Ethnic Differences in Patterns of Human Growth in Stature

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Human growth patterns may vary according to a range of socioeconomic and health factors including plane of nutrition and exposure and response to infectious disease (1–3). However, ethnic differences in growth patterns among nations have been observed, even after variables indicating underlying and basic causes for growth faltering—such as energy intake, maternal and child care, health services and environment, political and ideological factors, income distribution, and gross domestic product—have been controlled for (4). Although these differences are suggestive of genetic factors, this may not be wholly so, as ethnic classifications are not strong genetic markers (5), and ethnicity may serve as a proxy for unmeasured national characteristics (4). Any study of ethnic differences in human growth patterns must therefore allow that such differences, as observed, may be attributable to unmeasured or unmeasurable environmental characteristics as well as to genetic factors.

In this chapter, I will compare published reports on human growth patterns in different populations, aiming to identify features that have a low probability of being attributed to environmental factors. To this end, I have taken two approaches. The first is to compare growth characteristics of different well-off child populations at various ages and stages (stature attained at 7 and 8 years of age, age at peak height velocity, peak height velocity), with the understanding that such populations show growth patterns that are minimally constrained by environmental factors. The obvious flaw of this approach is that not all well-off populations show maximal growth trajectories, because mean body size is still increasing for many, as the secular trend toward increasing body size has not ceased for many populations (6,7). Thus, the second approach is to compare different populations across time to determine the extent to which the stature characteristics (stature attained at 7 and 8 years of age, age at peak height velocity) of populations of differing ethnicities might be approaching or attaining similar secular trend endpoints associated with the achievement of the genetic potential for growth.
THE CLASSIFICATION OF HUMAN POPULATIONS

Contemporary human populations have been shaped by demographic processes across evolutionary time and, in the more recent past, by modification of the human gene pools through natural selection associated with differential fertility, mortality, demic expansion, and migration (8–10). An understanding of the patterns of human dispersal since the emergence of anatomically modern humans can give some notion of how contemporary human populations might best be classified. As the balance of evidence supports the view that humans have a common place of origin in Africa—dispersion coming late in evolutionary time, about 100,000 years ago (11)—human populations, regardless of where they live, have enormous genetic similarity. Furthermore, the extended time frames of migrations of anatomically modern humans out of Africa and across the globe are likely to have led to continua of variations in physiological and morphological traits within and across populations, so that any classification on the basis of such traits is, to some extent, arbitrary. However, before the onset of agriculture, initially in the Near East, Asia, and Central America between 9,000 and 11,000 years ago (12–14), humans lived as hunter–gatherers at low population densities, often in isolation from each other, allowing genetic adaptation and regional population genetic differences, some of which could be associated with physical growth potential.

Migrations taking place after the onset of agriculture served to create larger, more genetically homogeneous populations across wide areas, with relatively genetically isolated populations left in less hospitable ecological niches. Such populations to be found in the contemporary world include tribal groups of hunter–gatherers in Africa, the Americas, and Asia (15). Colonization of the Pacific Islands also took place since the onset of agriculture, and demographic processes and natural selection pressures important to island migrations occurred (16). Later migrations during colonial times include the migrations of Europeans to the Americas, Australasia, and parts of Africa; of Africans, mostly of Bantu origin, to the Americas and the Caribbean; and of East and South Asians to most parts of the tropical world and to parts of the New World. Migrations in the postcolonial period were related largely to prospects for economic improvement and were usually associated with urbanization (17), such that many now form novel groupings and are often members of transnational communities. These form an important part of the new globally distributed social networks in labor, business, markets, political movements, and cultural flows (18) and include various Central European, South Asian, Central and Latin American, East Asian–African, and African-origin diaspora, among which Jewish, Polish, Indian, Pakistani, Bangladeshi, Chinese, Mexican, Moroccan, Algerian, Somali, Nigerian, and Caribbean communities feature strongly. The environmental characteristics common to transnational communities have been little studied.

Different human populations are known to vary from each other in a large and ever-growing list of genetic markers. Growth patterns, body size, and body composition are polygenic in character (19), but whereas genetic controls of growth-regulatory factors are increasingly understood (20), the genetic contribution to
variation in human growth patterns across different populations remains poorly resolved (21,22). It is possible to classify populations around the world in various different ways. Table 1 gives a modification of the Eveleth and Tanner (1990) classification (23) and some of the other ways in which human populations have been defined for the purposes of studies of growth and development.

