The people of Klaaskinderkerke

an assessment of stature of a Late Middle Age rural population

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Front page background: Picture taken by the author on 27-01-2013 showing the former location of the cemetery of Klaaskinderkerke.

Front page center: Family portrait of a family from the area of Brouwershaven taken around 1900 (collection author).

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1. Introduction

Generally it has been accepted that the Dutch are one of the tallest people of the world (e.g. ABC news; Metro; Steckel 1995, 1920; suite 101). With an average height of 1.81 m. for males and 1.68 m. for females as of 2007 (CBS.nl), it seems that the Dutch have reached their maximum genetic stature (Eveleth 1975, 38). This average stature has been a development of the last two centuries during which it dramatically increased, as before that there was a slow but definite stature decrease visible in the Low Countries (Maat 2005). With the use of osteoarchaeological and historical data Maat reconstructed the male mean stature through time, starting with the Roman period up until present day (fig. 1). In this study, data from many different populations are incorporated. Most of the data are from urban populations, with only one representation of an agrarian population in the Netherlands; Hellevoetsluis (Maat 2005, 278).

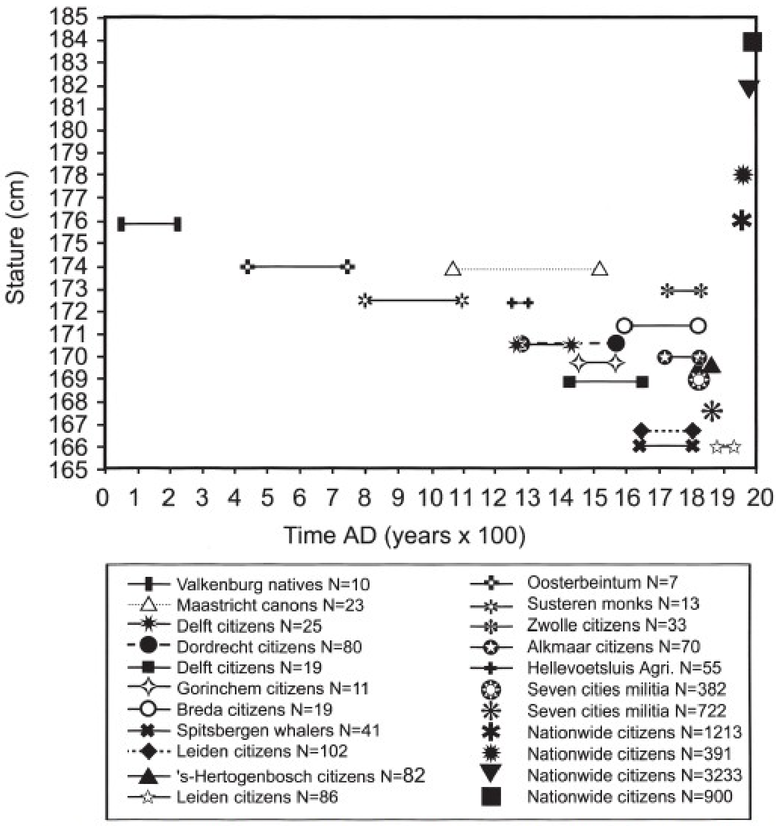


Fig. 1: Table depicting male mean stature in the Netherlands over time since the first century (Maat 2005, 280).

With this thesis the stature of a second agrarian population dating to the late middle ages will be assessed and compared to the previous research. It is expected that the data collected from this population will be most similar to the data from Hellevoetsluis because this site is similar in date, organization, and location (Carmiggelt *et al*. 1999; Maat 2005, 278). It is expected that the rural populations in general are slightly taller than their urban counterparts, as urban environments facilitate the spread of disease and open sewer systems and the like don't add to the general hygiene (Steckel 1995, 1925).

On the outset of this study, it is not clear whether it is valid to compare stature estimations originating from different methods. Especially since some doubts have been expressed concerning the methods used to estimate stature (Jantz *et al*. 1994; Trotter and Gleser 1952, 466). The methods used will be compared with each other to see whether they yield any significant differences and their effect on the comparison of several different populations.

The main question of this thesis is what does the average stature of the population of Klaaskinderkerke mean in comparison with contemporary Dutch populations? To answer this question, several sub-questions have been formulated, which can be divided into two groups: the stature estimation itself and the comparison with the average statures from other populations. In the first category the sub-questions are as follows:

- Which stature estimation method is best?
- Can statures estimated by different methods be compared to each other?
- What is the male average stature?
- What is the female average stature?

For the comparison with the other populations, these questions were answered:

- How does the male average stature from Klaaskinderkerke compare to the male average statures from contemporary populations?

- How does the female average stature from Klaaskinderkerke compare to the female average statures from contemporary populations?
- What can be deduced based on the differences/similarities between the Klaaskinderkerke population and the other populations?

2. Stature estimation and archaeology

Interest in the stature of our ancestors is not something new. In Roman times, Pliny believed that with each generation the mortals grew smaller (Telkkä 1950, 103). This belief persisted for a long time, as is demonstrated by the calculations of a French abbé in the late eighteenth century, who established the stature of Adam to have been 40 meters (Telkkä 1950, 103).

The first actual measurements on bones were published in 1831 by Orfila (Telkkä 1950, 103). Soon more accurate tables became available, of which the study by Rollet (1888) has been pivotal (Telkkä 1950, 103). Bertillon (in Manouvrier 1882) criticized these methods, as they used the stature as a starting point to calculate the corresponding bone length. He proved that the stature and the length of the limb or limb bone are not inversely proportional, which he called the "anthropological paradox" (in Telkkä 1950, 104). Manouvrier then published an improved study of the material used by Rollet in 1892 (Telkkä 1950, 104). However, with his tables the corpse length rather than living height is calculated and the tables are based on measurements from green bones instead of macerated bones, which has to be taken into account when using them. In 1898, Pearson published regression equations which could be used on macerated bones to obtain living stature (Telkkä 1950, 104). Since then, regression formulas have been published for many different populations. Stature is used in many different archaeological studies throughout the world (e.g. Pechenkina *et al*. 2002; Pfeiffer and Harrington 2011; Pomeroy and Stock 2012; Robins and Shute 1983; Shin *et al*. 2012).

The publications of Breitinger (1937), Trotter and Gleser (1952; 1958), Trotter (1970) and Ousley (1995) will be discussed more extensively, since these are used in this study. The methods of Trotter (1958) and (1970) are most often used in osteoarchaeology to estimate stature, while Breitinger (1937) is still used in the Low Countries (Maat 2005).

2.1 Stature and living standards

In the 1820's Villermé published data concerning social differences in mortality rates and height (Tanner 1992). His data suggested that there was a link in the attained adult stature and the social background of the individual. This caused a debate on whether stature was hereditary and thus genetic or entirely environmental (ibid.). The consensus at the moment is that both positions are valid. The individual differences in height are mainly due to genetics, while differences in mean statures between homogeneous groups generally reflect health status (Steckel 1995, 1903). Nowadays, stature has been generally accepted as a measure of health status and is used as an indicator of health since 1979 by various international organizations such as the United Nations (Steckel 1995, 1905).

This relation between health, living standards and stature has been studied extensively over the years (Steckel 1995, 1906; Tanner 1992, 106). The relation is based on the needs of an individual and the supply of nutrition. When the needs are not met, the individual's growth is hampered, which will lead to loosing in eventual adult height (Steckel 1995, 1910). This is effect can be enhanced by illness. For instance when a child gets ill, growth slows down as nutrition is needed to fight the disease (Tanner 1992, 113). When the child survives the disease, a short growth spurt will restore the child to his previous growth curve. This catch-up growth will not take place when insufficient nutrition is available, causing the child not to reach its genetic maximum length (Tanner 1992, 114). Thus children with insufficient nutrition will lose a little bit of final height for each infection or disease encountered (ibid.).

The effect is largest in periods of rapid growth, in infancy and in adolescence (Steckel 1995, 1910). This means that stature is only a proxy for living standards during childhood and not for adult life, although some studies show that small people have a greater morbidity than tall people (Tanner 1992, 115)[1].

Different mechanisms work on the impairment of growth. First, the lack of nutrition will keep a child from reaching its maximum height. Second, owing to limited access to health care, the child can suffer more and longer of infections and nutritional diseases, which will have an impact on its growth as mentioned above. Third, when the child or adolescent is exposed to hard labour, more nutrition is needed to keep working, which can slow down growth (Steckel 1995; Tanner 1992). Fourth, the more siblings the child has, the more chance there is to get infected and as the food has to be shared, the lack of nutrition becomes more likely (Tanner 1992, 111). These mechanisms all are indicators of living standards and thus stature is affected by living standards during childhood (Steckel 1995).

Secular changes in stature are cross-generational, non-genetic changes that result from changing living conditions (Albanese *et al*. 2012, 286.e1). They are considered to be a better tool in assessing living standards in the past than estimated living standards based on GNP or estimated incomes (Steckel 1995, 1935). This is mainly due to the factors that stature incorporates that cannot be put in numbers, such as social inequality, non-market activities and the accessibility of health care (Steckel 1995, 1904-5). Secular changes in stature can thus be used as a proxy to changing living conditions in the past.

