The Journal
of the Historical Society

James B. Lewis, Seong Ho Jun,
and Daniel Schwekendiek*

Toward an Anthropometric History of Chosŏn Dynasty Korea, Sixteenth to Eighteenth Century

Introduction

Mean height is an indicator of biological living standards as it reflects the quantity and quality of food consumed minus energy requirements used to fight disease and to maintain bodily functions (Coll, 1998). Particularly, economic historians have turned to height as a reliable indicator of socioeconomic development in the past (Fogel, 2004; Komlos, 1994; Komlos

*James Lewis would like to thank the Academy of Korean Studies for a three-month Senior Fellowship (July to October 2012) that allowed him the time to gather data and confer with his colleagues. Daniel Schwekendiek is supported by the National Research Foundation of Korea (NRF-2007–361-AL0014). Further thanks to Mr. Yi Tong'in, doctoral candidate at the Academy of Korean Studies, and Dr. Yi Myŏng-hŭi as well as Ms. Jun Mingoo for their assistance in data entry. Our final thanks go to Dr. Kim Sŏng-kap, Curator, the Land Museum; Ms. Kim Song-hye, Vice-Director of the Korea Army Museum; Professors Yi Hyŏn-su and Kim Ki-hun of the Korea Military Academy; Mr. Kim Chae-kyun, Director, and Ms. Pak Hyŏn-suk, Curator, The Museum of Agriculture; Mr. Yi Kŏn-uk, Curator, The National Folk Museum of Korea; and Dr. Lee In-Hwa, Curator, The Museum of Korean Weights and Measures.

Editor's note: For this article, the editor has decided to retain the authors' parenthetical citations rather than convert them to footnotes.

Corresponding author: Daniel Schwekendiek, Academy of East Asian Studies, Sungkyunkwan University, 53 Myeongnyun-Dong 3-Ga, Jongnu-Gu, Seoul 110–745, Republic of Korea, E-mail: danjosch@skku.edu

and Baten, 1998; Steckel, 2009). This is because demographic or other socioeconomic data are difficult to estimate or hard to find for pre-modern times, whereas many height measurements survived over the centuries. In Western Europe and North America, the most common historical sources used for this purpose were military rosters (Baten, 1999; Floud et al., 2011; Haines, 1998; Komlos, 1987; Schoch et al., 2012; Schuster, 2005), because conscripts were routinely measured during recruitment.

While previous studies focused on height of recruits in Europe and North America, there are no anthropometric studies in English on the pre-1900 military in Korea. There are previous studies on pre-modern anthropometry of recruits published in Korean, but these have mostly just introduced data sources or focused on methodological issues (Chŏng, 1994; Im, 2010; Kim U-ch'ŏl, 2000 and 2006; Kim Sŏng-kap, 2007; Yi, 1993; Cho, 2012). Several studies have elaborated on Korean biological living standards in modern times, including North Korea (Pak, 2004; Pak et al., 2011; Schwekendiek and Pak, 2009), South Korea (Schwekendiek and Jun, 2010), and Colonial Korea (Choi and Schwekendiek, 2009; Gill, 1998; Kim and Park, 2011), but there is a dearth of anthropometric studies on Koreans living prior to the nineteenth century. A recent osteometric study assessed the stature of pre-modern Koreans using data from tomb excavations (Shin, et al., 2012). As an osteometric study, height was not measured from living humans but estimated from skeletons, notably from long bone measurements, by using various model assumptions. The mean height of males was reported to be 161.1 cm for the entire observed period. However, sample sizes were low, with sixty-seven males for a 500-year period. Because there was no biographical information, Shin et al. (2012) were also unable to determine the birth century. Shin et al. (2012) argue that their study is the first to report on pre-modern changes in Korean stature. They apparently took no notice of Chosŏn-period military records as a reliable and systematic source of data.

The present paper has three objectives. Firstly, we introduce anthropometric data from available military rosters of pre-modern Koreans of the Chosŏn Dynasty (1392–1910). We show that basically two kinds of military records survived, data from the militia and the regular army. Secondly, this

paper addresses relevant methodological issues, including most importantly the conversion of Korean height units into common centimeters. Conversion is of paramount relevance for research as previous inquiries have been inconclusive or did not address conversion in a convincing fashion. Thirdly, focusing on the height of male militia recruits and applying our new conversion method, we show anthropometric trends in Chosŏn Dynasty Korea so as to explore how biological living standards have developed in pre-modern times.

Data

Like most historians, we are at the mercy of whatever written sources survived over the centuries. We do not know exactly why these military rosters (Table 1), which we could retrieve for this study, survived. Perhaps it is a matter of mere chance. We presume that there must have been more military rosters that were destroyed, the paper recycled, or that were simply lost and await discovery. We only have fragmentary information on the background of the respective military rosters. Therefore, we have excluded from our analysis all inconsistent sources, although we hope to include them in future research (Table 1). Our reasons for exclusion are inconsistency of recording, which will be elaborated on below.

The military rosters of the years 1679, 1697, 1751, 1770, and 1798 record ages and heights (Table 1), but each individual was apparently recorded in a different year prior to the years on the covers, and all information was brought together in one volume in the year written on the cover. Therefore, the cover year cannot be taken as the recording year and then birth years calculated backwards from the cover year. This is similar to the French army at that time, where the year reflected the date in which the standing of the regiment was recorded even if the recruits had entered earlier (Komlos et al., 2003: 161). Furthermore, although the 1679, 1697, and 1798 rosters indicate the actual recording year in one way (*ip* 入 "entered"), the 1751 and 1770 data indicate the actual recording year in another way (*ch'o* 抄 "selected," probably from those who had "entered"). Therefore, we have excluded the 1751 and 1770 data but will address them in a future study. Moreover, the 1770 data record a high proportion of persons under twenty

Table 1: Retrieved Military Rosters of the Chosŏn Dynasty

Year of Published Report	Place of Measure	Contemporary Location on the Korean Peninsula	Target Group (marker)	Valid Sample Size	Age Range in Years	Recorded Height Measurements	Data Analyzed in this Research
1596	P'yŏng'an-do (平安道)	Pyŏng'an Province, Northwest	Militia (no marker)	548	10 to 55	Full *ch'ŏk* units with decimals	Yes
1679	Ch'ungch'ŏng-do (忠淸道)	Ch'ungch'ŏng Province, Central-West	Militia (*ip* 入)	579	11 to 59	Half *ch'ŏk* units with decimals	Yes
1685	Cheju (濟州)	Cheju Island, island in the Southwest	Militia (no marker)	1437	13 to 57	Half *ch'ŏk* units with decimals	Yes
1697	Ch'ungch'ŏng-do (忠淸道)	Ch'ungch'ŏng Province, Central-West	Militia (*ip*入)	1504	8 to 67	Half *ch'ŏk* units with decimals	Yes
1728	Ch'ungch'ŏng-do (忠淸道)	Ch'ungch'ŏng Province, Central-West	Militia (no marker)	188	13 to 57	Half *ch'ŏk* units with decimals	Yes
1751	Hadong County (河東, 慶尙道)	Kyŏngsang Province, Southeast	Militia (*ch'o* 抄)	91	9 to 53	Half *ch'ŏk* units without decimals	No (*ch'ŏk* without decimals)

(Continued)

Table 1: Continued

Year of Published Report	Place of Measure	Contemporary Location on the Korean Peninsula	Target Group (marker)	Valid Sample Size	Age Range in Years	Recorded Height Measurements	Data Analyzed in this Research
1770	Ulsan County (蔚山, 慶尙道)	Kyŏngsang Province, Southeast	Militia (*ch'o* 抄)	n/a	n/a	Half *ch'ŏk* units without decimals	No (*ch'ŏk* without decimals)
1798	Hadong County (河東, 慶尙道)	Kyŏngsang Province, Southeast	Militia (*ip*入)	215	21 to 60	Half *ch'ŏk* units without decimals	No (*ch'ŏk* without decimals)
1875–1908	Ch'ungch'ŏng-do (忠淸道)	Ch'ungch'ŏng Province, Central-West	Regular army (no marker)	n/a	n/a	Half *ch'ŏk* units without decimals	No (*ch'ŏk* without decimals, minimum height requirements)

(Sources: 1596: *Chin'gwan kwanbyŏng yongmo ch'aek*; see also *Chin'gwan kwanbyŏng p'yŏn'o ch'aek chan'gwŏn 1, 2*; 1679: *Sukjong-dae Ch'ungch'ŏng-do sogo kunjŏk*; 1685: *Cheju sogo kunjŏkbu*; 1697: *Sukjong-dae Ch'ungch'ŏng-do sogo kunjŏk*; 1728: *Sukjong-dae Ch'ungch'ŏng-do sogo kunjŏk*; 1751: *Hadong-bu yukkun yang'in pyŏngbo imsul [1742] an chŏnsŏ kyŏng'o [1750] nyŏn kaean*; 1770: *Kyŏngsang-do Ulsan-bu yukkun chesaek kyŏng'in kae toan*; 1798: *Hadong-bu sogo kunbyŏng poin muo-nyŏn kae-toan*; 1875–1908: *Yukkun pangmulgwan sojang kunjŏk munsŏ*.)

Notes: See text for explanations.

years old and this also necessitates a further careful study of the peculiarities of the 1770 data. For example, the most commonly reported age was 15 and the average age was 22. The 1596, 1685, 1728, and 1875–1908 data have no indicator, suggesting that the cover year was the year of recording.