This typology is poor because it does not comfortably include mixed populations such as Spanish Indians in the Americas, European Africans in the Caribbean, USA, and Britain, or European Asians in the USA and Canada. Furthermore, it aggregates populations that have been shown to have clear differences in growth pattern. For example, the term “African” includes the majority of Bantu-descended populations of Africa as well as distinctively short-statured hunter-gatherer groups such as the Bakola of Cameroon and the Kung bushmen of Namibia. In addition, the term “Australian Aborigines and Pacific Islanders” covers populations with considerable genetic and morphological heterogeneity. However, clumsy though the classification is, it is the most commonly used at present, and I have chosen it in this chapter in considering broad population growth characteristics.
POPULATION DIFFERENCES IN GROWTH PATTERNS

Although between-population differences in aspects of adult human body size, shape, and form were documented before the 20th century (24), systematic compilations of growth data from different parts of the world have only been made more recently. The most notable publications in this field are the first two editions of *Worldwide Variation in Human Growth* by Eveleth and Tanner (23,25). The efforts that gave rise to these rich sources of human growth data came with the International Biological Program’s human adaptability studies, instigated in 1966. Since this time, very many studies of human growth and body size have been carried out worldwide. Most of these are of groups and populations living in poor environmental circumstances and cannot easily be used to study differences in growth resulting from ethnicity rather than from the environment. Possible differences in growth patterns that might be attributed to genetic factors can be examined either by considering a body size measure—such as the height of children at given ages from industrialized countries and from the highest socioeconomic groups in developing countries—or by examining evidence for secular trends in stature in European and non-European populations, identifying in which populations it has plateaued and the extent to which the stature of non-European populations at a given age has converged with that of European populations.

In the present examination of ethnic differences in growth, between-population comparisons are made at various stages of childhood. Mean stature in midchildhood and age at and magnitude of peak height velocity are used as comparative markers of childhood and pubertal growth, respectively. The possible effects of ethnic origin on birthweight are not considered, although it is acknowledged that seemingly well-off South Asians in Europe and African Americans have lower mean birthweights than their counterparts of European and European origin. At present, it is difficult to interpret available birthweight data in the absence of control for a range of environmental factors including nutrition, maternal size, education, birth interval, and antenatal nutrition (26), which correlate with ethnicity in any study area.