2.2 Complicating factors in stature estimation

Estimating stature seems a very rewarding activity, but some problems complicate the procedure. Even when alive, measuring stature is not as straightforward as it seems. Since when alive, the stature of one individual can vary as much as 2 cm on one single day, due to the compression of cartilage during the day (Ousley 1995, 769). After lying down for two hours, it is possible to grow one cm in

[1] As Tanner states, one must distinguish between small as a possession and small as a symptom: those who did not reach their potential height were more prone to disease during their childhood and this could have persisted into adulthood, causing the greater morbidity (Tanner 1992, 115).

length (Ousley 1995, 769). This so-called diurnal variation in stature exceeds the stature decline caused by age and it suggests that the estimated statures with decimals are overly precise (ibid.).

It is common knowledge that with age, you decrease somewhat in length. This stature loss is caused by the thinning of cartilage in both the spine and weight bearing joints (Trotter and Gleser 1951, 312). Trotter and Gleser estimated this loss to be 0.06 cm per year after the age of 30 (Trotter and Gleser 1951, 323; Trotter and Gleser 1952, 479; Trotter 1970, 75). This has been contested in subsequent publications, which consider the onset of stature decline to be later and the effect of the decline smaller (Ousley 1995, 769). Since in archaeology the exact age is difficult to estimate, especially in the older categories, the subtraction of some millimeters based on the age of the individual could be characterized as guesswork.

The measurements of the elements can also form some problems. Although the methods of measuring are well described in several publications (e.g. Knussmann and Bartlett 1988), there has been some confusion in the past concerning the tibia (Jantz *et al*. 1994). In addition, inter- and intra-observer errors need to be taken into account, as well as minor variations between measuring instruments (Ousley 1995, 769).

When one assumes that the measurements are correct, the next problem arises: which stature estimation method to use? The regression formulas provided by the method used are derived from a particular sample, for instance American whites born between 1900 and 1950. The particularities of this population are encapsulated within the formulas, which means that if the method is based on a population with relatively small tibiae, that the formula will reflect that. It has been argued for this reason that the formulas from one population cannot be used to estimate the stature of another population (Breitinger 1937, 250; Gleser and Trotter 1952, 465; Wurm and Leimeister 1986). The same can be said for the use of regression methods developed on modern populations used on ancient populations (Ousley 1995, 769; Pearson in Gleser and Trotter 1952, 465).

The estimation of stature is mostly developed for identification purposes in modern forensic investigations, and thus the problems mentioned above are taken for granted. In archaeology it is a different matter and since it is at the time not possible to create formulas for each time period and population under study, the use of stature estimation methods can be questioned.

2.3 Small stature in African Bushmen: a case study

The African Bushmen are notoriously small, and the cause for this small stature was explored and the results were published by Pfeiffer and Harrington in 2011 (Pfeiffer and Harrington 2011). It is suggested that possible selection for smallness occurred (Pfeiffer and Harrington 2011, 449). This was investigated for the Later Stone Age hunter-gatherer populations from South Africa. These populations were considered more pertinent than evidence from the Kalahari environment in which the relict populations live today (ibid.).

Several possible causes of smallness have come to the fore in the past years. Populations may have adapted to long-term limitations to the amount and type of food and the demands of thermoregulation in high-humidity habitats (Pfeiffer and Harrington 2011, 449). Small size can also occur when mobility is important, it will enhance mobility by reducing metabolic costs of activity. It has also been suggested that there is a relationship between a consistently high risk of young-adult mortality and an early onset of reproduction, which will truncate the growth (ibid.). It is this last suggestion that is researched in this publication.

The authors chose to use archaeological evidence rather than the modern descendents of this population, since many changes have been forced on the modern descendents (Pfeiffer and Harrington 2011, 450). Adult body size, number of burials and the age distribution of buried juveniles are reviewed from the perspective of possible selective pressures (ibid.). The imprecision of adult age estimation methods hampers the research in adult mortality, while the age at death of juveniles can be estimated more precise. The juvenile skeletal growth was evaluated relative to adult dimensions to estimate the timing and tempo of growth (ibid.).

The material comes from coastal and near-coastal South Africa and includes purposefully buried skeletons. These were buried in different ways, in rock shelters, in coastal dunes and shell middens, and occasionally somewhere else (Pfeiffer and Harrington 2011, 450). Previous studies revealed that the dead were buried in the region in which they lived (Sealy 2006 in Pfeiffer and Harrington 2011, 450). Studies of cranial and dental morphology indicated homogeneity across the region throughout the Holocene (Pfeiffer and Harrington 2011, 450). There are radiocarbon dates available and since the diet can create an offset and the necessary information is lacking, the authors used the uncalibrated dates (ibid.).

It is unsure when the small stature became established in the region due to the lack of remains from this period. Of the few remains that have been discovered, some are relatively small and some are not (Pfeiffer and Harrington 2011, 450). It seems that adult smallness existed on the southern coast 115,000 years ago, while it was established in the entire researched region by 10,000 years ago (ibid.).

Previous research provided a substantial sample of subadult skeletons with the relevant information (Pfeiffer and Harrington 2011, 450). The previous data confirmed the sample's validity for health-related studies, since it did not show instances of periostitis and the burial of a juvenile with a prolonged illness before death did not differ from other burials (ibid.). In juveniles of whom age at death could be estimated using dental maturation, it was demonstrated that their stature fell within 1 SD of what was to be expected of healthy children at the same age. This demonstrated that there was no substantial growth lag before death, suggesting that the cause of death was acute rather than chronic, as was expected (Pfeiffer and Harrington 2011, 450).

The material was studied between 2000 and 2009 and it was attempted to study all relevant material present (Pfeiffer and Harrington 2011, 450). For all relatively complete skeletal remains found in open context or in rock shelters it was attempted to get a radiocarbon date using accelerator mass spectrometry (ibid.). Since fragmentary and conserved material was not dated, only 8 from 36 infants have radiocarbon dates (Pfeiffer and Harrington 2011, 454).

The skeletons were categorized according to burial context (in middens or sand dunes, rock shelters or other contexts) and ecological zone (fynbos, forest and savanna) (Pfeiffer and Harrington 2011, 254-255). The majority of the age estimations were done using dental development (Pfeiffer and Harrington 2011, 455). This was not possible for 40% of the cases, in which long bone lengths were used to estimate age. The subset of juveniles of whom age could be estimated by dental development is the one that is central to the study (ibid.). The femur length was used as a proxy for stature. In juveniles until the age of 15, the diaphysis was measured, as it did not fuse until this age (ibid.).

The age distribution of the sample was compared with juvenile mortality values from a model life table and with data collected ethnographically (Pfeiffer and Harrington 2011, 455). When compared to the mortality curve of a pre-industrialized population, the number of perinatal infants is exceptionally low in the sample (ibid.). The same can be said for the ages between 1 and 4 in the sample. Biased recovery could have caused this distribution pattern (Pfeiffer and Harrington 2011, 456).

The dates of the dated skeletons range between 220 to 9120 BP. The dates from the juveniles follow a similar distribution as those available for 301 adult skeletons (Pfeiffer and Harrington 2011, 456). The number of dated individuals increases after 2000 BP, which is accompanied by a substantial drop in both adult and juvenile skeletons from the study region (ibid.). During the period from 3800 to 1800 BP, there are indications of stress. There are a large number of burials across the region and a high proportion of these are of older juveniles (Pfeiffer and Harrington 2011, 458). During the same period, there are some exceptionally short adults and four multiple burials are reported, three of which show evidence of violence (ibid.). After this period of stress there is a drop in number of discovered burials and this suggests a drop in population size (Pfeiffer and Harrington 2011, 459).

The oldest juveniles have achieved mean adult femur length, but in the oldest juveniles aged by dental development, this is not the case (Pfeiffer and Harrington 2011, 456). Although some show fusion of the femoral epiphyses, other components such as the pelvis show that the growth has not ceased yet (ibid.). This indicates that the attainment of average adult femur length occurs at ages that are compatible with a mean age at first reproduction of 19.5 years (Pfeiffer and Harrington 2011, 457). Small stature is thus not the result of an early onset of reproduction (Pfeiffer and Harrington 2011, 459).

2.4 Secular trends in Korea: a case study

The second case study is very similar to the study by Maat (2005), which will be discussed later, apart from the fact that it is situated in Korea rather than the Netherlands (Shin *et al*. 2012). In the last decades several studies concerning secular trends in average statures have been published and a general trend is emerging (Shin *et al.* 2012, 433). In developed countries, an increase is visible around the beginning of the twentieth century, sometimes this stature increase initiated earlier, sometimes later. This increase is absent in undeveloped countries, where the average stature was maintained or even decreased, as for instance in Siberia after the fall of the Soviet Union (Shin *et al.* 2012, 433). Studies that cover a wider time span are sparse in Asia and especially for past Korean cultures (Shin *et al.* 2012, 434). This study focuses on the Joseon dynasty, which dates to 1392 to

1897 and was one of the last countries to open its ports to the West, delaying modernization in Korea (ibid.).

The material was collected from a particular type of tomb, which was used between the fifteenth and nineteenth centuries in the Joseon culture (Shin *et al.* 2012, 434). A total 116 skeletons was collected. The tombs were first used by the upper class only, but spread into the lower social strata in subsequent centuries (ibid.). Sex was estimated based on the pelvis and cranium and in some cases using DNA. The femur, humerus, radius and tibia were used in estimating stature. The tibia was measured according to Trotter and Gleser (1958). One author did all measurements to minimize interpersonal errors.

