Proposal of a West-High–East-Low Hypothetical Theory forthe Longitudinal Distribution of Global Height

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1. Abstract

In this study, we seek to propose a hypothetical theory of western high-east low and the K&F theory (Kani and Fujii theory), similar to Bergmann's law of north-high and south-low for height, as laws based on latitude and longitude with regard to the trends in global height distribution. Judging from the changes in height over the 100-year span from 1870 to 1970, a composition was suggested in which, taking the European region as the center, height was clearly higher in the west and lower in the east with eastward movement. In other words, it was speculated that diversity decreased as people moved east, leading to slower economic development, lower wealth, and shorter stature. Therefore, we can hypothesize a west-high, east-low composition in the height distribution over longitude. Here, we propose the K&F theory (Kani and Fujii theory) to explain the hypothetical theory of west-high, east-low.

2. Introduction

In recent years, in developed countries, it seems as if the height has almost reached its end, and the final height seems to have come to an end. In countries where economic development has not progressed in Africa and Asia, adult height may increase in the future. However, the phenomenon from this increase in height to its end is unclear. Many things remain unexplained, such as why height has increased over time, how far height will increase, and how many centimeters tall the first humans were. At minimum, we have a crude understanding of how heights have trended since civilization was first built. We can even look at height in Japan from human bones excavated there. Figure 3 shows heights estimated by Hiramoto [1] from human bones excavated from the Jomon period to the present, and Figure 4 shows a graph of the historical trends in height that makes this easy to understand. According to Hiramoto [1], height was 159 cm in the Jomon period and 163.06 cm in the Kofun period. It was then 157–158 in the Kamakura, Muromachi, and Edo periods, and fell to its lowest point of 155 cm in the early modern years. From that time, it increased rapidly to 172 cm at present. Thus, as the Yamato race of Mongoloids, the historical trends in height reached their lowest point at 155 cm. In the Caucasoids of Europe, the minimum height was probably 160–165 cm.If the shortest height is understood, in this study we may be able to explore the end of height today by estimating the upper limit of how much height can increase after the lowest point. Around the time humans began building culture, as mentioned in the previous section, male height during the Jomon period in Japan was 159 cm and female height was 148 cm [1]. In the West, there is little comparable data for the period before Christ, but according to Parker [2] the average human height in ancient Greece was about 164 cm for men and 155 cm for women. However, there is no unequivocal evidence. In any event, viewed from the history of human evolution, there has been little change in homo sapiens and there are some scholars who say that

even if the average height increased by about 15 cm over 3,500 years, it is not a significant difference (Rene and Ralph, [3]. Even if not a significant difference in terms of the theory of evolution, there are obvious differences in height among humans around the world by region and race. Can the mechanisms for this be explained only by racial and ethnic differences.In recent years the concept of human race has come to be questioned. In the words of Takezawa [4], race is a system that was constructed based on social factors, and many people suggest that it does not in fact exist. Originally, the concept of race stemmed from the five classifications of the German physician Johann Friedrich Blumenbach (May 11, 1752– January 22, 1840) based on a comparative study of human skull bones: Caucasian (white race), Mongolian (yellow race), Ethiopian (black race), American (red race), and Malayan (brown race). Today, the four categories of Caucasoid, Negroid, Mongoloid, and Australoid are more commonly held. However, as indicated by Shinoda [5], if modern humans, that is, homo sapiens, are considered to be a single race physiologically, the concept of race that has been shown up to this time collapses. When human evolution is examined from genome analysis with the development of genetics research in recent years, the differences between geographic groups at the gene level are much smaller than the individual differences within groups. Nor can strict classifications be made in gene frequency data. Hence, no further divisions can be made in the species of homo sapiens. While a distinction can be made with Neanderthals and other early humans, scientific divisions cannot be made among homo sapiens. Notably, until recently it was thought that homo sapiens and Neanderthals, considered a separate species, could not interbreed, but in fact evidence of that interbreeding is found from genetics research.Dividing homo sapiens physiologically (anthropologically) seems to have already lost its scientific significance. However, given that height differences obviously exist in the global height distribution, no other methods to explain these regional differences are apparent when the concepts of race and ethnicity are eliminated. In fact, from an anthropological standpoint, there is discussion of the relationship between regional differences and the processes by which races were established. That is, when homo sapiens, born in Africa, spread to all parts of the world in the process of evolution, regional groups adapted to their respective natural environments and experienced some degree of isolation over long periods. The concept of human race that had been accepted until recent years was established as a result these geographical variations in physical traits. With this kind of explanation, it would seem that regional differences in the world could decide height distribution even without considering race.Location on earth is determined by latitude and longitude, and so we hypothesized that height distribution by region may be able to be explained from latitude and longitude. In fact, there is a history of using Bergmann's rule [6] for convenience in the habitat distribution of mammals in latitudinal north and south. Fujii [7] reported findings from applying this theory to the height distribution in Europe. An important point in those findings is that