PREPUBERTAL GROWTH IN STATURE

A comparison of mean heights of 7-year-old boys of different population typology from industrialized countries and from the highest socioeconomic groups in developing countries is given in Fig. 1. The range of means for 34 European and European-origin populations is 119.1–126.5 cm, similar to the range for African and African-origin (119.6–126.1 cm), Latin American (119.9–124.9 cm), and Indo-Mediterranean (119.5–126.0 cm) populations but slightly higher than those of Asiatic populations (118.1–124.2 cm). The median value for stature of 7-year-old boys of Asiatic origin is 1.0–1.2 cm less than those of Indo-Mediterranean, Latin American, and African populations, respectively, and 1.7 cm less than those of European and European-origin populations. This supports the suggestion of Martorell et al. (1) and Ulijaszek (6) that the genetic potential for prepubertal growth may be similar for all groups examined in this way, apart from Asiatic populations. However, this summary
FIG. 1. Mean statures of 7-year-old boys from industrialized countries and from well-off populations in developing countries. *European populations*—Sweden: Lindgren and Strandell (27); the Netherlands: Roede and van Weeringen (28), Gerver (29); UK: Ulijaszek (30), Rona and Chinn (31), Freeman et al. (32); England: Chinn et al. (33); Scotland: Chinn et al. (33); Norway: Waaler (34); USA: National Center for Health Statistics (35), Frisano (36); Hungary: Elben and Panto (37), Elben (38); Ireland: Hoey et al. (39); Denmark: Andersen et al. (40); France: Sempé et al. (41); Europeans in Jamaica: Ashcroft and Lovell (42); Italy: Kramer (43); German Democratic Republic: X. Hesse V. (unpublished) in Eveleth and Tanner (23); German Federal Republic: Danker et al. (44); Europeans in Colombia: Spurr et al. (45); Poland: Kurniewicz-Witczalowa et al. (46); Canada: Shephard et al. (47); Spain: Hernandez et al. (48); Switzerland: Prader and Budigler (49); Yugoslavia: Prebeg (50); Croatia: Z. Prebeg (unpublished) in Eveleth and Tanner (23); Europeans in Venezuela: Mendez-Castellano et al. (51); Germany: Kromeyer-Hauschild and Jaeger (52). *Latin American populations*—Brazil: Murillo Marques et al. (53); Guatemala: Johnston et al. (54); Costa Rica: Villarejos et al. (55); Puerto Rico: Knott (56); Argentina: Bolzan et al. (57); Mexican Americans: Roche et al. (58), Ryan et al. (59); Colombia: Spurr et al. (45); Venezuela: Mendez-Castellano et al. (51); Cuba: Jordan (60); Chile: Valenzuela and Avendano (61); Argentina: Lejarraza (62). *African and African-origin populations*—Jamaica: Ashcroft and Lovell (42); African Americans, USA: Frisano (36); Turkana: Little et al. (63); Nigeria: X. Janes MD. (unpublished) in Eveleth and Tanner (23); African British: Ulijaszek (30); African Americans, USA: National Center for Health Statistics (unpublished) in Eveleth and Tanner (23); Haiti: King et al. (64); Afro-Caribbean children in Britain: Chinn et al. (33). *Indo-Mediterranean populations*—Chandigarh, India: Prakash and Cameron (65); Turks in Sweden: Mjones (66); Sikhs in England: J. Peters and S. J. Ulijaszek (unpublished data); Pakistani in England: J. Peters and S. J. Ulijaszek (unpublished data); East African Asians in England: J. Peters and S. J. Ulijaszek (unpublished data); Indian Hindus in England: J. Peters and S. J. Ulijaszek (unpublished data); Jat Sikhs in the Punjab, India: Singh and Harrison (67); Urdu/Punjabi in Britain: Chinn et al. (33); Gujaratis in Britain: Chinn et al. (33); “other” Indians (predominantly Bengali speakers) in Britain: Chinn et al. (33); Pakistani children in England: Kelly et al. (68). *Asiatic populations*—Chinese in Jamaica: Ashcroft and Lovell (42); Southern Chinese: Chang et al. (69); Japan: Tanner et al. (70), Kikuta and Takaishi (71); Kobe, Japan: Tanner et al. (70); Koreans in Japan: Kim (72); China, urban: Zhang and Huang (73); Mongolians, Uyghurs, Koreans in China, Tibetans: Ji and Ohsawa (74,87); Hong Kong: Leung et al. (75); Singapore, Japan: unpublished data; cited in Guillaume (76) and Franklin (77); Japanese in Tokyo: Ashizawa et al. (78); urban Chinese: Ji et al. (74); Japan: Takaishi (79).
of studies incorporates both current data and data from the recent past and does not take into account possible effects of the secular trend toward increased body size, which has continued to take place among many populations, including well-off ones. Disaggregating the studies according to the year of study shows that median stature of Asiatic populations observed since 1990 is much more similar to that of their counterparts elsewhere in the world.

Evidence for secular increases in the mean stature of European and European-origin populations and Asiatic populations is shown in Figs. 2 and 3. Mean heights of 8-year-old girls in the Netherlands, Belgium, Britain, Sweden, Germany, USA, Canada, and Australia (Fig. 2) have all shown positive secular trends, having plateaued for the Dutch, Swedish, British, US, and Canadian populations but continuing to rise marginally for the Belgian, Australian, and German populations. These data tentatively support the view that North Europeans may have slightly greater genetic potential for growth than North Americans (6).

With respect to Asiatic populations, relatively recently published data suggest that there is a dramatic increase in stature among many of these groups (Fig. 3). The increased stature in many of the Asiatic populations since about 1960 is of similar magnitude to that of European populations between about 1900 and 1950. There is as yet no evidence that this trend has ceased among any Asiatic population studied. Although no definitive statement can be made about the genetic potential for

![Secular trend in height of European girls at 8 years of age.](image)