Since there is no regression equation available for stature estimation of Korean people, the most appropriate was selected (Shin *et al.* 2012, 435). Several methods based on Asian populations were tested, alongside the method of Trotter and Gleser (1958) based on the Mongloids and Pearson's equations for these were used often in Korea (ibid.). In addition for each equation the delta parameter of Gini (DG) was calculated. This parameter represents the average of the difference in stature values obtained from each individual's bones (Giannechini and Moggi-Cecchi in Shin *et al.* 2012, 435). The DG thus reflects the ratio similarity of each long bone to the stature (Shin *et al.* 2012, 437). The mean stature of the studied population was compared to the mean stature of the reference populations from the methods used to select an appropriate equation (Shin *et al.* 2012, 435).

The sample consisted of 67 males and 49 females (Shin *et al.* 2012, 435). The equations by Fujii were considered the most appropriate for this sample, based on low DG levels, the very similar average statures and the genetic similarities between the Koreans and the Japanese, who form the reference sample (Shin *et al.* 2012, 436). When possible, statures from known skeletal samples were recalculated using the regression formulas from Fujii (ibid.).

Historical documents on stature in Korea are scarce and the oldest known data date from the beginning of the twentieth century (Shin *et al.* 2012, 436). When the historical data are combined with the archaeological data, a slight increase in stature is seen during the fourth and fifth centuries, but this fluctuation does not result in a significant difference (Shin *et al.* 2012, 436). Most of the male statures remained relatively unchanged and ranged from 161.1 cm to 164.7 cm until the twentieth century (ibid.). A similar pattern is portrayed by the female average stature, ranging between 148.0 cm and 153.0 cm (ibid.). The start of the twentieth century brought a rapid change in stature. Both men and women showed a nearly linear increase in stature (ibid.).

Although many (but not all) of the samples were thought to be individuals from high society, it cannot be said whether the statures reflect differences among social classes during the Joseon dynasty (Shin *et al.* 2012, 438). Evidence from other burial contexts is needed to evaluate this matter (ibid.). When the average stature from the Joseon men was compared with the average statures known from contemporary peoples in Western countries, the Koreans were far shorter. The authors suggest that genetics are the main cause for this difference, but note that insufficient nutrition cannot be excluded, since even for the Joseon elites most dishes consisted of rice with some vegetables and dried fish, which is considered of low nutritional value (ibid.).

In northern Europe, average statures from the middle ages up until the twentieth century showed a U-shaped trend, which is in contrast with the Korean trend of the largely unchanged average statures (Shin *et al.* 2012, 438). The smallest average statures generally fall between 1450 and 1750, and if a U-shaped trend was present in the Korean statures, it is to be expected in the Joseon culture (Shin *et al.* 2012, 438-439). However, the stature remains relatively stable during this period. Where the negative trend in Europe is explained by increased population, urbanization and long-distance trade bringing in new diseases, none of these factors seem pertinent in the Joseon society (Shin *et al.* 2012, 439).

The population in Korea did increase steadily at a suggested rate of 4.8% per decade between the fifteenth and late sixteenth century (Shin *et al.* 2012, 439). However, population decreased abruptly from 1585 to 1645, due to wars with the Japanese and Manchurian (ibid.). Although the population recovered somewhat, no rapid growth phenomenon as witnessed in Northern Europe was observed in Korea (ibid.). It is suggested by the authors that the population decrease caused by the wars prevented food shortages by overpopulation (ibid.).

Mass urbanization that occurred in Europe during the middle ages, did not take place in Korea, where the urban population remained largely unchanged (Shin *et al.* 2012, 439). In addition, the Joseon culture was characterized by insularity and limited international trade prior to 1876 (ibid.). This meant that the spread of (new) diseases was prevented, and thus the isolation was beneficial to health (ibid.).

The abrupt increase in stature at the beginning of the twentieth century is seen in other countries as well (Shin *et al.* 2012, 439). The onset of the increase in stature is large concurrent with the industrialization process (ibid.). With industrialization, new techniques become available improving farming techniques and knowledge of medicine et cetera (ibid.). However, industrialization did not start properly before the 1960s in Korea, which does not explain the stature increase before that time (Shin *et al.* 2012, 439). The isolation that first helped keeping diseases out was ended by the opening of three harbors in 1876, introducing Western medicine and knowledge on sanitation to Korea and thus causing stature increase in the population (ibid.).

The pattern of stature trends in Korea differs somewhat from those observed in Western countries with respect to the decline in the middle ages and the onset of stature increase triggered by industrialization (Shin *et al.* 2012, 440). This is caused by a difference in social development, such as urbanization and trade (ibid.). The difference between Korea and European countries can be enlightening for both the European and the Korean cases, especially when the social differences between the two are known.

2.5 Two millennia of male stature development – the article by Maat (2005)

In his paper, Maat summarizes the data on the so-called positive secular trend in the Netherlands and offers new data concerning the turn of the twentieth century (Maat 2005, 277). In approximately 130 years the average stature of the Dutch male has increased 17 cm. This shift in average stature is accompanied by a substantial reduction in duration of the growth period (Maat 2005, 276-277). This phenomenon has been studied on the living and the dead.

Since most historical data concern male statures exclusively (e.g. conscripts), the study by Maat concerns male data only. When stature is calculated based on bone measurements, the outcome is the virtual stature, which is defined as "the stature that an adult male was assumed to have at the end of his growth period, that is, before he started shrinking by ageing" (Maat 2005, 277). To get to the stature at death, a certain amount per year needs to be subtracted, but some controversy exists on the onset and rate of stature decrease (Ousley, 770; Trotter and Gleser 1952, 479). In order to avoid these problems, only virtual statures are compared (Maat 2005, 277).

Records on the stature of the living were assumed to represent true stature in the best possible way, while records on the stature of deceased populations were derived in three different ways. It could be measured in the grave (in situ), from the highest point on the articulated skull to the lowest point on the heel (the calcaneal tuberosity). It is assumed that the postmortem stretch will have compensated the absence of skin (Maat 2005, 277-278). The second way is to calculate the virtual stature based on long bone lengths, most often the femur or tibia. This was done according to Breitinger (1937), Trotter and Gleser (1952, 1958) or Trotter (1970) (Maat 2005, 278). The corrected cadaveric stature is a third measurement used in this study. It was measured on the corpse in a dissection hall and 2 cm was subtracted to correct for postmortem stretch[2] (Maat 2005, 278). When available the maximum femoral lengths of the same populations of which the stature data had been collected were considered (Maat 2005, 279).

Data from 21 Dutch population samples were collected, which together cover a time span of about two millennia, from 50 to 2000 AD (Maat 2005, 279). The smallest sample consisted of seven, the largest sample of 3233 males. During this time span, average stature ranged between 166 and 184 cm, a difference of 18 cm. This shift from minimum to maximum occurred in the last century, which can be seen in fig. 1 (Maat 2005, 279). This figure shows a continuous stature decrease after the Roman period. This trend reaches its lowest point in the seventeenth and eighteenth century (ibid.). From the second half of the nineteenth century onwards, a definite increase in average stature is visible (ibid.).

Both the negative secular trend and the positive secular trend are considered more closely, as they can reveal information on changing living standards (Maat 2005, 283). Since the Roman period, the overall population increased and cities started to develop. By 1514, 46 percent of the Dutch population lived in towns (Maat 2005, 283). At the same time, the wages declined and thus the living standards dwindled (Maat 2005, 284). The lowest point reached in the seventeenth and eighteenth century coincided with a very prosperous period in the Dutch history, known as the Golden Ages (ibid.). This may have been the case, but still the capital was owned by a very small portion of the population and the ordinary man did not profit much from the Golden Age (Maat 2005, 284).

The crowded cities, food shortages and water wells juxtaposed to sewage pits were common ground in cities. This poor hygiene and poor nutrition resulted in a

[2] Postmortem stretch is due to the relaxation of the muscles and the flattening of the S-curve of the spine (Maat 2005, 281).

high frequency of non-specific infections and rickets (Maat 2005, 284-285). The presence of bilateral tibial periostitis, an inflammation of the membrane that envelopes the shinbone, may be used as an indicator of the pressure of infections on the population. A single affected tibia could be the result from skin lesions caused by trauma (Maat 2005, 285). Rickets (vitamin D deficiency that causes bowing of the shinbones) is another useful parameter for the nutritional status of a population (ibid.). Vitamin D is mainly obtained from sufficient sunlight and animal fat, which are needed to produce the vitamin in the human skin.