there is a drawback in looking height distribution at a given point in time; namely, that without considering the changes over time with economic development the height distribution will differ. To eliminate this bias, the wavelet interpolation model was applied and an annual span evaluation chart for height was constructed. This evaluation was performed and showed a "north-high," "south-low" trend. Kani et al. [8], using a similar method, showed a "north-high," "south-low" in height distribution in the southern and northern areas of the Japanese archipelago. Therefore, with regard to the regional differences in height distribution by latitude, Bergmann's rule may be applied for convenience.Galor [9] suggested that a certain level of human diversity may contribute to modern economic growth. He then implied that this may be a source of disparity in modern humans, and concluded that this diversity is proportional to the distance on earth that homo sapiens, the roots of humankind, moved away from Africa. On the phenomenon of human diversity, Harpending [10] reflected the "continuous founder effect" and explained that with repeated moves from one place to the next, diversity inevitably decreased the farther from Africa that human populations moved and settled, and the further away from Africa humans were, the more the diversity in the culture, language, behavior, and physical traits of societies decreased. Applying the theory of Galor [9] to longitudinal height distribution, we hypothesized that, taking the European region as the center, height becomes shorter with longitudinal movement eastward. Thus, diversity decreases with eastward movement longitudinally, and decreased diversity is thought to delay economic development and decrease wealth. Findings on the relationship between wealth and height have been reported Fujii [7].Therefore, the hypothesis of west-high–east-low is conjectured to hold for longitudinal height distribution. In this study, we constructed an annual span evaluation chart by applying the wavelet interpolation method to height in 47 countries from 1870 to 1970 from statistical results by the OECD [11] to see whether this hypothesis is valid. Then, by fitting the trends over time for mean height in each country to this chart, we evaluated actual height and investigated whether a height composition of west-high–east-low could be hypothesized when judging the height distribution of countries located longitudinally when moving east with the European region as the center.

3. Methods

3.1. Subjects

Data on the height trends over time from 1760 to 1980 were obtained from the statistical results of the Organization for Economic Cooperation and Development (OECD). From this data we limited the time period from 1870 to 1970, and used the data on average height for males from 47 countries, which were nearly complete. The global regions were 14 countries in Africa, 14 countries in Europe, 13 countries in Asia, and 6 countries in the Americas. Table 1 shows the average height values for 47 countries as of the year 1970.

3.2. Wavelet Interpolation Model

The theoretical background for the wavelet interpolation model (WIM) and its efficacy have been discussed in previous studies by Fujii [12-14]. Characteristics of the wavelet interpolation model are that local phenomena can be read sensitively and that it has a very high

Table 1: The average height values for 47 countries as of the year 1970.

Argentina	171.2	Germany	179.4	Niger	171.4
Brazil	171.6	Ghana	169.9	Nigeria	169.7
Burkina	172.8	Greece	177.5	Norway	179.5
Cambodia	162.7	Guinea	169.7	Poland	176.4
Cameroon	171.6	India	164.3	Portugal	171.4
Canada	178.8	Indonesia	163.1	Russia	177.0
Chad	173.8	Iran	170.9	Senegal	174.7
China	170.0	Ireland	176.4	Spain	175.2
Colombia	168.9	Italy	174.1	Sweden	180.0
Congo	169.0	Japan	166.8	Tanzania	167.8
Côte d'Ivoire	171.2	Laos	163.1	Thailand	168.5
Czech Republic	178.7	Malaysia	165.5	Turkey	168.6
Egypt	171.2	Mali	172.5	United Kingdom	177.1
Ethiopia	167.5	Mexico	167.1	United States of America	178.3
Finland	177.5	Myanmar	161.8	VietNam	160.7
France	175.1	Netherlands	182.3		(cm)

approximation accuracy. To achieve this, interpolation between data is done with a wavelet function and growth distance curves are drawn. These distance curves are then differentiated to derive growth velocity curves. Next, from the derived growth velocity curves, local peaks and the growth distance and growth distance velocity at the time of the local peaks are investigated.

