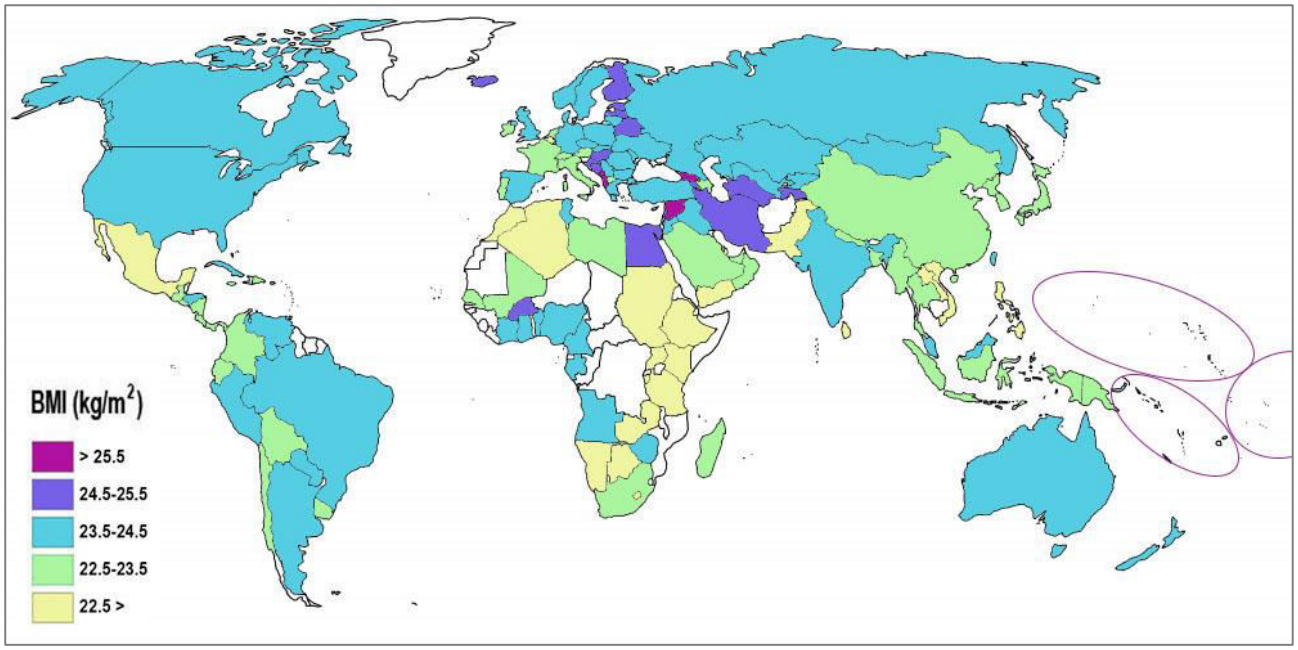


Fig. 4. Geographical distribution of BMI values in 149 men’s Olympic samples with a minimum number of 10 Olympians.

Regional differences in height and BMI

The average body size of all 149 men’s Olympic samples is 178.8±5.2 cm, 75.5±7.2 kg, and 23.48±1.26 kg/m^2. Similar to height, even the values of BMI tend to increase with the size of Olympic teams, and their standard deviation decreases (from 22.96±1.60 through 23.57±1.22 to 23.88±0.53 kg/m^2). Expectably, the largest Olympic teams tend to cluster around the „ideal“ value of BMI, whereas smaller teams occupy positions in the more specific parts of the graph. The geographical distribution of BMI values is displayed in Fig. 4 and the graphical comparisons of height and BMI are shown in Figs. 5-8, where they are projected against the mean physiques of finalists in athletic events. For better clarity, teams from each continent are assessed separately and in Figs. 6-8, they are compared with the Olympic teams from Europe. Additional graphs, in

which these data are projected against the typical physiques in other Olympic sports, are contained in the Supplementary material (Supplementary figs. 1-2).

Western Eurasia and North Africa

Fig. 5 displays differences among the Olympic teams from the western part of Eurasia and also from North Africa (which is described further below, in the context of other African teams). The Olympic teams from Europe are generally the tallest out of all Olympic teams examined (184.1±3.3 cm on average), and occupy top eight positions in the ranking of Olympic height. The height of the West European teams (184.7±2.1 cm) is roughly the same as that of the East European teams (184.5±3.8 cm), but the East European teams have a wider range. Countries from the Mediterranean are shorter (181.6±2.1 cm), similar to Tokyo. Montenegro is both the tallest and the heaviest at the Olympics (191.7 cm, 95.1 kg), being challenged by other countries of the former Yugoslavia (Croatia and Serbia), Iceland, and Lithuania.

The mean BMI in all 40 European teams is 24.01±0.98 kg/m^2, which is higher than in Tokyo (23.64±0.48 kg/m^2 in 23 teams). Understandably, this historical change is distorted by the fact that in Tokyo, many contemporary East European countries competed under the flags of Czechoslovakia, Yugoslavia, and the USSR. If we compared only 20 countries that competed both in Tokyo 1964 and between 2000-2016, the difference would be much smaller (23.58 vs. 23.71 kg/m^2) and insignificant (p = 0.40, t-test for dependent samples). Also noteworthy is the fact that BMI values in these 20 countries do not correlate significantly (r = 0.20, p = 0.40). However, the geographical trends found at the Olympics 2000-2016 are still very similar to those documented by Hirata in Tokyo 1964: West Europeans (23.43±1.04 kg/m^2) are significantly (p = 0.002, Mann-Whitney U test) lighter than East Europeans (24.51±0.75 kg/m^2), and this difference would correspond to 3.6 kg in a 180 cm tall male (75.8 kg vs. 79.4 kg). A subsample of eight Central European countries (23.95±0.50 kg/m^2) would lie exactly in the middle. Mediterranean countries reach a below-average BMI (23.50±0.51 kg/m^2) but with a wide variation – from low BMI in Portugal to moderately high BMI in Greece and Malta. Among teams with at least 20 male Olympians, Belgium is the leanest (22.46 kg/m^2) and Montenegro is the most robust (25.92 kg/m^2). This equals to a difference of ~11 kg in a 180 cm tall male (72.8 kg vs. 84.0 kg). Supplementary fig. 3 graphically illustrates that only 3.6% Belgian male Olympians reach BMI above 26 kg/m^2, whereas this proportion is 44.4% in the team of Montenegro and 29.5% in the team of Estonia. In general, the lowest values of BMI can be observed at the Atlantic coast, whereas the highest values can be found in the Baltic region, the Western Balkans, and in Iceland.

Similar geographical changes in physique can be observed in the Near East, but this time, they go in a north-south direction. The Olympic teams from the northern (non-Arabic) part are quite widely dispersed, but on average, they are slightly taller and significantly (p = 0.03, Mann Whitney U test) stockier (176.5±2.9 cm,

24.78±0.84 kg/m²) than Olympic teams from the southern (predominantly Arabic) part (175.7±2.8 cm, 23.41±1.04 kg/m²). In general, Olympic teams from the northern part have mean BMI values that are comparable to Eastern Europe, and result from the disproportionate concentration of local Olympians in combat and strength sports, especially wrestling. At the same time, the combination of high BMI with the height deficit contributes to the "unathletic" distribution of individual values (Supplementary fig. 4). BMI values in the southern part are similar to Western Europe and the local sports culture is more varied.

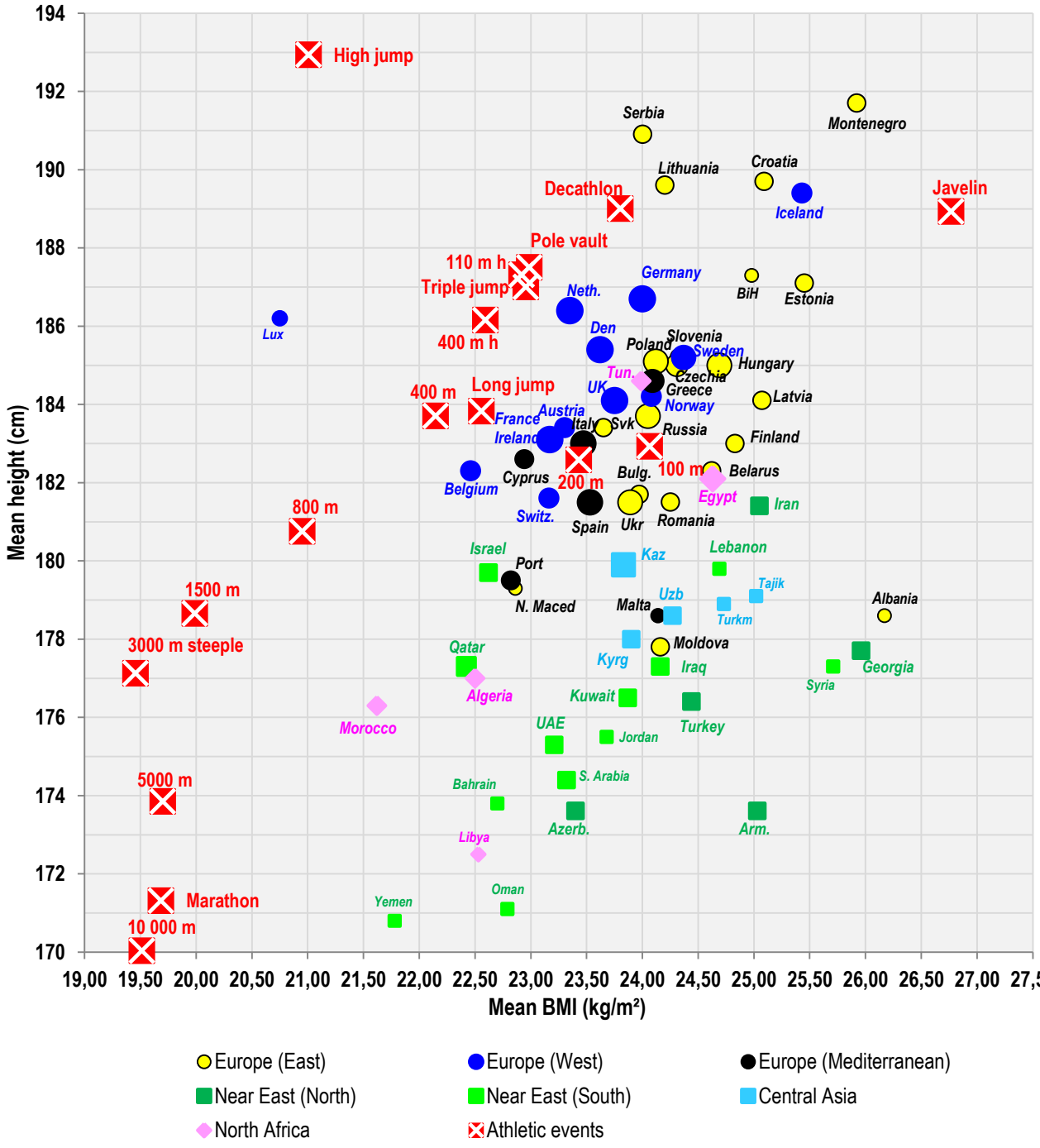


Fig. 5. Mean height and BMI of men's Olympic teams from Western Eurasia and North Africa, projected against the means of Top 8 Olympians in athletic events. The size of points corresponds to the size of the Olympic teams (small: 10-19 Olympians, middle: 20-199 Olympians, large: ≥ 200 Olympians).

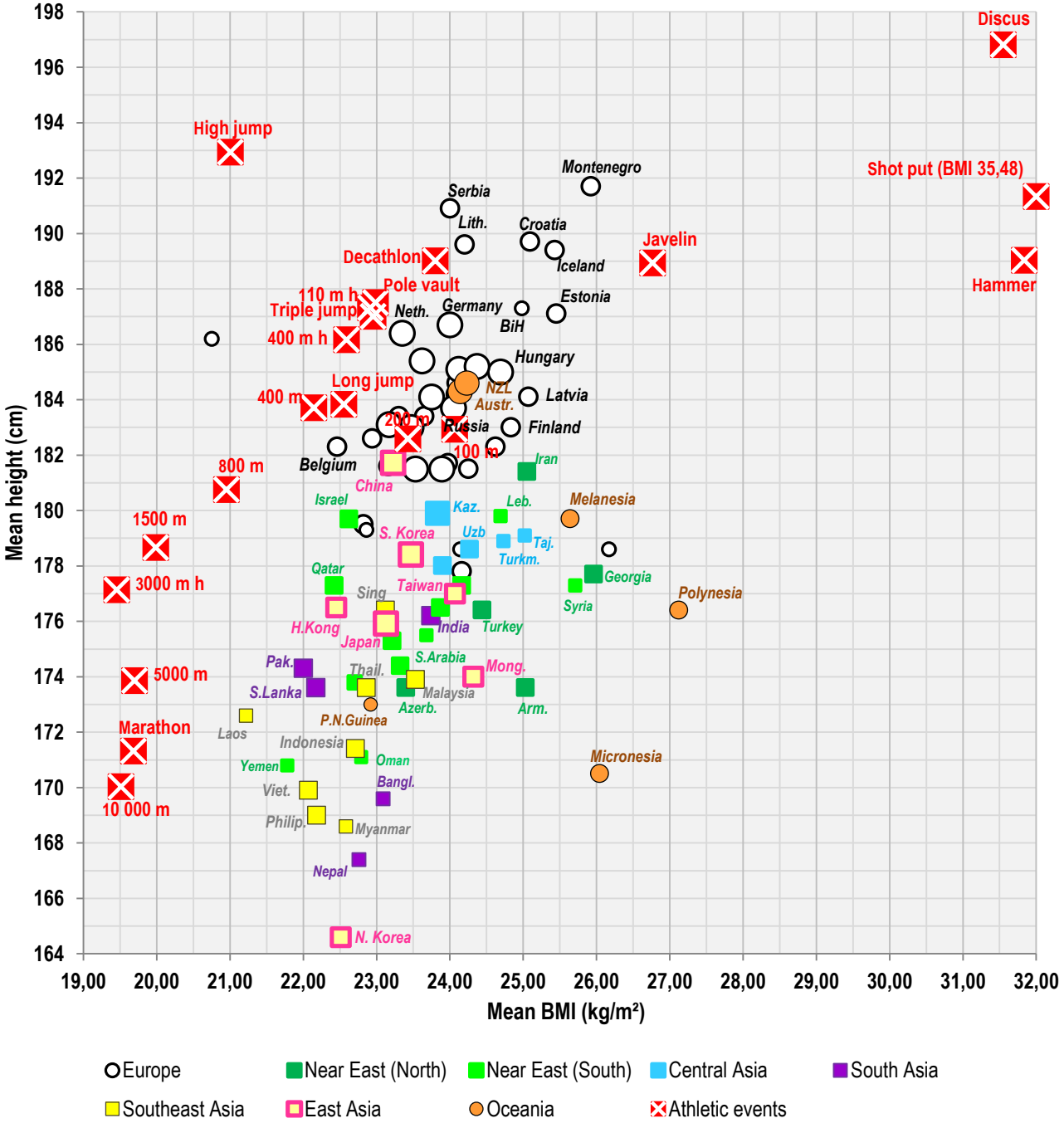


Fig. 6. Mean height and BMI of men's Olympic teams from Asia and Oceania, projected against the Olympic teams from Europe and the means of Top 8 Olympians in athletic events. The size of points corresponds to the size of the Olympic teams.

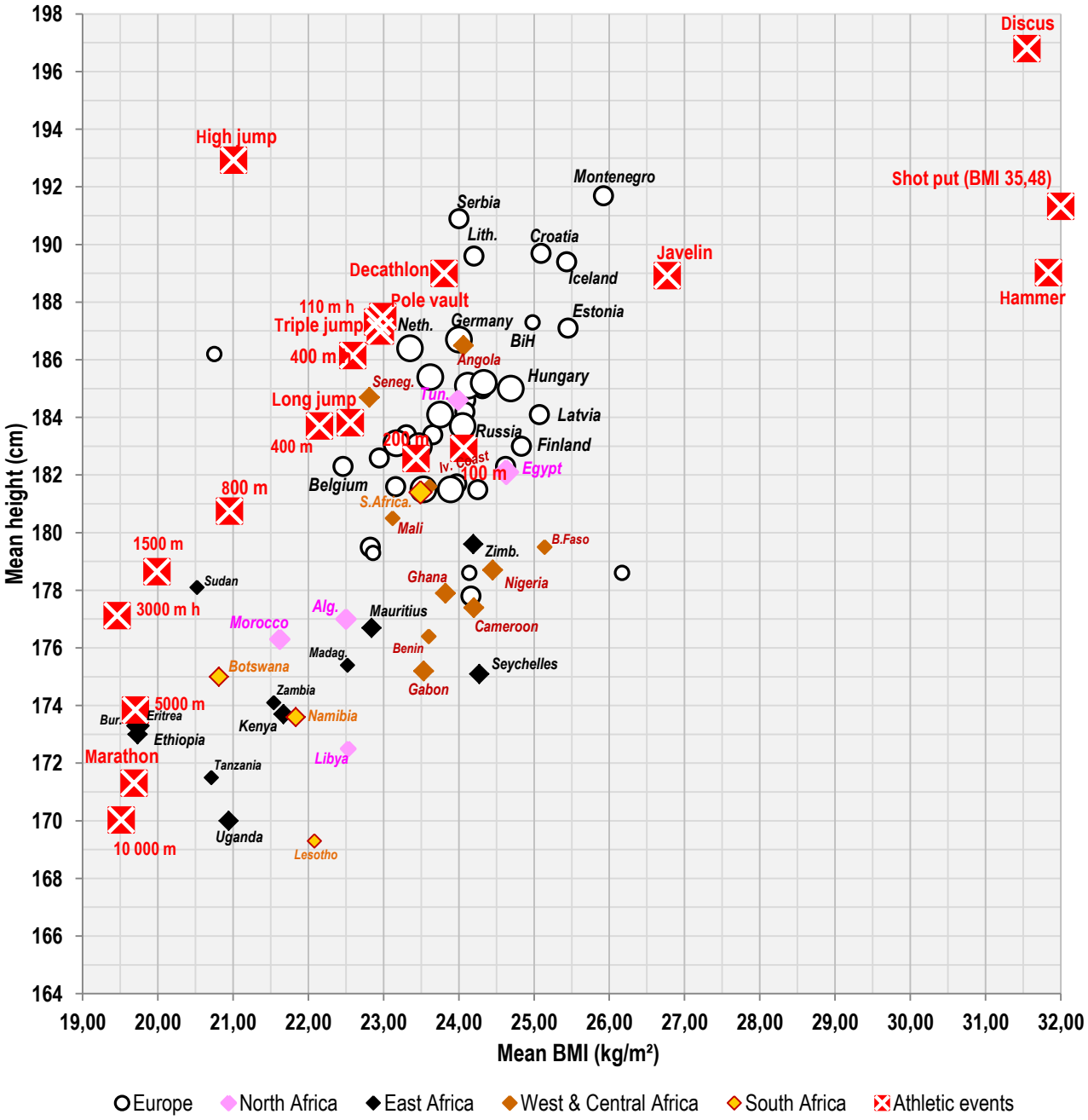


Fig. 7. Mean height and BMI of men's Olympic teams from Africa, projected against the Olympic teams from Europe and the means of Top 8 Olympians in athletic events. The size of points corresponds to the size of the Olympic teams.

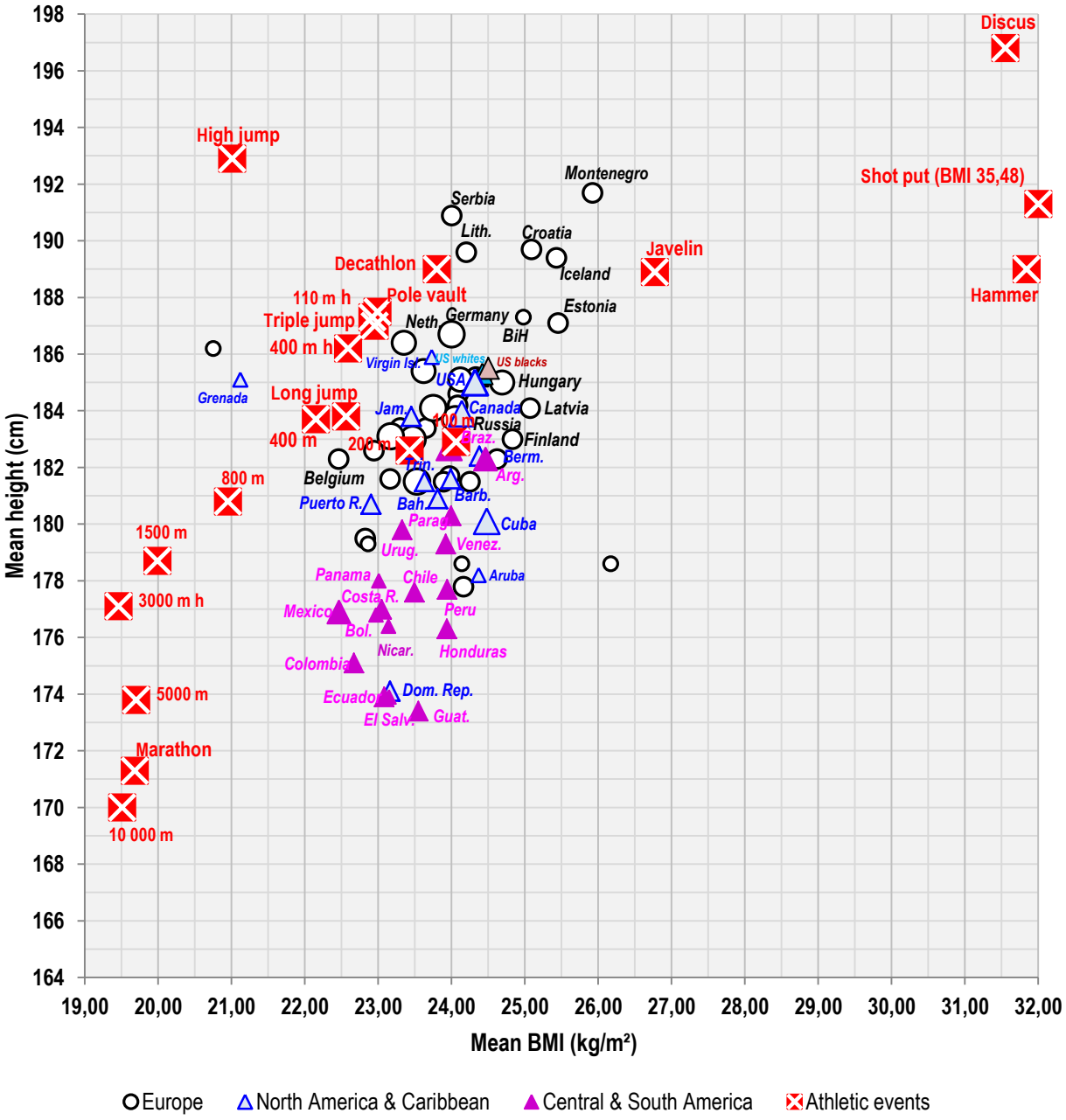


Fig. 8. Mean height and BMI of men's Olympic teams from America, projected against the Olympic teams from Europe and the means of Top 8 Olympians in athletic events. The size of points corresponds to the size of the Olympic teams.

The physical build of male Olympians from Central Asia is remarkably homogenous and specific, with moderate height ranging between 178-180 cm and relatively high BMI values between 23.83-25.02 kg/m^2. This must also be ascribed to the fact that they are concentrated in combat and strength sports. The average of these five Central Asian teams (178.9±0.6 cm, 24.35±0.46 kg/m^2) has no close parallel in the predefined neighboring regions, but can best be compared with the middle part of the Near East (Lebanon, Iraq).

Asia and Oceania

Fig. 6 illustrates differences among men's Olympic teams from Asia and Oceania. At first glance, the Olympians from South Asia (172.2±3.2 cm, 22.75±0.63 kg/m^2) occupy the same part of the graph as the Olympians from Southeast Asia (171.9±2.5 cm, 22.53±0.67 kg/m^2), and share a short, lean stature. Their similarity would further increase, if we excluded the outlier sample of one-billion India, which is expectably closer to the Olympic average (with an Olympic mean 11 cm above its population mean). Note also the similarity of both these regions to the Olympic samples of Yemen (170.8 cm, 21.78 kg/m^2) and Oman (171.1 cm, 22.79 kg/m^2) – again countries from the similar tropical latitude. Regrettably, there are only few Olympians available from Afghanistan, which is a very interesting, ethnically mixed country. In any case, the small Olympic team of Afghanistan (n = 7, 176.6 cm, 23.00 kg/m^2) tends to be taller and heavier, as expected from the geographical position.

When compared with Southeast Asia, East Asian Olympic teams are substantially taller and stockier (175.4±4.9 cm, 23.31±0.66 kg/m^2). The population averages of young men range from 165.6 cm in North Korea to 174.4 cm in South Korea – a striking paradox that testifies the importance of nutrition and living conditions within a single ethnicity. Quite expectably, one-billion China has the population potential to offset the drawback of short male stature (172.1 cm) and has the tallest Olympic team in this region (181.7 cm). However, it is still only on the level of the shortest European teams. Also noteworthy is the fact that the BMI of the stockiest East Asian team (Mongolia) is rather moderate (24.32 kg/m^2), comparable with Central Asian countries.

Oceania produces Olympians with the highest BMI values, who typically compete in athletics, swimming, and weightlifting. Polynesians are by far the stockiest (176.4 cm, 27.12 kg/m^2), with a wide range of BMI values, but their robust body build is not particularly athletic (Supplementary fig. 5). They are followed by Micronesians (170.5 cm, 26.04 kg/m^2) and Melanesians (179.7 cm, 25.64 kg/m^2). Apparently, these physical dimensions agree with the data described in the anthropological literature and constitute an anomalous exception from the ecological rules. They are even more remarkable, when we consider that the short and lean Olympians from Papua New Guinea (173.0 cm, 22.92 kg/m^2) fit these ecological rules well. Nevertheless, the height of Polynesian Olympians is surprisingly low because Polynesian males from independent islands are currently

174-177 cm tall (Tonga being the tallest with 176.7 cm). Their Olympic height should therefore easily reach 180 cm. A possible explanation lies in the fact that the local sports talent is channelled into rugby, which was excluded from Olympic sports after 1924. The teams of Australia (184.3 cm, 24.14 kg/m^2) and New Zealand (184.6 cm, 24.23 kg/m^2), which are composed mainly of Olympians of European descent, are close to the European average.

Africa

Fig. 7 compares men's Olympic teams from Africa that are characterized by a large physical diversity. The northern part of the continent, inhabited by Caucasian ethnicities, is generally represented by moderately built Olympic teams (178.5±4.3 cm, 23.05±1.10 kg/m^2), but this average hides an increase in BMI values from the west to the east – the same tendencies that we see in Europe. Whereas Morocco (21.62 kg/m^2) and Algeria (22.50 kg/m^2) have lean physiques, Tunisia is moderate in this regard (23.99 kg/m^2), and Egypt has the stockiest Olympians (24.63 kg/m^2). Even the small team of Libya (22.53 kg/m^2) does not deviate fundamentally from this geographical trend. This finding would explain the invisibility of Tunisia, Libya, and Egypt in middle and long distance running, in which Algeria and Morocco achieve big international success. In contrast with these two countries, the Olympians from Egypt compete mainly in team sports (especially handball and volleyball), and in wrestling.

The region of West and Central Africa (the homeland of black Olympians competing for many Western countries) is generally characterized by moderately tall teams with moderate values of BMI (179.8±3.4 cm, 23.83±0.63 kg/m^2). The tall team of Angola (186.5 cm) is an eccentric outlier, due to its basketball team, which includes 22 out of 37 Angolan Olympians. Still, we can see that the two Olympic teams from the desert zone of the Western Sahel (Mali, Senegal) are taller (> 180 cm) and leaner (around 23 kg/m^2) than the teams from the wetter coastal zone around the Guinean Gulf (Benin, Burkina Faso, Cameroon, Gabon, Ghana, Ivory Coast, Nigeria), where we consistently find stockier athletes with BMIs on the level of Central Europe (179.2±3.3 cm, ~23.5-25.0 kg/m^2, mean 24.05±0.51 kg/m^2). These physical characteristics resemble athletes in short sprints, in which these populations disproportionately excel. At the same time, their complete absence in distances above the 800 m strongly suggests that the roots of this excellence are also physiological [25-26].

The savannah area of East Africa has a rather short and very lean average (174.6±2.6 cm, 21.53±1.56 kg/m^2), with a wide range of BMI values between 19.5-24.5 kg/m^2. In reality, only the relatively narrow range of 19.5-21.5 kg/m^2 can be regarded as typical of this region because Madagascar, Mauritius, and Seychelles are ethnically diverse island countries, and Zimbabwe includes many Olympians of European descent. Without these mixed teams, we will obtain a short and ectomorphic body type (173.4±2.2 cm, 20.57±0.74 kg/m^2), which apparently corresponds well with the requirements of long distances in which the local athletes excel.

The BMI of countries with a large Nilotic population (Kenya, Sudan, Uganda) is generally higher than that of countries with the strong Cushitic genetic heritage (Eritrea, Ethiopia, and possibly even Burundi and Tanzania). This can be ascribed to the Bantu-speaking populations in Kenya and Uganda, as further evidenced by the wide range of BMI values in Kenya (Supplementary fig. 6). However, anthropometric studies show that Cushitic populations do have lower BMI values than Nilotes, despite the fact that their trunks are relatively longer (Supplementary fig. 7).