A further complexity is the increasing dominance from 1728 onwards of (Confucian) social concerns that prioritize father's name and social status over accurate measurement. Social concerns are clear from the retention of most other information (e.g., name, age, un-free or free, etc.) but the disappearance of bodily descriptions and, most importantly, the disappearance of decimals (called *ch'on*, with 10 *ch'on* equaling 1 *ch'ŏk*) in Korean height units (*ch'ŏk*) and the rounding that occurs (Table 1). Social concerns also become prominent in the 1751, 1770, and 1798 data as indicated by the names of stand-ins who served on behalf of the registered recruit and by the names of others who were assistants or servants. The use of stand-ins or proxies introduces a degree of selection and lowers the randomness of the sample, which we cannot yet control. We will use these entries in future research because we have not recorded those data yet. Furthermore, the 1798 data show an odd degree of consistency (Table 1): there is no variation in height measurements—all are exactly the same at 4 *ch'ŏk* (尺)—and although the document records facial appearance, none of those registered have any smallpox or measles scars (all are *ch'ŏl* 鐵 or clear), a possible but unlikely circumstance. Another anomaly is the advanced age of many of those registered in 1798. The average age of all soldiers recorded in other data is around 31 or 32, but the average age of the entries in 1798 is 47, which likewise hints at severe selection issues that we cannot explain. Finally, we have excluded the 1875–1908 data, because the data are not on militias but on the regular army. There were minimum height requirements for the regular army (see below), which, in turn, introduces the likelihood of serious truncation of the height distribution. In contrast, there were no known minimum height requirements for the militia, whose data we primarily employ herein. We have not entered the data of the army yet, but hope to use them in the future in a separate research paper. More importantly, height of the regular army was not reported in decimals, making statistical analysis meaningless (Table 1). In sum, we have excluded problematic data sets,

because their thorough treatment would lengthen the present paper too much.

The quality of the data we do use is probably reliable. There are two reasons for our assertion. The first reason relates to recruitment. Society was divided into three gross divisions: aristocratic elite (*yangban*), commoners (*sangmin*), and un-free laborers (*nobi*, often translated as "slave") in descending social rank. The size of each class is still a matter of debate, but the number of elites in the seventeenth and eighteenth centuries may not have been more than 5 percent of the entire population (probably less), and they were not conscripted. The size of the un-free labor class has been estimated at 30 percent of the population at the upper end, but this is controversial (Palais, 1995). The remainder of the population (estimated at 65 percent or more) was commoners. Military service was an aspect of taxation for commoners. The soldiers in the rosters examined here were commoners and un-free labor and were recruited as local militias (*sog'ogun* 束伍軍) to complement the regular, central army. The inclusion of un-free labor was an innovation that came out of necessity during the Japanese invasion known as the Imjin War (1592–1598), and our data from 1596 represent some of the earliest of these new local militia rosters. The regular army's role was to protect the king and the militias were drawn locally to meet invading forces (Kim, *Chosŏn hugi*, 2000: 10). While the regular army was selected (i.e., maintained a minimum height requirment) to be a standing army, the militias were marshaled as needed, so a roster of names was required in preparation for a crisis. Because they were conscripted, and because they were taken from among commoners and un-free labor, and because our selected data sources do not indicate the service of proxies, the conscripts in our rosters can be said to be a good representative sample of the middle and lower social strata of the male population, or about 95 percent of the population. Note that in order to further investigate social selectivity, our future research will make use of age-heaping methods (Crayen and Baten, 2010).

The second reason supporting the quality of the rosters is deduced from the type of data recorded. Beginning with our earliest data from 1596, and over the seventeenth century, the sources offer actual assessments of body height and general health (e.g., facial appearance to assess the presence of

and severity of smallpox and measles scars and to assess general health). By the early 1700s, the focus of the records had shifted from physical prowess to social status. The 1728 data, the last data set we use in our main analysis, offer little information on height, but the heights are still recorded in decimals (*ch'on*), indicating some concern with precision. The concern with accuracy may have been a result of the Musin Rebellion that occurred in that year (Jackson, 2011). However, the relative lack of interest in body information in the data from 1728 onwards indicates that there was less and less concern with actual military preparation. The change must reflect the general peace that had been maintained from the 1640s onwards. In other words, "accuracy" of the record shifted from the soldier's body to his social status by the eighteenth century, meaning that height inquiries become complicated thereafter due to rounding and more frequent omission of anthropometric data. Additionally, children were extensively recorded in the 1770 register, not because they would be immediately called up but because the names of all boys were recorded in anticipation of their maturity.

A comparison of all data sources retrieved from the Chosŏn Dynasty is given in Table 1. We used the militia rosters from the late sixteenth century to the early to mid-eighteenth century for five reasons: 1) their large sample sizes; 2) the fact that they carry a low selection bias; 3) their availability over several periods, and because they possess major methodological advantages such as 4) the lack of minimum height requirements, and 5) stature was reported in decimals (*ch'on*). On the negative side, this implies that we cannot observe the late eighteenth and early nineteenth centuries with military rosters, when non-decimal height stemming from heterogeneous sources become more often available, including data from the regular army (Table 1). Fortunately, the stature of Korean men coming from various social strata and being born in various provinces throughout the late nineteenth century was measured during Japanese colonial occupation (1910–1945). These height trends, based on political prisoners, were recently reported in Choi and Schwekendiek (2009), and allow us, at least, to compare the data used here with the height trend of the second half of the nineteenth century.

The military rosters examined below offer information on male recruits stemming from three regions of Korea (Table 1): the northwest, the

central-west, and an island in the southwest. Note that reported sample sizes refer to entries where we found both the height (with or without decimals) and the age recorded. If one or two of the variables were not reported, we declared the entry as invalid and did not record it. Our final sample sizes range from 188 to 1,504 recruits (Table 1). The 1596 roster (N = 548) is from P'yŏng'an Province in the north, and in 1596 P'yŏng'an Province stretched from around P'yŏngyang city northwards to the Chinese border in the northwest at the Yalu River. The 1685 roster (N = 1437) is from Cheju Island off the southern coast. The 1679 (N = 579), 1697 (N = 1504), and 1728 (N = 188) rosters are all from Ch'ungch'ŏng Province, which is located in the central region, north of Chŏlla Province to the southwest and Kyŏngsang Province to the southeast. Ch'ungch'ŏng Province lies to the south of the capital province of Kyŏnggi, where modern-day Seoul, which was also the capital of the Chosŏn Kingdom, is located. We here limit ourselves to showing the national anthropometric trend by pooling all local data. Future research will probably have to control for provincial differences using multivariate analysis.

To cross-check our anthropometric trends, we employed population data as a supplementary indicator of biological living standards. Censuses were taken for taxation and therefore only taxable individuals were initially counted, but after 1894, all people were included. Therefore, annual total population prior to 1894 was re-estimated from the censuses as previously reported in Kwŏn and Sin (1977) and Jun et al. (2008). Applying Malthusian logic, we hypothesize that improving living conditions resulted in both an increase in population size and average height, while macroeconomic shocks such as famines, wars, natural disasters, epidemics, and the like led to a noticeable reduction of mean height and population size.

METHODS

Converting Korean age to common age

None of the data sets used herein carries information on the exact date of birth. Instead, the age in years at the time when the recruits were measured was recorded. However, unlike Chinese or Japanese who are now using

Western ages, Korean age is still assessed using the traditional East Asian system and differs from standard age classifications recently introduced from the West. When considering Korean age, two points must be kept in mind. Firstly, Korean age includes gestation as the first year of life, so newborns are by default 1 year old at birth whereas they are 0 years old at birth in the West. Secondly, Koreans numerically advance in age with the lunar new year (and these days with the common solar new year), and not with their birth anniversary as is common in the West. For illustration, a baby born in June and measured in the next month will be 1 year old in Korea but only 0 years old (or about 1 month old) in the West. However, when measured in May of the next year, the newborn will already be two years old in Korea. This is because May is after the lunar new year, which falls somewhere within the first quarter of the solar calendar. The Korean newborn's Western peer, who was born on the same day, will still be 0 years old, or about 11 months old. To make things even more complicated, it should be noted that the lunar new year and solar new year are not in a constant relation to each other, meaning that the celebration of the lunar new year varies annually—although it usually falls in the first two months of the common solar calendar. In other words, depending on the exact date of birth and date of measurement, Koreans are one to two years older than their Western counterparts. It is common, however, to simply remove two full years from Korean age to make the ages comparable to international calculations for age (Pratt, et al., 1999: 2). Therefore, we have taken the age recorded and have subtracted two years to convert Korean age to Western age, although the true age gap might be just one year in a few unknown cases. Note that previous research on the biological standard of living of Koreans (Pak et al., 2011; Schwekendiek and Jun, 2010) did not have to deal with this issue because age was calculated by using the exact date of measurement and date of birth.