**FIG. 2.** Secular trend in height of European girls at 8 years of age. The Netherlands: van Weeringen (80); Sweden: Ljung *et al.* (81); Cornerud and Lindgren (82); Britain (London): Cameron (83); Britain (national): Freeman *et al.* (32); Belgium (Brussels): Meredith (84), Vercauteren (85); USA: Meredith (84), National Center for Health Statistics (35), Frisancho (36); Australia: Meredith (84), Pyke (86); Canada: Meredith (84), Shephard *et al.* (47); Germany: Kromeyer-Hauschild and Jaeger (52).
prepubertal growth in these populations, there is clear convergence in mean statures across populations of the world, including Asiatic ones. If economic prosperity continues to improve in many Asian nations, then it is reasonable to assume that the convergence in mean stature (standardized for chronological age) of preadolescents of well-off Asiatic populations and those elsewhere in the world will continue. The striking extent of the secular trend in stature of Asiatic populations is well exemplified by findings from a study of child growth before and after the implementation in China, in 1978, of economic reforms aimed at transforming the socialist economy to a free market one (89). Between 1975 and 1992, the mean stature of 3.5-year-old boys in perurban rural areas increased by 2.5 cm, while that of urban preschool children increased by 3.8 cm. Although the overall improvement in child growth during the economic reforms in China was enormous, it was not equitable. However, the analysis by Shen et al. (89) has shown that dramatic improvements in growth have taken place in both urban and rural areas because of improving circumstances.

PUBERTAL GROWTH

The adolescent period involves various physical changes associated with the onset of physiological reproductive function as well as with the pubertal growth spurt. The spurt in growth is both intense and rapid, and greater within-population variability in body size occurs across puberty because of differences in the size and timing of this spurt. The increase in the variance of almost any measure of growth during puberty is a result of individual variability, although different populations may display different mean rates of maturation. This can result in populations differing in measures of growth and maturation (90) such as peak height velocity, menarche, spermarche, and breast and genital development. Whereas the environment can influence
adolescent growth and maturation, the observation by Johnston *et al.* (91)—that during childhood, samples of children grow in a fashion similar to others who share the same environment even if they differ in ethnic background, whereas during adolescence, growth patterns are similar to those of others who are ethnically similar even if the environments are not the same—led them to speculate that adolescent growth may be under stronger genetic control than growth in childhood. I will now examine the extent to which well-off populations show similarities in two markers of pubertal growth—the size and timing of peak height velocity—and also the extent to which there are secular trends in these phenomena.

Figure 4 shows ages at peak height velocity of males from industrialized countries and from well-off populations in developing countries. Of a total of 43 studies, the median value for boys of Asiatic origin is between 0.3 and 0.8 year earlier than those of Indo-Mediterranean, Latin American, and African populations. Figure 5 gives peak height velocities (cm/year) of males from industrialized countries and from well-off populations in developing countries. This summarizes data from 35 studies.

**FIG. 4.** Age at peak height velocity of males from industrialized countries and from well-off populations in developing countries. *European populations*—Spain: Rosique and Rebato (92); the Netherlands: Kemper *et al.* (93), calculated by Hermanussen (94) from Roede and van Wieringen (28); Poland: Bielicki *et al.* (95); France: Roy (96); USA: Bock and Thissen (97), Berkey *et al.* (98), Tanner and Davies (99); Belgium: Beunen *et al.* (100), Bogin *et al.* (101); UK: Billewicz *et al.* (102), Preece and Baines (103), Bogin *et al.* (101), Buckler and Wild (104), calculated by Hermanussen (94) from Tanner *et al.* (105); Germany: calculated by Hermanussen (94) from Reinken *et al.* (106) and Reinken and van Oost (107); Sweden: calculated by Hermanussen (94) from Karlberg and Taranger (108); Switzerland: calculated by Hermanussen (94) from Prader *et al.* (109). *Latin American populations*—Cuba: Jordan (110); Guatemala: Bogin *et al.* (101,111). *African and African-origin populations*—African American: Verghese *et al.* (112), Berkey *et al.* (98); South Africa: Cameron *et al.* (113). *Indo-Mediterranean populations*—Northwest Indian: Pathmanathan and Prakash (114); urban Indian: Bogin *et al.* (101); India: Hauspie *et al.* (115); Raghavan *et al.* (116). *Asiatic populations*—China: Lai and Yaung (117); Chinese in Hong Kong: Chang (118); Inuit: Shephard and Rode (119); Japan: Liu *et al.* (120); Taiwan, China: Huang and Malina (88); Japan: calculated by Hermanussen (94) from Tanner *et al.* (70).
FIG. 5. Peak height velocity (cm/year) of males from industrialized countries and from well-off populations in developing countries. European populations—Spain: Rosique and Rebato (92); the Netherlands: Kemper et al. (93), calculated by Hermanussen (94) from Roede and van Wieringen (28); France: Roy (96); USA: Berkey et al. (98), Tanner and Davies (99); Belgium: Beunen et al. (100), Bogin et al. (101); UK: Billewicz et al. (102), Prece and Baines (103), Bogin et al. (101), Buckler and Wild (104); Germany: calculated by Hermanussen (94) from Reinken et al. (106) and Reinken and van Oost (107); Sweden: calculated by Hermanussen (94) from Karlberg and Taranger (108); Switzerland: calculated by Hermanussen (94) from Prader et al. (109). Latin American populations—Cuba: Jordan (110); Guatemala: Bogin et al. (101,111). African and African-origin populations—African American: Verghese et al. (112), Berkey et al. (98); South African: Cameron et al. (113); urban South African: Shamssain (121). Indo-Mediterranean populations—Northwest Indian: Pathmanathan and Prakash (114); urban Indian: Bogin et al. (101); India: Hauspie et al. (115), Raghavan et al. (116). Asiatic populations—Chinese in Hong Kong: Chang (118); Inuit: Shephard and Rode (119); Japan: calculated by Hermanussen (94) from Tanner et al. (70).