South Africa (174.8 cm, 22.05 kg/m^2) is represented by only four countries and has a moderate position between West & Central and East Africa, being closer to the latter. Although the local populations speak Bantu languages that came from West Africa, they are admixed with the aboriginal Khoisan people [27]. Furthermore, the racially mixed team of South Africa (181.4 cm, 23.49 kg/m^2) is again an outlier that is not representative of the aboriginal groups. The mean of Botswana, Lesotho, and Namibia (172.6 cm, 21.57 kg/m^2) is inevitably shorter and leaner.

America

Fig. 8 summarizes men's Olympic teams from America that are primarily represented by athletes of (West) European, West African, and Native American origin. European and West African ancestry dominates in North America and the Caribbean, and the mean physique of local Olympians (181.8±3.1 cm, 23.65±0.87 kg/m^2) is in agreement with this genetic heritage. Young men in this region are generally the tallest in America, and their height is positively correlated with the proportion of European and West African ancestry [13]. Understandably, despite a rather short national average of ~177 cm, the team of the United States has a sufficiently numerous population to cover all height-demanding sports and is slightly above-average, when compared with Europe (185.0 cm, 24.32 kg/m^2). Based on the photos from the Olympic.org database, we also tried to create two separate subsamples of US whites (185.3 cm, 24.42 kg/m^2, n = 708) and US blacks (185.5 cm, 24.50 kg/m^2, n = 229), but they were almost identical in terms of height and BMI.

Olympic teams from Central and South America (i.e. basically Latin America, where we find mainly Europeans of Iberian descent and Native Americans) are strikingly shorter and somewhat leaner (177.5±2.6 cm, 23.32±0.52 kg/m^2). The shortness of the local men positively correlates with Native American ancestry [13]. The tallest Olympic teams therefore typically come from countries with the largest European populations (Argentina, Brazil), although the tallest young men live in Uruguay (174.8 cm). On the other hand, Guatemala, Ecuador, and El Salvador are the shortest, and young men in these countries are very short as well. Still, their Olympic teams are highly selected. Relative to the geographical size of the continent, the local Olympians differ rather moderately in terms of BMI, clustering between ~22.5-24.5 kg/m^2. No clear geographical trend of BMI is visible, although the leanest team (Mexico) comes from the tropical zone.

Olympic medallists

The analysis of Olympic medallists in the industrialized area of Western Eurasia and North Africa constitutes an alternative approach to the research question of the present study. In theory, the tendencies observed in the entire Olympic teams should be even more pronounced because medallists should mainly represent physiques by which the respective country most differs from the global average. Indeed, Fig. 9 shows that both height and BMI of the teams positioned on the fringes of the Olympic distribution are even more extreme. As a result, the range of physical measurements in the displayed teams increases from 173.6-191.7 cm to 172.0-195.5 cm, and from 21.62-25.92 kg/m^2 to 19.78-28.03 kg/m^2. The physical change in the medallists from the Western Balkans, who are disproportionately represented by athletes from team sports, manifests rather in height than in BMI, but the BMI of medalists from the Baltic region and the northern part of the Near East increases quite dramatically. On the other hand, Morocco and Algeria move further to the "lean" parts of the graph.

The general picture thus remains the same, although we should note a remarkable anomaly in Southeastern Europe – from Greece to Ukraine – where the local medallists are shorter and much leaner than the entire Olympic teams. Apparently, Olympians from this region must be handicapped by some factor that puts them at a disadvantage at the international level. This crucial factor is undoubtedly height because nations from Southeastern Europe are among the shortest on the continent. The deficit of height applies even for Greece, whose Olympic team appears as highly selected, due to athletes from height-demanding team sports. However, the reason for this anomaly cannot be solely height because Near Eastern nations – that are even shorter – produce medallists with a much stockier physique than their team average. Therefore, it is rather a combination of short height and (insufficiently high) BMI values which leads to a situation, when these nations face taller and/or stronger competition in sports that would otherwise fit their body type. A similar exception in the Near East is Azerbaijan, which has a much lower BMI than the neighboring countries of the Caucasus. This must be ascribed mainly to the fact that Azerbaijan does not nominate a comparably high number of weightlifters and the reason may therefore be rather cultural.

Population height and Olympic BMI vs. genetic factors

In previous papers [13, 28-29], the main author of the present study successfully tested the predictive power of Y haplogroups in relation to the height of young males at the national level (Fig. 12A-12B). These findings have a meaningful rationale because Y haplogroups are genetic signatures of male founder effects, which were surprisingly rapid especially during the population upheavals in Late Eneolithic Europe [30-31]. In fact, Y haplogroups strongly correlate not only with height but even with other evolutionarily important traits such as the prevalence of lactose tolerance [28]. In the present study, we decided to focus on Europe, the Near East, and North Africa, which share a high number of Y haplogroups occuring at frequencies of at least 5%.

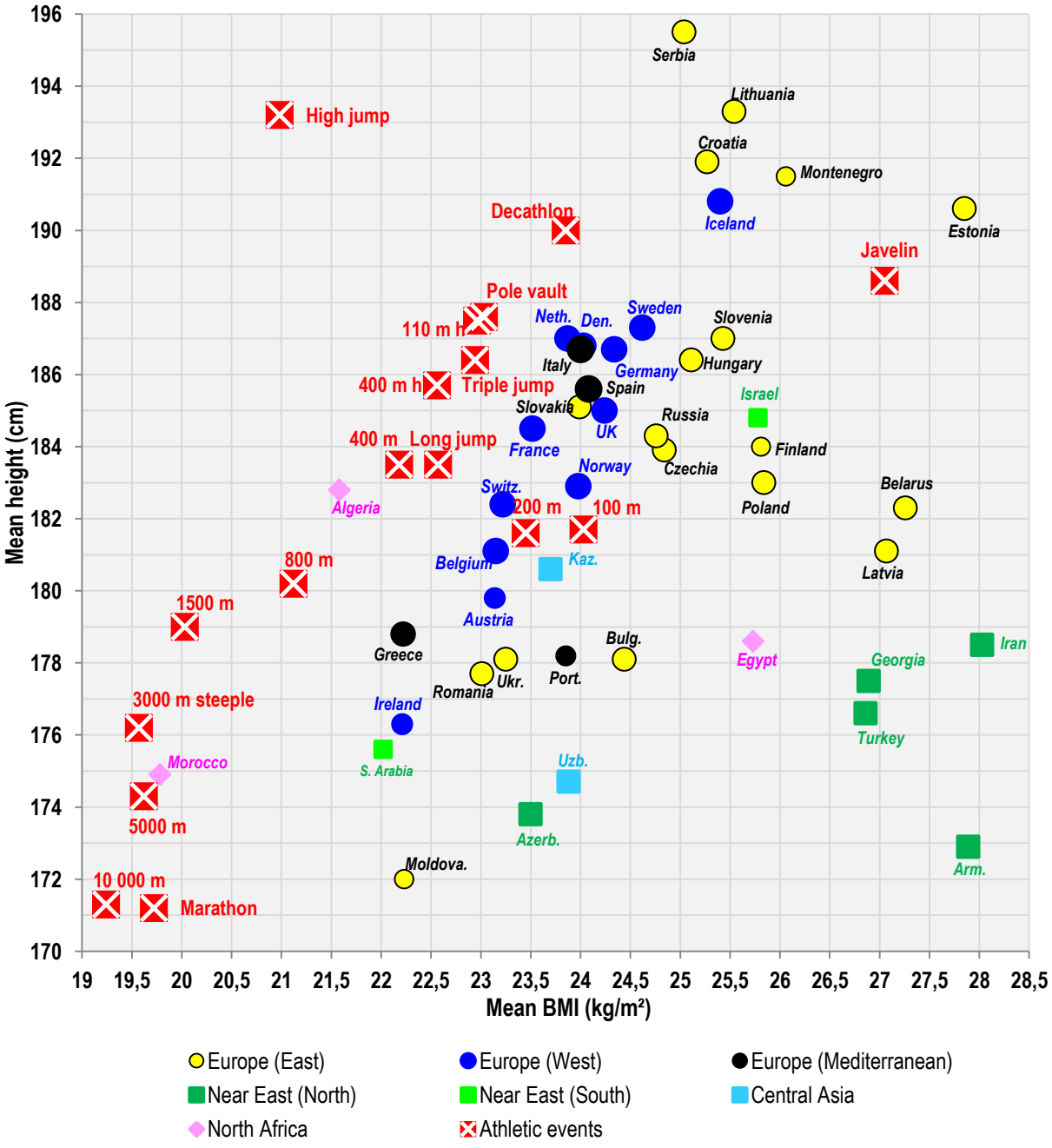


Fig. 9. Mean height and BMI of men's Olympic medallists from Western Eurasia and North Africa, projected against the means of Top 8 Olympians in athletic events. The size of points corresponds to the number of medallists (smaller: 3-10, larger: > 10).

The picture that we recently got from paleogenetic studies [31-37] shows that Late Upper Paleolithic Europe was occupied mainly by the hunter-gatherers from the Adriatic glacial refugium (genetic cluster "Villabruna", also known as "WHG"/Western European hunter-gatherers). These populations carried Y haplogroups I and R1b-V88, and were characterized by genetic predispositions for tall statures. A different group of hunter-gatherers inhabited Eastern Europe, and their prevailing lineages were R1a and R1b. The Neolithic agriculturalists from Anatolia, who started to spread towards Central Europe and the Western Mediterranean after 6000 BC, brought mainly Y haplogroup G and alleles for short height. Although the proportion of the

hunter-gatherer DNA in the Neolithic populations gradually increased, European hunter-gatherers were gradually pushed to the peripheral areas of Scandinavia and Eastern Europe. During the 3rd millenium BC, Europe experienced a dramatic population replacement due to the migrations of nomadic groups stemming from the Yamnaya culture in the East European steppes (genetic cluster "Yamnaya"). These groups carried genes for tallness and the available data suggest that their migrations consisted of several waves, which were always characterized by the predominance of a specific Y haplogroup (R1b-GG400, R1b-U106, R1b-S116, R1a-M417xZ645, R1a-Z93).

Our comparison of Y haplogroup frequencies and male height (Table 3A, Figs. 10A-10B, Supplementary figs. 8-10) shows that the major predictor of tallness in Europe (and in the total sample of 60 countries) is Y haplogroup I, which is currently typical of the Germanic-speaking regions and the Western Balkans, especially Herzegovina (70.9%) [38]. Another Y haplogroup associated with tall statures in Europe is R1b-U106 but data from five countries are missing. Still, the combination of I and R1b-U106 produces by far the strongest correlation (r = 0.73, p < 0.001 in 34 countries). Y haplogroup R1a (a male signature of the Baltic and Slavic nations) does not have any particularly important role in Europe, but reaches significance in the total sample. Its predictive power will probably increase in the future, as most nations in Eastern Europe are still relatively far from reaching their genetic maximum. In the Baltic region, R1a was largely replaced by the founder effect of the Siberian (Uralic) lineage N, but the autosomal genetic profile of the Baltic nations is almost purely European [39] and these two Y haplogroups are basically interchangeable in their relation to physical characteristics. The strongest correlates of short height in Europe are Y haplogroups of Near Eastern origin (E, G, J) (r = -0.59, p < 0.001) and particularly Y haplogroup J. In Western Europe, we can observe a negative relationship between height and R1b-S116, although the data are again incomplete.

In the Near East, the situation is very different and most Y haplogroups associated with shortness in Europe predict relatively taller (i.e. moderately tall) statures. This applies mainly to the combination of J2 and L (r = 0.76, p < 0.001), which has a frequency peak in Georgia (33.2%). Six lineages (E1b-M78, I, J2, L, N, R1a) improve this result even further, but only slightly (r = 0.80, p < 0.001). Although Y haplogroup G also reaches significance and is also the most prevalent in Georgia (38.9%), it has no additive effect because it overestimates the height of Georgian men. The strongest predictors of shortness are Y haplogroups E1b-M123 and J1 (r = -0.80, p < 0.001), whose frequencies reach a maximum in the Arabian peninsula, particularly in Yemen (73.7%). It is more difficult to find a common denominator of tallness in the Near East and North Africa, as it largely depends on the Berber lineage E1b-M81, whose high frequency in Morocco does not match the actual short stature of the local men. The relationships are thus weaker, but the most parsimonious combination is definitely E1b-M78, E1b-M81, J2 and L (r = 0.54, p = 0.011). However, E1b-M123 and J1 remain the strongest correlates of shortness even across the Near East and North Africa (r = -0.75, p < 0.001).

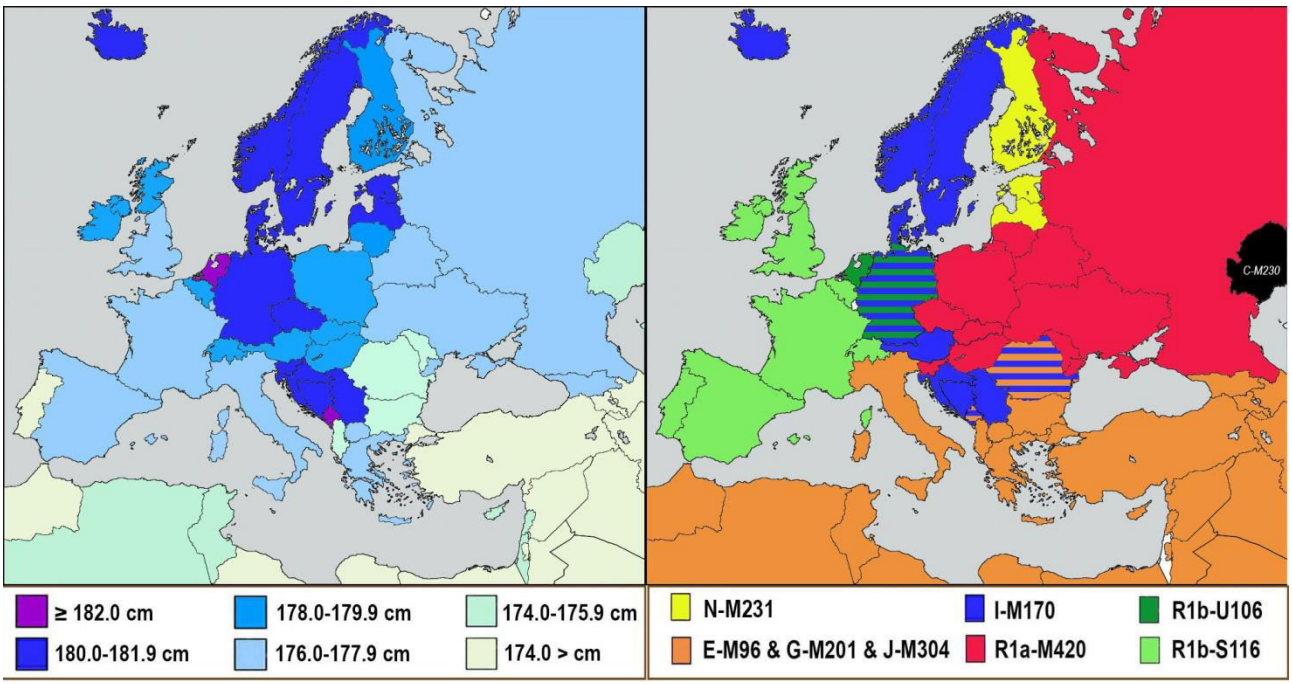


Fig. 10. A) Mean height of young males. B) The most frequent Y haplogroups (or their combination) in individual nations. The frequencies of Y haplogroups that do not differ by more than 1% are indicated by hatching.

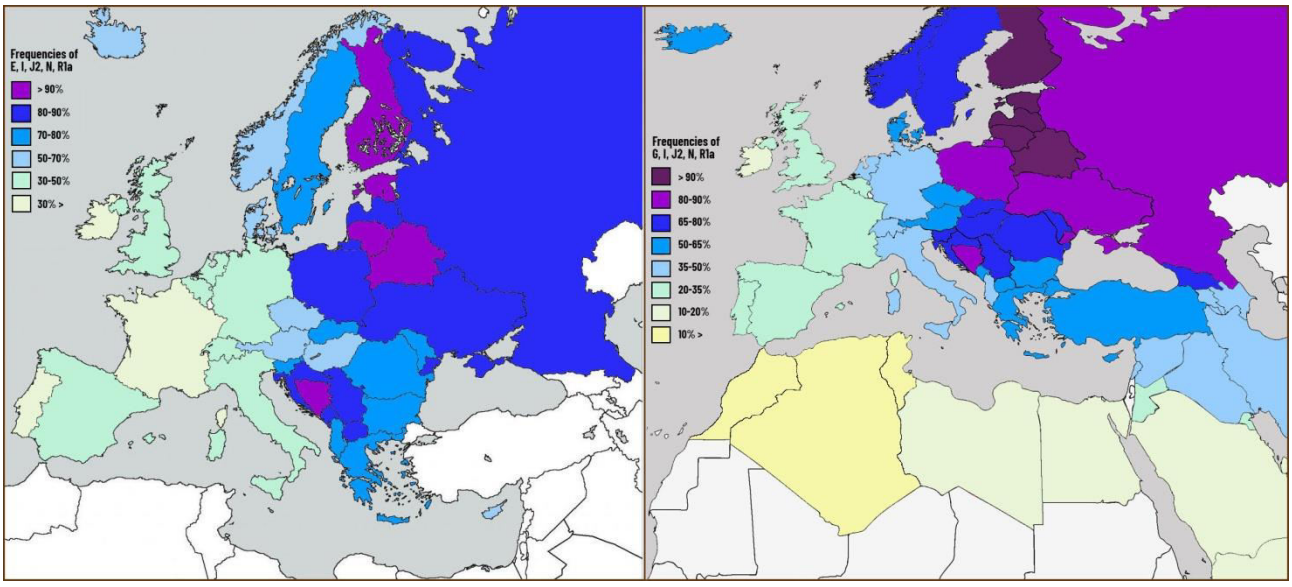


Fig. 11. A) Combined frequencies of Y haplogroups E, I, J2, N, and R1a, which predict high men's Olympic BMIs in Europe. B) Combined frequencies of Y haplogroups G, I, J2, N, and R1a, which predict high men's Olympic BMIs in the complete sample of 60 countries.

The comparison of Y haplogroups and the Olympic BMI (Table 3B, Figs. 11A-11B, Supplementary figs. 11-14) shows that the major predictor of robustness in Europe is the combination of five major Y haplogroups: E, I, J2, N,and R1a (r = 0.61, p < 0.001). The European branches of Y haplogroup E belong almost exclusively to E1b-M78 (E1b-V13) that experienced a strong founder effect centered around the Ghegs in northern Albania and Kosovo [40-41]. Low Olympic BMIs in Europe correlate with Y haplogroups G, R1b-S116, R1b-U106, and especially with R1b in general. This result is at odds with the presumed East European origin of R1b, but can

be explained by secondary founder effects because the Late Eneolithic expansion of R1b-S116 (Bell Beaker culture) was characterized by a markedly higher proportion of Neolithic ancestry [31] and the spread of a highly specific cranial morphology [42].

In the Near East, the situation is more similar than in the case of height. The most parsimonious predictors of high Olympic BMI are Y haplogroups J2 and G (r = 0.78, p < 0.001). The combination of seven Y haplogroups (E1b-M78, G, I, J2, L, R1a, R1b) increases this correlation even further, albeit rather marginally (r = 0.82, p < 0.001). The Near Eastern lineages of R1b mostly consist of R1b-GG400, which reaches a frequency peak in Armenians (~25%) and was closely tied with the early steppe migrations from Eastern Europe [43]. Lean Olympic physiques are again related to E1b-M123 and J1 (r = -0.79, p < 0.001). In the Near East and North Africa, it is E1b-M78, G, J2, and L that determine high Olympic BMI (r = 0.79, p < 0.001), whereas E1b-M81, E1b-M123, and J1 most reliably predict low Olympic BMI (r = -0.74, p < 0.001).

The major correlates of high Olympic BMI in the complete sample of 60 countries are Y haplogroups I, N, and R1a, but the highest correlation is obtained from the combination of G, I, J2, N, and R1a (r = 0.58, p < 0.001). Still, this combination underestimates Olympic BMI values in the Balkans, the Near East and North Africa, due to the incomplete frequencies of E1b-M78, L, and R1b-GG400. Low Olympic BMI is predicted by Y haplogroup J1, but again, the complete frequencies of E1b-M81 and E1b-M123 from Europe are missing.

Table 3A. Correlations between male population height and the frequencies of major Y haplogroups in Europe (western/eastern half), the Near East, and North Africa. Genetic data were not available for Israel and Luxembourg. Colors indicate the strength and direction of statistically significant findings. Correlations higher than r = 0.70 are highlighted. *p*-values are in the parentheses.

Y haplogroup	Europe			Near East (16)	Europe & Near East (55)	Near East & N. Africa (21)	Europe, N.East & N. Africa (60)
	Total (39)	western (16)	eastern (23)				
E	**-0.43 (0.007)**	**-0.73 (0.001)**	-0.37 (0.086)	**-0.65 (0.006)**	**-0.51 (<0.001)**	0.05 (0.84)	**-0.43 (<0.001)**
E1b-M78				0.47 (0.065)		0.32 (0.16)	
E1b-M81				-0.01 (0.96)		0.20 (0.39)	
E1b-M123				**-0.65 (0.006)**		**-0.65 (0.002)**	
G	**-0.47 (0.003)**	**-0.60 (0.014)**	-0.38 (0.070)	**0.50 (0.049)**	**-0.21 (0.12)**	0.36 (0.11)	-0.17 (0.20)
I	**0.54 (<0.001)**	**0.76 (<0.001)**	0.39 (0.066)	0.49 (0.055)	**0.73 (<0.001)**	0.36 (0.11)	**0.75 (<0.001)**
J	**-0.64 (<0.001)**	**-0.76 (<0.001)**	**-0.57 (0.004)**	**-0.67 (0.004)**	**-0.86 (<0.001)**	**-0.55 (0.010)**	**-0.83 (<0.001)**
J1	**-0.56 (<0.001)**	-0.43 (0.094)	**-0.64 (<0.001)**	**-0.74 (0.001)**	**-0.79 (<0.001)**	**-0.69 (<0.001)**	**-0.78 (<0.001)**
J2	**-0.61 (<0.001)**	**-0.72 (0.002)**	**-0.54 (0.008)**	**0.70 (0.002)**	**-0.54 (<0.001)**	0.33 (0.14)	**-0.48 (<0.001)**
L				**0.70 (0.002)**		0.43 (0.051)	
N	0.16 (0.33)	0.37 (0.15)	0.23 (0.30)	0.22 (0.42)	0.25 (0.064)	0.15 (0.50)	**0.27 (0.039)**
Q				0.38 (0.15)		0.26 (0.26)	
R1a	0.16 (0.33)	0.48 (0.057)	0.15 (0.50)	0.30 (0.25)	**0.40 (0.003)**	0.09 (0.69)	**0.43 (<0.001)**
N & R1a	0.20 (0.22)	**0.51 (0.045)**	0.26 (0.24)	0.34 (0.19)	**0.41 (0.002)**	0.12 (0.60)	**0.44 (<0.001)**
R1b				0.37 (0.16)	**0.33 (0.013)**	0.31 (0.17)	**0.37 (0.004)**
R1b-S116	-0.10 (0.57)[1]	**-0.57 (0.044)**[3]	0.05 (0.83)[5]				
R1b-U106	**0.52 (0.001)**[2]	**0.71 (0.004)**[4]	**0.54 (0.014)**[5]				
T				0.12 (0.65)		0.02 (0.92)	

Table 3B. Correlations between men's Olympic BMI and the frequencies of major Y haplogroups in Europe (western/eastern half), the Near East, and North Africa.

Y haplogroup	Europe			Near East (16)	Europe & Near East (55)	Near East & N. Africa (21)	Europe, N.East & N. Africa (60)
	Total (39)	western (16)	eastern (23)				
E	0.12 (0.48)	-0.42 (0.10)	0.06 (0.78)	**-0.63 (0.009)**	-0.10 (0.47)	**-0.46 (0.038)**	**-0.31 (0.017)**
E1b-M78				0.32 (0.22)		0.21 (0.36)	
E1b-M81				0.05 (0.85)		-0.38 (0.092)	
E1b-M123				-0.41 (0.12)		-0.08 (0.73)	
G	**-0.43 (0.007)**	-0.27 (0.32)	**-0.49 (0.019)**	**0.65 (0.006)**	0.19 (0.18)	**0.66 (0.001)**	0.23 (0.071)
I	**0.33 (0.040)**	**0.52 (0.039)**	0.19 (0.38)	**0.64 (0.008)**	**0.28 (0.038)**	**0.61 (0.003)**	**0.33 (0.010)**
J	-0.13 (0.45)	-0.07 (0.78)	-0.28 (0.20)	**-0.70 (0.002)**	-0.26 (0.055)	-0.14 (0.56)	-0.23 (0.078)
J1	**-0.37 (0.022)**	-0.47 (0.067)	**-0.49 (0.017)**	**-0.77 (<0.001)**	**-0.40 (0.003)**	**-0.49 (0.025)**	**-0.38 (0.003)**
J2	-0.07 (0.66)	0.00 (0.99)	-0.23 (0.30)	**0.73 (0.001)**	0.11 (0.43)	**0.68 (<0.001)**	0.16 (0.23)
L				0.44 (0.092)		**0.47 (0.033)**	
N	**0.33 (0.040)**	0.38 (0.15)	0.24 (0.27)	0.14 (0.61)	0.27 (0.050)	0.17 (0.45)	**0.27 (0.038)**
Q				0.34 (0.20)		0.38 (0.091)	
R1a	0.29 (0.077)	**0.69 (0.003)**	-0.18 (0.42)	0.06 (0.83)	0.24 (0.082)	0.25 (0.28)	**0.28 (0.028)**
N & R1a	**0.39 (0.015)**	**0.69 (0.003)**	0.06 (0.79)	0.09 (0.73)	**0.31 (0.023)**	0.27 (0.24)	**0.34 (0.008)**
R1b	**-0.57(<0.001)**			**0.50 (0.048)**	**-0.28 (0.042)**	0.43 (0.052)	-0.19 (0.15)
R1b-S116	**-0.54 (0.001)**[1]	-0.49(0.090)[3]	-0.05 (0.82)[5]				
R1b-U106	**-0.38 (0.025)**[2]	-0.08 (0.79)[4]	0.03 (0.88)[5]				
T				-0.06 (0.81)		0.19 (0.42)	

Notes: [1] 33 countries. [2] 34 countries. [3] 13 countries. [4] 14 countries. [5] 20 countries.

Population height, Olympic height, and Olympic BMI vs. climate

Similar to the authors of other studies examining the regularity of ecological rules, we compared male population height and the Olympic BMI with climatic data. Despite the fact that this analysis has obvious limitations and each country is represented only by a single locality (usually its capital), during a short time period (1999-2019), we obtained multiple highly significant relationships (Table 4). An important observation is that the correlations with both population height and the Olympic BMI go in the same direction but the correlations with the Olympic BMI are mostly weaker. This replicates the situation that we observed in the case of the Olympic BMI and Y haplogroups. Given that Olympic height also correlates more weakly than population height (e.g. r = -0.30 vs. r = -0.53 with the mean annual rainfall in Europe), a logical answer must be sought in the fact that Olympic physiques reflect the population somatotype only indirectly.

A visual inspection of Figs. 12A-12F shows that the tendency towards taller statures and higher Olympic BMI in cold climatic conditions (Bergmann's rule) is universal, but there are significant regional differences with regard to rainfall and humidity. Although both population height and the Olympic BMI tend to decrease in rainy regions (Fig. 12B and 12E), this comparison hides a positive correlation between rainfall and large body size in Europe, the Near East, and North Africa (Supplementary figs. 15-16). A multiple regression of stature in these three regions, incorporating all nine climatic variables in Table 4, produces a very strong model (adj. R^2 = 0.756, p < 0.001) working with seven variables, out of which mean July temperature, mean July rainfall, and especially mean January humidity would be significant (p > 0.05). The best model of the Olympic BMI was substantially weaker (adj. R^2 = 0.395, p < 0.001) and required six variables, out of which four reached significance (mean July rainfall, mean July temperature, mean annual rainfall, mean January temperature).