Age cut-offs for terminal height

Because terminal height is largely influenced by environmental factors prevailing around birth (Tanner, 1990), we pooled all surveys and projected

height by birth year. The ages of the recruits in our present samples range from 8 to 67 years (Table 1). However, final height of humans is largely affected by catch-up growth before and during adolescence as well as shrinking in old age. To proxy final height, our primary attention will be on the heights of individuals who were 20 to 40 years of (Western) age, because, for the sake of consistency and comparability, this age range was used in previous research on the biological standard of living in Korea (Choi and Schwekendiek, 2009; Schwekendiek and Jun, 2010). However, for the sake of completeness, we indicated mean heights according to three further age groups (20 to 50, 18 to 40, and 18 to 50) in a note below Table 4.

Determining which local measure was used for height of humans and particularly for soldiers

As is commonly known, Europeans and North Americans use centimeters and inches to measure human height. Similar to pre-modern Japanese (Shay, 1994: 180) and Chinese, pre-modern Koreans used a unit that they called *ch'ŏk*. The Chinese character for *shaku* (Japan), *chi* (China), and *ch'ŏk* (Korea) is the same (尺), but the actual lengths vary by country and historical period. Moreover, there were many *ch'ŏk* used in pre-modern Korea for various purposes (e.g., *ch'ŏk* to measure masonry for construction or cloth for clothes), and their conversion into centimeters varies. Table 2 gives a comparison of the measures in use over the Chosŏn period. For the period in which our rosters were produced, there were five different *ch'ŏk*. Our research points to one specific *ch'ŏk*—called *chuch'ŏk* (周尺)—as systematically used to measure soldiers' heights. This determination allows us later to convert Korean units of height into centimeters. There are three pieces of evidence to support our use of the *chuch'ŏk* as the measure for heights.

The first piece of evidence is a passage written by Pak Yun-wŏn (朴胤源1734–1799), where he discusses the length of the ceremonial belt that hangs down from the waist. He argues that the *chuch'ŏk* is most appropriate for measure. He states that an ordinary man's height is eight *ch'ŏk*, and a belt

Table 2: Conversion of Measures of Length of Chosŏn Dynasty Korea to cm

Measure	King Sejong (世宗 尺度) 1431	*Kyŏngguk taejŏn* (經國大典, 記錄尺度) 1485	King Yŏngjo reform (英祖 (改尺度) 1750	King Sunjo reform (釐正周 (尺時尺度) 1820
Hwangchong-ch'ŏk (黃鐘尺)	34.72	34.72	31.25	34.74
Chuch'ŏk (周尺)	20.81	21.04	20.83	20.81 (20.37)*
Yŏngjo ch'ŏk (營造尺)	31.24	31.21	31.22	31.24
Choyegi (造器)	28.64	28.57	28.41	28.64
P'opaek ch'ŏk (布帛尺)	46.73	46.8	46.73	46.73

(Source: Adapted from Yi, Chin-kap, "1590 nyŏndae": 117. See also: Pak, *Han-Chung*: 569ff, Table 3.)

Notes: All conversions are from 1 *ch'ŏk* into cm; * refers to our average conversion of height based on "master" measuring sticks (Table 3).

hanging down at 4.5 *ch'ŏk* is appropriate. Here, the *chuch'ŏk* is associated with body proportions.

The second piece of evidence is a note in the National Code (*Kyŏngguk taejŏn*, 1485) about the identification tag required of military personnel aboard ships in the navy. All subjects of the kingdom carried identification tags, but the naval identification tag specified the sailor's station (posting and navy), his age, his residence, and his appearance (i.e., his height, facial indication of pox, scars, and beard), which is the same information that appears in the rosters for army personnel. Critically, the diameter of the tag should be three *ch'on* (0.3 of a *ch'ŏk*), "using a *chuch'ŏk*" (*Kyŏngguk taejŏn*, Pyŏngjŏn, pŏnch'a tomok, sugun, 4:44b-45a). Here, the *chuch'ŏk* is associated with the identification tag that records the anthropometry of sailors. The note in the National Code is vague, but a guide (*Hop'ae samok*) was composed in 1625 regarding the identification tags, and it links *chuch'ŏk* with height. In the information to be recorded about physical appearance, the guide specifically states that the measure for general height should employ the same measure used to determine the heights of militia soldiers (身長尺用束伍軍身長尺) (*Hop'ae samok*, 7b). At the end of the guide are directions for the manufacture of the identification tag. There,

the authors draw a measure and state that "the *ch'ŏk* for measuring height is five *ch'on*, and adding another five *ch'on* makes one *ch'ŏk*. The tags should be made also using this *ch'ŏk* (此身長尺之五寸也,再加五寸則爲一尺,造牌亦用此尺)" (*Hop'ae samok* 11b). Therefore, if the identification tag should be made using a *chu'chŏk*, and the identification tag should be made using the "measure for heights," and soldiers' heights are measured with the "measure for heights," then the measure used for the heights of soldiers was a *chuch'ŏk*.

The third reason we believe the *chuch'ŏk* was used for height measures is that the previous scholarly consensus assumes the use of the *chuch'ŏk* for measuring height (Chŏng Ku-bok and Yi Chin-kap). Yi Chin-kap explicitly addresses the question of alternate *ch'ŏk* and argues that the *chuch'ŏk* was most commonly used for measuring fields and distance and would have been most familiar, while the other measures had specific purposes. Kim U-ch'ŏl first suggested an alternative: that the *chuch'ŏk* was used up to 1600, but another *ch'ŏk* was probably applied after the sixteenth century. He recommends using the *chuch'ŏk* for the 1596 data and the *hwangchong ch'ŏk* (黃鐘尺) (Table 2) afterwards (Kim U-ch'ŏl, "17 segi," 2006: 100). In a similar vein, Cho (2012: 152) has also proposed that different measures were used at different times but without specifying which ones.

The problem with arguments proposing variable *ch'ŏk* is that, if another *ch'ŏk* (e.g., *hwangchong ch'ŏk*) was used after 1600, then the mean heights of men born and measured in the seventeenth century would range below 139 cm, indicating a considerable collapse in heights, and it would also imply that the Chosŏn government was not concerned with consistency in its measures of soldiers. To be sure, the destruction of the Japanese invasion (1592–98) was great, but total population had recovered to prewar levels by the late 1670s. There were famines at the end of the seventeenth century, but the cumulative effect producing an average height of men of just 139 cm is unparalleled in macrohistorical anthropometric research. For instance, according to an osteometric study, mean height of European men ranged from 168 to 172 cm during the last two millennia despite frequent wars, famines, epidemics, and even climate changes (Koepke and Baten, 2005). Similarly, mean height of men born in all world regions, including Northeast

and Southeast Asia, never fell under 157 cm over a period of almost two centuries (Baten and Blum, 2012; Danubio et al., 2012). Moreover, such a radical change from earlier times would have produced more comment from the literate classes, and the literary record consistently refers to heights of men of eight *ch'ŏk*, implying heights over 160 cm. Furthermore, this lower range strongly contradicts the tomb data (Shin et al., 2012), making it clear that *hwangchong ch'ŏk* were not applied.

In conclusion, these associations and the general consensus point to the *chuch'ŏk* as the usual measure of human height, and, in particular, of the height of military personnel. An explicit statement for this, however, is still missing in the literature.

Determining the length of the chuch'ŏk *in centimeters*

Even if we use the *chuch'ŏk* as the measure, we still have the problem of its length in centimeters. The Japanese invasion of 1592–98 was so destructive that only one type of physical *ch'ŏk* measure for field surveys survived, which was a multiple of the *chuch'ŏk* (Pak, "Yijo": 219). From this surviving measure, people began to produce their own measuring sticks as the ratios were roughly known. More importantly, like many other pre-modern people, Chosŏn-period Koreans oftentimes bartered goods instead of paying in cash. The size of goods and property, say cloth and land, depended on the actual length of the measuring stick employed during the transaction. Not surprisingly, some began deliberately to modify their measuring sticks to give them an edge in trading, resulting in numerous lengths of *chuch'ŏk*. Because of these two factors, measures varied by region and time so that there were contradictory measuring sticks for *chuch'ŏk*, most of which were made out of wood and used by private people.

The Chosŏn government attempted to address these problems. For instance, it is known that King Chŏngjo (r. 1776–1800) ordered the creation and distribution of brass measuring sticks (*yuch'ŏk* 鍮尺) in 1778 to standardize the lengths of devices used in prisons for punishment (*Chŏngjo sillok*, 5:5a-6a, 1778.1.12). In 1783, his court was given excerpts from secret provincial inspectors' reports stating that, although brass measures for

volume and length had been distributed nationally, fraud with non-standard measures was widespread (*Chŏngjo sillok*, 16:59a-64b, 1783.10.29). Again, in 1798, the court heard that the widespread use of variable wooden measuring sticks had prompted the production of brass sticks and their dispatch (*Chŏngjo sillok*, 48:48a-50b, 1798.4.27). These brass measures were "master" measuring sticks that regulated the length of all known *ch'ŏk*, including the *chuch'ŏk*. The "master" measuring sticks were relatively expensive because they were made out of metal and were very sturdy. They were given to officials at every frontier pass, county office, garrison, and post station, who in turn probably used them for two purposes. First, they reproduced some semiofficial copies (mostly made out of wood), which they probably distributed to some minor magistrates and important private subjects. Second, people bartering goods oftentimes went to the governor's office to compare the length of measuring sticks with the official one in order to check whether or not they were being defrauded. In order to estimate the height of militia recruits, we focus on these "master" measuring sticks.