Median values for all five ethnic typologies range between 7.1 (Indo-Mediterranean) and 7.7 (European, African, and Asiatic populations) cm/year, with the Latin American median being slightly less than the latter value. These data support the view of Eveleth and Tanner (23,25), based on smaller population sets, that Asiatic populations show earlier onset of the pubertal growth spurt in stature than other major population typologies but have similar peak height velocities.

Figure 6 summarizes data on secular trends in the age at peak height velocity of boys, published by Hermanussen (94), and for Taiwan, as reported by Huang and Malina (88). No data are available on possible secular trends in peak height velocity in these populations. For the six European groups reported, there has been a decline in age at peak height velocity since the middle of the 19th century and across the 20th century. Values have leveled off for the Swedish and Swiss populations but not for
the German and US populations. It is not clear if age at peak height velocity has leveled off for British or Dutch children. For the two Asiatic populations, a rapid decline in age at peak height velocity has taken place in the second part of the 20th century, with no evidence that this trend has leveled off. Given that Asiatic values for this measure are lower than those for well-off and industrialized nation groups of other major population typologies, it is likely that the currently earlier age at peak height velocity of Asiatic populations will not converge with those of other regional origins. If this secular trend continues, it is possible that they might diverge further. It seems likely that the different pattern of growth in stature in puberty of Asiatic populations is not caused by environmental factors, supporting the view of Johnston (90) that adolescent growth may be under stronger genetic control during puberty than childhood.

CONCLUSIONS

An understanding of ethnic differences in growth in stature is essential to identify the extent to which international growth references can be used for the screening, monitoring, and surveillance of child growth among the world’s populations. The similarities in attained stature by midchildhood of children of most major population typologies apart from the Asiatic one suggest that an international growth reference could be used for European and European-origin populations as well as those of African and African origin and of Indo-Mediterranean origin. They may also be applicable to preadolescent Asiatic populations, given the dramatic secular increase in childhood stature in recent decades, if they are likely to achieve the same statures for age as well-off populations elsewhere in the world. With respect to pubertal growth, international references may be applied to all major population typologies apart from
the Asiatic one, as the earlier age at peak height velocity in these populations is unlikely to reflect differences in environmental quality. However, this conclusion is based on just a few studies of childhood growth in well-off Asiatic, African, Indo-Mediterranean, and Latin American populations, and further surveys among such populations are warranted. However, with such work should come more precise and detailed characterization of what constitutes well-off populations. In particular, the environmental descriptions of such populations should include income, income disparity, education, disease risk, health provision, food availability, nutritional status, social status, and social disparity.

Nothing has been said in this chapter about growth patterns of the many ethnically diverse small populations of the world. These include Australian aboriginal peoples, Pacific Islanders, and First Nation peoples of North America. It is still not possible to make clear recommendations about the validity of use of international growth references among such groups. This is because it is still not clear whether they are likely to show the same potential for growth as well-off populations elsewhere in the world when placed in favorable environments. Therefore, studies of physical growth and development in well-off populations of non-major ethnic typologies should be carried out as and when they emerge economically.