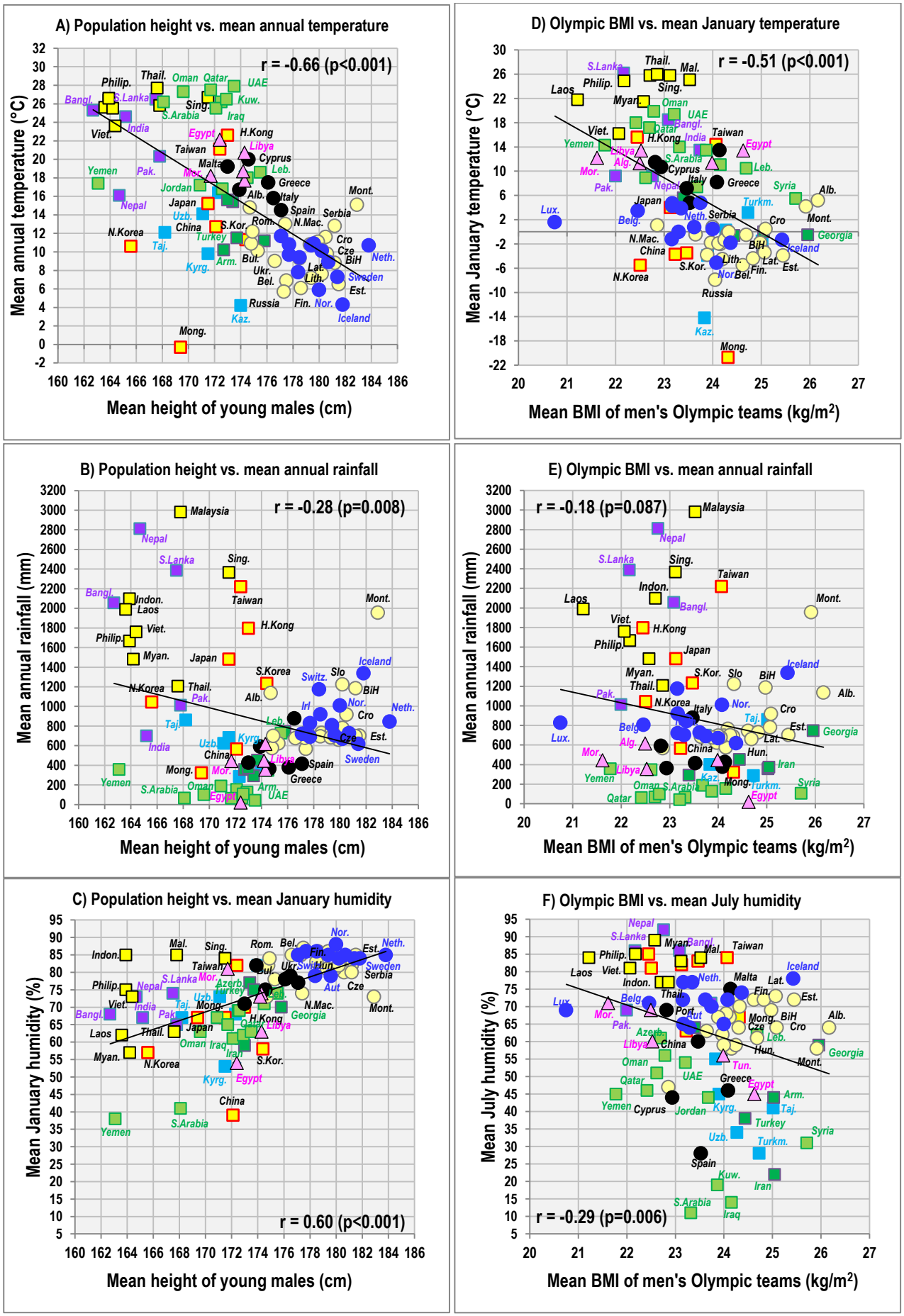


Fig. 12A-12F. Correlations between male population height, men's Olympic BMI, and climatic factors in Eurasia

Table 4. Correlations between male population height, men's Olympic BMI, and climatic factors. Colors indicate the strength and direction of statistically significant findings. Correlations higher than r = 0.70 are highlighted. The sample of Eurasia does not include Oceania.

		Mean temperature (°C)			Mean rainfall (mm)			Humidity (%)		
	Factor	Annual	January	July	Annual	January	July	Jan/July*	January	July
Europe (n=40)	population height	**-0.53 (p<0.001)**	**-0.41 (p=0.008)**	**-0.50 (p<0.001)**	**0.50 (p=0.001)**	**0.27 (p=0.09)**	**0.59 (p<0.001)**	**0.37 (p=0.018)**	**0.33 (p=0.035)**	**0.34 (p=0.034)**
	Olympic BMI	-0.18 (p=0.25)	-0.29 (p=0.069)	0.008 (p=0.96)	**0.40 (p=0.010)**	**0.31 (p=0.049)**	0.15 (p=0.37)	0.04 (p=0.80)	-0.15 (p=0.36)	0.12 (p=0.47)
Near East (n=17)	population height	-0.24 (p=0.35)	-0.40 (p=0.11)	0.03 (p=0.92)	0.38 (p=0.13)	**0.51 (p=0.038)**	-0.37 (p=0.15)	**0.55 (p=0.023)**	**0.84 (p<0.001)**	0.26 (p=0.31)
	Olympic BMI	**-0.57 (p=0.017)**	**-0.75 (p<0.001)**	-0.22 (p=0.41)	**0.49 (p=0.046)**	0.29 (p=0.25)	0.02 (p=0.94)	0.02 (p=0.94)	0.35 (p=0.16)	-0.19 (p=0.47)
Europe & Near East (n=57)	population height	**-0.70 (p<0.001)**	**-0.64 (p<0.001)**	**-0.63 (p<0.001)**	**0.72 (p<0.001)**	**0.50 (p<0.001)**	**0.70 (p<0.001)**	**0.75 (p<0.001)**	**0.82 (p<0.001)**	**0.63 (<0.001)**
	Olympic BMI	**-0.32 (p=0.016)**	**-0.45 (p<0.001)**	-0.12 (p=0.36)	**0.37 (p=0.005)**	**0.31 (p=0.017)**	0.14 (p=0.30)	0.08 (p=0.54)	0.14 (p=0.30)	0.04 (p=0.78)
Near East & North Africa (n=22)	population height	-0.24 (p=0.28)	-0.34 (p=0.12)	-0.02 (p=0.93)	0.40 (p=0.066)	**0.52 (p=0.012)**	-0.39 (p=0.076)	**0.52 (p=0.012)**	**0.74 (p<0.001)**	0.30 (p=0.17)
	Olympic BMI	**-0.44 (p=0.042)**	**-0.67 (p<0.001)**	-0.04 (p=0.85)	0.18 (p=0.41)	0.01 (p=0.98)	0.07 (p=0.76)	-0.22 (p=0.32)	0.07 (p=0.75)	-0.36 (p=0.099)
Europe & Near East & North Africa (n=62)	population height	**-0.71 (p<0.001)**	**-0.66 (p<0.001)**	**-0.64 (p<0.001)**	**0.73 (p<0.001)**	**0.47 (p<0.001)**	**0.71 (p<0.001)**	**0.72 (p<0.001)**	**0.79 (p<0.001)**	**0.60 (p<0.001)**
	Olympic BMI	**-0.33 (p=0.009)**	**-0.47 (p<0.001)**	**-0.12 (p=0.35)**	**0.35 (p=0.006)**	**0.21 (p=0.095)**	**0.20 (p=0.12)**	**0.04 (p=0.77)**	**0.12 (p=0.37)**	**-0.02 (p=0.89)**
Europe & Near East & North Africa & C.Asia (n=67)	population height	**-0.62 (p<0.001)**	**-0.51 (p<0.001)**	**-0.62 (p<0.001)**	**0.67 (p<0.001)**	**0.43 (p<0.001)**	**0.71 (p<0.001)**	**0.74 (p<0.001)**	**0.78 (p<0.001)**	**0.63 (p<0.001)**
	Olympic BMI	**-0.32 (p=0.009)**	**-0.44 (p<0.001)**	-0.09 (p=0.45)	**0.34 (p=0.005)**	0.22 (p=0.078)	0.16 (p=0.20)	0.00 (p=0.97)	0.09 (p=0.49)	-0.06 (p=0.61)
Asia (n=42)	population height	**-0.35 (p=0.024)**	**-0.43 (p=0.004)**	0.14 (p=0.37)	**-0.49 (p<0.001)**	-0.05 (p=0.76)	**-0.56 (p<0.001)**	**-0.31 (p=0.049)**	0.11 (p=0.48)	**-0.43 (p=0.004)**
	Olympic BMI	**-0.49 (p<0.001)**	**-0.55 (p<0.001)**	-0.06 (p=0.72)	**-0.38 (p=0.014)**	0.04 (p=0.82)	**-0.45 (p=0.002)**	**-0.38 (p=0.013)**	0.11 (p=0.48)	**-0.53 (p<0.001)**
Eurasia (n=82)	population height	**-0.66 (p<0.001)**	**-0.58 (p<0.001)**	**-0.53 (p<0.001)**	**-0.30 (p=0.007)**	0.11 (p=0.31)	**-0.43 (p<0.001)**	**0.24 (p=0.028)**	**0.61 (p<0.001)**	-0.05 (p=0.67)
	Olympic BMI	**-0.46 (p<0.001)**	**-0.51 (p<0.001)**	-0.19 (p=0.085)	-0.21 (p=0.057)	0.14 (p=0.21)	**-0.36 (p<0.001)**	-0.11 (p=0.34)	**0.21 (p=0.053)**	**-0.28 (=0.011)**
Eurasia & North Africa (n=87)	population height	**-0.66 (p<0.001)**	**-0.58 (p<0.001)**	**-0.52 (p<0.001)**	**-0.28 (p=0.008)**	0.12 (p=0.29)	**-0.42 (p<0.001)**	**0.24 (p=0.026)**	**0.60 (p<0.001)**	-0.05 (p=0.67)
	Olympic BMI	**-0.45 (p<0.001)**	**-0.51 (p<0.001)**	-0.18 (p=0.10)	-0.18 (p=0.087)	0.10 (p=0.35)	**-0.31 (p=0.003)**	-0.13 (p=0.24)	0.18 (p=0.096)	**-0.29 (p=0.006)**

*Mean for January and July.

Table 5. Correlations between male population height, men's Olympic BMI, and climatic factors in Asia and sub-Saharan Africa. Colors indicate the strength and direction of statistically significant findings. The sub-Saharan sample does not include five ethnically mixed countries. *p*-values are in the parentheses.

	Mean temperature (°C)			Mean rainfall (mm)			Humidity (%)					Weather instability	
Factor	**Annual**	**Coldest month**	**Hottest month**	**Annual**	**Rainiest month**	**Driest month**	**Mean***	**Most humid month**	**Least humid month**	**In the hottest month**	**In the rainiest month**	**Tempe-rature****	**Rainfall *****
Asia (n=42)													
popul. height	**-0.35 (0.024)**	**-0.43 (0.004)**	0.03 (0.87)	**-0.49 (<0.001)**	**-0.57 (<0.001)**	-0.09 (0.56)	-0.20 (0.20)	-0.29 (0.065)	-0.14 (0.39)	-0.20 (0.20)	-0.30 (0.053)	**0.52 (<0.001)**	**-0.60 (<0.001)**
Olympic BMI	**-0.49 (<0.001)**	**-0.55 (<0.001)**	-0.14 (0.36)	**-0.38 (0.014)**	**-0.42 (0.005)**	-0.10 (0.53)	**-0.34 (0.029)**	**-0.31 (0.045)**	**-0.32 (0.036)**	**-0.39 (0.10)**	**-0.33 (0.030)**	**0.57 (<0.001)**	**-0.44 (0.004)**
Sub-Saharan Africa (n=21)													
popul. height	0.39 (0.082)	0.26 (0.25)	**0.48 (0.029)**	-0.28 (0.22)	-0.09 (0.70)	-0.19 0.42)	-0.14 (0.54)	-0.02 (0.94)	-0.19 (0.42)	-0.12 (0.60)	0.01 (0.97)	0.26 (0.26)	-0.05 (0.83)
Olympic BMI	**0.62 (0.003)**	**0.59 (0.005)**	**0.61 (0.004)**	0.07 (0.76)	0.14 (0.53)	-0.03 (0.90)	0.31 (0.17)	0.44 (0.043)	0.19 (0.41)	0.23 (0.31)	**0.48 (0.029)**	-0.04 (0.86)	0.16 (0.50)

*Mean value of the most humid and the least humid month. **Difference between the hottest and the coldest month [ºC). ***Difference between the rainiest and the driest month [mm).

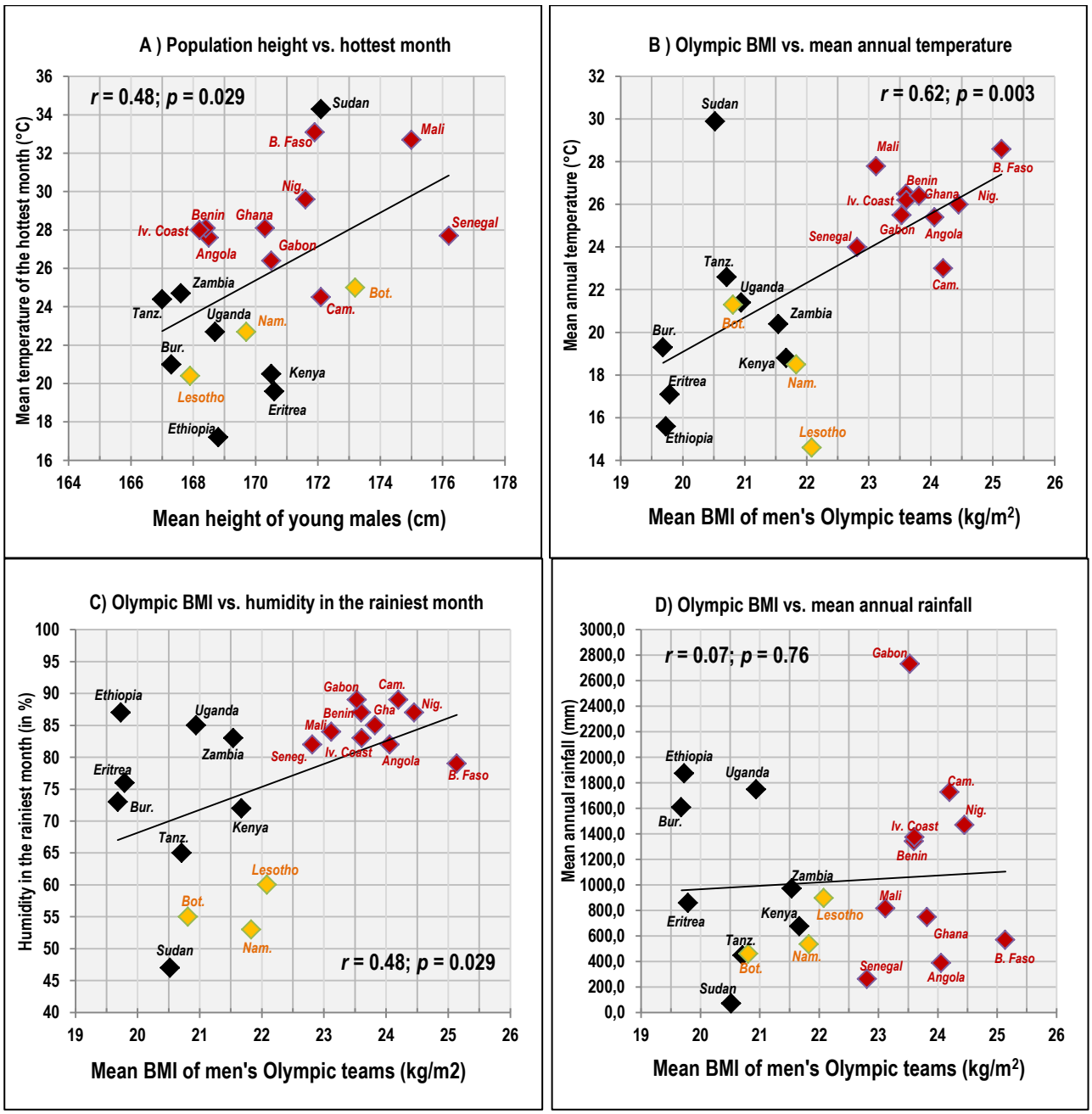


Fig. 13A-13D. Correlations between male population height, men's Olympic BMI, and climatic factors in sub-Saharan African populations.

The statistical findings in Asia must be taken with bigger caution, due to the fact that this sample includes a mix of highly developed and poor developing countries, with a variable level of socio-economic development and nutrition. Therefore, at least height in developing countries will be strongly affected by deep malnutrition. Still, the association of short, lean statures with the rainy, humid tropical belt is very stable in all comparisons, irrespective of the different genetic origin of the examined groups. A multiple regression model of male height in Asia would be relatively strong (adj. R^2 = 0.552, p < 0.001) and works with six variables (mean annual/January/July temperature, mean January rainfall, mean January/July humidity), out of which the first three reach significance. The BMI of Asian Olympians could also be explained by a fairly strong model (adj. R^2 = 0.534, p < 0.001), and only three variables, all significant (mean January temperature, mean January-July

humidity, mean July humidity). If we take into account the more stable climate in the tropics and substitute January and July for months with the highest and lowest values (Table 5), the correlations with humidity will get weaker. Nevertheless, humidity in the hottest month emerges as the most important aspect of humidity, and has a negative relationship with the Olympic BMI.

Concerns related to the environmentally conditioned, stunted growth of the local populations emerge even in sub-Saharan Africa. In a more relevant, smaller sample of 21 countries (without the ethnically mixed Madagascar, Mauritius, Seychelles, South Africa, and Zimbabwe), the correlations between male height and climate produce only one significant result, with the temperature in the hottest month (Table 5, Fig. 13A-13D). The best multiple regression model comprising 11 variables from Table 5 is weak (adj. $R^2 = 0.190$, $p = 0.058$) and works with the mean annual temperature and the temperature in the hottest month (both above $p > 0.05$).

The relationships between climate and the Olympic BMI produce more convincing results, and the three sub-Saharan regions create tighter clusters (Figs. 13B-13C). The best regression model explains 59.2% (adj. R^2) variability in the Olympic BMI ($p < 0.001$), and works with only three variables (mean annual temperature, humidity in the rainiest month, mean temperature in the coldest month) that all reach significance. However, even here, the relationships are not in accordance with expectations. The disproportionately high BMI in the Olympians from West and Central Africa is associated with a hot, humid climate, but not necessarily with the highest rainfall, which fluctuates mostly around 1000 mm annually (Fig. 11D). Only the core area of this region (Gabon, Nigeria, Cameroon) is rainy and reaches > 1400 mm. The slender physiques of South African Olympians come from moderately warm, dry areas with relatively large temperature fluctuations throughout the year. The region of East Africa is generally perceived as hot and dry but in reality, it is characterized by a very wide range of temperatures, precipitation, and humidity, depending on altitude, and there is no clear link between the local ectomorphic physiques and climate.

Discussion

The results of the present study have demonstrated that the physique of male Olympians mirrors the physique of their native populations. The correlation between Olympic height and population height is very strong ($r = 0.83$, $p < 0.001$) and we can justifiably assume that a similar relationship exists even between the Olympic BMI and the population BMI. Indeed, the position of Polynesian Olympians in our graphic comparisons confirms their status as notorious outliers from ecological rules, and the lean physiques of East African Olympians also reflect their well-known ectomorphic somatotype. Other findings, such as the short and lean physiques of Olympians from the tropical belt of Asia, or the stocky build of teams from the cold regions of East Europe and the Near East, can also be explained by Bergmann's rule. All these observations can be further supported by

the data from Deurenberg et al. [20] who found marked differences in the fat-mass/fat-free mass ratio among the world populations (Fig. 14).

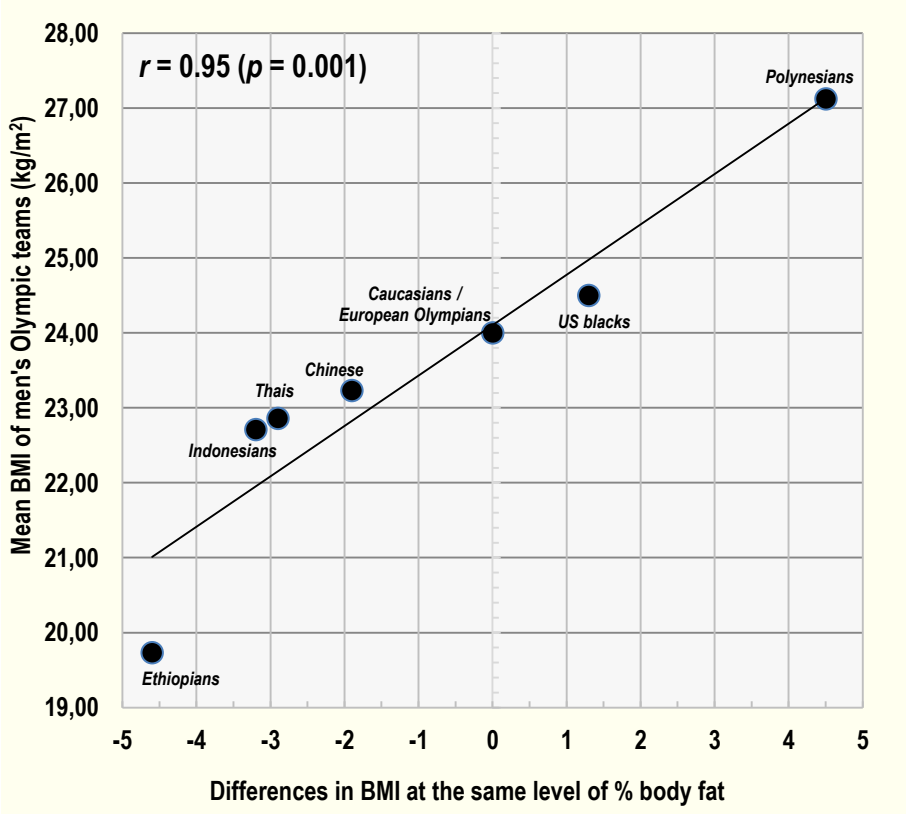


Fig. 14. Correlation between interethnic differences in BMI at the same level of % body fat (data from Deurenberg et al. [20]) and BMI in men's Olympic teams. Deurenberg et al.'s "Caucasians" are compared with the mean BMI value of European Olympic teams.

However, we are not aware of any modern research that would examine body composition differences within Europe or nearby regions. Although classical anthropological literature emphasizes the massive bone structure of the East European Mesolithic population [44] and the Western Balkan highlanders [45], data regarding physical robustness are currently limited to the comparison of the major racial groups, often in the United States [46-48]. This contrasts with physical stature, whose genetic determinants were already extensively examined by genome-wide-association studies [GWAS] [49]. Understandably, GWAS investigating the genetic determinants of BMI would be meaningless for our purpose because these physical characteristics in the sedentary population primarily reflect the degree of obesity. Indeed, GWAS of this sort are explicitly aimed at studying the genetic roots of obesity [50].

One of the rare studies that are at least partly relevant is that by Marnetto et al. [51], who compared the relationship between genetic ancestry and multiple physical traits in a large sample of Estonians. This population is particularly interesting because it harbors a very high proportion of both Yamnaya (51.3%) and Villabruna (40.8%) ancestry [33]. The Yamnaya ancestry had the strongest association with certain segments

of the genome, which were identified as the predictors of tallness and torso girth (waist and hip circumferences corrected for BMI) by GWAS. When the total proportion of genetic ancestries in an individual was compared with measured physical characteristics, the relationships were somewhat different. The authors attribute this to the shifts in the genome that occurred during the mixing of the founding populations. Still, these results agree better with our findings based on Y haplogroups: Villabruna (WHG) ancestry was clearly the strongest predictor of tallness, whereas Yamnaya ancestry was the strongest predictor of torso girth, albeit only marginally better than the Villabruna ancestry. The Anatolian (Near Eastern) and Siberian ancestries had a clearly negative effect on both height and torso girth.

Y haplogroups as the signatures of male founder effects

In accordance with the previous experience, we documented many impressive correlations of Y haplogroups with height (up to r = -0.86) and the Olympic BMI (up to r = 0.82), especially when more of these lineages were combined. These relationships support our assumption that the physiques of male Olympic athletes reflect true biological differences stemming from ancient male founder effects. Of particular note is the fact that a simple comparison of uniparental markers (Y haplogroups) can precisely capture interpopulation variability in such an extremely complex genetic trait as height. In fact, the combination of only two Y haplogroups (I and J) explains 74.5% variation (adj. R^2) in male height across 60 countries of Europe, the Near East, and North Africa. In contrast, the combinations of multiple SNPs [single nucleotide polymorphisms], which were identified by GWAS as the predictors of height, still achieve rather mixed success at the population level. This must be ascribed to their population specificity [52] and potential environmental confounding [37]. Although these issues are already being addressed [53], we should note that polygenic height scores derived from Western Europeans (individuals from the UK Biobank) do not appear to be an ideal tool for assessing the genetic variability in height in Europe, as they predict only low-to-moderate height in the populations from the Western Balkans [54].

Undoubtedly, even the actual data on height used in the present study do not fully express the genotype of the populations studied because the diet in the Near East and North Africa, as well as in the southern and southeastern parts of Europe, is generally inferior to that in Northern Europe [13, 28]. However, the negative impact of the Near Eastern Y haplogroups on height is evident even within individual regions. For example, male height in the seven countries of the Dinaric Alps (former Yugoslavia and Albania) is positively correlated with Y haplogroup I (r = 0.80, p = 0.030) and negatively correlated with Y haplogroup J (r = -0.88, p = 0.008). The dominant role of genetics over environmental factors in today's Europe is also reflected in regression models [13]. In any case, these exogenous factors are unlikely to distort the BMI of male Olympians.

When taken together, tallness in Europe, the Near East, and North Africa is consistently linked to Y haplogroup I but the more geographically restricted R1b-U106 plays a similarly strong role in Europe. Besides that, we expect that the East European lineages N and R1a will also gain in importance in the future. This can be illustrated by the example of Estonians, who are already 4th tallest in the world. High Olympic BMI is associated mainly with the European lineages I, N, and R1a, but the most accurate prediction would probably include eight Y haplogroups: E1b-M78, I, J2, L, N, and R1a in the entire sample, and G and R1b (R1b-GG400) in the Near East. Unfortunately, not all authors test a complete spectrum of Y haplogroup subbranches, and hence this combination cannot be used for all 60 countries examined.

Our data also suggest that each Y haplogroup relates to a very specific combination of physical characteristics, which would be worthy of further research. For example, R1b-S116 is connected with shorter (moderately tall) and lean physiques in Western Europe; R1b-U106 combines tallness with moderately built physiques in the Germanic-speaking nations; G, J2, and L emerge as predictors of moderately tall and robust statures in the Near East; E1b-M81 in North Africa has a relationship to moderate height and a very lean body structure. A very meaningful and consistent finding is the association of E1b-M123 and J1 with short and subtle body builds in the desert area of the Arabian peninsula. The link between these two lineages and the population history of the Arabian pastoralists was already observed by Chiaroni et al. [55]. The low genetic height in the Yemenese and other Arabic populations was also predicted by the autosomal data in the preprint by Berg et al. [52].

A notable anomaly in our results is the different geographical relationship between Y haplogroup G and the Olympic BMI: Negative in Europe but positive in the Near East. This is at odds with the very high Olympic BMI of Georgia, where Y haplogroup G reaches its frequency peak (38.9%). Although this contradiction can be explained by the low occurence of Y haplogroup G outside Georgia, it is also possible that the individual subbranches of this Y haplogroup differ in their relationship to physical characteristics - similar to Y haplogroups E, J and R1b. Another noteworthy discrepancy concerns the BMI of Icelandic Olympians that is deeply underestimated by all Y haplogroup combinations. At the same time, the local founding population included a large proportion of Celts from the British Isles, which should compromise the original Scandinavian genetic contribution. The most probable answer must be sought in the highly specific genetic history of this island, characterized by strong selective pressures in a harsh environment [56].

Physical build and climatic factors

Besides genetic factors, the meaningfulness of our results can also be supported by the association between physical build and climate. Correlations that emerge in the studies of non-industrialized nations are usually in accordance with the ecological rules, but are often vague, even without the notorious outliers from Oceania.

Therefore, it is remarkable that we found highly significant and strong relationships, particularly between climate and male population height. This may result from the fact that highly industrialized nations have already approached their genetic maximum, whereas the height of “natural peoples” is much more strongly influenced by environmental factors.

Still, we must note that these findings appear to be region-specific and are not always easy to interpret. In Europe, the Near East, and North Africa, we observe an expected connection of height and the Olympic BMI with low temperatures, but the possible evolutionary role of high precipitation and high (winter) humidity is less clear. At the same time, these two climatic factors reach higher correlation coefficients than temperature. Some idea of the relationship between male founder effects (Y haplogroups) and climatic conditions can be obtained from Supplementary tables 3-5: In Europe, Y haplogroup I is connected with moderately cold winters and high rainfall, N and R1a with cold winters, rainy summers, and high humidity, R1b-S116 with mild winters in Western Europe, R1b-U106 with cold summers and high humidity in the proximity of the North Sea. The Near Eastern lineages (E, G, J) are associated with the warm and dry climate in southern Europe, which follows from the direction of historical migrations, but their relationships in the Near East have a very specific pattern: Whereas the “pastoral” Y haplogroup J1 is expectedly widespread in warm and dry regions with low humidity, the “agricultural” lineages G and J2 are concentrated in areas with cold winters, higher rainfall and higher humidity. Also noteworthy is the correlation of E1b-M78 with high January rainfall and humidity, and R1b (R1b-GG400) with cold winters.

According to the hypothesis put forward by Wells et al. [11], the abundance of rainfall is a prerequisite for higher ecological productivity, which would guarantee regular food supply. This could potentially weaken the evolutionary impact of climate and lead to the sexual selection of more muscular males. Limited natural resources can meaningfully illuminate the short and ectomorphic statures in the desert area of the Near East, although it is paradoxical that the local shortness is closely tied with lactose tolerance – a trait that otherwise accompanies tallness in Northern Europe and the West African Sahel [57]. The high precipitation in Northern Europe and the Western Balkans is associated with the tallest statures and high Olympic BMI but contrary to Wells et al.’s assumption, it is not necessarily connected with historical food excess. Montenegro - presumably the tallest country in Europe - has the rainiest capital on the continent, with total annual precipitation comparable to tropical Asia (1956 mm) but most of it comes during winter. Summer is dominated by relatively dry conditions, which further exacerbate the infertility of the local limestone subsoil. Similarly, Northern Europe has natural conditions that are not well suited for agriculture. In both these regions, local populations have historically inclined towards animal husbandry/pastoralism, or fishing.

In this context, it is noteworthy that out of 47 food items from the FAOSTAT database examined in a recent study [13], the mean annual rainfall in 40 European countries correlates significantly positively only with items including dairy, especially total dairy protein (r = 0.46, p = 0.003). Across 60 countries of Europe, the Near East, and North Africa, this correlation is even higher (r = 0.66, p < 0.001) (Supplementary fig. 17). These findings offer a possibility that European populations living in infertile, humid, and relatively cold regions have benefitted from animal husbandry and the stable incorporation of dairy into their diets because it has guaranteed the supply of proteins of the highest biological quality. In fact, the top five consumers of dairy protein in the FAOSTAT database between 2010-2019 were Albania, Iceland, Finland, Montenegro, and Estonia [58]. Nevertheless, it is perplexing that both Northern Europe and the Western Balkans are simultaneously characterized by the highest frequencies of Y haplogroup I, which explains their tallness through a common Upper Paleolithic origin.