While countless private measuring sticks survived, only about a dozen "master" measuring sticks could be recovered (Yi, 2004). For this research, we examined one of the surviving measures that we were given access to in the Museum of Korean Weights and Measures in Ch'ungch'ŏng Province. Like all other master sticks, the one we examined was undated, but it was definitely made in the Chosŏn Dynasty. That measuring stick appeared to be made out of brass. It was long and cubic, with each of the four sides displaying the markings of exactly one specific *ch'ŏk* measure, except for one side that had the markings of two *ch'ŏk* measures (on the left and right of that side), so that there were altogether five *ch'ŏk* measures on the one cubic stick. These were the commonly known *ch'ŏk* (Table 2), including the *chuch'ŏk*. The latter we measured with a modern ruler to determine the length of one *chuch'ŏk* unit in centimeters. The result of this assessment, in addition to other *chuch'ŏk* measures from surviving "master" measuring sticks, is shown in Table 3.

How many cm was one *chuch'ŏk*? As seen in Table 3, even the sizes of the "master" measuring sticks varied somewhat as the standard deviation was 0.38 cm. There could be several reasons for this. First, as most of these values

Table 3: Conversion of the Chuch'ŏk Measure into cm Based on Extant "master" Measuring Sticks from the Korean Chosŏn Dynasty

No.	1 *chuch'ŏk* in cm	E.g. "8.0" *chuch'ŏk* in cm	Present status	
			Owner	Location
1	19.342	154.736	National Museum of Korea	Seoul city
2	20.038	160.304	Korea University Museum	Seoul city
3	20.070	160.560	Korea University Museum	Seoul city
4	20.460	163.680	Ch'angdŏk Palace	Seoul city
5	20.490	163.920	Ch'angdŏk Palace	Seoul city
6	20.500	164.000	Ch'angdŏk Palace	Seoul city
7	20.500	164.000	Museum of Korean Weights and Measures	Ch'ungch'ŏng Province
8	20.540	164.320	Ch'angdŏk Palace	Seoul city
9	20.590	164.720	Ch'angdŏk Palace	Seoul city
10	20.600	164.800	Ch'angdŏk Palace	Seoul city
11	20.620	164.960	Ch'angdŏk Palace	Seoul city
12	20.640	165.120	Ch'angdŏk Palace	Seoul city
Mean	20.365833	162.926667		
SD	0.378838	3.030703		

(Source: Yi [2004]: 52 for all values except the authors' assessment of the measuring stick in the Museum of Korean Weights and Measures.)

Notes: Only measuring sticks made out of brass were reported here. None of the measuring sticks was dated. Because measuring sticks no. 7 and no. 11 were halved scaled sticks, converted *chuch'ŏk* were doubled for comparative purposes.

vary about 1 millimeter, the tools and measurement methods to remeasure the *chuch'ŏk* probably played a role in the variations. We measured the "master" stick and found that it is about 20.5 cm, but our measurement depends on the precision of the modern ruler and on where one starts and ends the measurement (e.g., at the beginning, center, or end of the *chuch'ŏk* markings on the ruler). Secondly, from a technical point of view, the royal blacksmiths could probably not reproduce "master" measuring sticks with high precision. That could easily explain some of the minor variations. Thirdly, some Korean kings recalibrated *chuch'ŏk* during the Chosŏn Dynasty (Yi, 2004: 53), so that the blacksmiths had to readjust those "master" measuring sticks from time to time. Unfortunately, because none of these sticks are dated, we cannot track re-calibrations over time, but we can provide a lower to upper bound, which ranges from 19.342 to 20.640 cm (Table 3). If we convert an anecdotally reported common height of 8 *chuch'ŏk* for men (see below) into centimeters, a lower bound estimation gives us a height of 155 cm (8 *chuch'ŏk* ∗ 19.342 cm) whereas an upper bound estimation yields a height of 165 cm (8 *chuch'ŏk* * 20.640 cm). This results in a difference of 10 cm (Table 3), which is due to the technical circumstance that the conversion rate of the shortest and longest "master" measuring sticks differed by about 13 millimeters. The mean conversion value is about 20.37 cm for one *chuch'ŏk* (Table 2) and results in a reasonable anecdotal height of 163 cm for pre-modern men who were reported to be 8.0 *chuch'ŏk*.

The leading scholar of pre-modern Korean measures, Pak Hŭng-su, has gathered extensive data regarding measurements and has determined a narrow range for the length of the *chuch'ŏk*. He believes that the average of a *chuch'ŏk* was 20.81 cm. Pak Hŭng-su bases his opinion on a wide survey of material remains stretching from the fifteenth to the nineteenth century. Note that our value is lower by 4.4 millimeters compared to Pak Hŭng-su's previous meta-analysis that found an average of 20.81 cm. We prefer our measure (20.37 cm) because it is derived directly from measuring sticks. Pak Hŭng-su's value is derived indirectly or interpreted from constructed objects, not the measuring sticks themselves, and therefore produce various values. For example, the water level marker presently on the grounds of the National Folk Museum (Han'guk Minok Pangmulgwan), which once measured

water heights, in *chuch'ŏk*, in the Ch'ŏnggyech'ŏn stream in central Seoul, displays *chuch'ŏk* of 21.8 cm (authors' assessment). Direct assessment from measuring sticks is better than indirect assessment from objects.

In summation, we re-estimated the average conversion value of a *chuch'ŏk* at 20.37 cm (Table 3), which is more reliable than previous estimations because we base our calculation on the lengths of "master" measuring sticks. Note that in our analysis section, we applied an exact value of 20.365833 cm for one *ch'ŏk* in order to convert height to common centimeters.

Converting halved to full chuch'ŏk

The last issue related to the *ch'ŏk* measure is the number of *ch'ŏk* recorded in military rosters. While the 1596 military roster obviously states full *ch'ŏk* (i.e., 7 to 8), all later sources in Table 1 appear to state only one-half (i.e., 3 to 4) of those earlier heights. The average final height of men recorded in 1596 was 7.4 *ch'ŏk*, and as early as 1443, King Sejong had established the standard required height of infantry and armored soldiers as eight *ch'ŏk* and above (*Sejong sillok*, 99: 11b-12a, 1443.2.3: 步甲士試取之法, 欲於今春試之, 其先擇身長八尺以上). Extensive anecdotal evidence from obituaries and other writings state that an ordinary man's height was eight *ch'ŏk*, and eight *ch'ŏk* was an (idealized) expectation for men that carried through the entire Chosŏn Dynasty period. For example, Pak Yun-wŏn, in the passage quoted above, also mentions that the standard male height is eight *ch'ŏk*. The largest literary corpus (*Han'guk munjip ch'onggan*) ever compiled in the Koreas after 1945 shows that Chosŏn-era references to 8 *ch'ŏk* were most common, followed by references to 7 and 9 *ch'ŏk*. There are a smaller number of references to 6 *ch'ŏk*. There are three references to 10 *ch'ŏk*, one of whom is a foreigner, and two references to 5 *ch'ŏk*, but these are for Japanese. While the 1596 roster's average of final height was 7.4 *ch'ŏk*, averages from later rosters hover around 4 *ch'ŏk*. Since we have no reason to believe that Korean heights suddenly dropped by nearly 50 percent and because 8 *ch'ŏk* was a standard (idealized) height for men, we believe that the measure remained the same, but the statement of that measure changed—it was halved.

The assumption of halved *ch'ŏk* in the military rosters offers a way to convert Korean *ch'ŏk* into common centimeters. Previous research has addressed the problem by arguing that authorities introduced another undiscovered *ch'ŏk* (Cho, 2012) or by suggesting that the aforementioned *hwangchong ch'ŏk* was used (Kim U-ch'ŏl, "17 segi," 2006: 100). Above, we reviewed evidence showing that the *chuch'ŏk*, not the *hwangchong ch'ŏk*, was used to measure heights. The problem with the argument that another, unnamed *ch'ŏk* was used is that, while other, more specialized *ch'ŏk* did exist, they all had names. The measure in the documents in Table 1 is simply "*ch'ŏk*," most likely referring to some generic, well-known, and ubiquitous *ch'ŏk*, such as the *chuch'ŏk*. If the Chosŏn authorities had introduced a special *ch'ŏk* for the height of humans or even soldiers, it is likely that official documents would have mentioned it and that one of these measuring sticks would have survived, especially considering that authorities must have measured many, probably hundreds of thousands, of recruits throughout the entire country for over three centuries. Hence, our finding that another *ch'ŏk* for recruits' height has not been reported and that such a special pre-modern measuring stick has never been found leads to the conclusion that there was no special *ch'ŏk* to measure the height of recruits or of humans generally. Instead, military bureaucrats simply used the widely applied *chuch'ŏk*—but they halved the scale to measure height. The question then becomes, why would the Chosŏn Dynasty surveyors halve the measure?

The earliest available military roster of 1596 indeed refers to full *ch'ŏk* (Table 1). This was probably because recruits were measured in the midst of the Japanese invasion that was then ravaging the entire country and because it was one of the first registers of the newly introduced militia system. We believe that local administrators followed exact orders from the king to measure the height of the militia. Because the *chuch'ŏk* was the common measure for recruits and humans in general, surveyors literally recorded that exact figure. What is important to note is that pre-modern Korean authorities probably did not use special tools to measure the height of recruits, unlike soldiers in Europe or the United States who were commonly measured with stadiometers. Even in the mid-twentieth century, the South Korean government systematically measured thousands of pupils every year

in schools by simply writing marks on a wall using a ubiquitous, modern (folding) ruler.