3.3. Analysis Procedures

1) The wavelet interpolation model was applied to the average height data in 10-year time blocks from 1870 to 1970, and a curve of the change in height over time was derived.

2) The wavelet interpolation model was applied to the mean height ± 0.5 standard deviation (SD) and ±1.5 SD, and an annual span evaluation chart was constructed based on the changes over time in height.

3) The data for average height over time for each country in the same year were fit to the chart and the actual status was evaluated.

Hypothetical theory of west-high–east-low in height distributionGalor [9] theorized that diversity decreases in proportion to the distance on the earth that homo sapiens, the origins of humankind, moved away from Africa. Applying this theory to the height distribution on earth, a hypothesis can be constructed that, with Europe at the center, height decreases with eastward movement longitudinally. This means that diversity may also decrease with eastward movement longitudinally, and decreased diversity is thought to delay economic development and decrease wealth. Findings on the relationship between wealth and height have been shown by Fujii [7], and a west-high–east-low hypothesis has been proposed in which, judging from the earth's longitude, regional humans in locations relatively eastward have shorter heights while those located in the west have taller heights.
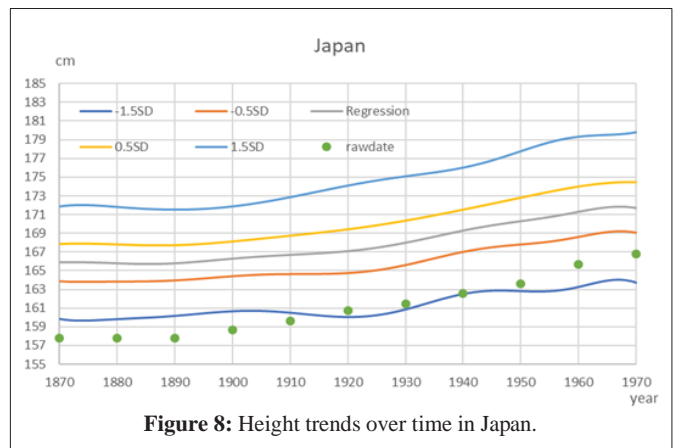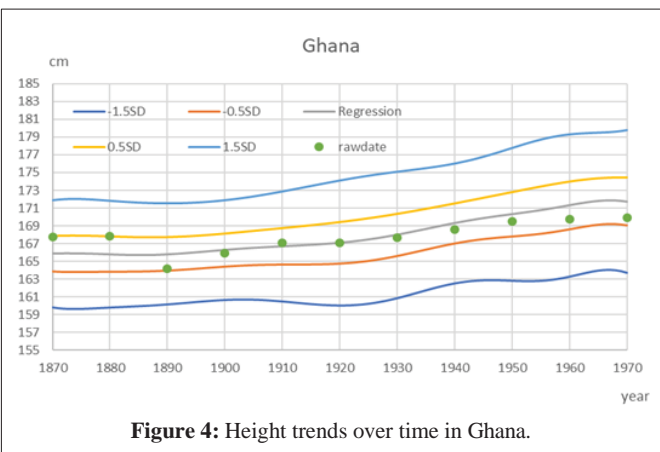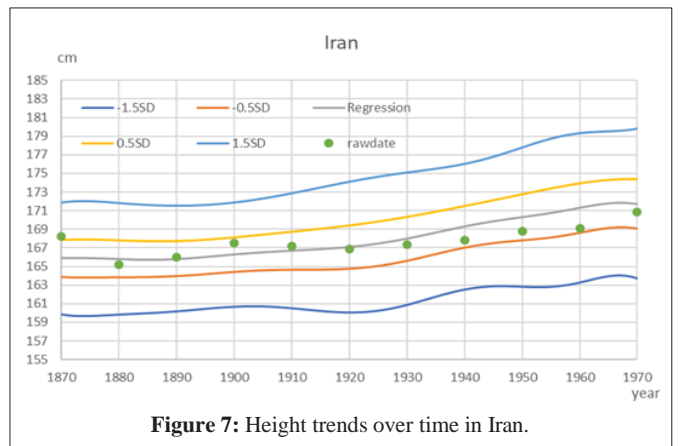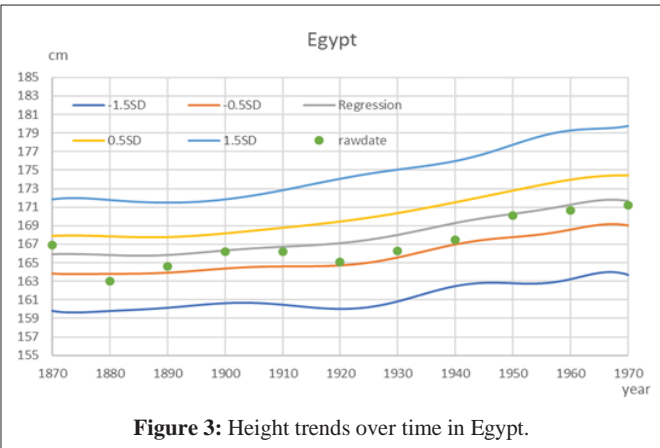
4. Results