A clue to the solution of this complex problem may lie in the fact that Y haplogroup I and the Near Eastern Y haplogroups (E, G, J) completely differ in their relationship to dietary factors in Europe: Whereas Y haplogroup I correlates most positively with high-quality animal products (dairy & pork protein r = 0.57, p < 0.001 in 58 countries) and most negatively with low-quality agricultural products (rice & legume protein r = -0.50, p < 0.001, cereal protein r = -0.46, p < 0.001), E & G & J show the strongest positive correlation with cereal protein (r = 0.63, p < 0.001) and the strongest negative correlation with animal sources (dairy & pork & egg protein r = -0.79, p < 0.001). In addition, Y haplogroup I is typical of cold European regions, whereas E & G & J are associated with high annual temperatures. Although it is again only a speculation, this striking polarity in eating habits and climatic associations allows us to assume that the current situation has deep roots in the subsistence style of ancient hunter-gatherer and agricultural populations. It was just the peripheral, barren European regions, where hunter-gatherers took refuge from the penetrating farming groups, and continued to practice their diet oriented towards animal products.

Due to the absence of data from Europe, Wells et al. confirmed their hypothesis only in “hot climatic settings” (at the mean annual temperature above 20°C), where high rainfall correlated with higher BMI. In “cold climatic settings” (below 20°C), high BMI was associated with low annual precipitation. These discrepancies are not surprising, as the cold climatic settings in Wells et al.’s study were represented mainly by high-BMI aboriginal groups from North America and Siberia, where we find a very low annual rainfall. If we used data from our present study, we can see that the closest analogies to this cold and dry geographical area (Mongolia and Central Asia) clearly lag behind Eastern Europe both in terms of height and the Olympic BMI. For change, the relationships in “hot settings” were driven mainly by high-BMI Native American tribes from rainy Amazonia, whereas in our study, the highest annual rainfall is associated with the tropical Asian belt, where we find males with short stature and low Olympic BMI.

These contradictory results cannot be explained by marked differences in climate because both Amazonia and tropical monsoon Asia have similar mean annual rainfall (Manaus: 3001 mm), a similar mean annual temperature (Manaus: 26.4 °C), and a similar range of monthly means of humidity (Manaus: 80-89%). At least part of the answer could again lie in the way of subsistence because out of all dietary factors, the mean annual rainfall in Asia correlates most strongly with the daily per capita supply of rice in the FAOSTAT database (r = 0.66, p < 0.001). As shown by previous studies [13, 29], rice is the main factor determining malnutrition (short height) not only in Asia but even worldwide because it offers a very small amount of nutrients relative to its energy content and volume. This remains valid even in the present Asian sample of 39 countries, for which FAOSTAT statistics were available (r = -0.69, p < 0.001). A rice-based diet should therefore lead towards the evolution of short and gracile populations. In fact, rice protein is also the strongest dietary correlate of low Olympic BMI in Asia (r = -0.62, p < 0.001), stronger than any climatic variable. However, the fact that rice protein improves the best regression model of height (from adj. R^2 0.552 to 0.631), but not the best model of the Olympic BMI (from 0.534 to 0.532), again points to its important dietary role, and distinguishing between cause and effect would require controlling for some genetic factor.

The hunter-gatherer lifestyle of the aboriginal groups in Amazonia should theoretically provide a more varied diet. However, even here, this explanation is not without problems because the Amazonian rainforest is characterized by a very small density of animal biomass [59]. The diet of Amazonian tribes consequently suffers from a high carbohydrate content and a low density of important nutrients [60], which is reflected by very short statures (around 160 cm in males). Therefore, it is possible that these Native American groups simply retained some of their adaptations to the cold climate [61].

Finally, we should mention the positive correlation between tallness and humidity in Europe, the Near East, and North Africa, which was apparently related mainly to January humidity. These results cannot be easily dismissed because they were the most convincing among all climatic factors, reaching r = 0.79 (p < 0.001) across the whole region, and r = 0.84 (p < 0.001) in the Near East (Supplementary fig. 18). It is therefore surprising that the possible role of humidity as a selective ecological factor is very little researched. Besides the cooling effect of air moisture, we can also consider the lack of sunshine, which amplifies low winter temperatures. Nevertheless, mean January humidity strongly correlates even with dietary factors, especially with the combination of proteins from dairy, pork, eggs, and potatoes, which were previously identified as the most reliable dietary determinants of height worldwide [13]. This correlation reaches r = 0.74 (p < 0.001) in the whole region, and r = 0.76 (p < 0.001) in Europe and the Near East. Therefore, winter humidity basically serves as a proxy for high-quality animal proteins in the diet and it is possible that climatic data are confounded by the nutritionally inadequate diet in the desert areas of North Africa and Arabian peninsula. Still, January humidity retains its high significance as the predictor of tallness (p < 0.001 in 60 countries), even after

controlling for the above mentioned effect of diet, and both these factors explain 70.3% (adj. R^2) of the variation in male height.

The validity of the ecological rules in Africa is the least clear and our analyses are undoubtedly influenced by widespread malnutrition, which must affect the phenotypic expression of height. Another important factor is the extensive migration within sub-Saharan Africa during the Holocene, which must blur the relationship with climate in East Africa. Furthermore, there are also fundamental interpopulation differences in the way of subsistence. Similar to other developing regions, male height in sub-Saharan Africa is most strongly correlated with total protein supply between 1995-2013 (r = 0.49, p = 0.018 in 23 countries), but the most important individual food item is dairy protein (r = 0.44, p = 0.037). Although Hiernaux and Froment [62] maintain that the tall statures of African pastoralists reflect reduced demands on heat dissipation in the open, dry savannah, the widespread use of milk in the pastoral diet [63], together with the occurence of lactose tolerance in the West African Sahel [57], point to the evolutionary importance of this dietary factor, which can largely explain the positive correlation between height and extreme heat. Indeed, the tall Sudanese Nilotes are predominantly cattle herders and, despite being lactose intolerant [64], they rely on the combination of milk, blood, and meat in their diet. In contrast, short-statured Nilotes in Kenya practice agriculture [65]. The origin of the Nilotic groups should be sought in the tropical savannah of South Sudan [27], which is characterized by very high mean annual temperatures around 28 °C, seasonal rains with a relatively high annual total (~1000 mm), and low humidity. The genetic heritage of the Cushitic populations is most strongly preserved among the Somalis [66], who inhabit a region that is comparatively hot, but much drier.

The more robust West Africans originate in the humid region of the Guinean Gulf, which would support Wells et al.' assumption about the relationship between high precipitation and high BMI. However, this explanation is also somewhat counterintuitive because the density of animal biomass in the West African rainforest (and hence the potential availability of high-quality animal proteins) is up to one order lower than in the East African savannah [59, 67]. On the other hand, Hiernaux et al. [68] argue that the West African rainforest does not suffer from severe weather fluctuations and provides a more stable food supply. This assumption could not be confirmed in the present study but it is noteworthy that in a sample of 19 sub-Saharan countries with predominantly aboriginal populations, high Olympic BMI is most strongly associated with the current supply of total energy (r = 0.65, p = 0.003). Paradoxically, it shows the most negative correlation with dairy protein (r = -0.49, p = 0.033), which completely contradicts the relationships ducumented in the case of height.

Rational programs of sports funding

The most practical significance of our data lies in the estimation of the global sports potential. Although most countries have naturally recognized, by trial and error, in which sports their athletes achieve the biggest

international success, we can reasonably assume that very few people can realize the connection with the body type of their home population, and they are not aware of the theoretical potential that their country has in other sports. When looking at the graphical comparisons of national Olympic teams and the means of Olympic finalists, one can notice striking discrepancies between the seeming potential and the complete lack of participation.

For example, the lightly built nations of tropical Asia should be more visible in endurance running, together with African runners. It is possible that besides the lack of athletic culture, a significant obstacle may lie in the lowland tropical climate, which is not ideal for extreme physical activity. A more exotic international participation could be expected e.g. in gymnastics, whose requirements are also close to the average physiques in tropical Asia. Out of individual countries, we can highlight the Netherlands, a wealthy nation with extraordinary predispositions for height-demanding sports and athletics, which, however, do not seem to be fulfilled. For example, the Dutch regularly win Olympic medals in field hockey - a sport with low physical demands (181.3 cm, 23.90 kg/m^2), but they do not consistently excel in basketball, handball, volleyball, or water polo. Instead, the Dutch sports system appears to concentrate on football (soccer), which apparently brings significant results on the international scene, but the price must be disproportionately high, as lots of talents for other sports must be wasted. A different extreme is that of the Western Balkans. The local sports culture prefers height-demanding team sports, for which these nations are ideally built, but due to the role of skills and psychological factors, and the unfavorable ratio between the number of athletes and the medal gain, the reward is not as high as these countries deserve. A more effective focus on individual sports can be seen in the case of Croatia that achieves greater Olympic medal success than Serbia, despite a smaller population.

In the Czech Republic (Czechia), the highest number of Olympic medals since 1993 has been won in water sports (rowing and canoeing), followed by athletics (mainly in the decathlon and the javelin). This picture well corresponds with the body type that we documented in the Czech population – very tall and moderately above-average in terms of BMI, with dispositions towards more dynamically manifested physical strength. This is clearly demonstrated by the example of athletics: Although its popularity largely stems from the Olympic triumphs of Emil Zátopek during the 1950s, there appeared no Zátopek's successors in endurance running. Instead, the main strength of Czech athletes clearly lies in the field events. In addition to the decathlon and the javelin throw, we can also predict relatively high potential in the high jump and the discus throw that place high demands on height and are not extreme in terms of BMI. In track, the 110 m hurdles and the 400 m would be the best choice, at least within Europe. There are also other sports areas, in which Czechs do not achieve expected success. In the first place, it is swimming and the heavy categories of combat sports. The recent double Olympic gold of judoist Lukáš Krpálek in Rio 2016 and Tokyo 2021 testifies that this assumption is justified. Further, we could expect greater international visibility in height-demanding team sports such as

basketball, handball, and volleyball. This was indeed the case until the late 1960s, when Czechoslovakian men won multiple international medals in the latter two. We suspect that the universal decline of these sports has a lot to do with the greater focus on ice hockey after the Soviet invasion in 1968, because it became an arena for "the settlement of accounts" with the Soviet Union. On the other hand, it would be unreasonable to invest into gymnastics; the current Czech generation is too tall to continue in the footsteps of Věra Čáslavská.

Countries that are able to understand these limitations and strengths of their national physical potential can invest funds more rationally and achieve greater international success. The knowledge of these facts is particularly important in the case of small countries, whose sports potential is limited by population size. At the same time, it is important to emphasize that the ideal sports are not necessarily those that are the closest to the country's Olympic average in the graphic comparisons. Rather, it is sports in which the respective country faces the least international competition. Therefore, tall countries should focus on sports with the highest means of height, and countries with high Olympic BMI should orientate towards sports with the highest BMI values. Understandably, optimal height, weight, and BMI must be combined with body proportions and physiological factors that are appropriate for a particular sport.

Given that most Olympic sports require above-average height, it is also possible to improve the nutritional status of the young population, in order to further expand its sports talent pool. A good example is the system of school catering in the Czech Republic, which is regarded as one of the most sophisticated in the world [69]. Based on our recent unpublished research, in which the height of Czech high school students increased with the frequency of the attendance of school lunches, we suspect that the height of young Czechs – who are the tallest in Central Europe – is significantly positively influenced by this factor.

Conclusion

Our current study had two main goals. First, we wanted to use the physical characteristics of Olympic athletes to document somatotype differences among a wide spectrum of human populations. This research could potentially fill a knowledge gap that exists in the highly industrialized nations, which are generally not included in studies examining the effects of ecological rules on the human body. Our results apparently agree very well with the results of available studies, and despite the absence of such supporting data from Europe and neighboring regions, we can demonstrate highly significant and meaningful correlations of physical characteristics with genetic and climatic factors. The relationships between these factors and height may be confounded by the actual dietary quality, but the BMI of male Olympians is unlikely to be affected by the actual nutritional status. Still, our data indicate that the relationship between physical build and climate may be very complex, being mediated by the historical way of subsistence that has been driven by climatic conditions. Future genetic and body composition research will hopefully bring further evidence but given that many

scientists probably do not realize the possible existence of relatively large physical differences among European nations, whose nature may be highly polygenic (similar to height), we do not expect a definitive answer from other scientific fields in the close future.

The second goal of our study follows from these anthropological findings because they could have very practical implications for the selection of sports talents. Based on these data, each country can primarily target sports in which it has the greatest chance of international success. Understandably, sports participation will always be influenced by sports culture and the size of the sports base, and we could find examples of nations that excel in sports, for which they are not ideally physically predisposed (eg. East Asians in badminton and table tennis, where champions are characterized by far taller statures than are the norm in East Asia). Therefore, the message of the present study is more likely to appeal to less populous nations, whose athletes inevitably face strong international competition.

Materials and methods

To collect the basic physical characteristics of Olympic athletes, we requested data on body height and weight of Olympians from five Summer Olympic Games (2000-2016) from the International Olympic Committee [IOC]. These data are part of the Olympedia.org database that was built by independent researchers. We decided to concentrate on male Olympians, for the understandable reason that men are more competitive in sports than women, and hence the level of international competition and participation, as well as the spectrum of Olympic sports, is higher. The sample of male Olympians included 22,397 individuals but these raw data required some editing. First, we excluded Olympians, who competed for a country other than the one in which they were born. Second, we excluded Olympians for which complete data on height and weight were not available. Third, when a range of weight was listed for some athletes (usually those competing in different weight categories), we opted for the highest value because it usually represents the athlete's highest level of trainability. Our samples included even Olympians, who changed their nationality and competed under different flags. The condition for their inclusion was at least one Olympic participation for the country in which they were born. Subsequently, we excluded all Olympic teams, which were represented by fewer than 10 athletes at these five Olympics. The only exception was Oceania, whose Olympic teams were universally small and required grouping into larger samples.

After these adjustments, 19,662 (87.8%) athletes from 159 countries remained in the dataset. When 13 Olympic teams from Oceania were assigned to three larger separate samples (Melanesia, Micronesia, and Polynesia), we had a total of 149 samples left in our dataset. These samples were subsequently divided into individual regions and sorted according to size: 'Small' with only 10-19 athletes (n = 37), 'medium-sized' with

20-199 athletes (*n* = 83), and 'large' with ≥ 200 athletes (*n* = 29). Our assumption was that too small teams will not be sufficiently representative, and too large teams (usually from very populous, or wealthy countries) will have enough sports talents to cover the widest spectrum of Olympic sports. Therefore, the physiques of medium-sized teams should theoretically be the closest to the average body type of each country, whereas too small teams will often constitute outliers and too large teams will be close to the average of Olympic sports.

The height and BMI of these samples was mutually compared in graphs and supplemented by the averages of height and BMI in Olympic sports between 2000-2016. We always selected Top 8 competitors in individual Olympic sports (divided into athletics and "other individual sports") and all members of Top 3 teams in team sports. To ensure sufficient representativeness, we only included sports that were part of the Olympic Games at least three times. In addition to the physique of the entire Olympic teams, we also compared the height and BMI of medallists in the Olympic teams from Western Eurasia and North Africa, because this industrialized area is not sufficiently covered by scientific studies examining interethnic differences in body composition, and requires more detailed attention. Given that medallists generally represent a subsample, whose physique is the most distant from the global average, their physique should also highlight the direction, in which the respective population most differs from the global average. This analysis incorporated all teams that had at least three medallists at the Olympics between 2000-2016.

The population height of young men, Olympic height, and the Olympic BMI were also compared with genetic and climatic factors. This comparison could further support the meaningfulness of the Olympic BMI as an indicator of human physical diversity. Genetic analyses concentrated on the frequencies of Y haplogroups (male lineages) in Europe, the Near East, and North Africa. Based on our previous positive experience with the use of Y haplogroups as the predictors of male height and lactose tolerance in Europe, Asia, Oceania, and North Africa [28-29], we expected that these genetic indicators would also show significant relationships with the BMI of Olympic teams. Nevertheless, the dataset of Y haplogroup frequencies in the above mentioned sources was extensively updated, edited, and expanded. Climatic data regarding temperature, precipitation, and humidity were taken from https://en.climate-data.org. For each country, we selected climatic statistics from its capital for the period 1999-2019. When there were no data available from the capital, we opted for the nearest locality at a similar altitude.

All the statistical relationships between anthropometric data and their possible exogenous predictors were examined using the statistical softwares Statistica 14.0 and PAST. The data used for each individual country are contained in the Supplementary dataset.

Author contributions: Conceptualization: PG. Writing—original draft: PG, JC. Methodology: PG. Data collection: OC, PG, ZH, TK, LS, SH, JO. Visualization: PG.

Competing interests: The authors declare no competing interests.

Data and materials availability: All data needed to evaluate the conclusions in the paper are present in the paper and/or the Supplementary Materials and the Supplementary dataset.

References

1. C. Bergmann. Über die Verhältnisse der Wärmeökonomie der Thiere zu ihrer Grösse. Göttinger Studien 1847; 3 (1): 595–708.
2. J. A. Allen. The influence of Physical conditions in the genesis of species. Radical Review 1877; 1: 108–140.
3. T.W. Holliday. Postcranial evidence of cold adaptation in European Neandertals. American Journal of Physical Anthropology 1997; 104(2):245-258.
4. D. F. Roberts. Body weight, race and climate. American Journal of Physical anthropology 1954; 11:533-558.
5. C. B. Ruff. Morphological adaptation to climate in modern and fossil hominids. American Journal of Physical Anthropology 1994; 37(S19), 65–107.
6. P. T. Katzmarzyk, W. R. Leonard. Climatic influences on human body size and proportions: ecological adaptations and secular trends. American Journal of Physical Anthropology 1998; 106(4):483-503.
7. J.C.K. Wells. Ecogeographical associations between climate and human body composition: Analyses based on anthropometry and skinfolds. American Journal of Physical Anthropology 2011; 147(2), 169–186.
8. F. Foster, M. Collard. A reassessment of Bergmann's rule in modern humans. PloS one 2013; 8(8):e72269.
9. D.F. Roberts, D.R. Bainbridge. Nilotic physique. American Journal of Physical Anthropology 1963; 21(3):341-370.
10. E. Strouhal. Anthropology of the Egyptian Nubian men. Anthropologie 2007; 45(2-3):105-245.
11. J. C. Wells, M.A. Saunders, A.S. Lea, M. Cortina-Borja, M.K. Shirley. Beyond Bergmann's rule: Global variability in human body composition is associated with annual average precipitation and annual temperature volatility. American Journal of Physical Anthropology, 2019; 170(1), 75-87.
12. A. Das, R. Alagirusamy. Science in clothing comfort. Woodhead Publishing India Pvt Limited; 2010. p. 31-53.

13. P. Grasgruber, E. Hrazdíra. Nutritional and socio-economic predictors of adult height in 152 world populations. Economics & Human Biology 2020; 37:100848.
14. D. Chali. Anthropometric measurements of the Nilotic tribes in a refugee camp. Ethiopian Medical Journal 1995; 33(4):211-217.
15. E. Rebacz. The physique of young males in east Africa from the biosocial point of view. Collegium Antropologicum 2006; 30(2):259-264.
16. R. Charchuk, S. Houston, M.T. Hawkes. Elevated prevalence of malnutrition and malaria among school-aged children and adolescents in war-ravaged South Sudan. Pathogens and Global Health 2015; 109(8):395-400.
17. K. Norton, T. Olds (Eds.) Anthropometrica: a textbook of body measurement for sports and health courses. UNSW press; 1996.
18. T. R. Ackland, B. Elliott, J. Bloomfield. Applied anatomy and biomechanics in sport. Human Kinetics; 2009.
19. J.L. Carter, B.H. Heath. Somatotyping: development and applications (Vol. 5). Cambridge University Press; 1990. p. 73-140.
20. P. Deurenberg, M. Yap, W.A. Van Staveren. Body mass index and percent body fat: a meta analysis among different ethnic groups. International Journal of Obesity & Related Metabolic Disorders 1998; 22(12).
21. P. Deurenberg, M. Deurenberg-Yap, S. Guricci. Asians are different from Caucasians and from each other in their body mass index/body fat per cent relationship. Obesity Reviews 2002; 3(3), 141-146.
22. A. Luke. Ethnicity and the BMI–body fat relationship. British Journal of Nutrition 2009; 102(4):485-487.
23. K.I. Hirata. Physique and age of Tokyo Olympic champions. Journal of Sports Medicine and Physical Fitness 1966; 6(4), 207.
24. T.J. Hatton. How have Europeans grown so tall? Oxford Economic Papers 2014; 66(2):349-372.
25. P.F. Ama, J.A. Simoneau, M.R. Boulay, O. Serresse, G. Theriault, C. Bouchard. Skeletal muscle characteristics in sedentary black and Caucasian males. Journal of Applied Physiology 1986; 61(5), 1758-1761.
26. W.J. Duey, D.R. Bassett, D.J. Torok, E.T. Howley, V. Bond, P.Mancuso, R.Trudell. Skeletal muscle fibre type and capillary density in college-aged blacks and whites. Annals of Human Biology 1997; 24(4), 323-331.
27. S.A. Tishkoff, F.A. Reed, F.R. Friedlaender, C. Ehret, A. Ranciaro, A. Froment, et al. The genetic structure and history of Africans and African Americans. Science 2009; 324(5930):1035-1044.
28. P. Grasgruber, J. Cacek, T. Kalina, M. Sebera. The role of nutrition and genetics as key determinants of the positive height trend. Economics & Human Biology 2014; 15:81-100.

29. P. Grasgruber, M. Sebera, E. Hrazdíra, J. Cacek, T. Kalina. Major correlates of male height: A study of 105 countries. Economics & Human Biology 2016; 21, 172-195.
30. T.C. Zeng, A. Aw, W.W. Feldman. Cultural hitchhiking and competition between patrilineal kin groups explain the post-Neolithic Y-chromosome bottleneck. Nature Communications 2018; 9, 2077.
31. L. Papac, M. Ernée, M. Dobeš, M. Langová, A.B. Rohrlach, F. Aron, et al. Dynamic changes in genomic and social structures in third millennium BCE central Europe. Science Advances 2021; 7(35), eabi6941.
32. M.E. Allentoft, M. Sikora, K.G. Sjögren, S. Rasmussen, M. Rasmussen, J. Stenderup, et al. Population genomics of bronze age Eurasia. Nature 2015; 522(7555), 167-172.
33. W. Haak, I. Lazaridis, N. Patterson, N. Rohland, S. Mallick, B. Llamas, et al. Massive migration from the steppe was a source for Indo-European languages in Europe. Nature 2015; 522(7555), 207-211.
34. I. Mathieson, I. Lazaridis, N. Rohland, S. Mallick, N. Patterson, S.A. Roodenberg, et al. Genome-wide patterns of selection in 230 ancient Eurasians. Nature 2015; 528(7583), 499-503.
35. Q. Fu, C. Posth, M. Hajdinjak, M. Petr, S. Mallick, D. Fernandes, et al. The genetic history of ice age Europe. Nature 2016; 534(7606), 200-205.
36. I. Mathieson, S. Alpaslan-Roodenberg, C. Posth, A. Szécsényi-Nagy, N. Rohland, S. Mallick, et al. The genomic history of southeastern Europe. Nature 2018; 555(7695), 197-203.
37. S.L. Cox, C.B. Ruff, R.M. Maier, I. Mathieson. Genetic contributions to variation in human stature in prehistoric Europe. Proceedings of the National Academy of Sciences 2019; 116(43), 21484-21492 .
38. M. Pericic, L.B. Lauc, I.M. Klaric, S. Rootsi, B. Janićijević, I. Rudan, et al. High-resolution phylogenetic analysis of southeastern Europe traces major episodes of paternal gene flow among Slavic populations. Molecular Biology and Evolution 2005; 22(10), 1964-1975.
39. T. C. Lamnidis, K. Majander, C. Jeong, E. Salmela, A. Wessman, V. Moiseyev, et al. Ancient Fennoscandian genomes reveal origin and spread of Siberian ancestry in Europe. Nature Communications 2018; 9(1), 1-12.
40. F. Cruciani, R. La Fratta, B. Trombetta, P. Santolamazza, D. Sellitto, E.B. Colomb, et al. Tracing past human male movements in northern/eastern Africa and western Eurasia: new clues from Y-chromosomal haplogroups E-M78 and J-M12. Molecular Biology and Evolution 2007; 24(6), 1300-1311.
41. S. Sarno, S. Tofanelli, S. De Fanti, A. Quagliariello, E. Bortolini, G. Ferri, et al. Shared language, diverging genetic histories: high-resolution analysis of Y-chromosome variability in Calabrian and Sicilian Arbereshe. European Journal of Human Genetics 2016; *24*(4), 600-606.
42. R. Menk. A synopsis of the physical anthropology of the Corded Ware complex on the background of the expansion of the Kurgan cultures. Journal of Indo-European Studies 1980; *8*(3-4), 361-392.

43. O. Balanovsky, M. Chukhryaeva, V. Zaporozhchenko, V. Urasin, M. Zhabagin, A. Hovhannisyan, et al. Genetic differentiation between upland and lowland populations shapes the Y-chromosomal landscape of West Asia. Human genetics 2017; 136(4), 437-450.
44. T. Konduktorova. Antropologiia naseleniia Ukrainy epokhi mezolita neolita i bronzovogo veka (Anthropology of the Population of Ukraine During the Mesolithic, Neolithic and Bronze Age). Moskva: Nauka (in Russian); 1973. p. 45.
45. C. Coon. The races of Europe. New York: Macmillan Publishers;1939. p. 592, 597.
46. A.M. Silva, W. Shen, M. Heo, D. Gallagher, Z. Wang, L.B. Sardinha, S.B. Heymsfield. Ethnicity-related skeletal muscle differences across the lifespan. American Journal of Human Biology 2010; 22(1), 76-82.
47. W.D. Leslie. Ethnic differences in bone mass—clinical implications. The Journal of Clinical Endocrinology & Metabolism 2012; 97(12), 4329-4340.
48. B. Jensen, T. Moritoyo, M. Kaufer-Horwitz, S. Peine, K. Norman, M.J. Maisch, et al. Ethnic differences in fat and muscle mass and their implication for interpretation of bioelectrical impedance vector analysis. Applied Physiology, Nutrition, and Metabolism 2019; 44(6), 619-626.
49. L. Yengo, J. Sidorenko, K.E. Kemper, Z. Zheng, A.R. Wood, M.N. Weedon, et al. Meta-analysis of genome-wide association studies for height and body mass index in ∼700 000 individuals of European ancestry. Human Molecular Genetics 2018; 27, 3641-3649.
50. E.K. Speliotes, C.J. Willer, S.I. Berndt, K.L. Monda, G. Thorleifsson, A.U. Jackson, et al. Association analyses of 249,796 individuals reveal 18 new loci associated with body mass index. Nature Genetics 2010; 42(11):937-48. doi: 10.1038/ng.686.
51. D. Marnetto, V. Pankratov, M. Mondal, F. Montinaro, K. Pärna, L. Vallini, Estonian Biobank Research Team, et al. Ancestral genomic contributions to complex traits in contemporary Europeans. Current Biology 2022; 2(6):1412-1419.e3.
52. J.J. Berg, X. Zhang, G. Coop, G. Polygenic adaptation has impacted multiple anthropometric traits. BioRxiv 2017; 167551.
53. Mostafavi, H., Harpak, A., Agarwal, I., Conley, D., Pritchard, J.K., Przeworski, M. Variable prediction accuracy of polygenic scores within an ancestry group. Elife 2020; 9, p.e48376.
54. M. Sohail, R.M. Maier, A. Ganna, A. Bloemendal, A.R. Martin, M.C. Turchin, et al. Polygenic adaptation on height is overestimated due to uncorrected stratification in genome-wide association studies. Elife 2019; 8, e39702.
55. J. Chiaroni, R.J. King, N.M. Myres, B.M. Henn, A. Ducourneau, M.J. Mitchell, et al. The emergence of Y-chromosome haplogroup J1e among Arabic-speaking populations. European Journal of Human Genetics 2010; 18(3), 348-353.