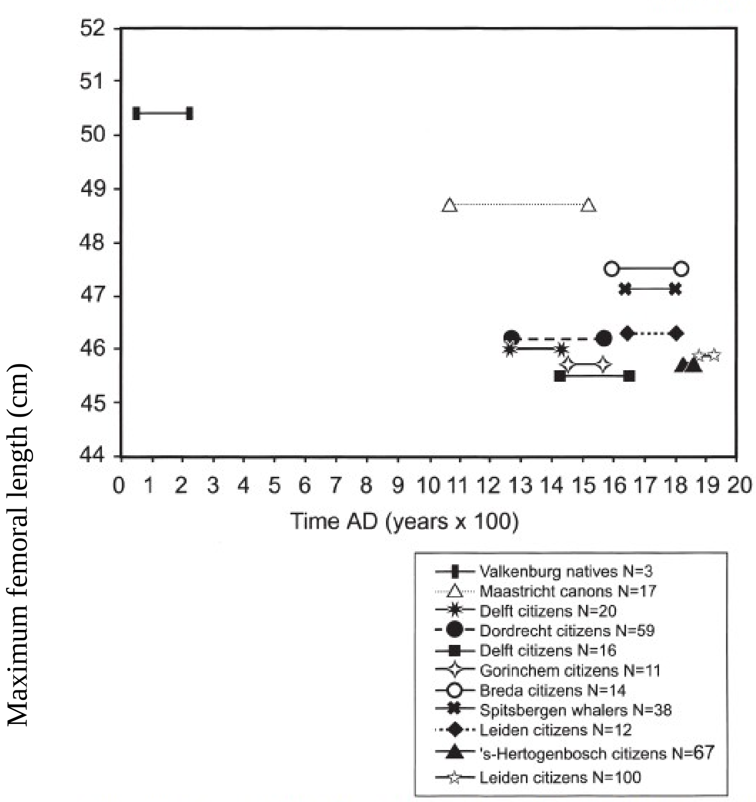


Fig. 2: Development of the maximum femoral length of adult males in the Netherlands (Maat 2005, 282).

Most individual statures were calculated using different combinations of long bones, which could have caused some deviation (Maat 2005, 281). Only the direct processing of the measurement of one element, for instance the maximum femoral length, would standardize such deviations. Since calculated stature is easier to comprehend, this has dominated the literature (ibid.). When the data were available, Maat also compared the maximum femoral lengths, seen in fig. 2. It shows that these data are in agreement with the data in fig. 1. The maximum femoral lengths were not available for all populations and could not be obtained from the living populations (Maat 2005, 279).

Maxim Maximum femoral length (cm)

In addition to the difference within the method stature estimation, there are also differences between the methods of stature calculation. The main problem addressed by Maat is the suitability of the reference population (Maat 2005, 281). Each method is developed using a reference population and it is generally accepted that a method is best used in populations similar to the reference population (Maat 2005, 281; Pearson in Gleser and Trotter 1952, 465). This said, Maat prefers the statures calculated using the method of Breitinger (1937). This method is based on a German population rather than on a American population as with the other available methods by Trotter and Gleser 1952, 1958 and Trotter 1970 which are used in this study (Maat 2005, 281; Wurm and Leimeister 1986, 70).

It is interesting to note that the average age at death over 20 did not show a distinct decline (Maat 2005, 285). Maat suggests that children, who need a vital share of the available food for their growth, had taken the toll. As children are rare in the skeletal archive (their small bones are easily overlooked by the archaeologists), this is difficult to prove (Maat 2005, 285-286).

During the period of the negative secular trend, two definite outliers are present, the males from the city of Leiden and the canons from Maastricht (Maat 2005, 286). The males in Leiden were exceptionally small for their time. At the time, the citizens of Leiden were known for the enduring mass poverty and unemployment, which could explain the small stature. At the same time, the canons in Maastricht were exceptionally tall (ibid.). Canons usually came from high social classes and during their life as cleric they did not live a simple life; they were known for their excessive lifestyle.

The Industrial Revolution started around the 1860's, causing the wages to rise faster than the costs for living and improvements in public health (Maat 2005, 286). As a result, a distinct positive secular trend is visible from this period onwards, accompanied by a sharp rise in the number of inhabitants (ibid.). Similar processes are recorded for Scandinavia and Germany. In Scandinavia, the positive trend in stature has since come to a standstill in 1983 at almost 180 cm and something similar is happening to the Dutch population[3] (CBS.nl; Maat 2005, 287).

In conclusion, the historical and pathological data seem to concord well with the negative and positive secular trend in stature, indicating that the average male stature may be used as a parameter of population health and wealth (Maat 2005, 287). The two outliers (Scheemda and Maastricht) could be explained by their social background (Maat 2005, 288).

3. The history of Klaaskinderkerke

The now extinct village of Klaaskinderkerke was located between Scharendijke and Brouwershaven on the island of Schouwen (fig. 3). Like many other small villages at the time, Klaaskinderkerke was built on a creek ridge (kreekrug, formed by sand deposited by a creek in an area that is compacted over time, thus

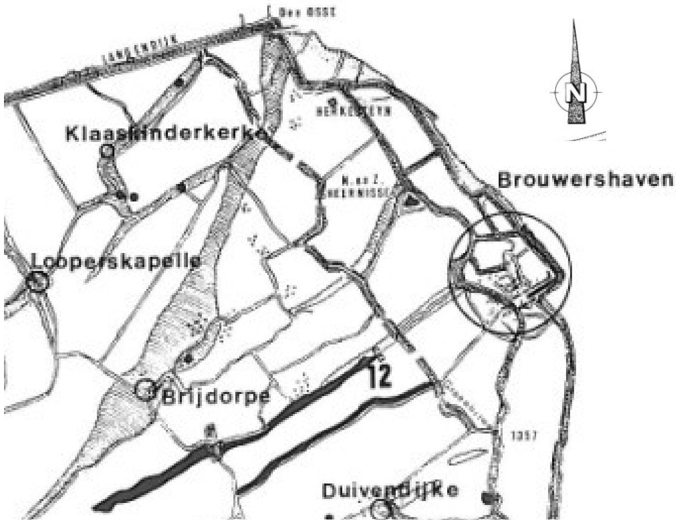
[3] Maat states that the average length of the Dutch male is 184 cm and increasing, but when looking at the numbers published by the CBS (Central bureau of statistics), the average male stature has been 181 cm for some years now.

creating a higher sandy ridge, fig 3; Brusse and Henderikx 2012, 197). The village is first mentioned in 1286 in a treaty between two sons of sir Clais and count Floris V (Bruin *et al*. 1982, 165). The parish church was dedicated to Saint Nicolas and was related to the church of nearby Brijdorpe (Post 1928, 104). The social landscape did not change much after the thirteenth century, even though floods and 'the plague' hit the island several times (Brusse and Henderikx 2012, 214).

By 1569, nearly 65% of the inhabitants of the island of Schouwen lived in the two largest towns: Zierikzee and Brouwershaven. A year later on All Saints' Day another flood struck Schouwen and afterwards there is no sign of people moving back to Klaaskinderkerke (De Bruin *et al.*, 165). However, two of the studied individuals showed pipe notches. As pipes and tobacco did not come into use till the early seventeenth century, this suggests a later end date of the cemetery (Brongers 1964, 25; Goes 1993, 20). It could well be that two or three families returned after the flood – this is supported by a text from 1773, stating that nothing is left of Klaaskinderkerke, except the cemetery and a few farmsteads - and that these were buried at the cemetery, at least until 1812, when Klaaskinderkerke was included in a new municipality. This meant that any dead in Klaaskinderkerke after 1812 were buried on the new municipal cemetery in Duivendijke (H. Uil, pers. com.; Huizinga and Trimpe Burger 1963, 562). It is also mentioned that someone remembered that his grandfather buried a drowned man at the cemetery (Huizinga and Trimpe Burger 1963, 563). The cemetery remains visible until 1959, when reallocation activities demanded that the land was leveled out (Huizinga and Trimpe Burger 1963, 559).

3.1 The excavation

The Rijksdienst van Oudheidkundig Bodemonderzoek (ROB, Civil service of Archaeological Soil exploration) excavated the site in the fall of 1959 (Huizinga and Trimpe Burger 1963, 559). The cemetery was about 50 square meters in size and was surrounded by a ditch (fig. 4; Huizinga and Trimpe Burger 1963, 559). The most recent floodings of 1944-1945 and 1953 had caused the top layer to be disturbed and partially washed away: the foundations of the church became visible and human remains were scattered around the cemetery (ibid.).



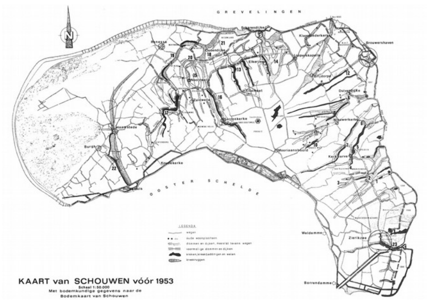


Fig. 3: Detail of map of Schouwen as it was before 1953. The creek ridges are indicated by the shaded areas (after Kuipers 1982).

Only the section with the church was excavated, with the trenches arranged to get a cross section of the cemetery. A vertical section was created between the points A and B in figure 4, which showed two phases of artificial elevation: the first one is thought to have taken place in the twelfth century, and in the second phase in the late thirteenth century the hill was expanded to allow for the church to be built (Huizinga and Trimpe Burger 1963, 160). Although little was left of the church, measurements could be taken and the archaeological remains are congruent with the first mention of the village in the late thirteenth century (Huizinga and Trimpe Burger 1963, 560). After the excavation John Huizinga examined the skeletal material further at the anthropological institute of the University of Utrecht in 1962 and 1963 (SCEZ dossier 2016).