Finally, some attention should be paid to the appropriate identification of new mixed populations emerging in many urban centers of the world. Major social and economic processes are associated with migration, urbanization, and the often changing marriage and reproductive patterns among urban populations. It is important to characterize the physical growth characteristics of novel populations arising from these processes to determine the extent to which they fit more general patterns.

REFERENCES


DISCUSSION

Dr. Guesry: I have a comment and a question. My comment is that it is not correct to consider Europeans as one ethnic group, when we know what big differences there are between the Celts, Scandinavians, Southern Europeans, and so on, and when we know that Europe was colonized during the first centuries of our era by
people coming from the east, mostly from Asia. My question is about puberty. The
difference in size between ethnic groups seems to be related to age at onset of
puberty, with Asians earlier by about 1 year compared with the other ethnic groups.
Don’t you think this may be related to the widespread use in Asia of soya prepara-
tions containing phytoestrogens? Why not investigate populations with a high con-
sumption of soya and a low consumption of soya and correlate them with size and
age at puberty?

Dr. Ulijaszek: First, about your comment. I agree with you. There is considerable
human variation in a number of physical characteristics. To characterize Europeans
as a single group presents the same problem as characterizing South Asians as one
group. Anybody from India knows about the huge variation in population typology
from the south to the north of India, and any Indian would say immediately, “Why do
you put somebody from Madras together with somebody from Delhi, when we are
clearly different people?” The same applies to Europe. We know there are physical
characteristics—age at menarche, for example—that differ between Southern
European and Northern European populations. If you are from Italy, Spain, or
Greece, you have earlier age at menarche than if you are from Northern Europe.
These are clear differences, and I did state that the typologies used are clumsy. The
question is: Do we split human populations, or do we combine them? We have to
consider how we split or combine populations according to the problem we have to
deal with. In creating an international growth reference, we have to ask the question:
To what extent, for public health purposes, can we combine the world populations?
We may have to ignore all the imperfections in order to make it fit. The decisions are
pragmatic ones, which are made in the public health sphere.

With respect to the phytoestrogen issue, this is certainly an aspect of the environ-
ment that needs to be controlled for, and I do not at present have an answer to your
question. I think we need to do a controlled study of phytoestrogen-consuming and
non-phytoestrogen-consuming Asiatic populations, but probably not in Asia—per-
haps in California, perhaps in Hawaii, where we may be able to control for many of
the environmental differences and the differences in diet.

Dr. Haschke: You mentioned that there are differences between the north and the
south of Europe. In the Euro-Growth Study, we had three Northern European study
centers, in Sweden, Scotland, and Ireland, and in the south, we had study centers in
Greece, Italy, Spain, and Portugal. Surprisingly, up to 3 years of age, there is no dif-
ference between the children, either in weight or in length.

Dr. Ulijaszek: That does not particularly surprise me. My understanding is that
the differences come at puberty. What we really need to understand are the factors
that create those differences in the timing of puberty. I think they are reasonably
characterized, but at a fundamental level, we need to understand why Asian popu-
lations and South European populations are distinctive. South European popula-
tions may be similar to Asiatic populations because they came from the same mi-
gration diaspora from Africa around 100,000 years ago, and what changed was the
Northern European pattern. But that begs another question, which is why Africans
are different from Asians and South Europeans. I don’t have an answer, but for me,
the need on the distant horizon is to try to link specific genetic markers—which
probably code for the insulin-like growth factor-1-growth hormone axis—with the
up-regulation of reproductive endocrinology and to be able to look at those popu-
lation markers in relation to physical characteristics.
Dr. Martorell: I agree with your comment that we know least about growth in adolescence, and we need to do many more studies. I want to provide some data on children and adolescents of Mexican origin living in the USA. It is clear that before puberty, growth in length is very similar to that in the general population; if there are differences, they are very small, though there is more obesity in the Mexican–American population. In puberty, there is a dramatic change that fits the patterns of the Asian populations you were describing. Mexicans in the USA are of mixed Spanish/Indian ancestry, and it seems that puberty and menarche occur earlier; thus, peak height velocity is also earlier, and though they enter puberty at around the 50th centile, by the end of adolescence they are around the 25th centile. This information is based on cross-sectional data from national surveys, and we don’t have an environmental explanation for it.