56. S.S. Ebenesersdóttir, M. Sandoval-Velasco, E.D. Gunnarsdóttir, A. Jagadeesan, V. B. Guðmundsdóttir, E.L. Thordardóttir, et al. Ancient genomes from Iceland reveal the making of a human population. Science 2018; 360(6392), 1028-1032.
57. Y. Itan, B.L. Jones, C.J. Ingram, D.M. Swallow, M.G.Thomas A worldwide correlation of lactase persistence phenotype and genotypes. BMC Evolutionary Biology 2010; *10*(1), 1-11.
58. FAOSTAT. Food balances. 2022.https://www.fao.org/faostat/en/#data/FBS
59. H.H.T. Prins, J.M. Reitsma. Mammalian biomass in an African equatorial rain forest. The Journal of Animal Ecology 1989; 851-861 (1989).
60. D. L. Dufour Nutritional ecology in the tropical rain forests of Amazonia. American Journal of Human biology, 1992; 4, 197-207.
61. B. M. Auerbach. Skeletal variation among early Holocene North American humans: Implications for origins and diversity in the Americas. American Journal of Physical Anthropology 2012; 149(4), 525-536.
62. J. Hiernaux, A. Froment, A. The correlations between anthropobiological and climatic variables in sub-Saharan Africa: revised estimates. Human Biology 1976; 757-767.
63. K. Sadler, C. Kerven, M. Calo, M. Manske, A. Catley. The fat and the lean: review of production and use of milk by pastoralists. Pastoralism 2010; 1(2), 291-324.
64. H.Y. Hassan, A. van Erp, M. Jaeger, H. Tahir, M. Oosting, L.A. Joosten, M.G. Netea Genetic diversity of lactase persistence in East African populations. BMC Research Notes 2016; 9(1), 1-7.
65. J.A. Shoup. Ethnic groups of Africa and the Middle East: an encyclopedia. ABC-CLIO; 2011. p. 210.
66. J.J. Sanchez, C. Hallenberg, C. Børsting, A. Hernandez, N. Morling. High frequencies of Y chromosome lineages characterized by E3b1, DYS19-11, DYS392-12 in Somali males. European Journal of Human Genetics 2005; 13(7), 856-866.
67. R. East. Rainfall, soil nutrient status and biomass of large African savanna mammals. African journal of Ecology 1984; 22(4), 245-270
68. J. Hiernaux, P. Rudan, A. Brambati Climate and the weight/height relationship in sub-Saharan Africa. Annals of Human Biology 1975; 2(1), 3–11.
69. Ministry of Education. 50 let školního stravování v České republice (50 years of school catering in the Czech Republic). 2013. https://www.msmt.cz/ministerstvo/novinar/50-let-skolniho-stravovani-v-ceske-republice (press report).

Supplementary tables and figures

Supplementary table 1. Sitting height ratio (sitting height/height) in males, by continent.

AFRICA				
Ethnic group (language group, country)	**Sitting height ratio (%)**	**Height (cm)**	**Sitting height (cm)**	***Source***
Maasai (Nilotes, Kenya)	47.7	173		*Field (1952); Quoted in: Hiernaux (1974)*
Nuer (Nilotes, Sudan)	47.7	184.9	88.2	*Twiesselmann (1951); Quoted in: Strouhal (2007)*
Sudanese (refugees in Kenya)	48.04	178.1	85.5	*Rebacz (2006)*
Tenda Koniagi (Niger-Congo, Guinea)	48.5	169		*Lestrange (1950); Quoted in: Hiernaux (1974)*
Nigerians (southeast)	48.6			*Ukwuna (2010)*
Aka Pygmies	48.61	144.4	70.2	*Froment (1993)*
Bella (Tuareg slave caste, Mali)	48.7	170.8	83.2	*Chabeuf & Olivier (1954)*
Fulani (Niger-Congo, Guinea)	48.8	168		*Lestrange (1950); Quoted in: Hiernaux (1974)*
Dorobo (mixed Cushitic & Nilotic)	48.9			*Holliday & Falsetti (1995)*
Mossi (Niger-Congo, Burkina Faso)	49.12	167.8	82.4	*Froment & Hiernaux (1984)*
Tanzanians	49.14	171.8	84.4	*Rebacz (2006)*
Tuareg (Libya)	49.19	173.8 (n=78)	85.5 (n=12)	*Briggs (1955)*
Tenda Badyaranke (Niger-Congo, Guinea)	49.2	170		*Lestrange 1950; Quoted in: Hiernaux (1974)*
Baya (Niger-Congo, C.A.R.)	49.2	164		*Cresta 1965; Quoted in: Hiernaux (1974)*
Songhay/Sonrai (Mali)	49.23	171	84.2	*Chabeuf & Olivier (1954)*
Ntomba (Niger-Congo, Zaire)	49.36	168.5	83.2	*Austin et al. (1979)*
Kenyans	49.39	170.9	84.4	*Rebacz (2006)*
Ethiopians (North & West-Central)	49.5	169.3	83.8	*Fekadu et al. (2010)*
Tenda Bedik (Niger-Congo, Guinea)	49.6	167		*Gomila 1971; Quoted in: Hiernaux (1974)*
Bella (Tuareg slave caste, Burkina Faso)	49.69	168.4		*Froment & Hiernaux (1984)*
Sab Somali (Cushites)	49.7	173		*Puccioni 1917; Quoted in: Hiernaux (1974)*
Nigeria (Ilorin City, southwestern Nigeria)	49.71	173	86	*Adeyemi et al. (2009)*
Fulani (Niger-Congo, Mali)	49.75	171.9	85.5	*Chabeuf & Olivier (1954)*
Tutsis (Niger-Congo, Rwanda)	49.78	176.5	87.9	*Chabeuf (1959)*
Fulani (Niger-Congo, Central Cameroon)	49.8	173		*Olivier 1946; Quoted in: Hiernaux 1974)*
Malebe (Burkina Faso)	49.84	168.8	84.1	*Froment & Hiernaux (1984)*
Nigeria (North Central)	49.86			*Adeyemi et al. (2009)*
Tenda Bassari (Niger-Congo, Senegal/Guinea)	49.88	166.4	83	*de Lestrange 1950; Quoted in: Gessain (1979)*
Dogon (Niger-Congo, Mali)	49.98	170.4	85.2	*Froment & Hiernaux (1984)*
Nago (Yoruba sub-group, Niger-Congo, Benin)	50	169		*Cresta & Spedini 1968; Quoted in: Hiernaux (1974)*
Bwaba (Niger-Congo, Burkina Faso)	50.01	170.7	85.4	*Froment & Hiernaux (1984)*
Rimaibe (Niger-Congo, Burkina Faso)	50.04	172.5	86.3	*Froment & Hiernaux (1984)*
Oromo (Cushites, Ethiopia)	50.06	170	85.1	*Twiesselmann 1951; Quoted in: Strouhal (2007)*
Mossi from Kokologo (Niger-Congo, Burkina Faso)	50.07	168.9	84.6	*Froment & Hiernaux (1984)*
Fulani (Niger-Congo, C.A.R.)	50.1	172		*Cresta 1965; Quoted in: Hiernaux (1974)*
Koma (Niger-Congo, Northern Cameroon)	50.13	163.3	81.8	*Froment (1989)*
Oromo/Galla (Cushites, Ethiopia)	50.3	171		*Oschinsky 1954; Quoted in: Hiernaux (1974)*
Basua Pygmies	50.35	144	72.5	*Froment (1993)*
Algerians	50.37	175.7	88.5	*Mokdad (2002)*
Fang (Niger-Congo, Gabon)	50.4	167.9		*Lalouel (1957)*
Zaire Pygmies (Twa)	50.4	159.5	80.4	*Austin et al. (1979)*
Banda (Niger-Congo, C.A.R.)	50.5	167		*Cresta 1965; Quoted in: Hiernaux (1974)*
Beti: Ewondo (Niger-Congo, Cameroon)	50.5	168.4		*Lalouel (1957)*
Zulu (Niger-Congo, Southern Africa)	50.53	169.6	85.7	*Chabeuf (1959)*
Sara Kaba ((Nilo-Saharan, C.A.R.)	50.55	171.9	86.9	*Jaeger (1973)*
Fon (Niger-Congo, Benin)	50.6	168		*Cresta & Spedini 1968; Quoted in: Hiernaux (1974)*
Ganda (Niger-Congo, Uganda)	50.66	166	84.1	*Chabeuf (1959)*
Warsingali Somali (Cushites)	50.7	168		*Oschinsky 1954; Quoted in: Hiernaux (1974)*
Gurmanche (Niger-Congo, Burkina Faso)	50.73	172	87.3	*Froment & Hiernaux (1984)*
Vili (Niger-Congo, Congo)	50.76	167.5		*Chabeuf (1959)*
Beti: Eton (Niger-Congo, Cameroon)	50.8	168.9		*Lalouel (1957)*
!Kung (Botswana)	50.8			*Holliday & Falsetti (1995)*
Beti: Bané (Niger-Congo, Cameroon)	50.9	170.3		*Lalouel (1957)*
Kran (Niger-Congo, Liberia)	50.9	165		*Holas 1952; Quoted in: Hiernaux (1974)*
Mosambique (Maputo)	50.9	171.6	87.3	*Padez et al. (2009)*
Hutu (Niger-Congo, Rwanda)	50.92	167.1	85.1	*Chabeuf (1959)*
Egyptians (Qift, Central Egypt)	50.93	166.1	84.6	*Strouhal (2007)*
Loumbou (Niger-Congo, Gabon/Congo)	50.93	165.7		*Chabeuf (1959)*

Ethnic group (language group, country)	Sitting height ratio (%)	Height (cm)	Sitting height (cm)	*Source*
Kougni (Niger-Congo, Congo-Brazzaville)	50.95	167.5		*Chabeuf (1959)*
Bamileke (Niger-Congo, Central Cameroon)	51	168		*Olivier 1946; Quoted in: Hiernaux (1974)*
Bondjo area (Cameroon)	51			*Lalouel (1957)*
Soundi (Niger-Congo, Congo-Brazzaville)	51.05	166.9		*Chabeuf (1959)*
Aka Pygmies (C.A.R.)	51.08	152.7	78	*Froment (1993)*
Yassa (Niger Congo, NW Cameroon)	51.1	166.2	84.9	*Froment (1989)*
Baka Pygmies (Yokaduma/Molundu, Cameroon)	51.13	154.9	79.2	*Froment (1993)*
Nubians (Upper Egypt)	51.16	168.1	86	*Strouhal (2007)*
Binga/Aka Pygmies (C.A.R.)	51.21	152.3	78	*Froment (1993)*
Sara Madjingay (Nilo-Saharan, Tchad)	51.26	173.5	89	*Crognier (1973)*
Kaka area (Gabon)	51.3			*Lalouel (1957)*
Fang-Mvae (Niger-Congo, SW Cameroon)	51.33	164.9	84.6	*Froment (1989)*
Adouma (Niger-Congo, Gabon)	51.46	164.9		*Chabeuf (1959)*
Lari (Niger-Congo, Congo-Brazzaville)	51.49	162.7		*Chabeuf (1959)*
Bushong (Niger-Congo, Congo-Kinshasa)	51.55	170.4	87.9	*Hiernaux (1966)*
Pounou (Niger-Congo, Gabon)	51.55	162.4		*Chabeuf (1959)*
Teké (Niger-Congo, Congo-Brazzaville)	51.55	163.3		*Chabeuf (1959)*
Yombé (Niger-Congo, Congo-Brazzavile)	51.56	162.1		*Chabeuf (1959)*
Malgasy (Madagascar)	51.62	163.5	84.4	*Olivier (1969)*
Baka Pygmies (Lomié Messamena, Cameroon)	51.73	153.1	79.2	*Froment (1993)*
Egyptians (Lower Egypt, Abusir)	51.75	165.8	85.8	*Strouhal (2007)*
Gyeli (Pygmoids, SW Cameroon)	51.79	157.2	81.4	*Froment (1989)*
Bandjabi (Niger-Congo, Cameroon)	51.8			*Lalouel (1957)*
Pounou (Niger-Congo, Gabon)	51.9			*Lalouel (1957)*
Cwa (Pygmies, Congp-Kinshasa)	51.98	160.8	83.6	*Hiernaux (1966)*
Egyptians (Western desert, Oasis Kharga)	52.05	165.8	86.3	*Twiesselmann 1951; Quoted in: Strouhal (2007)*
Mbuti Pygmies	52.36	141.7	74.2	*Froment (1993)*
Bako area (Cameroon)	52.4			*Lalouel (1957)*
Mbuti Pygmies (Ituri Forest, Zaire)	52.43	144.2	75.6	*Froment (1993)*
Mbuti Pygmies (Ituri Forest, Zaire)	52.56	144.4	75.9	*Froment (1993)*
Twa (Konda, Zaire)	52.73	157.4	83	*Froment (1993)*
Binga Pygmies (Mekambo, Gabon)	52.75	157.9	83.3	*Froment (1993)*
Efe Pygmies	52.75	142	74.9	*Froment (1993)*
Kola Pygmies (Cameroon)	53.48	158	84.5	*Froment (1993)*

EUROPE				
Ethnic group / country	**Sitting height ratio (%)**	**Height (cm)**	**Sitting height (cm)**	***Source***
South Italians	50.87	172.8	87.9	*Masali et al. (2002)*
Dutch	51.30 (med.)	184.0 (med.)	94.7 (median)	*Fredriks et al. (2005)*
Croats (Zagreb)	51.5	180.4	92.9	*Zivicnjak et al. (2003)*
Greeks (univ. students)	51.69	177.6	91.8	*Manolis et al. (1995)*
Bosniacs (Tuzla)	51.9	~179		*Hadzihalilović et al. (2001)*
Czechs	51.91	175.3	91	*Seliger& Bartůněk(1977);Quoted in:Jirák et al.(2003)*
French professional soldiers	51.91	176.4	91.6	*Mollard et al. (2008)*
Belgians	51.98	179.5	93.3	*DINBelg (2005)*
Norwegians	51.98	179.3	93.2	*Bolstad et al. (2001)*
Czechs (mostly Moravia)	52	179.6	93.4	*Kovařík (2011)*
Croats (Adriatic coast - south)	52.04	184.3	95.9	*Grasgruber et al. (2019)*
Austrians	52.06 (med.)	179.6 (med.)	93.5 (median)	*Gleiss et al. (2013)*
Danes	52.09	180.7	94.1	*Hertel et al. (1995)*
Italians (Bologna, Northern Italy)	52.09	172.2	89.7	*Facchini &Gualdi-Russo (1982)*
Bulgarians (univ. students)	52.11	178.8	93.2	*Atanassova-Timeva (2005)*
Herzegovinians	52.11	184.1	95.1	*Grasgruber et al. (2017)*
Czechs (Northern Moravia)	52.13	178.9	93.3	*Jirák et al. (2003)*
Germans	52.23	179	93.5	*Kasyanov et al. (2010)*
Italians (Genova, Northern Italy)	52.3	173.6	90.8	*Fullenkamp et al. (2002)*
Spain (Zaragoza)	52.3			*De Arriba Munoz, A., et al. (2013)*
Croats (Adriatic coast - north)	52.32	180.5	94.4	*Grasgruber et al. (2019)*
Frenchmen (univ. students, Nantes)	52.41	173.9	91.1	*Robert &Resche (1983)*
Romanians (northeast, Iaşi)	52.42	178.4	93.5	*Stirbu (2002)*
Romanians (northeast, Iaşi county)	52.45	173	90.7	*Stirbu (2002)*
Bosnians	52.48	180.7	94.8	*Grasgruber et al. (2017)*
Swedes (only native born Swedes)	52.49	181	95	*Hanson et al. (2009)*
Poles (old subjects)	52.5	172.2	90.4	*Webb et al. (2008)*
Ukrainians	52.52	172.3	90.5	*Kasyanov et al. (2010)*
Italians	52.58	170.6	89.7	*Al-Haboubi (1992)*
Czechs (Southern & Central Moravia)	52.63	181.0	95.2	*Grasgruber (2014)*
Great Britain	52.62	177.3	93.3	*Al-Haboubi (1992)*
Hungarians	52.65	177.5	93.5	*Bodzsár & Zsákai (2008)*
Irish	52.65	173.1	91.1	*Gallwey & Fitzgibbon (1991)*
Icelanders	52.74	180.6	95.3	*Dagbjartsson et al. (2000)*
English (southeastern England)	52.83	178.3	94.2	*Dangoura et al. (2002)*

ASIA & OCEANIA				
Ethnic group / country	**Sitting height ratio (%)**	**Height (cm)**	**Sitting height (cm)**	***Source***
India (East-Central, Chhattisgarh state)	47.3	163.8	77.5	*Victor et al. (2002)*
Aboriginal Australians (North & Central)	47.7	168	80	*Norgan (1995)*
Aboriginal Australians (review of 17 studies)	48.8			*Norgan 1994; Quoted in: Larsen et al. (2004)*
Indians (South India)	49.22	160.7	79.1	*Victor et al. (2002)*
Indians (Central Indian tribes)	49.62	161.9	80.3	*Adak et al. (2006)*
Indians (Central Indian Rajputs-upper caste)	49.7	166.1	82.5	*Adak et al. (2006)*
Indians (Central Indian lower castes)	49.92	163	81.4	*Adak et al. (2006)*
Indians (Central Indian middle castes)	49.95	163.8	81.8	*Adak et al. (2006)*
Indians (Bathudi tribe, Orissa, East India)	50	159.4	79.7	*Bose & Chakraborty (2005)*
Melanesians: Manus island (town)	50.18	165.2	82.9	*Schall (unpubl.); Quoted in: Eveleth & Tanner (1990)*
Saudi Arabs	50.33	167.5	84.3	*Al-Haboubi (1992)*
Indians (Central Indian muslims)	50.33	165	83	*Adak et al. (2006)*
Filipino	50.8	167	84.8	*Del Prado-Lu (2007)*
Indians (Central Indian Brahmins-upper caste)	50.83	166.5	84.6	*Adak et al. (2006)*
Onge (Andaman Islands)	50.9			*Holliday &Falsetti (1995)*
Melanesians: Manus island (Pere)	50.94	164.3	83.7	*Schall (unpubl.); Quoted in: Eveleth & Tanner (1990)*
Saudi Arabia (30% Saudi Arabs)	51.03	170.5	87	*Al-Haboubi (1992)*
Malaysia (63% Malays, 28% Chinese, 7% Indians)	51.07	170.1 (m)	86.9 (m)	*Daruis (2010)*
Malays	51.29	168.6	86.5	*Deros et al. (2009)*
Malaysia (industrial workers)	51.51	165.6	85.3	*Taha et al. 2001; Quoted in: Daruis (2010)*
Melanesians: Ulawa island	51.57	162.9	84	*The Solomon Islands Project (1987)*
Papuans: New Guinea (Ketengban tribe)	51.63	150.1	77.5	*Tommaseo-Ponzetta et al. (2013)*
Melanesians: Bougainville island (Nasioi)	51.65	163.2	84.3	*The Solomon Islands Project (1987)*
Melanesians: Fijians	51.68	176.1	91	*Clegg 1989; Quoted in: Eveleth &Tanner (1990)*
Papuans: New Guinea (Wopkaimin)	51.69	159.6	82.5	*Lourie et al. (1986);Quoted in:Eveleth&Tanner(1990)*
Singaporeans (50% Chinese)	51.72	174 (m)	90 (m)	*Chuan et al. (2010)*
Indonesians (36% Chinese)	51.74	172 (m)	89 (m)	*Chuan et al. (2010)*
Kurds	51.78	170.7	88.4	*Pittard 1939; Quoted in: Field (1939)*
Indians (Singapore)	51.9	168	87.2	*Yap et al. (2001)*
Indians (urban Muslims, Uttarpradesh, N.India)	51.91	167.1	86.8	*Ganguly (1974)*
Indians (urban Brahmins, Uttarpradesh, N.India)	51.99	166.6	86.6	*Ganguly (1974)*
Papuans: New Guinea (Una tribe)	52.03	150.1	78.1	*Tommaseo-Ponzetta et al. (2013)*
Turks (univ. students, Zonguldak, NW coast)	52.14	174.9	91.2	*Tunay &Melemez (2008)*
Semang (Negritos, Malay Peninsula)	52.2			*Holliday &Falsetti (1995)*
Tajiks (mountain areas)	52.18	165.8	86.4	*Ginzburg 1937; Quoted in: Field (1939)*
Australians (military personnel)	52.19	178.5	93.2	*Coleman (2011)*
India (Central)	52.38	160	83.8	*Victor et al. (2002)*
Syrians	52.42	167.2	88.1	*Seltzer 1936; Quoted in: Field (1939)*
India (West)	52.43	164.4	86.2	*Victor et al. (2002)*
Thais (Southern Thailand, univ. students)	52.44	171.9	90.2	*Klamklay et al. (2008)*
Malaysia (National University Defense cadets)	52.45	169.7	89	*Daruis et al. 2007; Quoted in: Daruis (2010)*
Western Eskimo (Polar)	52.57	167.9	88.2	*Justice et al. (2010)*
Melanesians: Malaita island (Baegu)	52.59	162	85.2	*The Solomon Islands Project (1987)*
Turks (Ankara)	52.59	172.8	90.9	*Ozer (2007)*
Batak (Austronesians, Northern Sumatra)	52.6			*Holliday &Falsetti (1995)*
Thais (Bangkok, univ. students)	52.72	168.6	88.9	*Yodpijit et al. (2004)*
Thais (Bangkok)	52.83	171.1	90.4	*Wacharasindhu et al. (2002)*
Iranians (univ. students)	52.88	172.5	91.2	*Mououdi (1997)*
Malays (Singapore)	52.95	166.2	88	*Yap et al. (2001)*
Vietnamese (army personnel)	52.96	160.5	85	*White (1964)*
Melanesians: Bougainville island (Aita)	53	159.6	84.6	*The Solomon Islands Project (1987)*
Eastern Eskimo (Polar)	53.04	156.7	83.1	*Justice et al. (2010)*
Polynesians: Tahitians (admixed)	53.2	170.5	90.7	*Biot &Wangermez (1968)*
Turks (Istanbul)	53.25	174.4	92.9	*Bundak et al. (2014)*
Ainu (Japan)	53.3			*Holliday &Falsetti (1995)*
Armenians	53.37	166.2	88.6	*Seltzer 1936; Quoted in: Field (1939)*
Polynesians: Ontong Java atol	53.37	166.2	88.7	*The Solomon Islands Project (1987)*
Taiwanese	53.38	169.9	90.7	*Lin et al. (2004)*
Japanese	53.42			*Ali et al. (2000)*
Melanesians: Malaita island (Kwaio)	53.54	161	86.2	*The Solomon Islands Project (1987)*

Ethnic group / country	Sitting height ratio (%)	Height (cm)	Sitting height (cm)	*Source*
Polynesians: Tahitians (unadmixed)	53.56	171.2	91.7	*Biot & Wangermez (1968)*
Chinese (Shandong, Eastern China)	53.6	174.2	93.6	*Zhang &Wang (2009)*
Tibetans (Orissa state in India)	53.66	168.1 (n=42)	90.2 (n=40)	*Tripathy &Gupta (2007)*
Japanese	53.79	169	90.9	*Lin et al. (2004)*
Chinese (Singapore)	53.87	166.7	89.8	*Yap et al. (2001)*
South Koreans	53.95	170.7	92.1	*Lin et al. (2004)*
Tibetans (Karnataka state in India)	54.08	169.2	91.5	*Tripathy &Gupta (2007)*
Chinese	54.11	167.8	90.8	*Lin et al. (2004)*

AMERICA				
Ethnic group / country	**Sitting height ratio (%)**	**Height (cm)**	**Sitting height (cm)**	***Source***
Nat. Americans: Choctaw (US Southeast)	49.43	170.9	84.5	*Justice et al. (2010)*
Nat. Americans: Yaqui (US Southwest)	49.85	166.7	83.1	*Justice et al. (2010)*
Nat. Americans: San Luis Rey (USA, California)	50.52	169.9	85.8	*Justice et al. (2010)*
Nat. Americans: Trio (Guyana)	50.6	157.7	79.8	*Stinson (1990)*
Nat. Americans: Yokuts (USA, California)	50.63	170.3	86.2	*Justice et al. (2010)*
Nat. Americans: Ojibwa (US Northeast)	50.83	171.4	87.1	*Justice et al. (2010)*
US blacks	50.96	177	90.2	*NHANES III (1988-1994)*
Nat. Americans: Cherokee (US Southeast)	51.17	169.8	86.9	*Justice et al. (2010)*
Nat. Americans: Caingang (Southern Brazil)	51.18	161	82.4	*Stinson (1990)*
Nat. Americans: Tarahumara (Mexico)	51.23	163	83.5	*Justice et al. (2010)*
Nat. Americans: Micmac (US Northeast)	51.31	172.7	88.6	*Justice et al. (2010)*
Nat. Americans: Cayapo (Central Brasil)	51.33	165.4	84.9	*Stinson (1990)*
Nat. Americans: Cree (Canadian subarctic zone)	51.33	168.5	86.5	*Justice et al. (2010)*
Nat. Americans: Sioux (USA, Plains)	51.34	172.3	88.5	*Justice et al. (2010)*
Nat. Americans: Hoopa (USA, California)	51.37	166.5	85.5	*Justice et al. (2010)*
Nat. Americans: Kwakier (SW Columbia)	51.37	152.8	78.5	*Stinson (1990)*
Nat. Americans: Chippewa (US Northeast)	51.5	171.5	88.3	*Justice et al. (2010)*
Nat. Americans: Maya (Central Mexico)	51.66	156.4	80.8	*Justice et al. (2010)*
Nat. Americans: Papago (US Southwest)	51.71	168.8	87.3	*Justice et al. (2010)*
Canadians	51.84	176.5	91.5	*Al-Haboubi (1992)*
Nat. Americans Ribeirinhos (the Amazon delta)	51.87	160.4	83.2	*Vercellotti & Piperata (2012)*
Nat. Americans: Crow (USA, Plains)	51.88	173.1	89.8	*Justice et al. (2010)*
Nat. Americans: Ona, Tierra del Fuego	51.9			*Stinson (1990)*
Nat. Americans: Tuscarora (US Northeast)	51.98	171.2	89	*Justice et al. (2010)*
Nat. Americans: Chickasaw (US Southeast)	52.03	168.9	87.9	*Justice et al. (2010)*
Nat. Americans: Kiowa (USA, Plains)	52.04	157.8	82.1	*Justice et al. (2010)*
Nat. Americans: Yuki (USA, California)	52.13	161.3	84.1	*Justice et al. (2010)*
Nat. Americans: Popoluca (Central Mexico)	52.15	160.5	83.7	*Justice et al. (2010)*
Nat. Americans: Paiute (USA, Great Basin)	52.2	167.7	87.5	*Justice et al. (2010)*
Nat. Americans: Ute (USA, Great Basin)	52.21	165.3	86.3	*Justice et al. (2010)*
Nat. Americans: Shushwap (USA, Plains)	52.22	166	86.7	*Justice et al. (2010)*
Nat. Americans: Haida (Western Canada)	52.24	168.1	87.8	*Justice et al. (2010)*
Nat. Americans: Apache (US Southwest)	52.26	169.3	88.5	*Justice et al. (2010)*
Nat. Americans: Thompson (USA, Plains)	52.26	161.9	84.6	*Justice et al. (2010)*
Nat. Americans: Mixtec (South Mexico)	52.27	156.1	81.6	*Justice et al. (2010)*
Nat. Americans: Punenos (NW Argentina)	52.34	162.6 (n=182)	85.1 (n=181)	*Stinson (1990)*
Nat. Americans: Oneida (US Northeast)	52.35	171.9	90	*Justice et al. (2010)*
Nat. Americans: Klamath (USA, Plains)	52.38	167.8	87.9	*Justice et al. (2010)*
Nat. Americans: Lillooet (USA, Plains)	52.38	161	84.3	*Justice et al. (2010)*
Nat. Americans: Chilcotin (Western Canada)	52.46	164.6	86.4	*Justice et al. (2010)*
US whites	52.48	177.4	93.1	*NHANES III (1988-1994)*
Nat. Americans: Chol (Mexico)	52.49	158.5	83.2	*Justice et al. (2010).*
Nat. Americans: Zapotecs (Mexico)	52.49	160.8	84.4	*Malina et al. (2004)*
Nat. Americans: Wapishana (Guyana)	52.6	161.6	85	*Dangour (2003)*
Nat. Americans: Patamona (Guyana)	52.68	158.5	83.5	*Dangour (2003)*
Mexican Americans (USA)	52.71	169.8	89.5	*NHANES III (1988-1994)*
Nat. Americans: Quechua (Ecuador)	52.72	156.5	82.5	*Stinson (1990)*
Nat. Americans: Cuzco Quechua (Peru)	52.77	158.8 (n=243)	83.8 (n=244)	*Stinson (1990)*
Nat. Americans: Tsimshian (Western Canada)	52.77	167.2	88.2	*Justice et al. (2010)*
Nat. Americans: Yahgan, Tierra del Fuego	52.8			*Stinson (1990)*
Nat. Americans: Chubut province (S. Argentina)	52.89	163.9	86.7	*Torres et al. (2002)*
Nat. Americans: Cuitlateco (Central Mexico)	52.89	161.1	85.2	*Justice et al. (2010).*
Nat. Americans: Netsilik (Northern Canada)	52.9			*Holliday &Falsetti (1995)*
Nat. Americans: Zapotec (Mexico)	52.9	155.4	82.2	*Justice et al. (2010)*
Nat. Americans: Stalo (Western Canada)	52.92	163.2	86.4	*Justice et al. (2010)*
Eastern Eskimo	53.04	156.7	83.1	*Justice et al. (2010)*
Nat. Americans: Totonac (Central Mexico)	53.1	158	83.9	*Justice et al. (2010)*
Nat. Americans: Yanomama (Southern Venezuela)	53.1	153.1 (n=353)	81.3 (n=316)	*Stinson (1990)*
Nat. Americans: Zuni (US Southwest)	53.11	161.8	85.9	*Justice et al. (2010)*
Aleuts: St. George Island	53.28	170.3	90.7	*Justice et al. (2010)*
Nat. Americans: Huastec (Central Mexico)	53.37	157.2	83.9	*Justice et al. (2010)*
Nat. Americans: Tzotzil (Mexico)	53.47	158.4	84.7	*Justice et al. (2010)*
Nat. Americans: Makah (US Northwest)	53.48	164.4	87.9	*Justice et al. (2010)*
Eskimo Yupik: Savoonga, St. Lawrence Island	53.68	163.9	88	*Justice et al. (2010)*
Eskimo Yupik: Gambell, St. Lawrence Island	53.7	165.8	89	*Justice et al. (2010)*
Aleuts: St. Paul Island	53.72	165.9	89.1	*Justice et al. (2010)*

Supplementary table 2. Height, weight, and BMI of males from African tribal and regional groups.