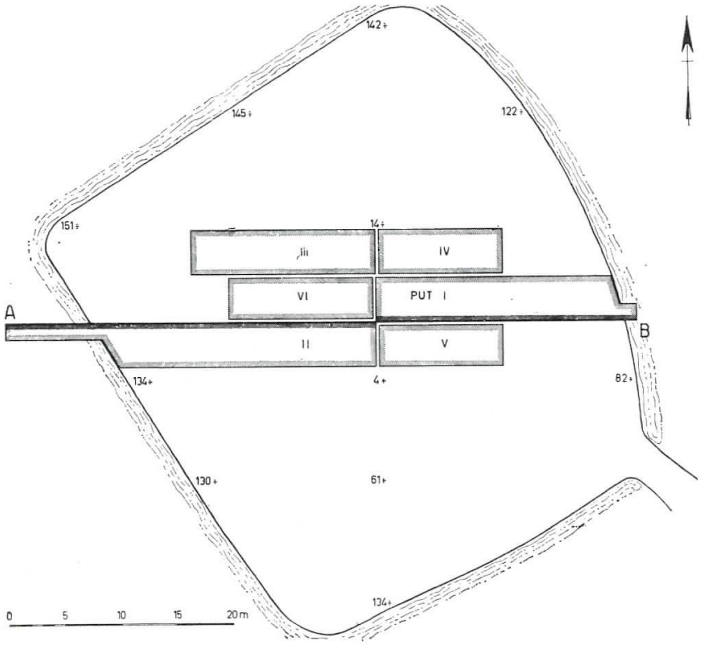


Fig. 4: Drawing of the cemetery of Klaaskinderkerke and the ditches which were excavated (Huizinga and Trimpe Burger 1963, 560).

3.2 The skeletal material

In 1963, the results of the excavation were published by Huizinga and Trimpe Burger in ROB Berichten (messages from the civil service of archaeology; pp 559-570). The research done by dr. Huizinga was published, along with the history of Klaaskinderkerke, a description of the excavated area and the drawings of the excavation (fig. 4 and appendix 1; Huizinga and Trimpe Burger 1963). He distinguished between three groups of different materials: group A contained complete skeletons with crania (n=29), group B contained skeletons without crania (n=24) and group C contained 57 isolated crania, which could have partially belonged to the individuals from group B (Huizinga and Trimpe Burger

1963, 563). In all groups the sex was estimated and there was a tendency of more males than females (A 19:10, B 17:7, C 41:16). Huizinga suggested that this could have been caused by the inhumation of victims of the battle of Brouwershaven in 1426 at this site, but could not prove this proposition.

Dr. Huizinga was interested in this material because of a discussion on the origin of the inhabitants of Zeeland. People with more long heads (dolichocranic people) were said to live along the west coast, while people with more rounded heads (bracycranic people) were said to live in the east of Zeeland (Huizinga and Trimpe Burger 1963, 564). These two kinds of head forms were seen to represent the Nordic and Alpine race respectively and dr. Huizinga was interested in these races and their presence in Zeeland (ibid.). Of the examined crania, 80% were bracycranic and some had very high values, which made Huizinga speculate about the possibility of inbreeding within the Klaaskinderkerke community (ibid.).

The two races were also connected to stature: the Nordic race was thought to be tall, while the round headed Alpine race would have a smaller stature (Huizinga and Trimpe Burger 1963). He assessed the stature of thirty three individuals using the tables of Manouvrier (Huizinga and Trimpe Burger 1963, 567). The results were different from what he expected them to be: he found no correlation between the stature and the head form of the individuals (Huizinga and Trimpe Burger 1963, 568-9).

4. Materials and methods

4.1 Materials

As discussed in the previous chapter, the material has been excavated in 1959 on the island of Schouwen (Huizinga and Trimpe Burger 1963). Since 1570, this location has been flooded several times and during the most recent flood (1953) skeletal elements and the foundation of the church surfaced (Huizinga and Trimpe Burger 1963). This has had an influence on the completeness and preservation of the skeletal remains. The preservation is usually excellent, but some water damage is present in the form of barnacles or white deposits. In most of the individuals at least one skeletal element was damaged by a shovel or trowel during the excavation. The completeness of the individuals varied. Some were nearly complete, missing only a few elements, while others were only represented by some fragmentary long bones.

4.2 Sample

Out of a minimum of 86 individuals (groups A and C as defined by Huizinga summed up), 37 individuals have been examined for this study. These were selected based on the presence of complete long bones to estimate stature. Sex, age and stature has been assessed for these individuals. This was done using a form adapted from Rachel Schats on which the observations were noted (appendix 2). Only adults were included, as well as individuals with at least two intact long bones and of whom sex could be estimated. To enlarge the sample sizes, the probable females and females and the probable males and males were grouped together.

4.3 Methods

The examination of the material was executed from January till March 2013 in osteological laboratory at the Faculty of Archaeology in Leiden. For each individual a form was created (appendix 2, after R. Schats), which stated the different methods and the different characteristics used to estimate sex, age and stature.

4.3.1 Sex estimation

Sex can only be accurately estimated in adult individuals, as the characteristics that are used only develop during puberty (Folkens and White 2005, 385). A range of characteristics were used in this study, according the recommendations of the Workshop of European Anthropologists (WEA 1980). The cranium, mandible and pelvis were separately considered, scoring several traits female, probable female, indeterminate, probable male or male. This is then converted into numbers (female is -2, male is +2). All scores for each of the three elements are then multiplied by either 1, 2 or 3 depending on the reliability of the trait and these are then added up to get a total of the scores. This total is then divided by the total weights, which gives a number between -2 and +2, indicating the average sex of the cranium, mandible or pelvis. The three scores can then be used to give an overall estimation of sex. In this process, the mandible is considered the least reliable, since it has been suggested that the Dutch females have a relatively male jaw (Maat *et al*. 1997). The pelvis is considered to be the most highly correlated with the sex of the individual (Folkens and White 2005, 385). In this population, the males often had a female frontal bone. This was probably caused by the overall very rounded form of the head which was already noted by Huizinga (1963, 564).

When the outcome of the calculations was mostly negative, the individual was considered female, and when it was mostly positive, the individual was considered male. This was further divided into probable and definite sexes based on how far away from zero the scores were. Scores around zero (-0.3 to +0.3) were considered indeterminate and when the scores varied a lot, they were reconsidered. Scores around -1 and +1 were considered to be a probable female and a probable male respectively.

In addition to these non-metrical traits, also some metrics were included to help estimate the sex. Two measurements on the scapula, two on the clavicle, three measurements of the humerus and the femoral head diameter are taken to help determine the sex of the individual.

4.3.2 Age estimation

To estimate age, eight different methods could be used, but it was hardly ever possible to use all eight at the same time. First it was checked whether the individual was over eighteen by looking at some epiphyses that close around the age of twenty (Folkens and White 2005, 372). The auricular surface was most often present and thus is mostly used to age an individual in this study. Both the methods by Buckberry and Chamberlain (2002) and by Lovejoy *et al.* (1985) were used. In addition, the pubic symphyses were scored according to Todd (males only) (1920) and Suchey and Brooks (1990). When teeth were available, the wear of the molars was scored according to Maat (2001) and on the cranium the sutures were scored according to Meindle and Lovejoy (1985). In some rare occasions a sternal rib-end was present to use for aging, which was done using the method by Işcan and Loth (1986).

When all possible methods were used, it was estimated in which age category the individual belonged: adult or eighteen plus for those of whom no further distinction in age could be made; young adult or between 18 and 25; young middle adult or between 26 and 35; old middle adult or between 35 and 46 and mature adult for all individuals of 46 or over. The individual was ascribed to the category in which he/she most likely belonged by looking at all the outcomes of the different methods, and sometimes this meant that some methods were not congruent with the eventual estimation. Most often the method by Maat did not agree with the outcomes of the other methods used.

4.3.3 Stature estimation

Measurements of all long bones were taken according to the authors of the stature estimation methods and the standards set by Knussmann (Breitinger 1937; Gleser and Trotter 1958; Knussmann 1988; Trotter 1970; Ousley 1995). Care was taken to make sure that all measurements were taken on the same osteometric board, to reduce the intra-observer error. The measurements of the long bones are included in appendix 3.

There are many different ways to calculate stature from long bone measurements. As with the methods to estimate sex and age, these were developed mainly for the forensic field to identify the remains from for instance war victims (e.g. Trotter and Gleser 1952). There is a debate on whether these methods, which are developed on recent populations, also apply on older and ancient generations (Wurm and Leimeister 1986, 73). The methods used in this study are further elaborated below.

After the length was calculated for all individuals, an average stature based on the outcomes of the different methods was calculated for each individual. All methods were considered to be equally correct, so no weight was considered in the averaging of the statures. The reduction caused by age was not included in this study, as the virtual stature (maximum attained stature) was calculated as opposed to the stature at death (Maat 2005, 277).