Dr. Ulijaszek: The Mexican–American population was included in my descriptions, and it fits the pattern perfectly. The question is: Is the dominant ancestry the Indian one, which we believe to be of Asiatic origin, or the Spanish one? Or, maybe the two are equal in effect. We don’t know what happens when we have transitional populations with different characteristics, and this is increasingly the case in the USA. We cannot assume that the Mexican–American population now is the same as it was 20 years ago. There are likely to be very different social and cultural characteristics and different places of origin, and we don’t possess the environmental variables that will allow us to control for those factors adequately if we want to derive a statistical model to control for environmental variation. I know that some of the cities in the south of the USA are currently undergoing considerable demographic change with respect to these populations.

Dr. Lejarraga: Do you think the very important increase in communications and traveling that has taken place during the last century is resulting in a trend toward a more homogeneous genetic background?

Dr. Ulijaszek: People never become homogeneous. The USA is not a melting pot, and I imagine that Argentina is not a melting pot either apart from its dominant European population. Populations do not homogenize; in fact, like seeks like. People distinguish themselves by a range of cultural factors, among which language is the most important. Even though populations may migrate from South Asia to England, to Sweden, to the USA, Canada, and elsewhere, they still socialize among similar linguistic groups, and this is the first thing that will divide populations. When the day comes that there is one language that dominates all global cultures to the extent that everybody chooses this language as their first language, then you will start to move toward homogenization, but I can’t see that happening. What is happening is that in urban centers, marriage patterns are changing. In the UK, for example, some South Asians will still follow traditional marriage patterns, because this is what the parents want, but people are beginning to break out of the system. There are huge social disruptions involved in this, but I think traditional marriage patterns will persist, because people will continue to feel more comfortable among those who fit into the same environmental niche as them, speak the same language, share the same foods, and have some similar values. So, there are cultural systems that persist, and they persist because human populations are now forming transnational communities. For example, the South Asian person living in London may have family in East Africa or in India, Australia, Fiji, the USA, or Canada, all living in an urban environment and all in niches that are more similar to the niches that their relatives live in other countries.
than they are to the local population. We do not yet understand the way in which these transnational communities operate. But these new kinds of network mean that we are unlikely to achieve homogenization of populations.

Dr. Grummer-Strawn: I think you made a strong case that ethnicity is really not a good explanatory variable for differences in prepubertal growth, but I'm struck by how much variation there is from one population to another. There are tremendous differences in attained stature, and that leads me to wonder whether we have missed what the factor involved actually is. Unless the populations studied are extremely small and we are looking at random variation or problems in the way the samples were drawn, it seems that there really are great differences between population means in stature. That means there must be factors that describe the effect. I wonder if we should look further for what those factors might be. Do we need to be thinking more about midparental height or parental body mass indexes as explanatory variables of putting a child on the appropriate growth curve for that child, rather than the "one size fits all" kind of growth curves?

Dr. Ulijaszek: I think midparental height would be a good way to go; again, it would be a pragmatic operationalization of growth reference curves. It still would not explain why there is this great variation, but it would control for some of the biological/genetic variation. But even when we control midparental height, we are not controlling for genetics per se but genetic–environmental interaction. The fact is that the children are brought up in households where midparental height represents both the genetics and the environment. What we are saying in this epidemiological operationalization is that we are not interested in unraveling what is actually going on—we just want to be able to get the best fit. We are saying: This does not answer a fundamental question, but it controls for interactions at the household family level that we cannot get using other variables. Even when you control for everything else—energy intake, maternal and child health care, health services, environmental factors, politics, ideology, income distribution, gross domestic product, and so on—there are still residual differences that cannot be explained.

Dr. Grummer-Strawn: I think it is an interesting dilemma we are in of how to move from global perspectives down to individual perspectives, and going to midparental height takes us to the individual. We might want to think about whether there are things below ethnicity but before we get down to the family level. I don't know what those are.

Dr. Guesry: We discussed the difficulty of assessing ethnicity. Do you know anybody who is using genetic mapping to be more certain about the real origin of populations?