Ethnic group (language, country)	Age	Date	n	Height (cm)	Weight (kg)	BMI kg/m²	Source
Nuer (Nilotes, Sudan)	adults		38-51	184.9±7.1			*Twiesselmann 1951; Quoted in: Strouhal (2007)*
Dinka (Nilotes, Sudan)			54	183.9	59.1	17.48	*Crognier (1973)*
Dinka Ageir (Nilotes, Sudan)	adults	1953-54	52	182.6±4.9	59.0±6.0	17.7	*Roberts & Bainbridge (1963)*
Dinka Ruweng (Nilotes, Sudan)	adults	1953-54	227	181.3±6.4	58.0±5.9	17.6	*Roberts & Bainbridge (1963)*
Somali (Cushites, Jijiga in Ethiopia)	28.2±8.7	2000	214	179.3±6.3	54.7±8.1	16.9	*de Lucia et al. (2002)*
Shilluk (Nilotes, Sudan)			106	178.9	59.5	18.59	*Crognier (1973)*
Shilluk (Nilotes, Sudan)	adults	1953-54	48	178.7±7.2	58.0±7.4	18.2	*Roberts & Bainbridge (1963)*
Sudanese (refugees, Kenya)	young	1999-2000	154	178.1±7.5	59.0±6.5	18.6	*Rebacz (2006)*
Tutsis (Niger-Congo, Rwanda)			172	176.5	57.4	18.43	*Crognier (1973)*
Fulani			32	176.3			*Sellen (1995)*
Sara Madjingay (Nilo-Saharan,Chad)	20-30	1965	308	176.2±5.4			*Crognier (1973)*
Sudanese Nilotes (refugees, Ethiopia)		90's	1618	175.9±9	59.7±8	19.4	*Chali (1995)*
Dinka		90's		176.4±9			*Chali (1995)*
Nuer		90's		175.7±9			*Chali (1995)*
Shilluk		90's		172.6±6.1			*Chali (1995)*
Anuak		90's		171.7±8			*Chali (1995)*
Tutsis (Niger-Congo, Burundi)			119	175.2	56.3	18.34	*Crognier (1973)*
Fulani (Niger-Congo, Senegal)	adults	1995	77	(175.0)	65.3±9.7	21.3	*Simondon & Bénéfice (2001)*
Turkana, nomads (Nilotes, Kenya)	44.5±15.2	1992	130	174.9±6.8	53.1±.6	17.3	*Campbell et al. (2006)*
Sara Madjingay (Nilo-Saharan,Chad)	20-39	1968-70	235	173.5±7.0	66.8±7.5	22.17	*Crognier (1973)*
Gambia (Bakau)	42.0±5.3	2003	50	173±5			*Siervo et al. (2006)*
Nigeria (Ilorin City, SW Nigeria)	15-56		200	173	63.9	21.33	*Adeyemi et al. (2009)*
Turkana, settled (Nilotes, Kenya)	47.7±15.3	1993	94	172.5±7.3	54.2±6.8	18.2	*Campbell et al. (2006)*
Gambia (Bakau)	19.3±2.6	2003	50	172±8			*Siervo et al. (2006)*
Rimaibe (Niger-Congo, Burk.Faso)			38	172.5±6.9	62.2±7.2	20.90	*Froment & Hiernaux (1984)*
Gurmanche (Niger-Congo,Burk.Faso)			30	172.0±4.7	59.2±6.1	20.01	*Froment & Hiernaux (1984)*
Fulani (Niger-Congo, Mali)	adults	1952	20	171.9			*Chabeuf &Olivier (1954)*
Sara Kaba (Nilo-Saharan, C.A.R.)	20-40	1971-72	34	171.9±5.5	64.9±7.0	21.96	*Jaeger (1973)*
Ariaal, settled (Nilotes, Kenya)	46.9±16.7	2004	102	171.8±6.5	53.3±7.6	18.0	*Campbell et al. (2006)*
Mozambique (Maputo)	17	2000	45	171.6±5.2	61.4±7.2	20.85	*Padez et al. (2009)*
Mahasi (Nubians, Northern Sudan)	adults		26	171.4±4.4			*Field 1952; Quoted in: Strouhal (2007)*
Nigeria (Benin City)	19, urban		23	171.3±7.3	60.2±8.5	25.6	*Nwokoro et al. (2006)*
Mali (north, rural)			121	171.3±6.6	58.8±6.5	20.0	*Dettwyler (1992)*
Torokoro			23	173.3±5.7	60.5±3.8	20.14	*Dettwyler (1992)*
Merediela			26	170.1±6.6	58.9±5.9	20.36	*Dettwyler (1992)*
Maasai (Nilotes, Kenya)			88	171.2			*Sellen (1995)*
Songhay/Sonrai (Mali)	adults	1952	63	171.0			*Chabeuf & Olivier (1954)*
Somalia (Mogadishu)	18.5		36	170.9±6.8	50.3±8.1	17.22	*Gallo & Mestriner (1980)*
Bella (Tuareg slave caste, Mali)	adults	1952	28	170.8			*Chabeuf &Olivier (1954)*
Bwaba (Niger-Congo, Burkina Faso)			33	170.7±7.3	59.3±6.4	20.35	*Froment & Hiernaux (1984)*
Bushong (Niger-Congo, Zaire)	adults	1953	41	170.4±6.1	59.5±6.3	20.49	*Hiernaux (1966)*
Dogon (Niger-Congo, Mali)			145	170.4±6.6	58.9±6.9	20.29	*Froment & Hiernaux (1984)*
Mbukuso (Niger-Congo, Angola)			100	170.2	61.0	21.06	*Crognier (1973)*
Amhara (Semites, Ethiopia)	26.8±7.8	2000	206	170±5.8	55.1±6.9	19.1	*de Lucia et al. (2002)*
Nigeria (Igbo-Ora & Ibadan)	39.9±12.8		30	170.0±7.8	60.8±12.6	20.5	*Luke et al. (2002)*
Oromo (Cushites, Ethiopia)	adults		34-45	170.0±6.7			*Twiesselmann 1951; Quoted in: Strouhal (2007)*
Kazama (Niger-Congo, Angola)			66	169.7	55.9	19.41	*Crognier (1973)*
Nigeria (Igbo-Ora & Idere)	21-30		125	169.5±8.3	60.0±9.1	20.8	*Ayoola et al. (2009)*
Nigeria (Benue state)	~25		298	169.3	67.4	23.52	*Sola et al. (2011)*
Tigre (Semites, Ethiopia)	28.2±8.7	2000	214	169±6	53.7±6.4	18.8	*de Lucia et al. (2002)*
Hausa (Nigeria, Kano State)	23.7±4.8		599	169±8	62.1±10.7	21.77	*Taura (2011)*
Mossi (Niger-Congo, Burkina Faso)			27	168.9±6.5	56.7±7.4	19.88	*Froment & Hiernaux (1984)*
Malebe (Burkina Faso)			59	168.8±7.6	59.6±7.7	20.92	*Froment & Hiernaux (1984)*
Thonga (Niger-Congo, Mosambique)			327	168.8	63.2	22.18	*Crognier (1973)*
Ntomba (Niger-Congo, NW Zaire)	~18-40		51	168.5±6.2	58.2±8.0	20.5	*Austin et al. (1979)*
Ronga (Niger-Congo, Mosambique)			341	168.5	63.0	22.19	*Crognier (1973)*
Bella (Tuareg slave caste,Burk.Faso)			23	168.4±7.5	56.5±6.4	19.92	*Froment & Hiernaux (1984)*
Malawi (Blantyre City)	25-33		189	168.3±6.0	60.2±5.9	21.24	*Msamati & Igbigbi (2000)*
Oromo (Cushites, Ethiopia)	29.4±11.6	2000	260	168.2±6.8	55.1±7.2	19.4	*de Lucia et al. (2002)*
Nyungwe (Niger-Congo, Mosamb.)			120	168.0	57.9	20.51	*Crognier (1973)*
Mossi (Niger-Congo, Burkina Faso)			49	167.8±6.0	58.2±7.2	20.67	*Froment & Hiernaux (1984)*
Songye (Niger-Congo, Zaire)			41	167.8	59.8	21.24	*Crognier (1973)*
Hutu (Niger-Congo, Rwanda)			249	167.4	59.5	21.23	*Crognier (1973)*
Rubatab (Sud. Arabs, N. Sudan)	adults		36-38	167.5±5.8			*Field 1952; Quoted in: Strouhal (2007)*
Fulani (Niger-Congo, N. Nigeria)	55.5±13.5		22	167.0±5.6	60.3±8.1	21.6	*Glew et al. (2010).*
Chopi (Niger-Congo, Mosambique)			107	166.9	61.6	22.11	*Crognier (1973)*
Luba (Niger-Congo, Zaire)			214	166.9	60.0	21.54	*Crognier (1973)*
Makonde (Niger-Congo, Mosamb.)			200	166.4	55.1	19.90	*Crognier (1973)*
Yassa (Niger-Congo, SW Cameroon)	adults	1984-87	26	166.2±4.6	61.8±7.2	22.37	*Froment (1989)*
Hutu (Niger-Congo, Burundi)			216	166.1	56.7	20.55	*Crognier (1973)*
Zulu (Niger-Congo, S. Africa)			106	166.1	66.8	24.21	*Crognier (1973)*
Kakonda (Niger-Congo, Angola)			5443	166.0	53.5	19.42	*Crognier (1973)*

Ethnic group (language, country)	Age	Date	n	Height (cm)	Weight (kg)	BMI kg/m²	Source
Nyaturu (Niger-Congo, N-Centr.Tanz.)			50	165.4	52.2	19.08	*Crognier (1973)*
Mvae (Niger-Congo, SW Cameroon)	adults	1984-87	29	164.9±7.1	61.3±8.1	22.54	*Froment (1989)*
Kikuyu (Niger-Congo, Kenya)			530	164.6	51.9	19.16	*Crognier (1973)*
Sandawe (Tanzania)			100	164.6	49.4	18.23	*Crognier (1973)*
Mbun (Niger-Congo, Zaire)			509	164.5	49.9	18.44	*Crognier (1973)*
Luba (Niger-Congo, Zaire)			112	164.4	56.6	20.94	*Crognier (1973)*
Chuabo (Niger-Congo, Mosambique)			50	164.3	59.5	22.04	*Crognier (1973)*
Hunde (Niger-Congo, Zaire)			100	164.0	56.5	21.01	*Crognier (1973)*
Shi (Niger-Congo, Zaire)			108	163.9	53.5	19.92	*Crognier (1973)*
Ganda (Niger-Congo, Uganda)			61	163.6±6.6	59.0±6.4	22.04	*Barnicot et al. (1972)*
Kikuyu (Niger-Congo, Kenya)			412	163.6			*Orr & Gilks, (1931)*
Koma (Niger-Congo, N. Cameroon)	adults	1984-87	36	163.3±5.3	53.2±6.8	19.95	*Froment (1989)*
Lari (Niger-Congo, Congo-Brazzaville)			46-50	162.7			*Chabeuf 1959; Quoted in: Schwidetzky(1975)*
Yans (Niger-Congo, Zaire)			106	162.6	49.7	18.80	*Crognier (1973)*
Hadza (Tanzania)	39.0±15.7	2001-04	238	162.5±6.7	53.2±6.0	20.1	*Sherry & Marlowe (2007)*
Khoisan (Nama)			73	162.4			*Shapira 1930; Quoted in: Holden & Mace (1999)*
Havu (Niger-Congo, Zaire)			100	162.3	53.4	20.27	*Crognier (1973)*
Lega (Niger-Congo, Zaire)			100	162.2	57.2	21.74	*Crognier (1973)*
Yombe (Niger-Congo, Congo basin)			48-50	162.1			*Schwidetzky (1975)*
!Kung San (Namibia)			114	161.4±5.1	50.4±6.2	19.35	*Kirchengast (2000)*
Luango (Niger-Congo, Angola)			100	161.0	51.5	19.87	*Crognier (1973)*
Twa Pygmies (Lake Tumba, Zaire)			53	160.9			*Froment (1993)*
Cwa (Pygmies, Zaire)	adults	1953	295	160.8±6.0	46.1±5.7	17.83	*Hiernaux (1966)*
!Kung San (Namibia)	25-40		103	160.4±5.8	49.4±6.9	19.2	*Kirchengast (2000)*
Hadza (Tanzania)			36	160.5±6.9	53.5±6.4	20.77	*Barnicot et al. (1972)*
Mbala (Bantu, Zaire)			205	160.5	47.7	18.52	*Crognier (1973)*
Korana (Khoisan/Khoi, S. Africa)			47	160.1	49.0	19.12	*Crognier (1973)*
Hungu (Bantu, Zaire)			100	160.0	50.3	19.65	*Crognier (1973)*
Twa Pygmies (NW Zaire)	~18-40		46	159.5±5.8	47.5±5.6	18.67	*Austin et al. (1979)*
Lese (Bantu, Zaire)			23	159.3±7.4	51.4±11.4	20.25	*Dietz et al. (1989)*
Fuliru (Bantu, Zaire)			100	159.1	47.8	18.88	*Crognier (1973)*
Tembo (Bantu, Zaire)			100	159.0	49.9	19.74	*Crognier (1973)*
Kola Pygmies (Cameroon)			28	158.0±5.6	49.9±5.3	19.99	*Froment (1993)*
Binga Pygmies (Mekambo, Gabon)			53	157.9	50.1	20.09	*Froment (1993)*
Twa Pygmies			64	157.9			*Froment (1993)*
Twa Pygmies (Konda, Zaire)			163	157.4			*Froment (1993)*
Gyeli (Pygmoids, SW Cameroon)	adults	1984-87	17	157.2±4.8	49.5±4.7	20.03	*Froment (1989)*
Baka Pygmies (Cameroon)			80	154.2±6.1	48.2±5.1	20.27	*Froment (1993)*
Biaka Pygmies				152.7			*Anagnostou et al. (2010)*
Binga Pygmies			200	155.0			*Froment (1993)*
Baka Pygmies (Cameroon)			55	154.9			*Froment (1993)*
Baka Pygmies (Cameroon, Ndongo)	~20-30	1996	75	154.4±6.0	49.6±6.2	20.8	*Yamauchi et al. (2000)*
Binga Pygmies (Cameroon)			49	153.4	49.1	20.87	*Froment (1993)*
Baka Pygmies (Cameroon)			60	153.1			*Froment (1993)*
Twa (Rwanda)			101	153.0			*Froment (1993)*
Aka (Central Africa)			43	152.7	48.3	20.71	*Froment (1993)*
Binga/Aka Pygmies (Central Africa)			87	152.3	46.4	20.00	*Froment (1993)*
Mbenzele Pygmies (C.A.R.)				151.0			*Anagnostou et al. (2010)*
Efe Pygmies (Zaire)	39.7±10.5	1987	23	146.4±5.6	43.2±4.7	20.16	*Shea & Bailey (1996)*
Efe Pygmies (Zaire)			17	144.9±.6	43.3±4.4	20.62	*Dietz et al. (1989)*
Basua Pygmies (Ituri Forest, Zaire)			50	144.6			*Froment (1993)*
Aka Pygmies			115	144.4			*Froment (1993)*
Mbuti Pygmies (Ituri Forest, Zaire)			71	144.4			*Froment (1993)*
Mbuti Pygmies (Ituri Forest, Zaire)			69	144.2	41.5	19.96	*Froment (1993)*
Basua Pygmies			170	144.0			*Froment (1993)*
Bakongo Pygmies (Ituri Forest, Zaire)			102	143.9			*Froment (1993)*
Efe Pygmies (Ituri Forest, Zaire)			98	142.9			*Froment (1993)*
Efe Pygmies			136	142.0			*Froment (1993)*
Mbuti Pygmies			115	141.7			*Froment (1993)*

Supplementary table 3. Correlations between the frequencies of major Y haplogroups and climatic factors in 60 countries of Europe, the Near East, and North Africa.

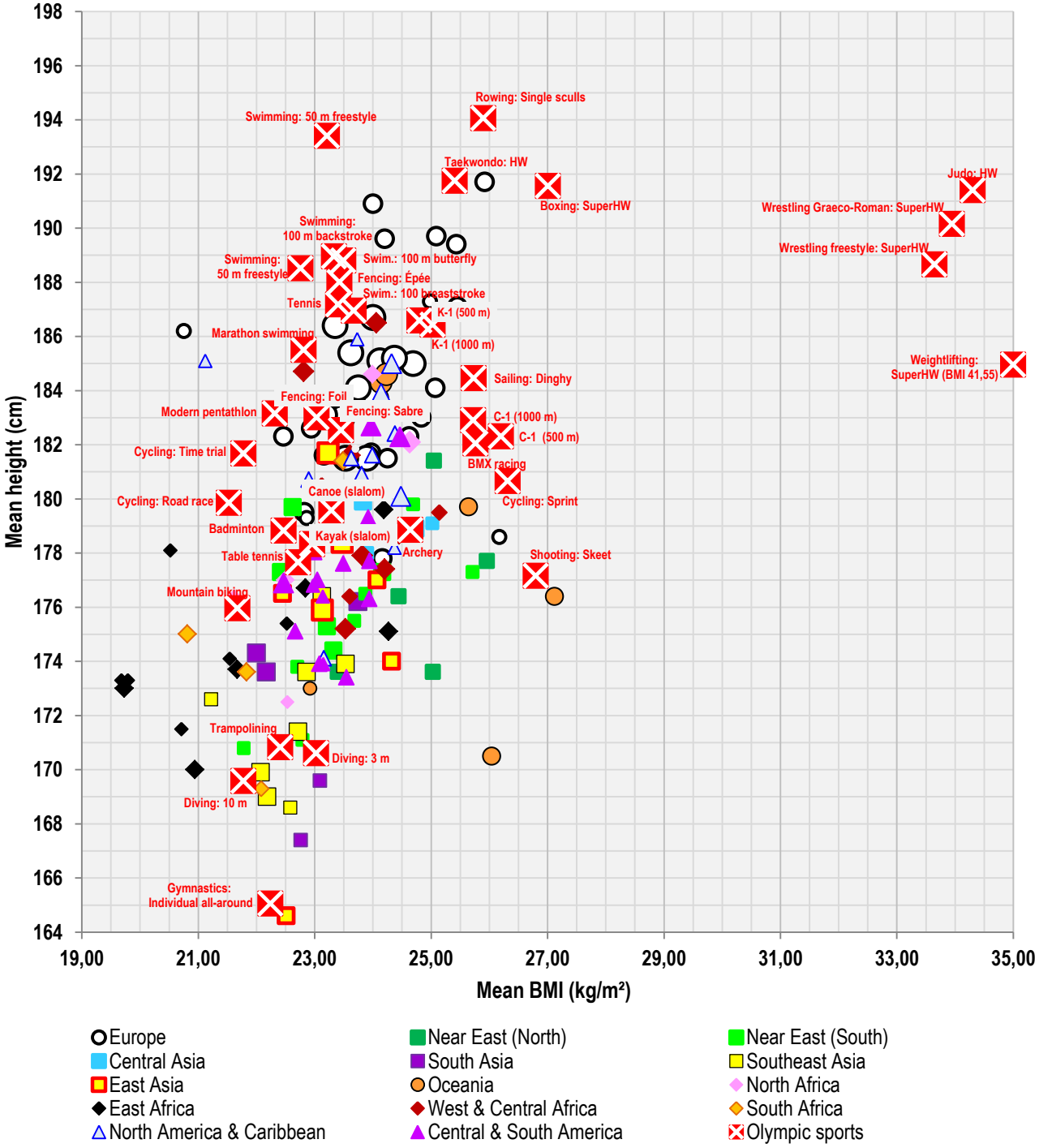
Y haplogroup	Mean temperature (°C)			Mean rainfall (mm)			Humidity (%)		
	Annual	January	July	Annual	January	July	Annual	January	July
E	**0.48 (p < 0.001)**	**0.53 (p < 0.001)**	**0.36 (p = 0.005)**	-0.24 (p = 0.070)	0.07 (p = 0.60)	**-0.55 (p < 0.001)**	-0.25 (p = 0.058)	**-0.33 (p = 0.009)**	-0.16 (p = 0.22)
G	0.08 (p = 0.54)	-0.00 (p = 0.98)	0.17 (p = 0.19)	-0.11 (p = 0.40)	-0.16 (p = 0.23)	-0.22 (p = 0.097)	-0.24 (p = 0.070)	-0.21 (p = 0.11)	-0.23 (p = 0.083)
I	**-0.65 (p < 0.001)**	**-0.63 (p < 0.001)**	**-0.58 (p < 0.001)**	**0.66 (p < 0.001)**	**0.33 (p = 0.009)**	**0.72 (p < 0.001)**	**0.56 (p < 0.001)**	**0.60 (p < 0.001)**	**0.47 (p < 0.001)**
J	**0.83 (p < 0.001)**	**0.74 (p < 0.001)**	**0.80 (p < 0.001)**	**-0.69 (p < 0.001)**	**-0.39 (p = 0.002)**	**-0.76 (p < 0.001)**	**-0.82 (p < 0.001)**	**-0.86 (p < 0.001)**	**-0.70 (p < 0.001)**
J1	**0.78 (p < 0.001)**	**0.73 (p < 0.001)**	**0.69 (p < 0.001)**	**-0.66 (p < 0.001)**	**-0.43 (p < 0.001)**	**-0.59 (p < 0.001)**	**-0.75 (p < 0.001)**	**-0.83 (p < 0.001)**	**-0.60 (p < 0.001)**
J2	**0.48 (p < 0.001)**	**0.36 (p = 0.005)**	**0.56 (p < 0.001)**	**-0.37 (p = 0.003)**	-0.10 (p = 0.45)	**-0.64 (p < 0.001)**	**-0.51 (p < 0.001)**	**-0.44 (p < 0.001)**	**-0.49 (p < 0.001)**
N	**-0.39 (p = 0.002)**	**-0.41 (p = 0.001)**	**-0.29 (p = 0.027)**	0.12 (p = 0.35)	0.01 (p = 0.95)	**0.32 (p = 0.013)**	**0.30 (p = 0.018)**	**0.30 (p = 0.019)**	**0.27 (p = 0.036)**
R1a	**-0.52 (p < 0.001)**	**-0.63 (p < 0.001)**	**-0.36 (p = 0.005)**	**0.27 (p = 0.039)**	-0.06 (p = 0.63)	**0.62 (p < 0.001)**	**0.39 (p = 0.002)**	**0.45 (p < 0.001)**	**0.32 (p = 0.014)**
N & R1a	**-0.57 (p < 0.001)**	**-0.65 (p < 0.001)**	**-0.40 (p = 0.002)**	0.25 (p = 0.056)	-0.04 (p = 0.77)	**0.59 (p < 0.001)**	**0.43 (p < 0.001)**	**0.47 (p < 0.001)**	**0.36 (p = 0.005)**
R1b	**-0.35 (p = 0.006)**	-0.16 (p = 0.22)	**-0.49 (p < 0.001)**	**0.32 (p = 0.012)**	0.23 (p = 0.071)	**0.29 (p = 0.026)**	**0.38 (p = 0.003)**	**0.42 (p < 0.001)**	**0.31 (p = 0.015)**

Supplementary table 4. Correlations between the frequencies of major Y haplogroups and climatic factors in 39 countries of Europe.

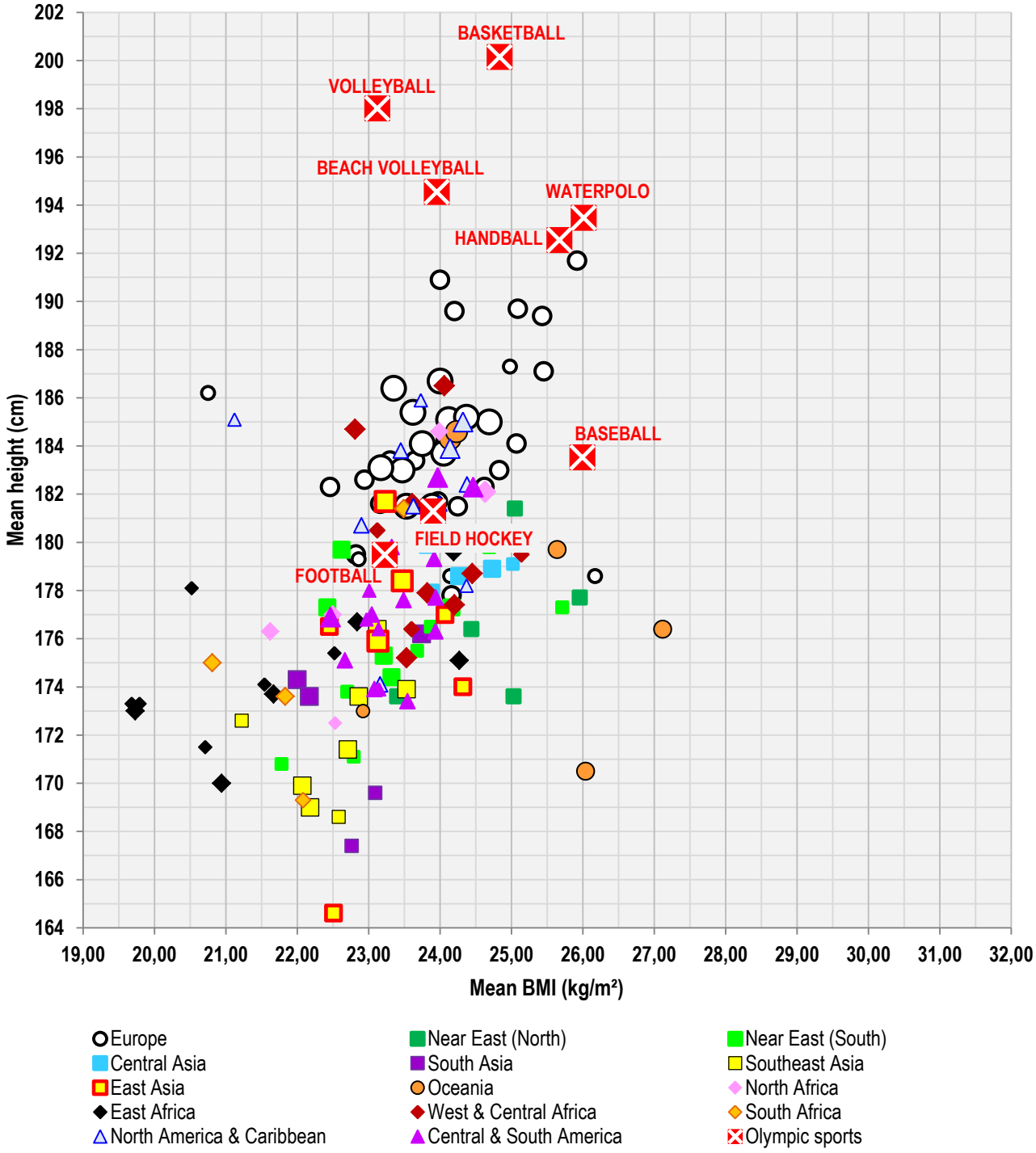
Y haplogrou(p	Mean temperature (°C)			Mean rainfall (mm)			Humidity (%)		
	Annual	January	July	Annual	January	July	Annual	January	July
E	**0.70 (p < 0.001)**	**0.47 (p = 0.003)**	**0.75 (p < 0.001)**	0.07 (p = 0.69)	0.26 (p = 0.12)	**-0.62 (p < 0.001)**	**-0.74 (p < 0.001)**	**-0.78 (p < 0.001)**	**-0.62 (p < 0.001)**
G	**0.69 (p < 0.001)**	**0.61 (p < 0.001)**	**0.58 (p < 0.001)**	-0.28 (p = 0.084)	-0.10 (p = 0.54)	**-0.53 (p < 0.001)**	**-0.48 (p = 0.002)**	**-0.55 (p < 0.001)**	**-0.38 (p = 0.017)**
I	**-0.34 (p = 0.034)**	**-0.39 (p = 0.013)**	-0.23 (p = 0.16)	**0.38 (p = 0.016)**	0.15 (p = 0.36)	**0.44 (p = 0.005)**	0.19 (p = 0.25)	0.17 (p = 0.30)	0.17 (p = 0.30)
J	**0.85 (p < 0.001)**	**0.69 (p < 0.001)**	**0.80 (p < 0.001)**	-0.29 (p = 0.073)	0.03 (p = 0.86)	**-0.78 (p < 0.001)**	**-0.69 (p < 0.001)**	**-0.78 (p < 0.001)**	**-0.55 (p < 0.001)**
J1	**0.60 (p < 0.001)**	**0.41 (p = 0.009)**	**0.64 (p < 0.001)**	**-0.44 (p = 0.006)**	-0.23 (p = 0.16)	**-0.65 (p < 0.001)**	**-0.72 (p < 0.001)**	**-0.45 (p = 0.005)**	**-0.73 (p < 0.001)**
J2	**0.83 (p < 0.001)**	**0.69 (p < 0.001)**	**0.77 (p < 0.001)**	-0.24 (p = 0.14)	0.07 (p = 0.65)	**-0.75 (p < 0.001)**	**-0.63 (p < 0.001)**	**-0.79 (p < 0.001)**	**-0.48 (p = 0.002)**
N	**-0.45 (p = 0.004)**	**-0.46 (p = 0.003)**	-0.24 (p = 0.14)	-0.06 (p = 0.70)	-0.11 (p = 0.50)	0.22 (p = 0.17)	**0.33 (p = 0.039)**	**0.36 (p = 0.025)**	0.27 (p = 0.091)
R1a	**-0.50 (p = 0.001)**	**-0.69 (p < 0.001)**	-0.18 (p = 0.27)	-0.05 (p = 0.78)	**-0.32 (p = 0.050)**	**0.50 (p = 0.001)**	0.25 (p = 0.13)	**0.33 (p = 0.042)**	0.18 (p = 0.27)
N & R1a	**-0.60 (p < 0.001)**	**-0.73 (p < 0.001)**	-0.26 (p = 0.10)	-0.07 (p = 0.67)	-0.28 (p = 0.088)	**0.47 (p = 0.003)**	**0.36 (p = 0.023)**	**0.43 (p = 0.006)**	0.28 (p = 0.081)
R1b	0.10 (p = 0.55)	**0.45 (p = 0.004)**	-0.31 (p = 0.052)	-0.01 (p = 0.95)	0.09 (p = 0.57)	-0.09 (p = 0.58)	0.15 (p = 0.37)	0.17 (p = 0.29)	0.12 (p = 0.48)
R1b-S116 (n = 33)	0.16 (p = 0.38)	**0.51 (p = 0.002)**	-0.28 (p = 0.12)	0.01 (p = 0.95)	0.26 (p = 0.15)	-0.20 (p = 0.27)	0.09 (p = 0.61)	0.18 (p = 0.31)	0.05 (p = 0.77)
R1b-U106 (n = 34)	-0.18 (p = 0.30)	0.11 (p = 0.52)	**-0.48 (p = 0.004)**	0.15 (p = 0.40)	0.16 (p = 0.38)	0.30 (p = 0.081)	**0.43 (p = 0.011)**	**0.35 (p = 0.040)**	**0.42 (p = 0.013)**

Supplementary table 5. Correlations between the frequencies of major Y haplogroups and climatic factors in 16 countries of the Near East.