4.4 Methods of stature estimation

From the measurements of long bones stature was estimated according to several different methods for males: Trotter and Gleser (1958) and Breitinger (1937); for both males and females Trotter (1970) and Ousley (1995) and Trotter and Gleser (1952) for females only. The methods by Breitinger (1937), Trotter (1970) and Trotter and Gleser (1952; 1958) are used in earlier work on stature estimation in the Netherlands and are included to enhance the comparison (Maat 2005, 278), and Ousley (1995) is included to have an additional method to estimate stature for females. Even though the formulas of Trotter and Gleser (1952) using only one element are the same in Trotter (1970), it is possible that the formulas based on multiple elements were used in the earlier studies on stature estimation in the Netherlands.

4.4.1 Breitinger (1937)

Breitinger noticed many shortcomings in the research of stature estimation up until then (Breitinger 1937, 249). In fact, he disregards the research of Manouvrier by saying “50 südfranzösiche Anatomieleichen sind kein Standard” (fifty cadavers from the south of France don’t make a standard, translation by author) (Breitinger 1937, 257). Firmly based in the German politics at the time, he feels that the people from the south of France are a different race than the Germans, making a separate method necessary to accurately estimate stature for Germans (ibid.).

To create formulas to be used for Germans, Breitinger measured approximately 2400 German men, of which most were gymnasts and athletes (Breitinger 1937, 259). The other subjects were male students (Breitinger 1937, 260). The subjects were living, so Breitinger assumed that living stature was measured correct to within a centimeter, although when alive stature can vary up to two centimeters in one day (Breitinger 1937, 258; Ousley 1995, 769). The measurements of the skeletal elements were more problematic and were taken by palpating for landmarks (Breitinger 1937, 258-259). This means that to be able to use the method by Breitinger, the measurements taken on the osteometric board are slightly different from the measurements taken for the other methods.

Although this study is still used, it has been heavily commented on. Most authors mention that the palpating of landmarks on the long bones cannot lead to accurate measurements that resemble measurements on their dry counterparts (Trotter 1970, 71). And even though Breitinger argues himself that taking measurements from cadavers creates a bias in the sample, over half of the individuals studied in his study are part of a very specific subsample, namely the participants of an athletic meet (Breitinger 1937, 258; Trotter and Gleser 1952, 466). It can be argued that these have a different physique than the average population with some muscles being more developed than others. Still this method is included in this study, because it has been used quite often for Dutch populations. It is considered to be the most accurate method for Dutch populations since the reference population for this method is both genetically and topographically close to Dutch populations (Wurm and Leimeister 1986, 70).

4.4.2 Trotter and Gleser 1952

In 1952 the first of many publications by Trotter and Gleser on the estimation of statures appeared (1952). The victims of World War Two gave the opportunity of measuring long bones of individuals whose living stature was also known (each individual was measured at his induction). In addition, the individuals include a broader and more representative cross-section of the (in this case) American population (Trotter and Gleser 1952, 467). In addition to the data of the military personnel, data from the Terry collection were included to derive regression formulas for females (Trotter and Gleser 1952, 469).

The living stature was measured at many different stations for the military personnel, however the directions for taking height are very clear (Trotter and Gleser 1952, 471). The data from the Terry collection were compared to the cadaveric stature, which was measured with a specially constructed panel (Trotter and Gleser 1952, 472). All measurements on the bones were done by Trotter herself and recorded to the nearest millimeter (Trotter and Gleser 1952, 472). The average of a pair of bones was used to calculate stature (ibid.).

The humerus, radius, ulna and fibula were measured by placing the head to the fixed vertical part, the block was applied to the other extremity and the bone was moved slightly to attain the maximum length (Trotter and Gleser 1952, 472-473). The method differed for the femur and the tibia. For the maximal femoral length, the medial condyle of the femur was applied to the fixed vertical part, its axis parallel to the board. The block was placed at the head and the maximum length was measured the same way as described above (ibid.). For the bicondylar length of the femur both condyles were adjusted to the vertical part of the board. The block was then placed at the head of the femur. The maximum length of the tibia was measured by placing the end of the malleolus against the fixed vertical wall, its axis parallel with the board. The block was then applied to the most prominent part of the lateral half of the lateral condyle (ibid.). The ordinary length of the tibia was measured with spreading calipers from the center of the articular surface of the lateral condyle to the center of the inferior articular surface (ibid.).

It is the measurement of the maximum length of the tibia that caused some confusion and discussion in subsequent years (Jantz *et al*. 1994). Her original measurements of the Terry Collection were used to check the method used to measure the tibia (Jantz *et al.* 1994, 525). They concluded that during measuring, Trotter excluded the malleolus, resulting in an error when the regression formula was used with the malleolus included (Jantz *et al.* 1994, 527). Since the measurement of the tibia is problematic, the formulas containing the tibias were not used during this study.

The equations for females are derived entirely from the Terry collection, which means that the cadaveric stature is calculated with this method. To correct for post-mortem stretch, two cm has to be subtracted to get the living stature (Maat 2005, 282). For the individuals over 30, the stature has to be corrected for shrinkage due to aging, but, as mentioned before, this correction is not applied in this study (Trotter and Gleser 1952, 488).

4.4.3 Trotter and Gleser 1958

In 1958, Trotter and Gleser published a follow-up of their 1952 study (Gleser and Trotter 1958). In addition to new data from the Korean War, they validated and refined the 1952 formulas for males (Gleser and Trotter 1958, 80). The materials thus comprised young males who died during their service in the American Army.

In total, 5517 males of various origins were studied (Gleser and Trotter 1958, 81). Unlike the study of 1952, the measurements of the paired bones were not averaged, but considered separately because this was easier in the documentation of the measurements (ibid.). The different populations that were included in the sample were white, negro, Mongloid, Mexican and Puerto Rican, though the whites form the largest group (4672 of 5517 in total) (Gleser and Trotter 1958, 81).

The method used to measure the bones was the same as they used in the study of 1952, though two measurements were not taken in 1958: the bicondylar length of the femur and the normal length of the tibia (Gleser and Trotter 1958, 81). As with Trotter and Gleser 1952, the measurement of the tibia is problematic and thus not included in this study.

4.4.4 Trotter (1970)

In 1970, another publication under Trotter's name appeared in *Personal identification in mass disasters* (1970). As the title of the work suggests, the article is primarily intended for forensic cases to help identify individuals (Trotter 1970, 71). Her regression formulas were based on both military and civilian individuals and apply for the white, negro, mongoloid, Mexican and Puerto Rican American populations (Trotter 1970, 72). For this study, only the white regression formulas were used. The war victims were from the Second World War and the Korean War and were all young males (ibid.). The civilians were cadavers assigned to the Washington University School of Medicine, and were part of the Terry collection (ibid.). In total, 3845 white males and 63 white females were examined to calculate the regression formulas (ibid.). As mentioned above, the regression formulas for females published in 1970 are the same as those published in 1952 by Gleser and Trotter, no new data had been added for the female formulas (Gleser and Trotter 1952, 489; Trotter 1970, 75).

These formulas were made for the humerus, ulna, femur, tibia and fibula separately and for some combinations (Trotter 1970, 73). The lengths of paired bones were averaged when possible, although the advantage is very slight (Trotter 1970, 74). The bones were measured in the same way as in 1958 and 1952, and Trotter herself found some inconsistencies in the measurements of the tibia between the Korean War dead (measured by Dr. R.W. Newman (Trotter 1970, 72)), and the Second World War dead and the Terry Collection (measured by Trotter herself) (Jantz *et al.* 1994, 525). Again, the formulas based on the tibia were not used in this study.

4.4.5 Ousley (1995)

Ousley published an article in 1995 comparing measured statures (MSTATs, calculated from long bone lengths according to Trotter 1970) with forensic statures (FSTATs, statures known from documentation, like a drivers license) (Ousley 1995, 768). He developed new regression formulas based on the Forensic Data Bank (FDB) (Ousley 1995, 772). The length is calculated in inches, even though the measurements are in mm (to convert to cm the outcome is multiplied by 2.54) (ibid.).

There is no overview of the materials used and no clear explanation of the sample used to calculate the regression formulas (Ousley 1995). Furthermore, Ousley states in his conclusion that the Trotter and Gleser method is generally more accurate, except for modern forensic cases (Ousley 1995, 272).

4.5 Statistics

To test if the observed differences are significant, statistical calculations were executed in SPSS 17.0. A p-value smaller than 0.05 was needed for the difference to be significant. The difference between females and males within the population were assessed, as it has been shown that females are generally significantly smaller than males. As the number of females is smaller than ten, the difference is assessed by the Mann-Whitney U test, which is the equivalent of the paired t-test.

The difference between the stature estimation methods used is tested. When one or more of these methods appear to be significantly different from the others, it can be argued that one cannot compare average statures obtained by two different stature estimation methods. This is done by using the independent sample t-test. For the outcomes to be valid, the data have to be normally distributed. This was tested by the Levene's test for equality of variances. The p-value of this test needs to be $p>0.05$. Where this requirement is not met and for the female subsample (since it is to small), a Mann-Whitney U matched pairs test was executed to still be able to make a comment on the validity of the comparison.

In addition to the overall comparison of the methods, the male methods were also compared in two separate groups based on the average stature. Group 1 consisted of individuals with an overall average stature of smaller than 175 cm, group 2 consisted of individuals with an overall average stature of 175 cm or taller. Then the independent t-test was repeated within these two groups (and when normalcy was violated, the Mann-Whitney U test was also done). A p-value smaller than 0.05 was needed for the difference to be significant.