Dr. Ulijaszek: This is a huge research agenda. There is no one single marker that will tell you the true origin of a population. In fact, the more genetic markers people look at, the more variation is established, and the clearer it becomes to people like myself that ethnicity and race are cultural constructs inappropriate for use in the public health arena. We should be concerning ourselves with human biological variation and the factors that create it. If you look at one particular population marker that might explain human migration across Asia and into the Pacific, that says one thing. You look at another marker, it says something else. So, there are different explanatory routes. The answer is: Humans did not simply migrate out of Africa in a straightforward way. The time span we are talking about is extremely long, and the process was highly complex. There is no straightforward population marker that can tell you about ethnicity, in fact, what there are suggest that we are all extremely similar.
Dr. Stoltzfus: When you showed the scatterplots of stature for the different groupings that you used, it seemed that the main basis for your caveat over the Asiatic populations was two points that appeared particularly low. Can you tell us about those two points? If they are influencing our thinking so much, would it be reasonable to reconsider them—perhaps to go back and remeasure those populations?

Dr. Ulijaszek: One of those two points was the Hong Kong Chinese. That population has been remeasured, and they are getting bigger. Perhaps we should throw away those older data and not look at scatterplots for the older data for the Asiatic population. The problem is that we don’t have enough Asiatic populations to make a reasonable comparison, but the Hong Kong Chinese have certainly been getting bigger and the trend is continuing there among preschool children.

Dr. Frongillo: We should remember that the analyses presented here have told us about the variability in attained size, but when we consider public health and clinical uses of anthropometric information as growth references, it is the pattern over time that is most important. So, it is even more important for us to try to understand whether there are similarities in the way in which growth unfolds from one place to another and from one population to another. It is those judgments that make the most difference in terms of public health and clinical importance, not so much the attained size.

Dr. Gasser: I have a comment on the influence of age at peak height velocity. Age at peak height velocity is grossly equivalent to the total growth period, so it is plausible that early-maturing groups will lose some centiles. However, in our analysis of the Zurich longitudinal growth study, we found almost no correlation between age at peak height velocity and adult height. The early matures are roughly equivalent in adult size to the late matures. The early matures gain additional centimeters by a higher pubertal velocity. I find this biologically intriguing.

Dr. Ulijaszek: You are looking at within-population variation, and what I was comparing was between-population variation. I suspect that if we did the same within-population variation analyses in our Asiatic populations, we would find the same phenomena that you find in your data.

Dr. Adair: You based your discussion primarily on height, but I wonder what the picture might look like if you were to consider weight for height, particularly in light of the worldwide trend toward increasing obesity and a potential for different levels of overweight that might be associated with disease risk by ethnic background.

Dr. Ulijaszek: I did not do that analysis, and the straightforward answer is: I don’t know. But I can see complexities in trying to identify what an appropriate weight/height ratio might be, because the populations that we are interested in are transitional populations that haven’t plateaued with respect to a secular trend; thus, we might expect to find weight/height ratios that differ from those of reference European populations. Among the populations in transition that I am specifically looking at, we are finding great distortions across childhood. During the modernization period, which we can clearly define, we are finding a considerable increase in growth velocity and greater weight-for-height ratios, but as to what this means in terms of long-term health is usually problematic. Your paper presented at this meeting, stating the fact that we need to know about environmental effects on programming across the whole period and not just the later outcomes, is extremely pertinent (see Dr. Adair’s chapter in this book).
Dr. Uauy: We are all concerned with linear growth retardation, but what about countries where height norms are being exceeded? What outcomes would you wish to explore in such populations in terms of benefits or potentially adverse effects?

Dr. Ulijaszek: We tend to assume that maximal growth is optimal growth, which need not necessarily be true. We should really re-examine our Western populations and see how the growth patterns correlate with obesity and long-term disease risk. Growth reference standards need to be looked at in the context of optimal growth achievement, which may not be maximal growth achievement. Going for maximal growth may not be the answer for maximal health.

Dr. Uauy: In animals, maximum growth is also associated with complications in terms of chronic diseases and degenerative diseases. Obviously, we need to redefine the concept of optimal in the light of nutrition throughout the life cycle.

Dr. Ulijaszek: I totally agree. To make a ridiculous comparison with animal studies, if we want to live longer, the answer is simple: Live in a disease-free environment and semistarve ourselves for the whole of our life. It's not a very pleasant idea!