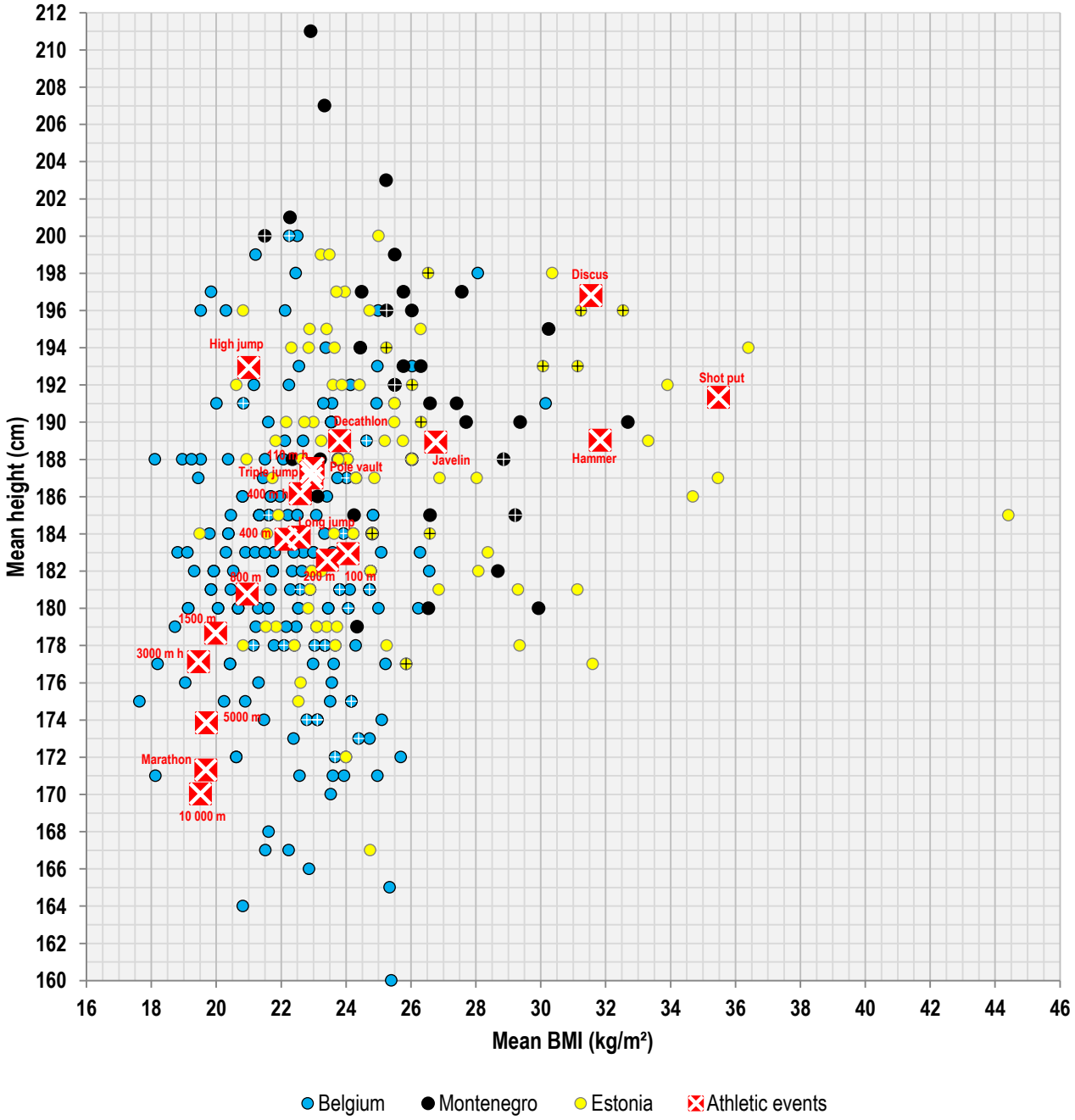
Y haplogrou(p	Mean temperature (°C)			Mean rainfall (mm)			Humidity (%)		
	Annual	January	July	Annual	January	July	Annual	January	July
E	**0.53 (p = 0.033)**	**0.71 (p = 0.002)**	0.14 (p = 0.60)	-0.44 (p = 0.090)	-0.07 (p = 0.79)	-0.09 (p = 0.75)	-0.18 (p = 0.50)	-0.42 (p = 0.10)	0.00 (p = 0.99)
E1b-M78	-0.01 (p = 0.97)	-0.08 (p = 0.77)	0.07 (p = 0.79)	0.11 (p = 0.69)	**0.63 (p = 0.009)**	-0.49 (p = 0.055)	0.23 (p = 0.38)	**0.55 (p = 0.027)**	-0.00 (p = 0.99)
E1b-M81	-0.13 (p = 0.63)	-0.07 (p = 0.79)	-0.22 (p = 0.42)	0.03 (p = 0.91)	0.34 (p = 0.20)	-0.20 (p = 0.45)	0.09 (p = 0.74)	0.14 (p = 0.60)	0.04 (p = 0.89)
E1b-M123	0.03 (p = 0.93)	0.25 (p = 0.36)	-0.29 (p = 0.28)	-0.11 (p = 0.69)	-0.12 (p = 0.66)	0.27 (p = 0.31)	-0.10 (p = 0.72)	-0.40 (p = 0.12)	0.11 (p = 0.69)
G	**-0.59 (p = 0.016)**	**-0.62 (p = 0.010)**	-0.40 (p = 0.12)	**0.69 (p = 0.003)**	0.11 (p = 0.70)	**0.52 (p = 0.038)**	0.28 (p = 0.29)	0.29 (p = 0.28)	0.22 (p = 0.41)
I	**-0.79 (p < 0.001)**	**-0.73 (p = 0.001)**	**-0.69 (p = 0.003)**	**0.60 (p = 0.015)**	**0.55 (p = 0.028)**	0.06 (p = 0.83)	0.47 (p = 0.063)	**0.61 (p = 0.012)**	0.30 (p = 0.26)
J	**0.67 (p = 0.004)**	**0.77 (p < 0.001)**	0.38 (p = 0.15)	**-0.55 (p = 0.026)**	-0.34 (p = 0.20)	-0.02 (p = 0.95)	-0.41 (p = 0.12)	**-0.58 (p = 0.018)**	-0.22 (p = 0.42)
J1	**0.67 (p = 0.004**	**0.77 (p < 0.001)**	0.37 (p = 0.15)	**-0.58 (p = 0.019)**	-0.41 (p = 0.11)	0.01 (p = 0.98)	-0.44 (p = 0.086)	**-0.65 (p = 0.006)**	-0.23 (p = 0.40)
J2	**-0.54 (p = 0.030)**	**-0.62 (p = 0.010)**	-0.30 (p = 0.27)	**0.51 (p = 0.045)**	0.45 (p = 0.077)	-0.05 (p = 0.86)	0.42 (p = 0.11)	**0.65 (p = 0.007)**	0.19 (p = 0.47)
L	-0.24 (p = 0.37)	-0.28 (p = 0.30)	-0.07 (p = 0.79)	0.33 (p = 0.21)	0.31 (p = 0.25)	-0.08 (p = 0.77)	0.47 (p = 0.066)	**0.61 (p = 0.012)**	0.29 (p = 0.28)
N	-0.43 (p = 0.10)	-0.42 (p = 0.10)	-0.31 (p = 0.24)	0.19 (p = 0.48)	0.13 (p = 0.63)	-0.05 (p = 0.86)	0.20 (p = 0.45)	0.43 (p = 0.096)	0.02 (p = 0.93)
Q	-0.14 (p = 0.60)	-0.29 (p = 0.28)	0.08 (p = 0.78)	0.21 (p = 0.44)	0.28 (p = 0.29)	-0.19 (p = 0.48)	0.02 (p = 0.93)	0.20 (p = 0.46)	-0.09 (p = 0.75)
R1a	0.24 (p = 0.36)	0.08 (p = 0.78)	0.42 (p = 0.10)	-0.28 (p = 0.30)	-0.2 (p = 0.45)	-0.34 (p = 0.20)	0.06 (p = 0.83)	0.250 (p = 0.35)	-0.07 (p = 0.80)
N & R1a	0.11 (p = 0.69)	-0.05 (p = 0.86)	0.30 (p = 0.25)	-0.21 (p = 0.44)	-0.15 (p = 0.58)	-0.33 (p = 0.21)	0.11 (p = 0.69)	0.35 (p = 0.18)	-0.06 (p = 0.83)
R1b	**-0.75 (p < 0.001)**	**-0.81 (p < 0.001)**	-0.49 (p = 0.057)	0.40 (p = 0.12)	0.26 (p = 0.33)	-0.01 (p = 0.97)	0.21 (p = 0.45)	0.34 (p = 0.20)	0.08 (p = 0.76)
T	0.43 (p = 0.098)	0.29 (p = 0.28)	**0.53 (p = 0.035)**	-0.25 (p = 0.35)	0.06 (p = 0.83)	-0.45 (p = 0.081)	-0.08 (p = 0.77)	0.03 (p = 0.91)	-0.13 (p = 0.62)



Supplementary figure 1. Mean height and BMI of 149 men's Olympic samples, projected against the means of Top 8 Olympians in 39 individual Olympic sports between 2000-2016. Note that the calculation of mean weight in the sub-heavyweight categories of combat and strength sports was not possible due to varying individual weights and / or constantly changing weight categories.



Supplementary figure 2. Mean height and BMI of 149 men's Olympic samples, projected against the means of Top 3 teams in eight Olympic team sports between 2000-2016.

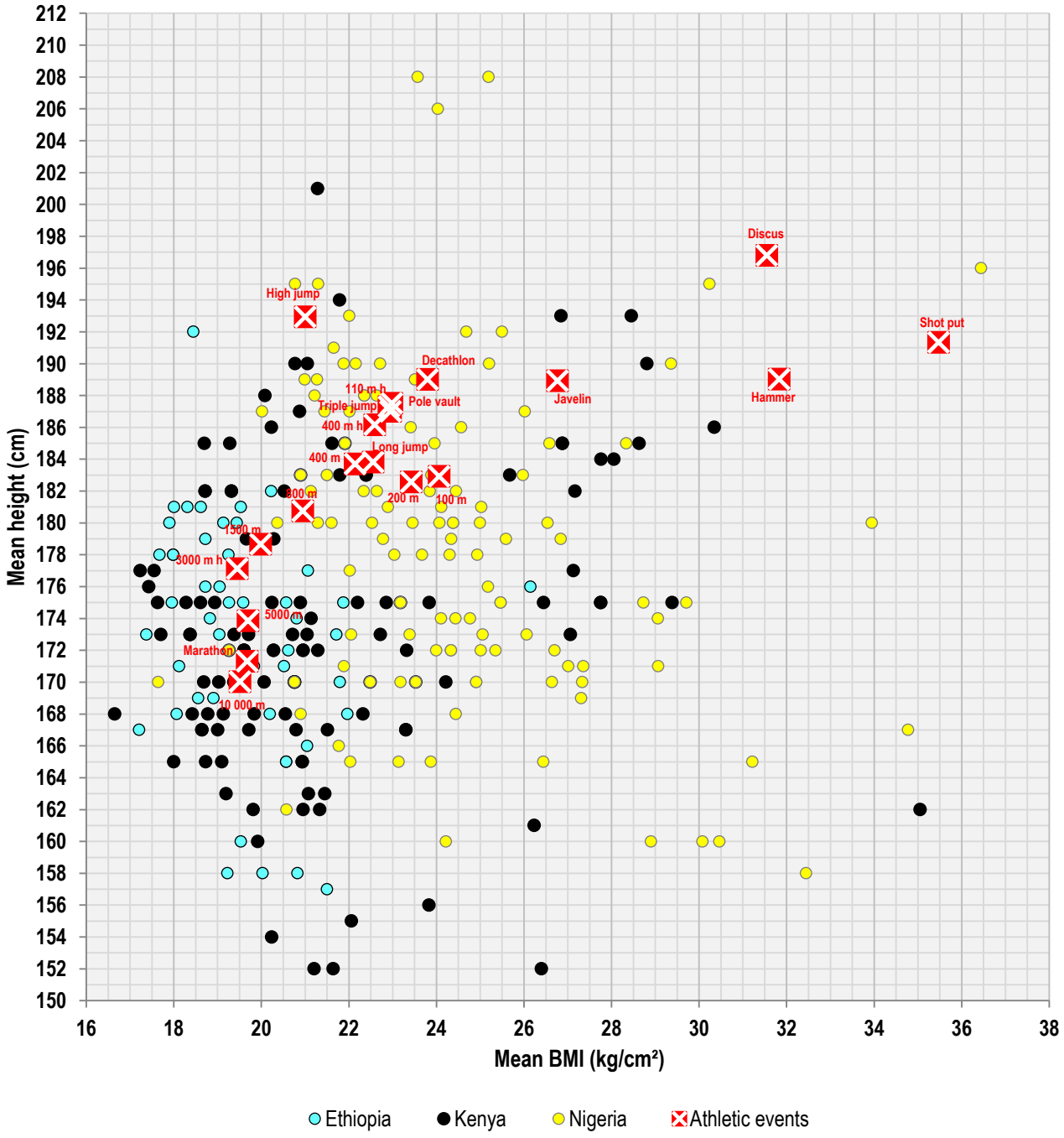


Supplementary figure 3. Individual values of male Olympians from European Olympic teams of moderate size: Belgium (the lowest BMI), Montenegro (the tallest, with the highest BMI), and Estonia (the highest BMI in the comparison of medal winners). Medal winners are marked with crosses inside the circles.

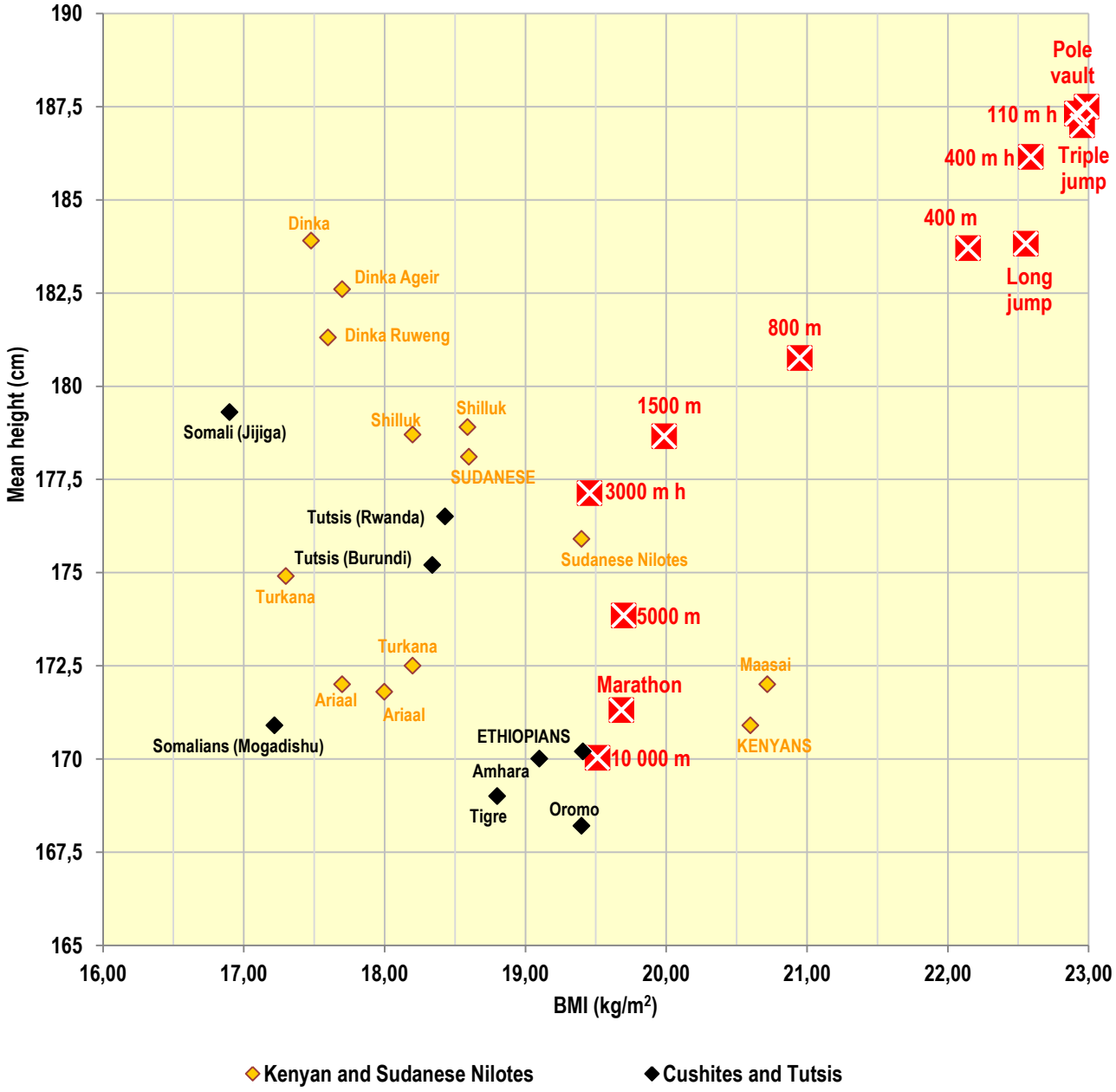


Supplementary figure 4. Individual values of male Olympians from Near Eastern, North African, and Central Asian Olympic teams of moderate size: Morocco (the lowest BMI), Uzbekistan, and Georgia (the highest BMI). Medal winners are marked with crosses inside the circles.

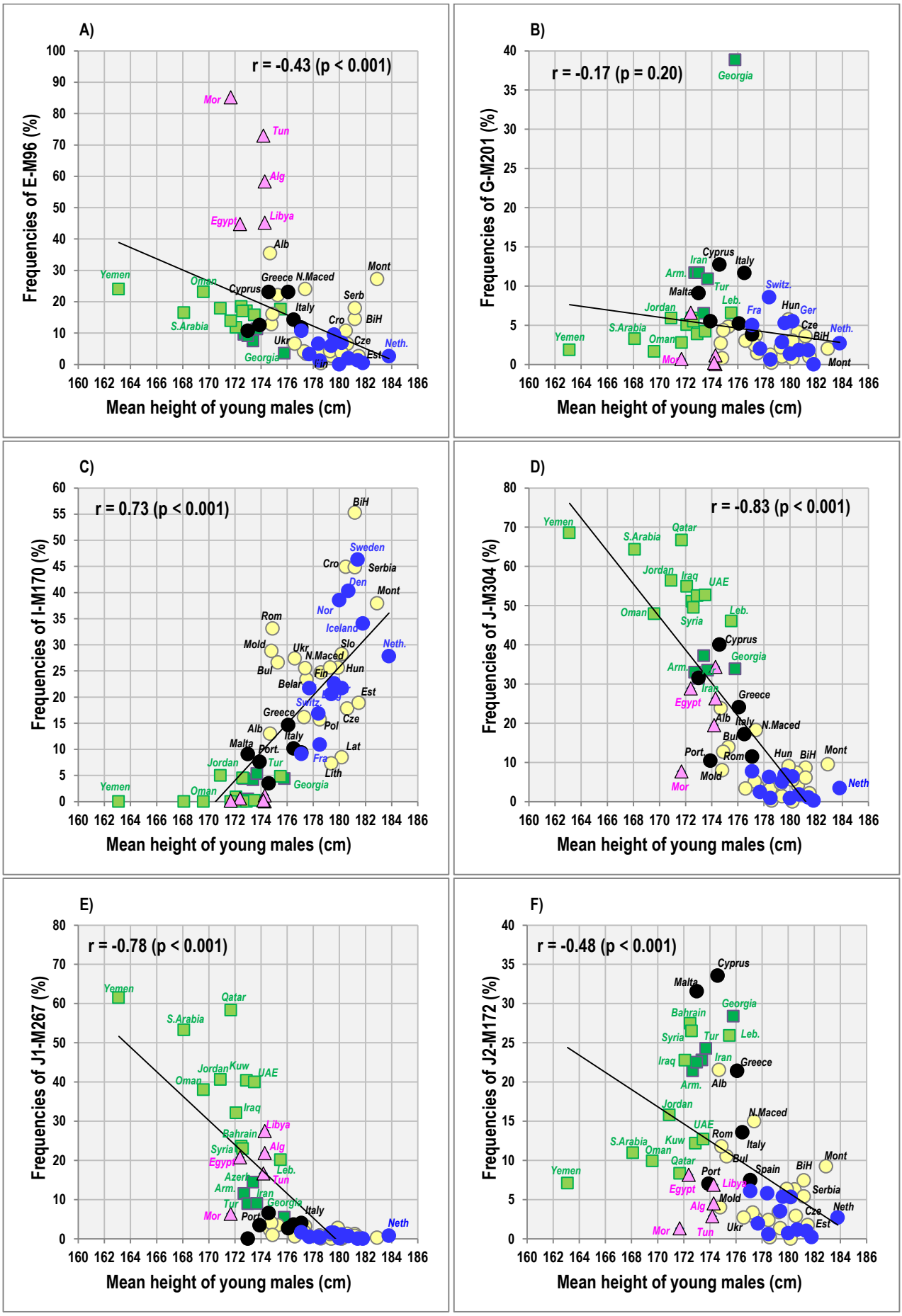
Supplementary figure 5. Individual values of male Olympians from Asian Olympic teams of moderate size: Pakistan (the lowest BMI), Indonesia (the closest to the Southeast Asian mean), and Polynesia (the highest BMI).



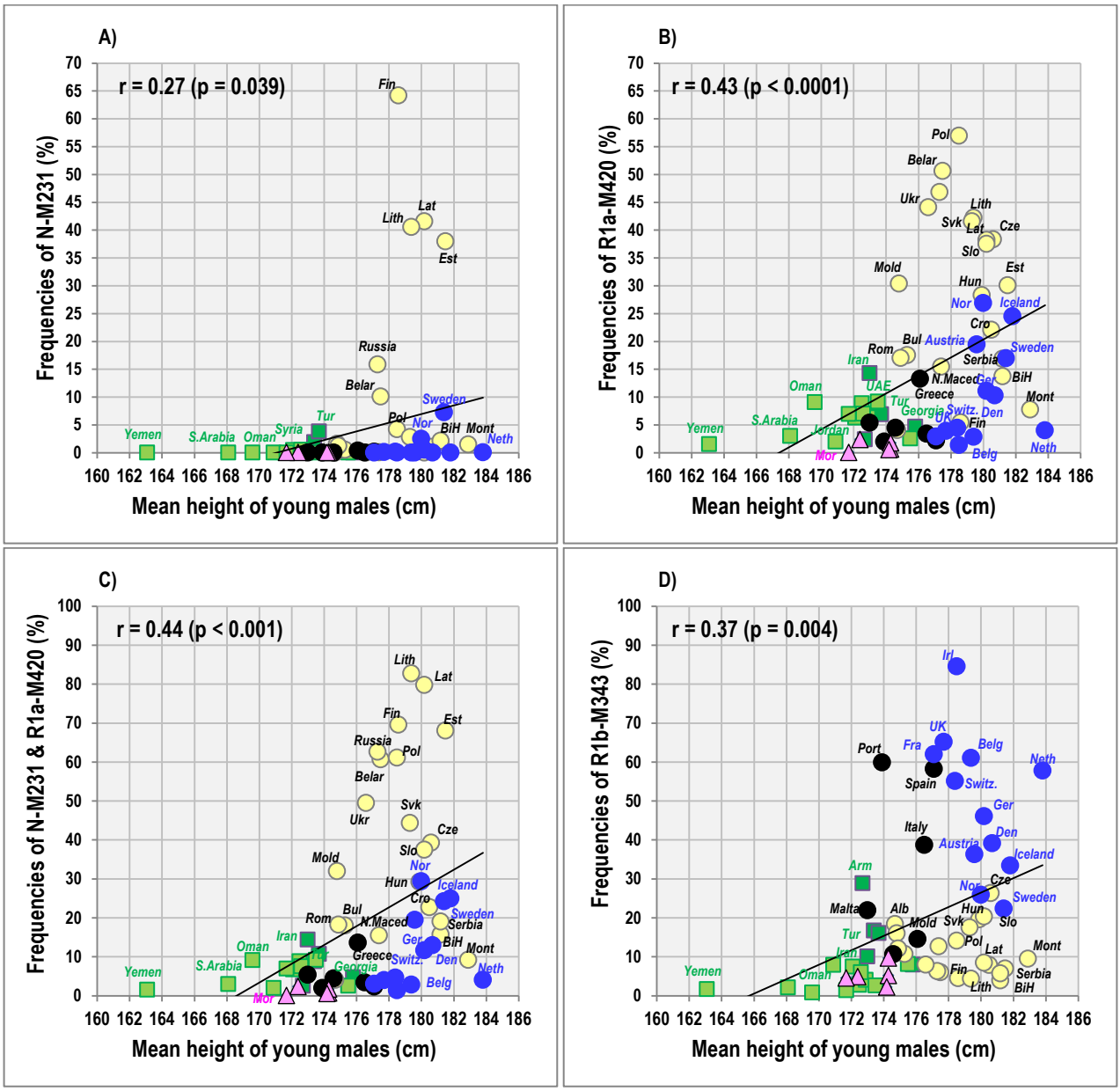
Supplementary figure 6. Individual values of male Olympians from sub-Saharan African Olympic teams of moderate size: Ethiopia, Kenya, and Nigeria.



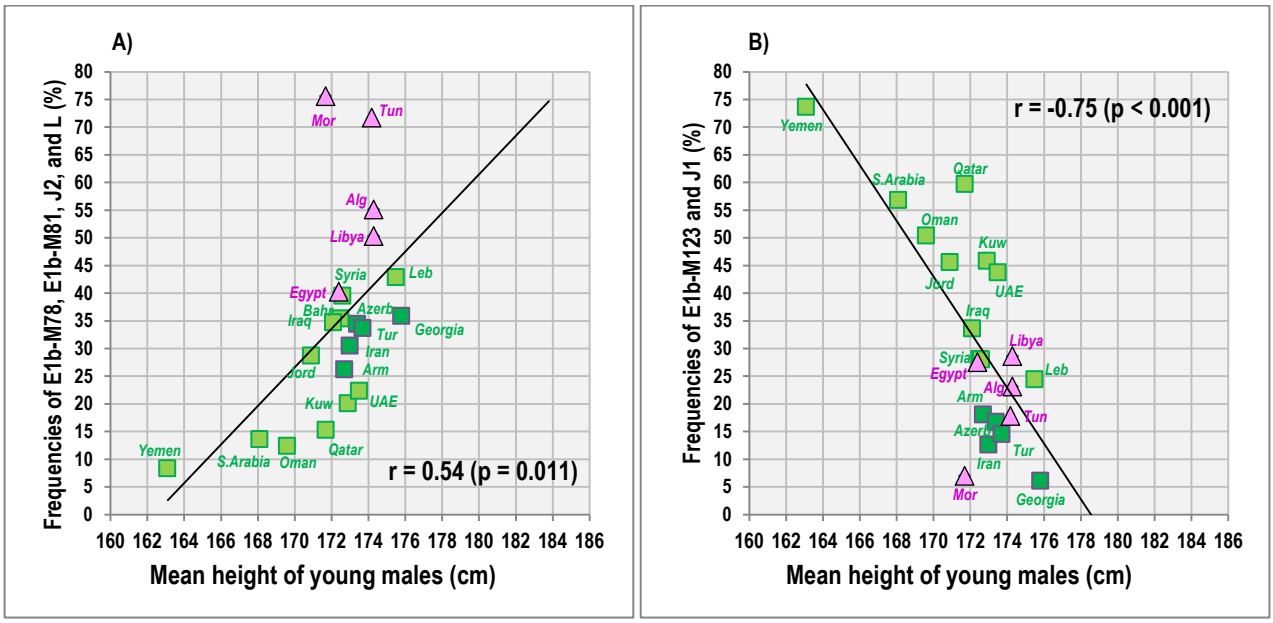
Supplementary figure 7. Height / BMI relationships in adult men from East African ethnic groups.
Note the outlier position of the Nilotic-speaking Turkana and Ariaal from northern Kenya. In this case, their language may not necessarily reflect true genetic affiliation, due to the close historical contact of these groups with the Cushitic pastoralists. Indeed, the Ariaal reportedly descend from the Nilotic-speaking Samburu, who are genetically Cushites (Tishkoff et al., 2009).
For sources, see Supplementary table 2.