Apparently, after 1600, the military surveyors doubled the *chuch'ŏk* (which halves the measure), and then used the doubled *chuch'ŏk* measure to draw marks on the wall. Our strongest piece of evidence supporting this claim is a note that we recently discovered: it explicitly specifies that recruits' heights are to be recorded on a halved scale. Above, we referred to a 1625 document (*Hop'ae samok*, 7b) that related the measure to be used for height to the *chuch'ŏk*. In the same passage, we see a direction to use a half *ch'ŏk* to measure height: "the *ch'ŏk* for measuring height is five *ch'on* and adding another five *ch'on* makes one *ch'ŏk*." If one half-*chuch'ŏk* (about 10 cm) had been actually used as a measure for one *ch'ŏk*, then the military rosters would have literally doubled a man's height of 8 *ch'ŏk* and recorded 16 *ch'ŏk*. The fact that they actually recorded 4 *ch'ŏk* suggests that the five *ch'on* was doubled in actual length and became one *chuch'ŏk* (still about 20 cm). In Figure 1, Type A reproduces a normal *chuch'ŏk* (used in 1596) and Type B (used after 1596) shows the same *chuch'ŏk* but with larger values. Apparently, Type B was the recorded measure after 1596. We do not know why authorities suddenly changed from Type A to Type B afterwards. Perhaps this was because Type B enabled them to record height faster and more conveniently, as surveyors had, on average, just to count four "large" marks instead of eight "large" marks on the wall when they measured the recruits. Furthermore, in many documents, where *ch'ŏk* are depicted, it is common to see only 5 *ch'on* drawn out, with the assumption that this could be doubled to get the actual length of the *ch'ŏk* (e.g., Kungnip Minsok Pangmulgwan, 1997: 42–43). Moreover, it is common to find a full *chuch'ŏk* on one side of a stick and 5 *ch'on* of a *yŏngjo ch'ŏk* on the other, although a full *chuch'ŏk* is not equivalent to 5 *ch'on* of a *yŏngjo ch'ŏk* (e.g., Kungnip Minsok Pangmulgwan, 1997: 18). Various *ch'ŏk* that were drawn as only 5 *ch'on* were commonly displayed and half-*ch'ŏk* paired with full *ch'ŏk* were commonly made. Thus, the interchangeability of half-*ch'ŏk* and full *ch'ŏk* was apparently a part of the *mentalité* of the measure.

As a disadvantage of the halving of the scale, the height intervals also double, which considerably reduces anthropometric accuracy: one recorded

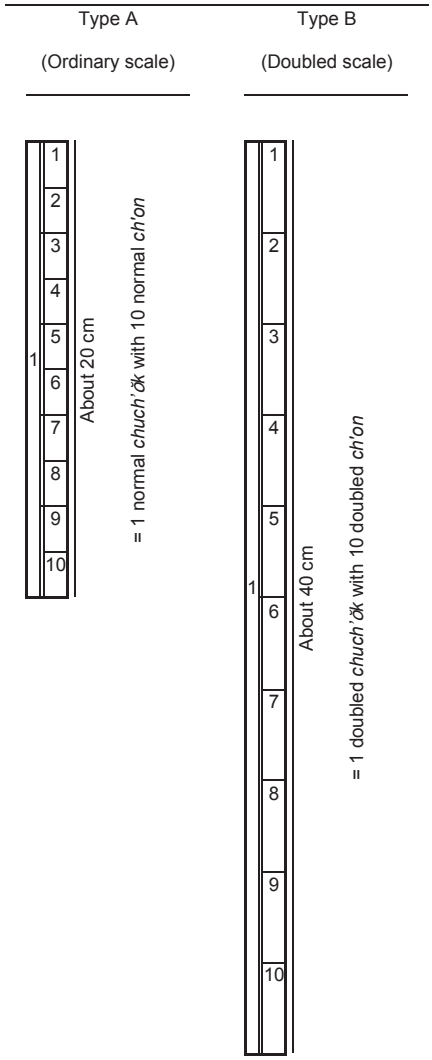

Figure 1: Two Types of Scales for Chuch'ŏk in Chosŏn Dynasty Korea. (Source: See the discussion in the text.) Note: An alternative scale could have been a scale with a doubled *ch'ŏk* and single *ch'on* (instead of a doubled *ch'on* as represented by Type B). Mathematically, this would have implied that *ch'on* range between 0 and 19 to represent one doubled *ch'ŏk*. However, *ch'on* range from 0 to 9 in the military rosters (Table 1), providing evidence that both *ch'ŏk* and *ch'on* were doubled, the result of which produces Type B.

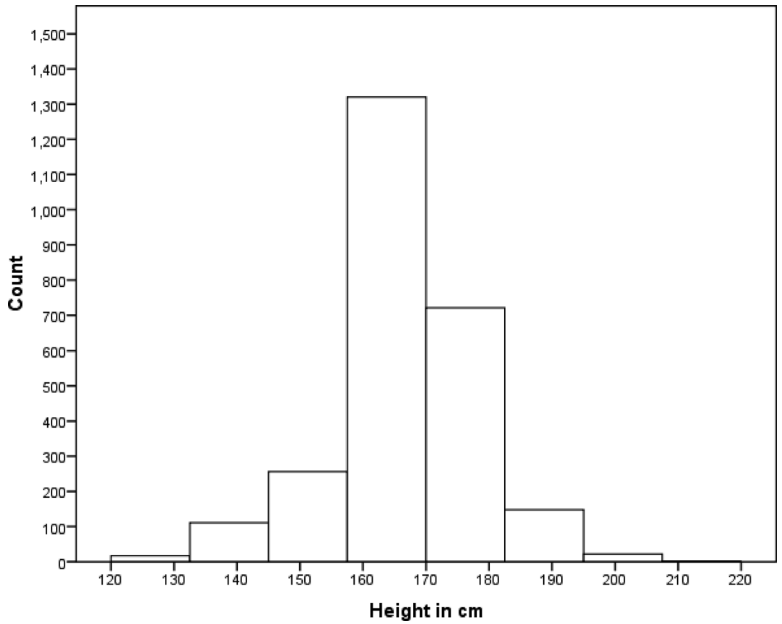

Figure 2: Height Distribution of 20- to 40-Year-Old Men.

chuch'ŏk increases from about 20 cm to about 40 cm. Hence, one *ch'on* increased from 2 cm (Type A) to 4 cm (Type B) in Figure 1.

In summation, we suggest that the number of *ch'ŏk* recorded in the military rosters in fact reflects the number of marks on the wall, each of which corresponded, in reality, to a double *ch'ŏk* after 1596, because the scale of the ruler was halved for bureaucratic or convenience reasons. Previous research automatically assumed that the reported height figure must reflect one full *ch'ŏk*, but it is nowhere specified in these records what the actual statement of the *ch'ŏk* was. It follows from our argument that all values reported in the records after 1596 have to be doubled. For instance, a recruit's height measure of 4 *ch'ŏk* 1 *ch'on* in the seventeenth century, therefore, was 8 *ch'ŏk* and 2 *ch'on*, or about 164 cm.

Analysis

Final height of 20- to 40-year-old recruits are plotted in Figure 2. Minimum height was found at around 122 cm and maximum height at around

Table 4: Summary Statistics

	All Age Groups			Age 20 – 40		
	Height in cm	Age at Measurement	Year of Birth	Height in cm	Age at Measurement	Year of Birth
Mean	164.45	29.94	1643.96	165.69	29.19	1643.64
SD	11.95	10.95	34.70	10.77	6.07	34.89
N	4256	4256	4194	2596	2596	2559

(Source: Table 1).

Notes: Age was converted from Korean to Western age and height was converted from *ch'ŏk* into cm, both of which are discussed in the text. Also note that mean heights in age groups 20–50, 18–40, and 18–50 were found at 166.00, 165.20, and 165.57 cm—indicating that pre-modern Korean heights ranged around 165–166 cm if one includes older adolescents and men between 40 and 50.

216 cm. Height seems to be distributed normally and centered around 164–165 cm. If there were indeed minimum height requirements for the recruits, the distribution would be visibly skewed to the right. As explained above, unlike the regular army, the militia was conscribed and not selected, which explains why shorter recruits were also included in the rosters.

Summary statistics for converted height, age at measurement, and year of birth are shown in Table 4. Overall, mean height of recruits measured in the Chosŏn Dynasty was 164.45 cm. Focusing on the age group of 20 to 40, mean final height improved to 165.69 cm—indicating that final mean height is higher by about 1.2 cm due to the catch-up growth effect of young individuals in combination with the shrinking effect of older individuals. Using skeletal remains from tombs dating back to the fifteenth to nineteenth centuries, Shin et al. (2012) estimate mean height of Chosŏn Dynasty Korean men at 161.1 cm, but this study reveals that Koreans were noticeably taller in pre-modern times. The discrepancy could be due to sampling differences in the study of skeletal remains (with a sample size of just sixty-seven males for a 500-year period). Because we calculated mean height based on 2,596 to 4,256 individuals (Table 4) for a similar period, we think that our estimation is more reliable.