4.1. Construction of Annual Span Evaluation Chart for Height

The wavelet interpolation model was applied to data for average height from 1870 to 1970 in 10-year blocks. Figure 1 is an annual span evaluation chart for height constructed by applying the wavelet interpolation model to mean values and the mean ± 0.5 SD and ± 1.5 SD for each year. In the established values for the evaluation strata, the mean val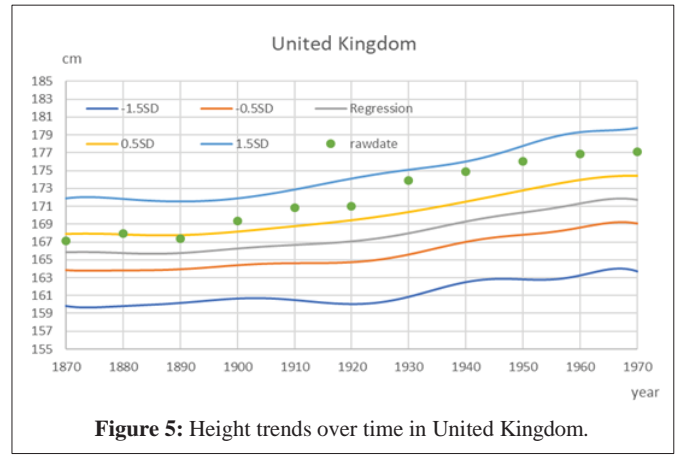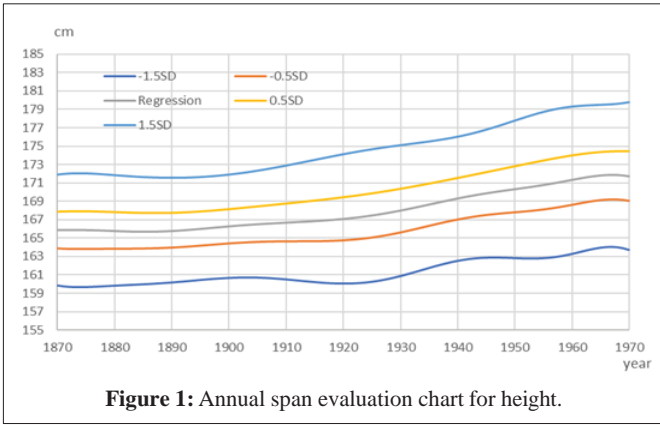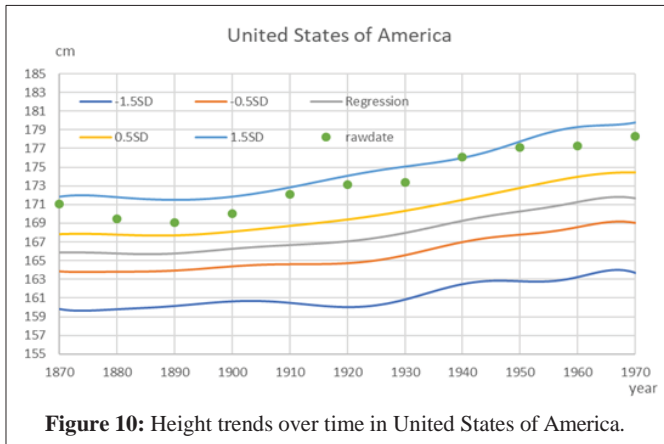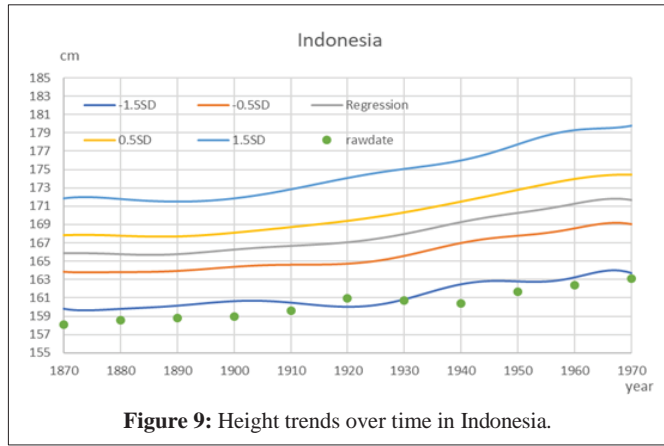ue + >1.5 SD was "tall," mean + 0.5 SD to mean + 1.5 SD was "somewhat tall," mean − 0.5 SD to mean + 0.5 SD was "standard," mean − 0.5 SD to mean − 1.5 SD was "somewhat short," and mean − <1.5 SD was "short." If the trends in height over time from 1870 to 1970 on this annual span evaluation chart were constant, movement would be located within an average movement range over time, but if economic conditions differ depending on the region, a behavior would probably be shown in which the location of the evaluation range differs with the trends in height over time. It was then possible to evaluate differences in height and a west-high–east-low hypothesis, the purpose of this study, was proposed.