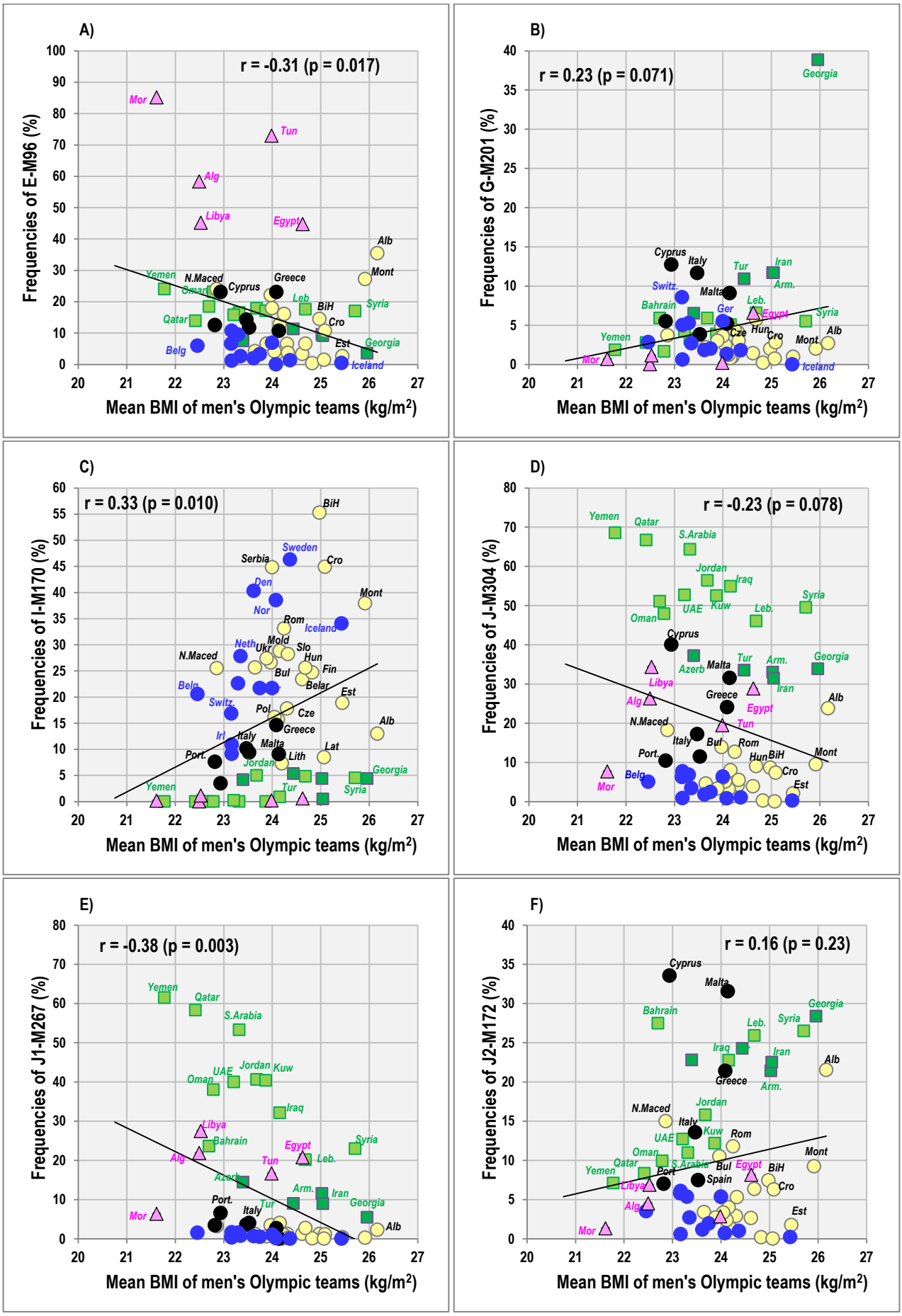
Supplementary figure 8. Correlations between male population height and Y haplogroup frequencies in Europe, the Near East, and North Africa.



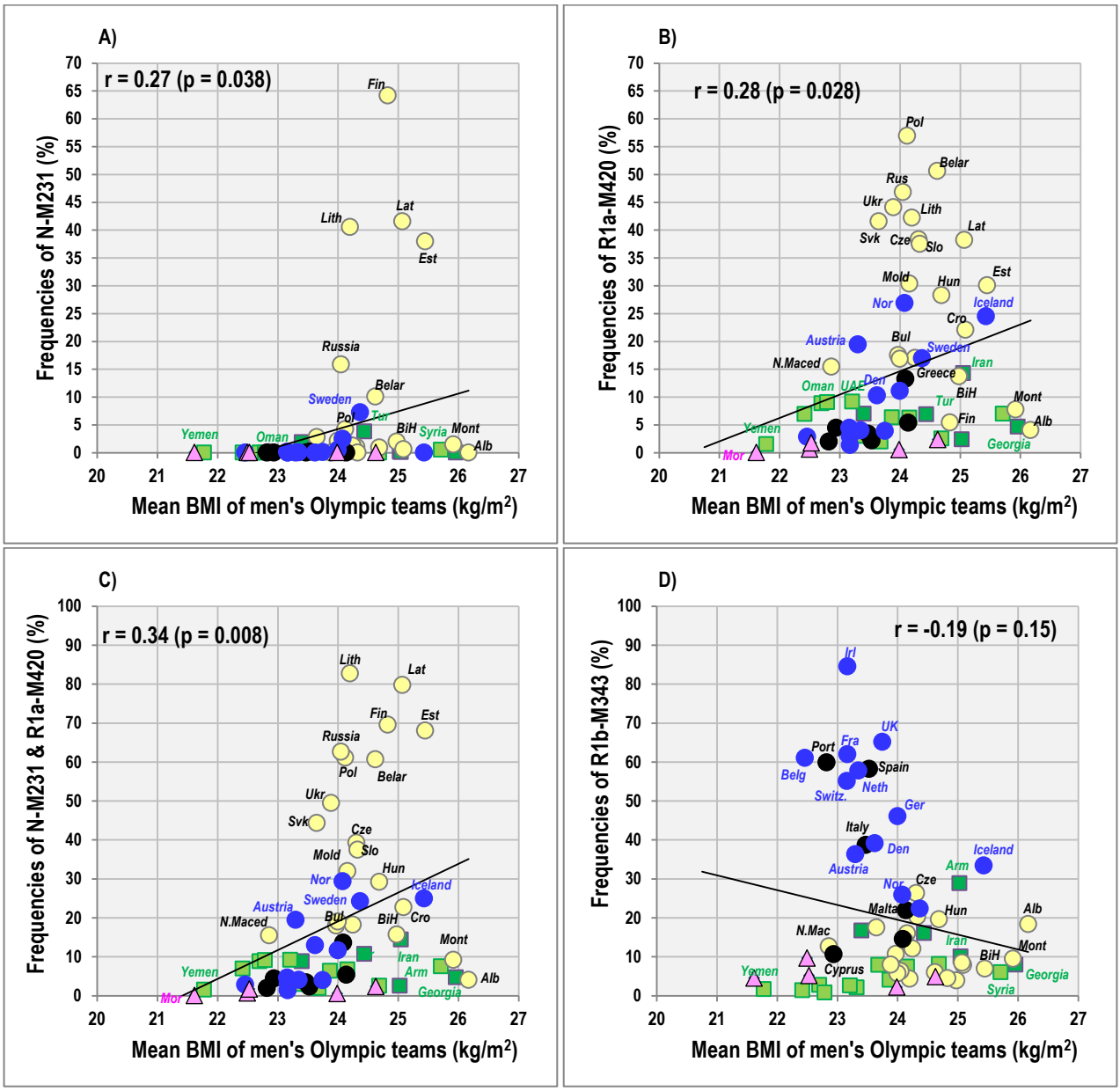
Supplementary figure 9. Correlations between male population height and Y haplogroup frequencies in Europe, the Near East, and North Africa.



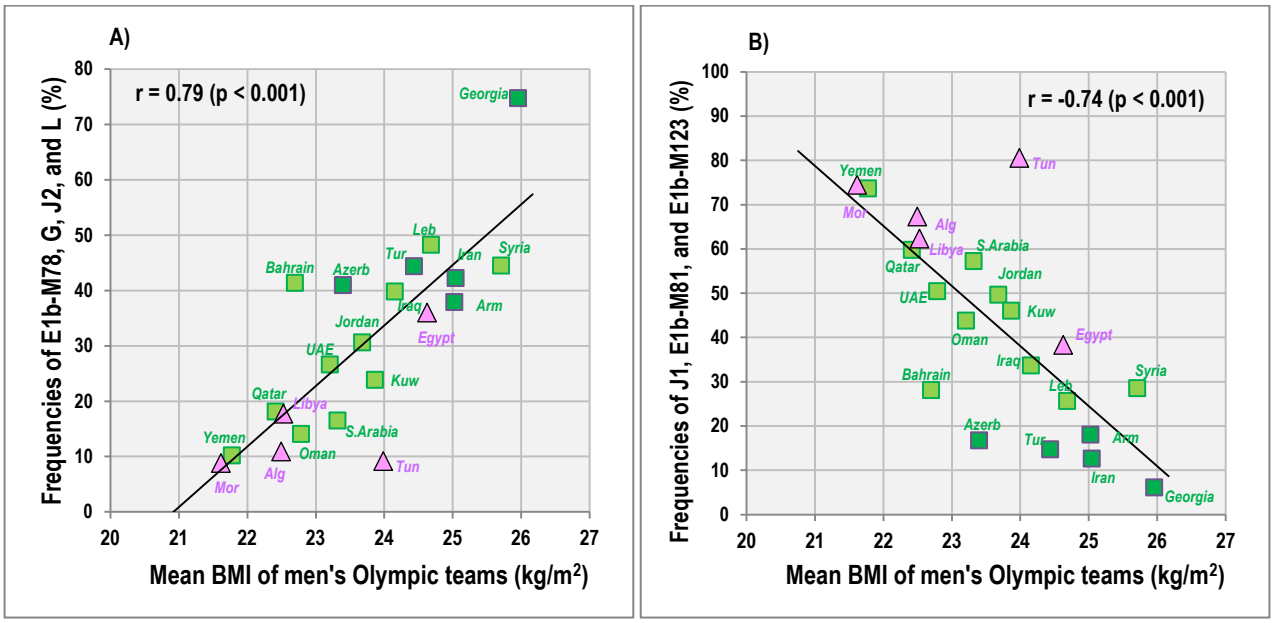
Supplementary figure 10. Correlations between male population height and combined Y haplogroup frequencies in the Near East and North Africa. A) E1b-M78, E1b-M81, J, and L – the strongest predictors of high male height. B) E1b-M123 and J1 – the strongest predictors of short male height.



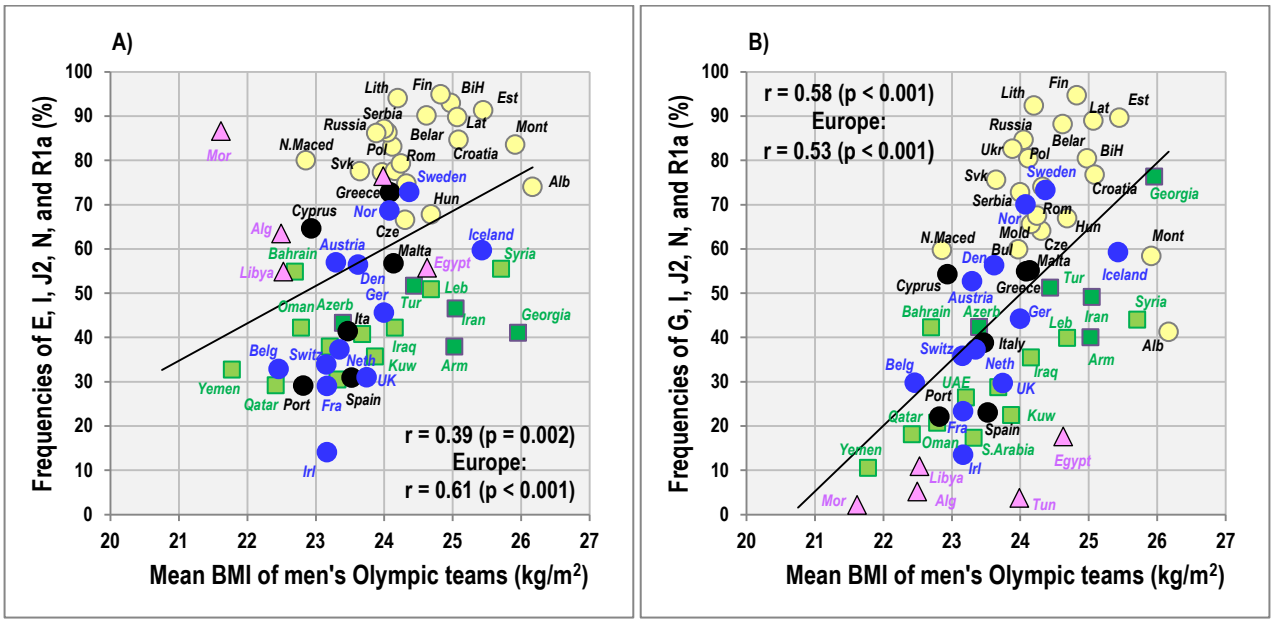
Supplementary figure 11. Correlations between men's Olympic BMI and Y haplogroup frequencies in Europe, the Near East, and North Africa.



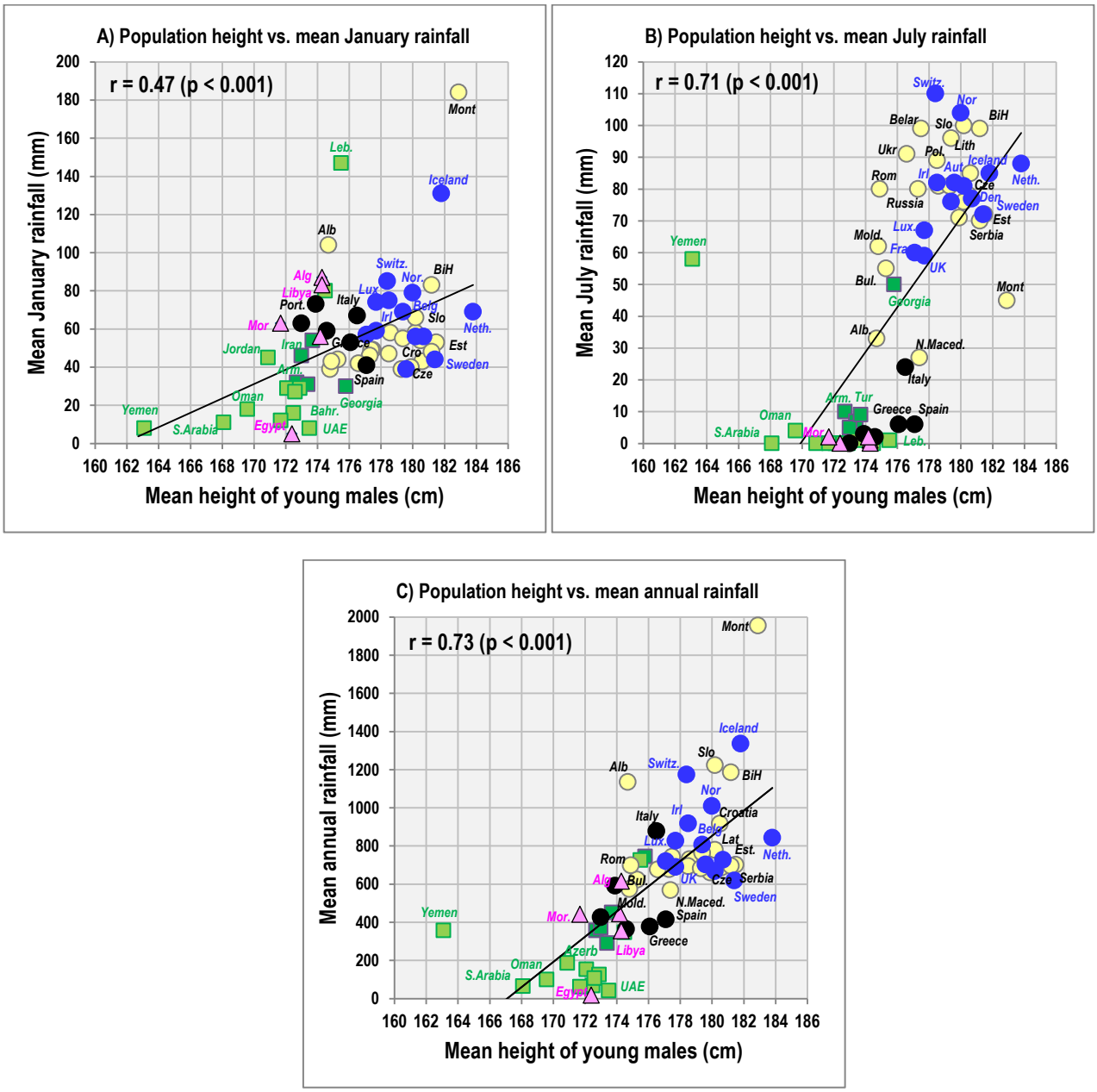
Supplementary figure 12. Correlations between men's Olympic BMI and Y haplogroup frequencies in Europe, the Near East, and North Africa.



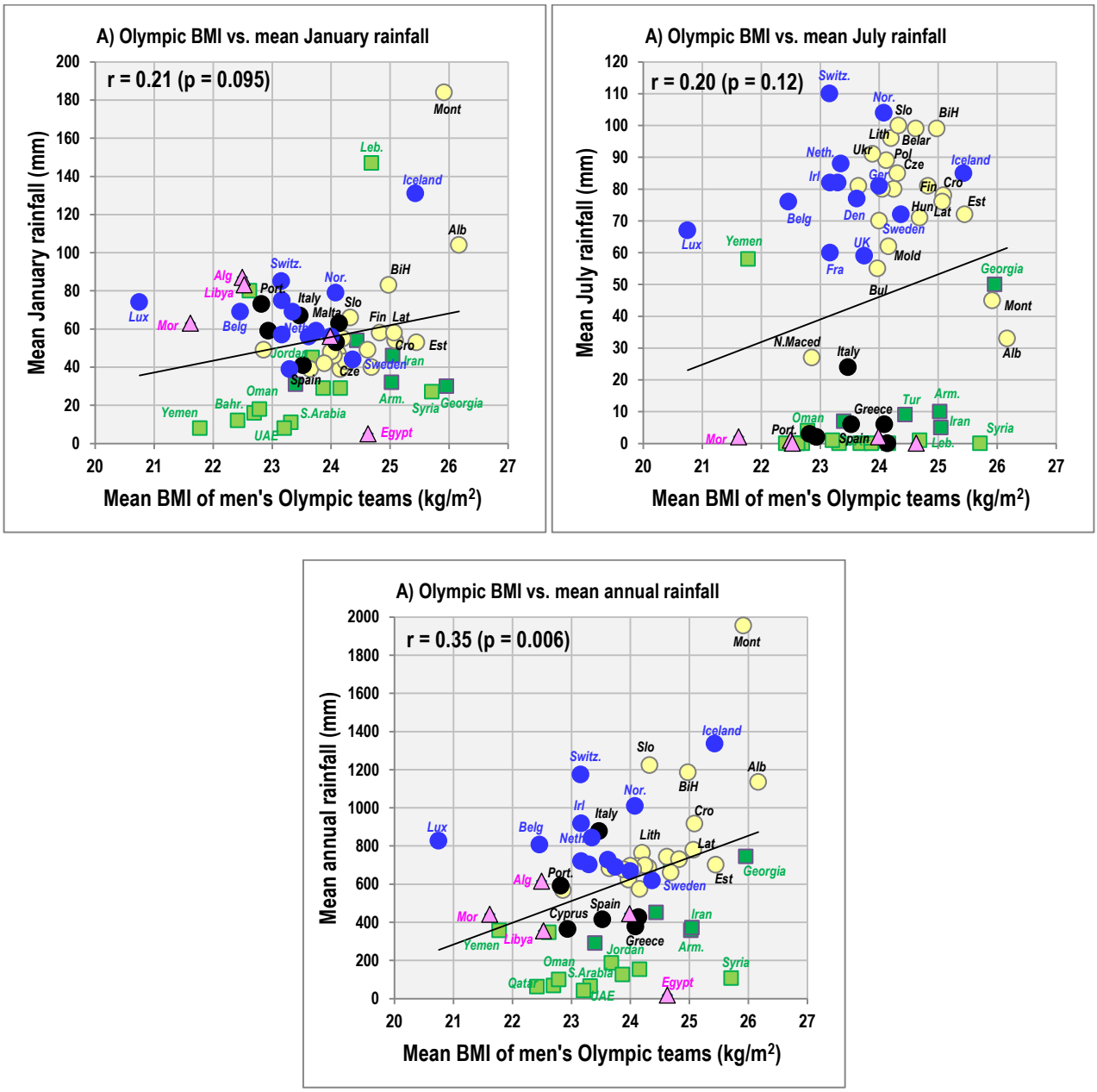
Supplementary figure 13. Correlations between men's Olympic BMI and combined Y haplogroup frequencies in the Near East and North Africa. A) E1b-M78, G, J2, and L – the strongest predictors of high Olympic BMI. B) J1, E1b-M81, and E1b-M123 – the strongest predictors of low Olympic BMI.



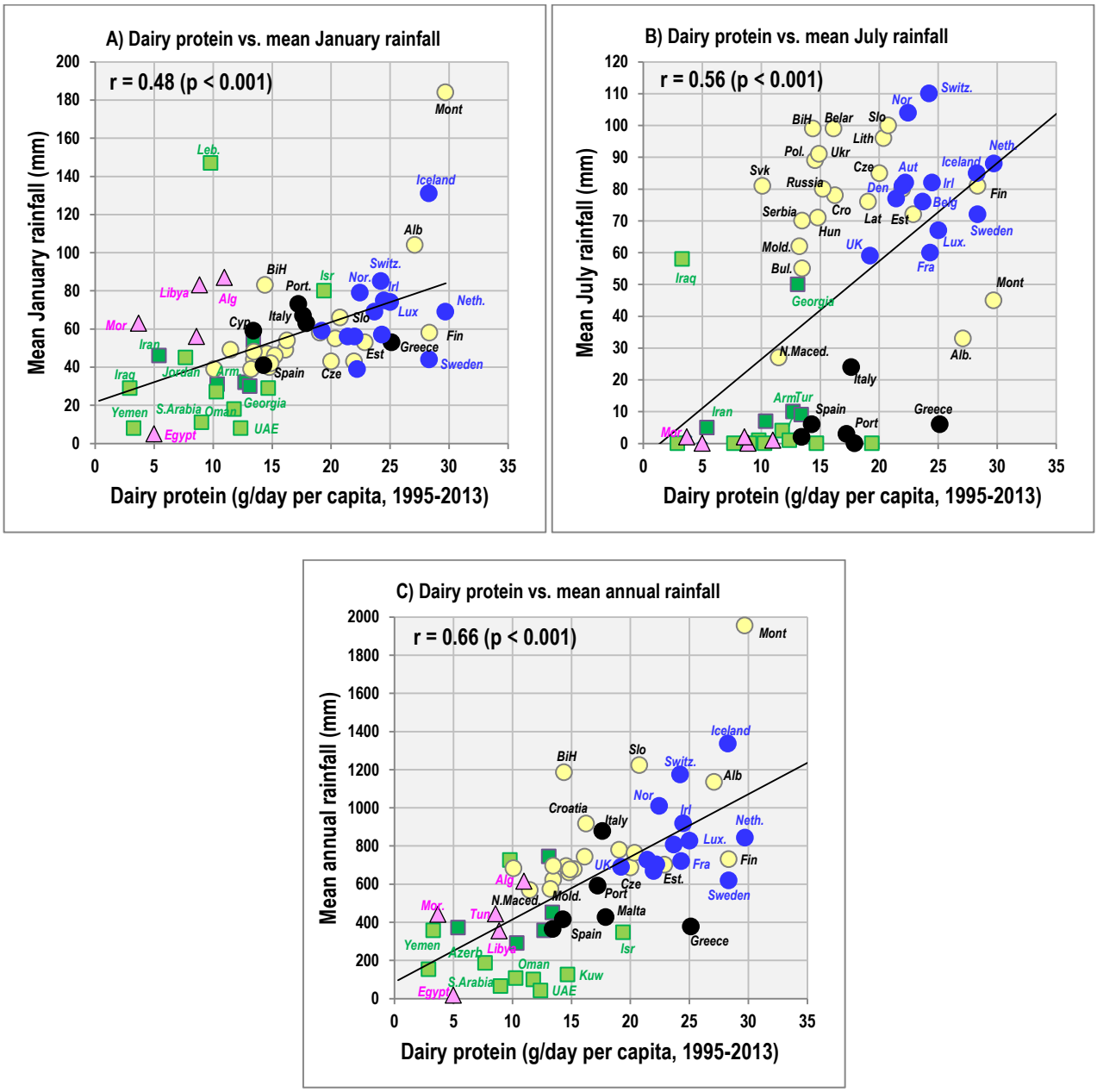
Supplementary figure 14. Correlations between men's Olympic BMI and combined Y haplogroup frequencies. A) E, I, J2, N, and R1a – the strongest predictors of high Olympic BMI in Europe. B) G, I, J2, N, and R1a – the strongest predictors of high Olympic BMI in the complete sample of 60 countries.



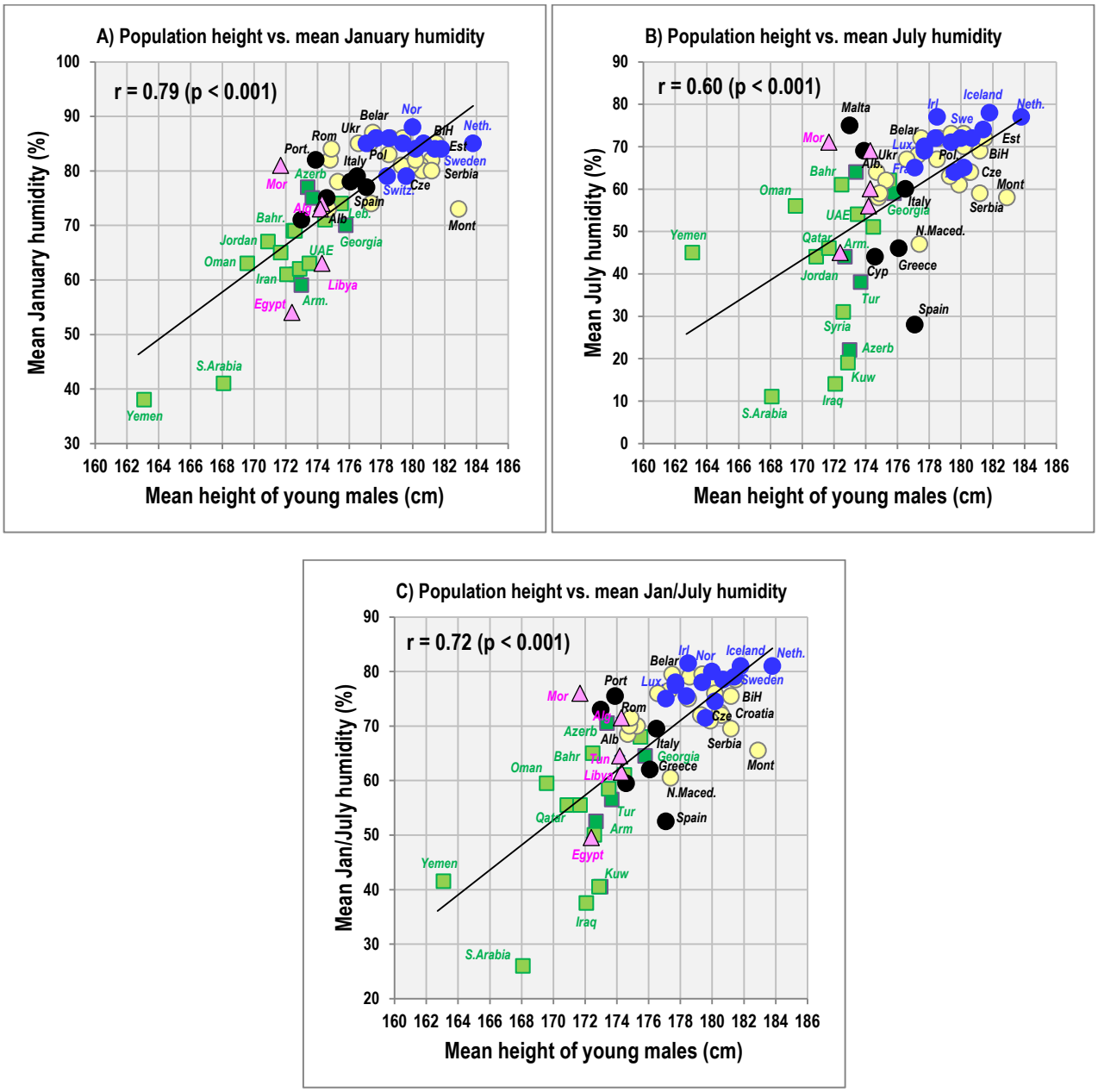
Supplementary figure 15. Correlations between male population height and the mean annual rainfall in Europe, the Near East and North Africa.



Supplementary figure 16. Correlations between men's Olympic BMI and the mean annual rainfall in Europe, the Near East, and North Africa.



Supplementary figure 17. Correlations between the mean supply of dairy protein (FAOSTAT 1995-2013, g/day per capita) and the mean rainfall in Europe, the Near East, and North Africa.



Supplementary figure 18. Correlations between male population height and humidity in Europe, the Near East, and North Africa.