Compared to heights measured from the living, the height of pre-modern European men living in France in the latter half of the seventeenth century

averaged 161.7 cm with ups and downs over the eighteenth century, reaching a maximum of 167.8 cm between 1725 and 1740, but falling back to 164.9 cm in the next twenty years to 1760 (Komlos et al., 2003: 168). The mean height of men born between 1848 and 1889 and recruited into the Habsburg military has been estimated at between 163.3 cm and 166.6 cm (Komlos, 2007: 216). The Korean osteometric study would suggest that pre-modern Korean men were somewhat shorter than their pre-modern European counterparts, but our estimate of 165.69 cm for living Korean men suggests that they had the same (if not even somewhat taller) height as some of their European counterparts. More interestingly, a mean height of 165.69 cm among 20- to 40-year-old pre-modern Korean recruits is consistent with a previous study on height trends in the late nineteenth century (Choi and Schwekendiek, 2009), which found that the mean height of men was about 164 cm.

Because comparable anthropometric studies are lacking for the sixteenth and seventeenth centuries in East Asia, we can only compare our findings to height as of the eighteenth to nineteenth centuries. Among those studies, Shay (1994) demonstrated that pre-modern Japanese heights of 20-year-old conscripted men hovered around 156 cm as of the late nineteenth century. Our study indicates that pre-modern Korean men were strikingly taller, by about 10 cm. On the other hand, Chinese men born in the early nineteenth century who had immigrated to Australia from southern China stood at 164 cm (Morgan, 2009), which suggests that southern Chinese had a height level similar to Koreans in pre-modern times. Then again, Baten and Hira (2008) estimate the height of southern Chinese who had immigrated to Indonesia and Suriname at 161–164 cm from the early to mid-nineteeth century. This indicates that some pre-modern southern Chinese were worse off than pre-modern Koreans. The difference between these studies is explained by Baten and Hira (2008) as one of socioeconomic selection. The immigrants to Australia had to provide agricultural land as collateral to get to Australia while those to Indonesia were recruited, so the two groups may have represented an "upper" and "lower" band for the heights of southern Chinese (Baten and Hira, 2008: 220–21). Perhaps the more important point is that all Chinese data come from immigrants abroad and all Japanese data before

the Meiji period (1868–1912) come from osteometric analyses. No one has yet discovered any Chinese military rosters comparable to those found in Korea, and Japanese military service was hereditary, with no recruitment and no measurements. In this light, the Korean rosters appear to be unique in East Asia.

The high standard deviation of mean height (10.77 to 11.95 cm) warrants a few comments (Table 4). Standard deviations of (modern) Korean heights are about half of these values (Choi and Schwekendiek, 2009; Pak et al., 2011) or around 5 to 6 cm. The obvious reason for our higher standard deviations is that we converted height into cm, with decimal intervals ranging between 2–4 cm (Figure 1). Earlier studies of later periods used a common 1 cm interval of height, which explains why we observe larger variations around the mean. Another reason for our high standard deviations is that we have a few outliers in our sample, with the shortest individual standing at 122 cm and the tallest at 216 cm (Figure 2).

Mean age at measurement was found to be at 29.94 years with a standard deviation of 10.95 with respect to all age groups, and 29.19 years with a standard deviation of 6.07 among individuals who were 20 to 40 years of age at the time of their measurement (Table 4). We only collected data where we have both height and age, but we did not discard the entry if the birth year was missing. Therefore, compared to the height and age samples' sizes (Table 4), birth year was less often reported (sixty-two cases fewer among all age groups and thirty-seven cases fewer among the age group 20 to 40). The mean year of birth (for all cohorts as well as for 20 to 40 year olds) was about 1644 with a standard deviation of 35. This indicates that the average individual in our data was measured around the mid-seventeenth century.

Next, we plotted the final height trend of recruits who were 20 to 40 years of age (Figure 3) by 5-year birth periods. In addition, we show the 5-year trend of political prisoners born in the late Chosŏn Dynasty and measured during Japanese colonial rule. Because of low sample sizes, with some quinquennial birth periods represented only by a few individuals, we observe a lot of noise in the data (Figure 3). We therefore added moving averages. Figure 3 demonstrates that mean final height of men improved remarkably from the late sixteenth century to the early seventeenth century. This was an

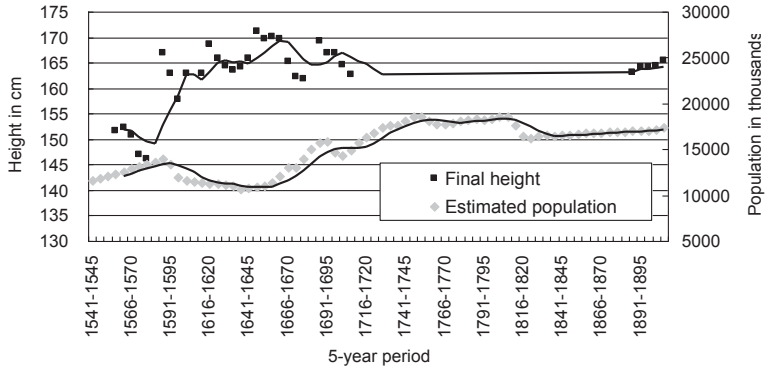

Figure 3: Anthropometric and Demographic Trends in Chosŏn Dynasty Korea.

(Source: Table 1; Choi and Schwekendiek [2009]; Jun et al. [2008]; and Kwŏn and Sin [1977].) Notes: The lines represent quinquennial moving averages. Height was converted from *ch'ŏk* into cm as discussed in the text. Anthropometric data are based on final height of Sŏdaemun prisoners (late nineteenth century) and of military recruits (all other centuries).

unexpected result. We expected that mean heights would have been lower for those born in the early seventeenth century as a result of the devastation of the Japanese invasion (1592–1598). The opposite result—lower mean heights before the invasion and higher mean heights afterwards—could come from several causes. The cause of lower heights in the latter part of the sixteenth century was suggested by Jun et al. (2008: 253–54), who argued that the shift of relative prices (the collapse of cotton cloth prices and inflation of rice prices) in the sixteenth century, prior to the Japanese invasion, probably indicates a high frequency of famines, disease, and banditry, and a serious disequilibrium that would have affected human growth negatively. Perhaps that accounts for the lower sixteenth-century heights. Another reason may be an artifact of the data itself. The 1596 data may be the result of selection. Because the Japanese invasion began in 1592 and many men were pressed into regular military service and killed, taller men in the population may have been drafted first because of physical advantage for combat. However, as we only detected minor height truncation in the 1596 militia roster, survivor

bias alone cannot explain the low heights in 1596. Under the assumption that other sampling biases of 1596 do not matter too much, we tentatively conclude that recruits were indeed extremely short at that time. The case of taller heights after 1600 probably comes from a faster than expected recovery from war and reduced population pressure on the land due to the large loss of life during the war. It may well indicate more normal heights in a population that did not see its tall men culled by war. Mean final height in the seventeenth century stagnates around 168 cm and then declines again by the early eighteenth century to about 164 cm—which in turn corresponds to the level of mean final height of the late nineteenth century. This finding suggests that living standards peaked around 1670, fell slightly, and then plateaued over the eighteenth and into the nineteenth century, but such a conclusion is tentative and awaits the analysis of further data.

Population data were added to Figure 3 to control for fluctuations in living conditions. Both demographic and anthropometric data indicate lower living standards in the late sixteenth and early seventeenth centuries, which were probably due to the bad conditions of the sixteenth century described above as well as the lingering effects into the early seventeenth century of the Japanese invasion in the 1590s. Counter intuitively, the anthropometric data and the population data diverge over much of the seventeenth century: the anthropometric data show that living standards were probably better than expected in the early seventeenth century and rose through the late seventeenth century, while the population was devastated by the Japanese (1590s) and Manchu invasions (1627 and 1636) and struggled to recover. Stature and population then climbed together from the 1640s to the 1690s, and while population continued to climb, height stabilized. It is likely that population began to put pressure on nutrition availability. A previous study on pre-modern Europeans indeed found that rising population density had a negative impact on height (Koepke and Baten, 2005), as demographic growth apparently began to outpace food production.

Conclusion

This paper has presented and discussed new anthropometric evidence from available military rosters of pre-modern Koreans of the Chosŏn

Dynasty (1392–1910). For this purpose, we used mean height collected from up to 4,256 males. Military rosters from the sixteenth to early eighteenth century were identified as the most homogenous and precise ones, because they record the height of the militia consistently and in decimals. The militia can act as a proxy for the majority of the male population in pre-modern times. Additionally, the selection bias was considerably reduced because there were no minimum height requirements for the militia as opposed to the regular army. Moreover, this paper gave great attention to methodological issues, including, most importantly, the conversion of Korean height units into common centimeters. Although Korean scholars had already rediscovered some of the military rosters of the Chosŏn Dynasty used herein and have examined them for many years, nobody has successfully converted recorded height measured in local Korean units, called *ch'ŏk*, into common centimeters. Previous anthropometric studies therefore could not make meaningful height comparisons to people living in other areas of the world in pre-modern times. We believe that we solved this conversion problem by providing evidence that one special measure, called *chuch'ŏk*, was used throughout the entire period, and that the scale of recorded heights was halved in the military rosters from the seventeenth century onwards for bureaucratic or convenience reasons. Using our new conversion method, we show that throughout the entire observed period, the mean terminal height of men (age 20 to 40) was a little less than 166 cm, indicating that Koreans broadly enjoyed the same living standards as Europeans at that time.