4.2. Evaluation of longitudinal Height Distribution with the Annual Span Evaluation Chart

Fitting the mean height data every 10 years for all 47 countries to the annual span evaluation chart for height from 1870 to 1970 as in Figure 2, we investigated how things changed. Reviewing the basic changes in height distribution by longitude, we decided to place Europe at the center. First, as shown in Figures 5 and 6, the trends in height over time in the western and central European countries of England and Germany trended in the same evaluation range after moving from the standard to somewhat tall levels. The southern European countries of Portugal, Spain and Italy trended mostly in the standard range, but in other countries there was in most cases movement in the same evaluation range after moving from the standard to somewhat tall levels or from the somewhat tall to tall levels. Next, Figures 7–9 show the height trends over time in the Asian countries of Iran (west Asia), Japan (east Asia), and Indonesia (southeast Asia). With the exceptions of Turkey and China, Iran trended in the standard range, while Japan and Indonesia trended in the somewhat short and short levels. Figure 10 shows the trends in height over time in the United States (North America) and Brazil (South America) in the Americas. The North American countries of the USA and Canada trended at the somewhat tall level. Mexico trended in the somewhat short level. The South American

Figure 1: Annual span evaluation chart for height.

Figure 2: Average height data for every 10 years to be applied to the annual span evaluation chart.

Figure 3: Height trends over time in Egypt.

Figure 4: Height trends over time in Ghana.

Figure 5: Height trends over time in United Kingdom.

Figure 6: Height trends over time in Germany.

Figure 7: Height trends over time in Iran.

Figure 8: Height trends over time in Japan.

Figure 9: Height trends over time in Indonesia.

Figure 10: Height trends over time in United States of America.

countries of Brazil and Argentina trended in the standard range. Columbia trended in the somewhat low level. Finally, in Figures 3 and 4, the trends in height over time in the two African countries of Egypt and Ghana both trended in the standard band. Ethiopia, Congo, and Tanzania were at the somewhat short level in some years but mostly trended in the standard range. Therefore, when Europe is taken as the center, it was shown that countries located greater distances eastward from Africa tended to be at the "somewhat short" and "short" levels.

5. Discussion

The findings of Fujii [7] and Kani et al. [8], who explained the height distribution trends in Europe and the height distribution in the Japanese archipelago with Bergmann's rule for convenience, are useful in that the bias from the generational shifts in economic development could be excluded. That is because they were able to establish an annual span evaluation chart for height that was constructed with the wavelet interpolation model. It has been said that for some time that, within the scope of races or ethnicities that are nearly the same, the increasing or decreasing trends in height differences in those regions could be understood by excluding the bias of economic development. Based on this, in the present study we clarified the increasing or decreasing trends in height differences based on region from the application of the annual span evaluation chart for height.That is because the diversity and economic growth of countries in those regions can be understood from height differences. As mentioned previously, until recent years the concept of race was established as a result of regional variations in physical traits as regional populations adapted to their respective natural environments and experienced some degree of isolation over long periods as homo sapiens, who arose in Africa, spread to all regions of the world in the process of evolution. With such an explanation, it would seem that regional differences in the world could determine height distribution even without considering race. If each region is investigated based on this, with Africa and Europe considered to be the main axis longitudinally, first, many countries in Europe tend to be "somewhat tall" or "tall." Next, in Asia, western Asia is judged to be "standard" and East and Southeast Asia to be "somewhat short" or "short." In the Americas, trends are shown at the "somewhat tall" level in North America and the "standard" level in South America. In Africa on the main axis, there are countries that