A similar procedure was followed for the female methods. Group 1 consisted of individuals with an overall average stature of smaller than 160 cm, group 2 consisted of individuals with an overall average stature of 160 or taller. The difference between the methods within a group was tested using a Mann-Whitney U test, since the sample size is too small to use an independent t-test.

Since historical data suggest that only wealthy people were buried inside the church, a comparison was made between the stature from people inside the church and people buried outside the church (Brusse and Henderikx 2012, 182). This is done for the males using the independent t-test and for females using the Mann-Whitney U test. Three groups were created based on the location on the field drawing (appendix 1). Group 1 consists of individuals buried inside the church, group 2 consists of individuals buried outside the church and group 3 consists of two individuals buried beneath the foundations and one individual that could not be located on the map. Group 3 was excluded from the calculation.

In addition, the male average stature and female average stature of Klaaskinderkerke is compared to male and female average statures from contemporary Dutch populations. This was done by a Kolmogorov-Smirnov test (which is the non-parametric equivalent of the 1-sample t-test), since from most populations only the mean is known (Carmiggelt *et al*. 1999; Maat 2005). When the raw data were published, the difference was tested using a independent sample t-test.

5. Results

As Huizinga already noted, more males than females are present in the sample (Huizinga and Trimpe Burger 1963, 563). Out of the 37 individuals examined, seven females, two probable females, one indeterminate, twelve probable males and fifteen males were identified. This means that when the probable and definite females are grouped together, 24.3% of the sample is female and since the sample is smaller than ten individuals, statistical analysis is problematic.

In figure 5 the adult age distribution is shown. For five individuals it was not possible to establish the age more accurately than over eighteen. Three were young adults, fifteen were young middle adults, eight were old middle adults and five were mature adults. There were no mature females in the sample, but this could be due to the small number of females included.

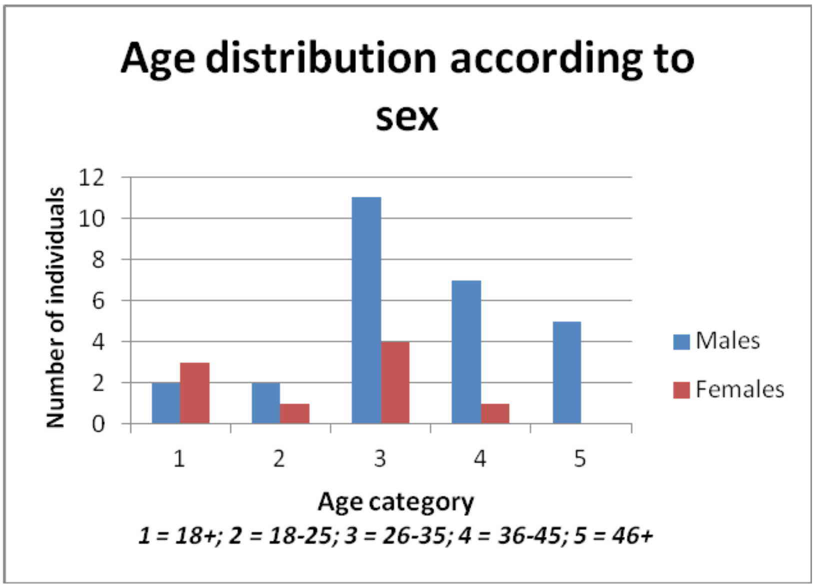


Fig. 5: Age distribution according to sex.

The average of all stature estimations for Klaaskinderkerke was 170.55 ± 4.76 cm and ranged between the average of 143.61 for find number 34 and the average of 187.23 for find number 10. The average stature per individual is shown in figure 6, which makes clear that the females are generally smaller than males. This is also expressed in their means: for males the average stature is 173.81 ± 4.68 cm, for females the stature estimations average at 162.26 ± 5 cm. The averages per estimation method are shown in table 1 and 2 for males and females respectively.

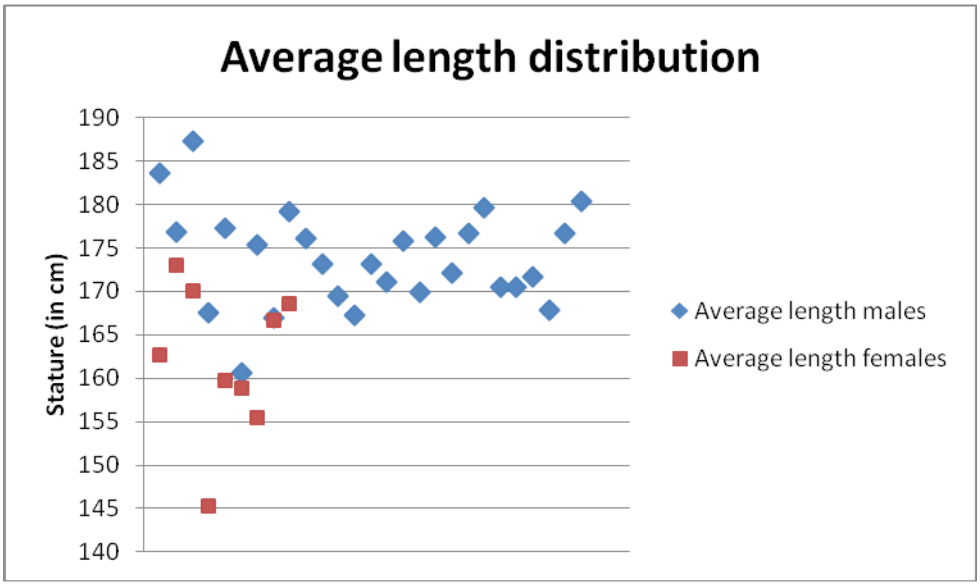


Fig. 6: Average stature estimations for males and females.

Table 1: Average, minimum and maximum of male statures as determined by Breitinger 1937, Gleser and Trotter 1958, Trotter 1970, and Ousley 1995.

	Breitinger 1937	Gleser and Trotter 1958	Trotter 1970	Ousley 1995	Average
Average	171.84 ± 4.84	174.51 ± 3.86	173.53 ± 3.30	175.37 ± 6.68	173.81 ± 4.68
Minimum	161.17 ± 4.75	161.17 ± 3.62	159.47 ± 3.27	160.43 ± 6.35	160.56 ± 4.50
Maximum	181.5 ± 4.8	188.5 ± 3.94	187.5 ±3.27	191.41 ± 7.11	187.23 ± 4.78

Table 2: Average, minimum and maximum of female statures as determined by Trotter and Gleser 1952, Trotter 1970 and Ousley 1995.

	Trotter and Gleser 1952	Trotter 1970	Ousley 1995	Average of the methods
Average	164.46 ± 3.53	160.65 ± 3.77	161.86 ± 6.24	162.26 ± 4.56
Minimum	148.55 ± 3.51	143.76 ± 3.72	143.45 ± 6.1	145.25 ± 4.44
Maximum	174.94 ± 3.55	170.44 ± 3.72	173.66 ± 6.1	173.01 ± 4.46

The Mann-Whitney U test showed that the difference between male and female stature is significant, with a two tailed significance of 0.000037 and a point probability of 0.0000028.

There are no large differences observed between the different female methods. This is confirmed by the Mann-Whitney U test, indicating that the difference is not significant for Trotter 1970 and Ousley (Z= -0.962; p= 0.336) and for Trotter and Gleser 1952 and Ousley (Z=-0.674; p= 0.501). The difference between Trotter and Gleser 1952 and Trotter 1958 was also not significant (Z= -0.486; p=0.627).

To estimate the difference between the male stature estimation methods, the independent t-test was executed. For the comparisons between Breitinger (1937) and the other methods, the Levene's test showed that equal variances could not be assumed. The p-value for the comparison between Breitinger (1937) and Trotter and Gleser (1958) was not significant at 0.057, but since the value is very close to significance, it was recalculated with a Mann-Whitney U test. The other two p-values were 0.023 and 0.047 for the comparison with Trotter (1970) and Ousley (1995) respectively.

The comparisons between the other methods did not violate normalcy. The difference between Trotter and Gleser (1958) and Trotter (1970) is not significant (F= 0.1; t= 0.591; p=0.557), as is the difference between Trotter and Gleser (1958) and Ousley (1995) (F= 0.68; t= -0.493; p= 0.624). The difference between Trotter (1970) and Ousley is also not significant (F=0.89; t=-1.0; p=0.3).

The Mann-Whitney U test indicates that the difference between Breitinger (1937) and Trotter and Gleser (1958) is not significant (Z= -1.747; p= 0.081). The difference between Breitinger (1937) and Trotter (1970) is also not significant (Z=-1.012; p= 0.311). The difference between Breitinger (1937) and Ousley (1995) however *is* significant (Z= -2.145; p= 0.032).