Previous research on this time period has drawn upon reconstructed heights from bones excavated from tombs in South Korea, mostly near modern-day Seoul (Shin et al., 2012). Our study finds that pre-modern Korean men, who stood at 164 cm (all age groups) to 166 cm (20 to 40 year olds), were in fact about 3 to 5 cm taller than those previously estimated by tomb data (161 cm). This difference is probably due to the low sample sizes in the tomb data (with sixty-seven males for a 500-year period), where genetic influences of short and tall genotypes of height might not cancel each other out, in addition to obvious sampling and methodological differences. Among those methodological differences, an issue could be the conversion method of the skeleton height in Shin et al. (2012). Because they

base their conversion on Japanese people, they generally tend to underestimate mean height because pre-modern Japanese were much shorter than Koreans (Choi and Schwekendiek, 2009; Shay, 1994). Interestingly, using a slightly larger sample size and a different reconstruction method based on Mongoloid people—a broad anthropological classification that includes Koreans, Chinese, and Japanese, among others—instead of Japanese only, a recent skeleton study (published in Korean) estimated reconstructed height of men at 164.49 cm (N = 85) for the Chosŏn period (Pak, 2011). This is close to our values of 164 cm (all age groups) and 166 cm (20 to 40 years of age), suggesting indeed that sample sizes and methodological differences could account for the lower heights estimated by Shin et al. (2012). Because we detect that final height of Chosŏn Koreans was extremely low in the sixteenth century, another simple explanation could be that a large portion of heights sampled in Shin et al. (2012) were drawn from that period.

Drawing on large sample sizes, comparable studies on biological living standards in pre-modern East Asia have, to our knowledge, not been published. Therefore, this paper fills a gap in the flourishing discipline of anthropometric history. From a technical point of view, we limited ourselves to the introduction of the new data sources in conjunction with a discussion of the most important methodological issues, and we offer a descriptive exploration of the height trend. Future studies will present more advanced analysis of the data by controlling for the underlying socioeconomic, demographic, and epidemiological variables recorded in the military rosters. Future studies will also address the sources excluded from this study.

Korean References

Cheju sogo kunjŏkbu (濟州束伍軍籍簿) 1685. Available as *T'amna Munhwa ch'ongsŏ 16* (耽羅文化叢書 16), *Cheju sogo kunjŏkbu* (濟州束伍軍籍簿). Cheju: Cheju taehakkyo, T'amna Munwha Yŏn'guso (濟州大學校 耽羅'ñ'á'ă'ñ研究所), 2001.

Chin'gwan kwanbyŏng yongmo ch'aek (鎭管官兵容貌册) 1596. Han'gukhak Chung'ang Yŏn'guwŏn Changsŏgak, (한국학중앙연구원 장서각) *Komunsŏ chipsŏng,* vol. 17 (古文書集成), no.17, Sŏngnam: Academy of Korean Studies, 1994. pp. 557–602. Also appears in *Sŏae sŏnsaeng nyŏnbo* (西厓先生年'¼'ú). Photolithographic reproduction. Seoul: Kyŏng'in munhwasa, 1974. Soae sŏnsaeng ki'nyŏm saŏphoe (西厓先生紀念事業會) ed., *Sŏae chŏnsŏ* (西厓全書). Seoul: Soae sŏnsaeng ki'nyŏm saŏphoe, 1991, pp. 643–689.

Chin'gwan kwanbyŏng p'yŏn'o ch'aek chan'gwŏn 1, 2 (官兵編伍册 殘卷1, 2) 1596. Han'gukhak Chung'ang Yŏn'guwŏn Changsŏgak, (古文書集成) *Komunsŏ chipsŏng*, Vol. 17 (亂後雜錄), no.17, Sŏngnam: Academy of Korean Studies, 1994. pp. 408–480; pp. 481–556. The *Ranhu chamnok* (亂後雜錄) is written on the back and bleeds through making the photolithograph difficult to see. Also appears in *Sŏae sŏnsaeng nyŏnbo* (西厓先生年譜). Photolithographic reproduction. Seoul: Kyŏng'in munhwasa,

1974. Soae sŏnsaeng ki'nyŏm saŏphoe (西厓先生紀念事業會) ed., *Sŏae chŏnsŏ* (西厓全書). Seoul: Sŏae sŏnsaeng ki'nyŏm saŏphoe, 1991, pp. 491–568, pp. 569–642. Available in Chôsenshi henshûkai (朝鮮史編修會) ed., *Chôsen shiryô sôkan*, vol. 10 (朝鮮史料叢刊v. 10), *Chinkan kanhei-hen gosatsu zankan* (鎭管官兵編伍册殘卷). Keijô: Chôsenshi henshûkai, 1936, which is available in Han'gukhak Chung'ang Yŏn'guwŏn Changsŏgak (한국학중앙연구원 장서각) Microfilm MF35–6686 / K2–5095 [1] + K2–5095 [2] and Kosŏsil (고서실) Ha (霞) B13HB2 [1] and Ha (霞) B13HB2 [2].

Cho, Yŏng-jun (조영준). 'Chosŏn sidae munhŏn ŭi sinjang chŏngbo wa ch'ŏkdo munje: kunchŏk kwa kŏm'an ŭl chungsim ŭro' (조선시대 문헌의 身長 정보와 尺度 문제: 軍籍 과 檢案을 중심으로), *Komunsŏ yŏn'gu* (古文書硏究) 41 (2012.8): 125–159.

Chŏng, Ku-bok (鄭求福). '1596 P' yŏng'an-do *Chingwan Kwanbyŏng p'yŏno-cha'ek* (1596年 平安道 鎭管官兵編伍册),' *Komunsŏ yŏn'gu* (古文書硏究) 5 (1994.5): 99–125, which also includes photolithographic reproductions of *Chin'gwan kwanbyŏng yongmo ch'aek* and *Chin'gwan kwanbyŏng p'yŏn'och'aek chan'gwŏn*.

Chŏngjo sillok (正祖實錄).

Hadong-bu yukkun yang'in pyŏngbo imsul [1742] an chŏnsŏ kyŏng'o [1750] nyŏn kaean (河東府陸軍人幷保壬戌[1742]案傳書庚午[1750]年改案) 1751. Seoul taehakkyo, Kyujanggak 12323. Also photolithographically reproduced in Kuksa P'yŏnch'an Wiwŏnhoe (국사편찬위원회). Kaksa tŭngnok (각사등록), Kyŏngsang-do, poyup'yŏn, 4 (경상도 보유편 4), vol. 52, 1991, pp. 582–588.

Hadong-bu sogo kunbyŏng poin muo-nyŏn kae-toan (河東府束伍軍兵保人戊午式改都案) 1798. Seoul taehakkyo, Kyujanggak 12333. Also photolithographically reproduced in Kuksa P'yŏnch'an Wiwŏnhoe (국사편찬위원회). Kaksa tŭngnok (각사등록), Kyŏngsang-do, poyup'yŏn, 4 (경상도 보유편 4), vol. 52, 1991, pp. 589–603.

Han'guk munjip ch'onggan (韓國文集叢刊, Complete Series of Literary Anthologies of Korea). Seoul: Institute for the Translation of Korean Classics (한국고전번역원).

Hop'ae samok (號牌事目). Kyujanggak Seoul taehakkyo, Kyujanggak 12344. Microfilm MF70–6–2-D, MF71–8–1–1-A.

Im, Sŭnghŭi (임스희), 'Chosŏn hugi Cheju chiyŏk chibanggun ŭi p'yŏnch'e wa shilt'ae (조선후기 제주지역 지방군의 편체와 실태),' unpublished MA thesis, Cheju University, 2010.

Kim, Sŏng-kap (김성갑). 'Sukcho dae Ch'ungch'ŏng-do sog'o kunchŏk sogae (肅宗代 忠淸道 束伍軍籍 소개),' *Munhŏn kwa haesŏk* (문헌과 해석) 41 (2007): 199–210.

Kim, U-ch'ŏl (金友哲). *Chosŏn hugi chibang kunjesa* (朝鮮後期 地方軍制史). Seoul: Kyŏng'in munhwasa, 2000.

Kim, U-ch'ŏl (金友哲). '17 segi huban Cheju sog'ogun ŭi p'yŏnsŏng shilt'ae: Cheju sog'o kunchŏkbu ŭi punsŏk (17세기 후반 濟州 束伍軍의 編成 實態 -<<濟州束伍軍籍簿>>의 분석),' *Han'guksa yŏn'gu* (韓國史硏究) 132 (2006): 75–108.

Kwŏn, T'ae-hwan (權泰煥) and Sin Yŏng-ha (愼鏞廈), 'Chosŏn wangjo sidae in'gu ch'ujŏng e kwan han il siron (朝鮮王朝時代 人口推定에 關한 一試論),' *Tong'a munhwa* (東亞文化) 14 (1977.12): 289–330.

Kungnip Minsok Pangmulgwan (國立民俗博物館). Han'guk ŭi toryanghyŏng (한국의 도량형). Seoul: Kungnip Minsok Pangmulgwan, 1997.

Kyŏngsang-do Ulsan-bu yukkun chesaek kyŏng'in kae toan (慶尙道蔚山府軍諸色庚寅改都案) 1770 (cover). Seoul taehakkyo, Kyujanggak 15022.