tend to be at the "somewhat tall" level, but most countries tend to move within the "standard" range. That is, countries located at distances further eastward with Europe as the center are shown to trend at the "somewhat short" or "short" levels, suggesting a west-high–east-low composition longitudinally. However, Africa is south of Europe by latitude, and applying Bergmann's rule it would be shorter than Europe. The height distribution in Africa is also probably affected by economic development. However, human diversity contributes to economic growth, and regardless of the relationship between economic growth and the human body, in Africa, where humankind arose, no characteristic trends in economic growth and the body like those in Europe were shown. As factors for this, Galor [9] indicated the possibility that diversity in society gives rise to opposing forces and has an opposing effect on the development of society. The hurdles to growth in Africa, which has among the highest diversity on earth, may be attributable to the negative effects of ethnic diversity on social unity. He also concluded that in moderation diversity promotes prosperity. With regard to secular trends in height, Malina [15] showed three aspects: positive, negative, and absent. Japan shows a positive trend, but parts of Africa and Mexico show negative or absent trends in some cases, and it is conjectured that negative trends are shown as a result of poor living conditions, illness, infectious disease, and the like. That few countries in Africa trend at the "somewhat short" or "short" levels may suggest the possibility that genetic factors affect the human resource of height.Next, questions remain about the "somewhat tall" trend in the USA and Canada in North America. However, Fujita [16] stated that American Indians, the indigenous peoples in the Americas, are the ancestors of people who crossed over from the Asian continent via the Bering Straits when it was connected by land during the last ice age, and have the characteristics of Mongoloids. Tomita [17] wrote that, starting with immigrants from England in 1607, Dutch people and Africans (Black people) who were sent as slaves came to the Americas. Around 1775, when the American war of independence started, the total population in the thirteen colonies in North America was about 2.5 million people. Among them, the Black population was a little more than 500,000 people, or about 20 percent. Including White people, there are thought to have been about 1.5 million immigrants, and with this historical background it can be explained that in North America a height distribution with characteristics similar to that in Europe was shown. In any event, similar to the north-high–south-low trend, which is Bergmann's rule, a west high-east low composition may be hypothesized in the longitudinal height distribution.It may therefore be possible to propose a west-high–east-low composition in height distribution as a new hypothetical theory that can explain the height distribution of homo sapiens on the earth. If Bergmann's rule of north-high–south-low in latitude is fit to this hypothetical theory, the regional height distribution on earth may be covered with the Bergmann rule of north-high–south-low and the west-high–east-low theory (Kani and Fujii theory; K&F theory).

6. Conclusion

This study explored whether certain rules exists in accordance with latitude and longitude in relation to trends in global height distribution. Those rules are Bergmann's rule of north-high–south-low and the hypothetical theory of west-high–east-low (Kani and Fujii theory; K&F theory). Here we specifically propose the hypothetical theory of the K&F theory. First, an annual span evaluation chart for height in 47 countries from 1870 to 1970 was constructed. The data for average height over time were then fit to that chart for each country, and by evaluating the actual situation it was possible to determine height differences due to human diversity and longitude by region. Judging from the changes in height over a span of 100 years from 1870 to 1970 with this method, a height composition of west-high–east-low was clearly suggested with eastward movement when Europe was taken as the center. That is, diversity declines with movement eastward and it is conjectured that when diversity is low economic growth tends to be delayed, wealth to be lower, and height to be shorter. Moreover, this study was conducted not for a single geographical point but rather was judged from the trends over a period of 100 years, and so the bias of human economic development is likely to have been excluded. Thus, like Bergmann's rule of the north-south relation by latitude, in longitudinal height distribution a composition of west-high–east-low can probably be hypothesized. Therefore, the regional height distribution on the earth can be covered by Bergmann's rule of north-

high–south-low and the Kani and Fujii theory (K&F theory) of west-high–east-low.

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