Kyŏngguk taejŏn (經國大典) (1485), Pyŏngjŏn (兵典), pŏnch'a tomok (番次都目), sugun (水軍).

Pak, Hŭng-su (박흥수). 'Yijo ch'ŏkdo e kwan han yŏn'gu (朝尺度에 關한 硏究),' *Taedong Munhwa Yŏn'gu* (大東文化硏究) 4 (1967): 199–274.

Pak, Hŭng-su (박흥수). *Han-Chung toryanghyŏng chedosa* (韓-中度量衡制度史). Seoul: Sŏnggyungwan taehakkyo ch'ulpanbu, 1999.

Pak, Sunyoung, 2011. An Estimation of Adult Males' Average Stature from the Skeletal Remains of Joseon Period. *Korean Journal of Physical Anthropology* 11, 185–193.

Pak, Yun-wŏn (朴胤源) (1734–1799). *Kŭnje-jip* (近齋集), kwŏn 5, 'Yŏ Milam Kim gong (與密庵金公)'.

Sejong sillok (世宗實錄).

Sukjong-dae Ch'ungch'ŏng-do sogo kunjŏk (肅宗代 忠淸道 束伍軍籍) 1679/1697/1720. T'oji chut'aek pangmulgwan (土地住博物館), Kyŏnggi-do (京畿).

Yi, Chin-kap (鎭甲), '1590 nyŏndae Yi-cho chin'gwan kwanbyŏng ŭi shinchang mit kullŏk e kwanhan yŏn'gu—Sŏae sŏnsaeng yugo *Kunmun tŭngnok*, *Kwanbyŏng p'yŏn'o ch'aek*, mit *Kwanbyŏng yongmo ch'aek* ŭi charyo e ŭi hayo (1590年代 朝鎭官官兵의 身長 및 筋力에 關한 硏究—西厓先生遺稿『軍門謄錄』, 『官兵編伍册』, 및 『官兵容貌册』의 資料에 의하여—),' *Andong munhwa* (安東文化) 5 (1984): 113–129.

Yi, Chong-pong (宗峯, Lee Jong-Bong). 'Chosŏn hugi toryanghyŏngje yŏn'gu (朝鮮後期 度量衡制 硏究)', *Yŏksa wa kyŏnggye* (역사와 경계) 53 (2004): 41–76.

Yi, Hyŏn-su (이현수). 'Chosŏn malgi ŭi kunjŏk: yukkun pangmulgwan sojang kunjŏk munsŏ ŭi punsŏk (朝鮮末期의軍籍: 陸軍文書의 分析)', Yukkun sagwan hakkyo (陸軍士官學校), Yukkun pangmulgwan (陸軍博物館) ed., *Hagyeji* (學藝誌) 3 (1993): 49–69.

Yukkun pangmulgwan sojang kunjŏk munsŏ (陸軍 博物館 所藏 軍籍 文書). 1875–1908. Photolithographically reproduced in Yukkun sagwan hakkyo (陸軍士官學校), Yukkun pangmulgwan (陸軍博物館) ed., *Hagyeji* (學藝誌) 3 (1993): 361–423.

Non-Korean References

Joerg Baten, *Ernährung und wirtschaftliche Entwicklung in Bayern, 1730–1880* (Stuttgart: Steiner, 1999).

Joerg Baten and Matthias Blum, "Growing Tall but Unequal: New Findings and New Background Evidence on Anthropometric Welfare in 156 Countries, 1810–1989," *Economic History of Developing Regions* 27 (2012).

Joerg Baten and Sandew Hira, "Anthropometric Trends In Southern China, 1830–1864," *Australian Economic History Review* 48 (2008): 209–226.

Seong-Jin Choi, Daniel Schwekendiek, "The Biological Standard of Living in Colonial Korea, 1910–1945," *Economics and Human Biology* 7 (2009): 259–264.

Sebastian Coll, "The Relationship between Human Physical Stature and GDP (Some Experiments with European Time Series)," in John Komlos and Joerg Baten, eds., *The Biological Standard of Living in Comparative Perspective* (Stuttgart: Franz Steiner, 1998).

Dorothee Crayen and Joerg Baten, "Global Trends in Numeracy 1820–1949 and its Implications for Long-term Growth," *Explorations in Economic History* 47 (2010): 82–99.

Maria Enrica Danubio, Joerg Baten, Matthias Blum, Alexander Moradi, Emanuele Sanna, Emilia Arcaleni, Domenico Mancinelli, and Rita Vargiu, "Anthropology and Economic History: How Socioeconomic Development Shapes Body Dimensions," *Journal of Anthropological Sciences* 90 (2012): 1–22.

Roderick Floud, Robert W. Fogel, Bernard Harris, and Sok Chul Hong, *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700* (Cambridge: Cambridge University Press, 2011).

Robert W. Fogel, *The Escape from Hunger and Premature Death, 1700–2100* (Cambridge: Cambridge University Press, 2004).

Insong Gill, "Stature, Consumption, and the Standard of Living in Colonial Korea," in John Komlos and Joerg Baten, eds., *The Biological Standard of Living in Comparative Perspective* (Stuttgart: Franz Steiner, 1998), 122–138.

Michael Haines, "Health, Height, Nutrition, and Mortality: Evidence on the 'Antebellum Puzzle' from Union Army Recruits for New York State and the United States," in John Komlos and Joerg Baten, eds., *The Biological Standard of Living in Comparative Perspective* (Stuttgart: Franz Steiner, 1998): 155–180.

Seong Ho Jun, James B. Lewis, and Han-Rog Kang, "Korean Expansion and Decline from the Seventeenth to the Nineteenth Century: A View Suggested by Adam Smith," *Journal of Economic History* 68 (2008): 244–282.

Andrew D. Jackson, "The 1728 Musillan Rebellion: Resources and the Fifth-columnists" (unpublished Ph.D. thesis, SOAS, University of London, 2011).

Duol Kim and Heejing Park, "Measuring Living Standards from the Lowest: Height of the Male Hangryu Deceased in Colonial Korea," *Explorations in Economic History* 48 (2011): 590–599.

Nikola Koepke and Joerg Baten, "The Biological Standard of Living in Europe During the Last Two Millennia," *European Review of Economic History* 9 (2005): 61–95.

John Komlos, "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America," *Journal of Economic History* 47 (1987): 897–927.

John Komlos, *Stature, Living Standards, and Economic Development: Essays in Anthropometric History* (Chicago: University Of Chicago Press, 1994).

John Komlos, "Anthropometric Evidence on Economic Growth, Biological Well Being, and Regional Convergence in the Habsburg Monarchy, 1850 – 1910," *Cliometrica* 3 (2007): 211–237.

John Komlos and Joerg Baten, *The Biological Standard of Living in Comparative Perspective* (Stuttgart: Steiner, 1998).

John Komlos, Michel Hau, and Nicolas Bourguinat, "An Anthropometric History of Early-Modern France, 1666–1766," *European Review of Economic History* 7 (2003): 159–189.

Stephen Morgan, "Stature and Economic Development in South China, 1810–1880," *Explorations in Economic History* 46 (2009): 53–69.

Sunyoung Pak, "The Biological Standard of Living in the Two Koreas," *Economics and Human Biology* 2 (2004): 511–521.
Sunyoung Pak, Daniel Schwekendiek, and Hee Kyoung Kim, "Height and Living Standards in North Korea, 1930s-1980s," *Economic History Review* 64 (2011): 142–158.
James B. Palais, "A Search for Korean Uniqueness," *Harvard Journal of Asiatic Studies* 55 (1995): 409–425.
Keith Pratt, Richard Rutt, and James Hoare, *Korea: A Historical and Cultural Dictionary* (Richmond, UK: Curzon Press, 1999).
T. Schoch, K. Staub, and C. Pfister, "Social Inequality and the Biological Standard of Living: An Anthropometric Analysis of Swiss Conscription Data, 1875–1950," *Economics and Human Biology* 10 (2012): 154–173.
Klaus Schuster, *Wirtschaftliche Entwicklung, Sozialstruktur und biologischer Lebensstandard in München und dem südlichen Bayern im 19. Jahrhundert* (St. Katharinen: Scripta Mercaturae Verlag, 2005).
Daniel Schwekendiek and Seong-Ho Jun, "From the Poorest to the Tallest in East-Asia: The Secular Trend in Height of South Koreans," *Korea Journal* 50 (2010): 151–175.
Daniel Schwekendiek and Sunyoung Pak, "Recent Growth of Children in the Two Koreas: A Meta-analysis," *Economics and Human Biology* 7 (2009): 109–112.
Ted Shay, "The Level of Living in Japan, 1885–1938: New Evidence," in John Komlos, ed., *Stature, Living Standards, and Economic Development: Essays in Anthropometric History* (Chicago: The University of Chicago Press, 1994), 173–201.
Dong Hoon Shin, Chang Seok Oh, Yi-Suk Kim, and Young-il Hwang, "Ancient-to-Modern Secular Changes in Korean Stature," *American Journal of Physical Anthropology* 147 (2012): 433–442.
Richard Steckel, "Heights and Human Welfare: Recent Developments and New Directions," *Explorations in Economic History* 46 (2009): 1–23.
James Tanner, *Foetus into Man* (Cambridge: Harvard University Press, 1990).