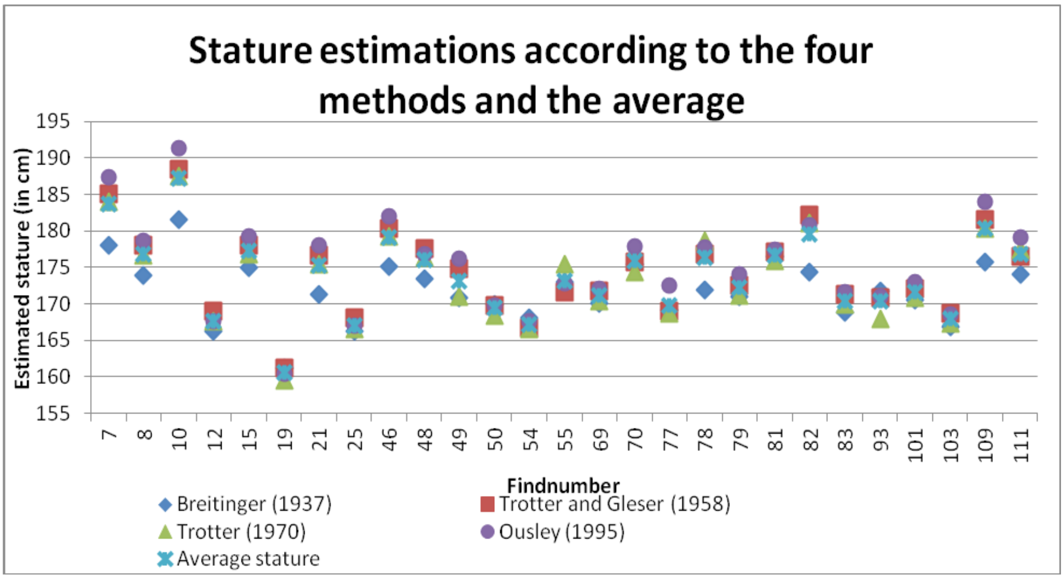


Fig. 7: The stature estimations for males according to the four different methods and the average.

As is seen in fig. 7, the taller the individual, the further apart are the different estimations. This is reflected in the p-values of the independent t-tests of the two different groups. New tests were executed, and again a significant difference was found between Breitinger (1937) and Ousley (1995) in the group with an average stature over 175 cm (F=0.109; t= -4,034; p=0.0005). In addition, a significant difference is found between Breitinger (1937) and Trotter and Gleser (1958) in the group over 175 cm (F=0.127; t= -3,472; p= 0.002). The same is true for the comparison between Breitinger (1937) and Trotter (1970) in the group over 175 cm (F=0.219; t= -2.889; p= 0.008). All other comparisons did not yield any significant values. This indicates that Breitinger (1937) significantly underestimates the higher statures in comparison with the other methods.

This is also shown in fig. 8, which shows the regression lines for all male stature estimation methods. The methods of Trotter and Gleser (1958) and Trotter (1970) are very similar to each other, but the lines of Ousley (1995) and Breitinger (1937) diverge.

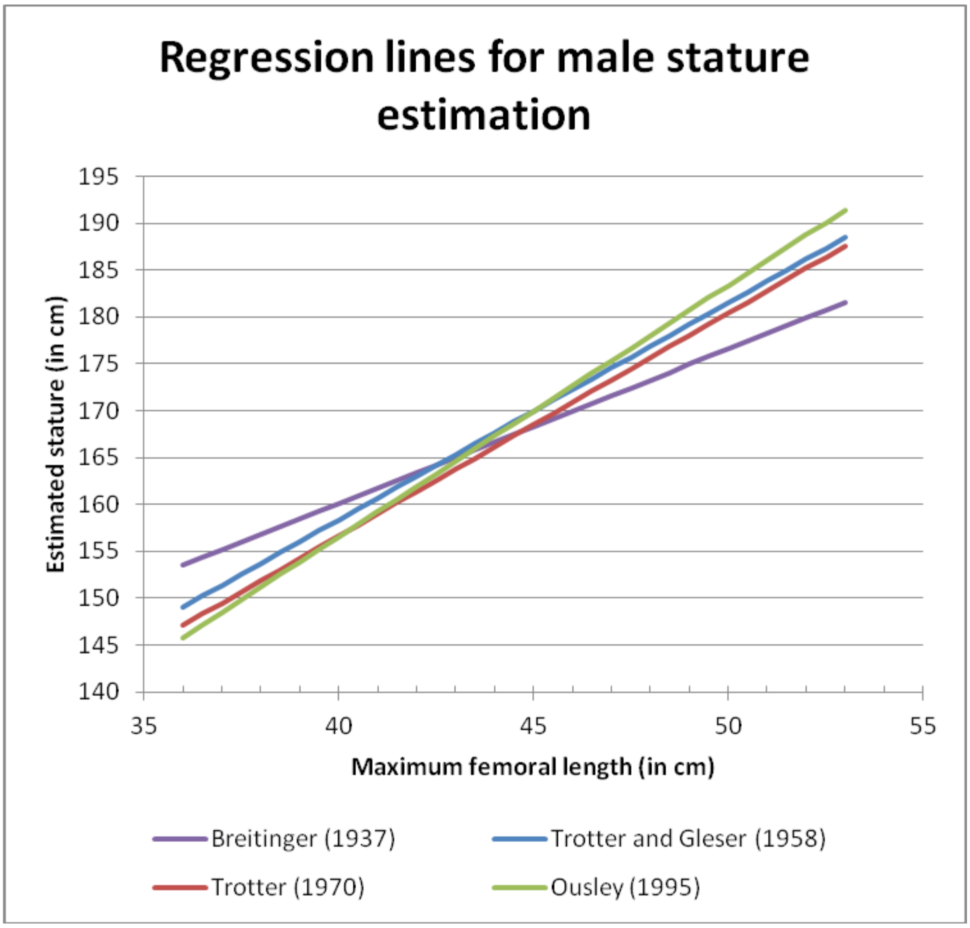


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Fig. 8: Regression lines based on femoral length for the male stature estimation methods.

The same figure is made for the female methods excluding Trotter and Gleser (1952), as the formula to calculate stature from maximum femoral length is identical to the one published in Trotter (1970). Here, the methods are less divergent (and do not significantly differ), but also in this case Ousley (1995) estimates high statures higher than Trotter (1970). This was tested using a Mann-Whitney U test, which showed no significant difference (smallest p-value was 0.063 (Z= -1.96) for the comparison between Trotter and Gleser (1952) and Trotter (1970) in the second group).

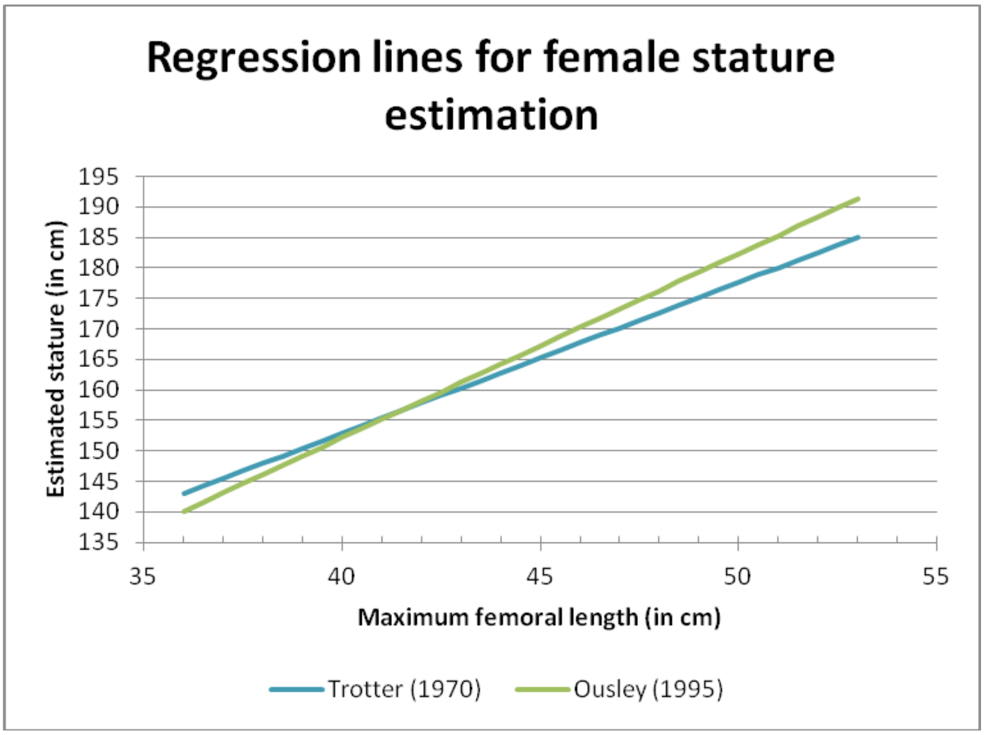

Fig. 9:Regression lines based on femoral length for the female stature estimation methods.

The average statures of the males were also compared between those buried within the church and those buried outside the church. One male was buried beneath the foundations and thus predates the church, his stature was excluded from the calculation. An independent t-test showed that the difference in average stature between the two groups is significant (F=0.861; t=2.468; p=0.021). Eleven males were buried inside and fifteen outside the church. The mean statures are 176.7 cm and 171.8 cm respectively (overall averages).

For the females, a Mann-Whitney U test was used to see whether there is a significant difference between the average stature of the women buried inside the church and those buried outside it. Only two females were buried inside, one was buried beneath the foundations and one could not be located on the field drawing (find number 26); both were eliminated from this calculation, which leaves five females whom were buried outside the church. There was no significant difference between the two groups ($Z=-1.549$; $p=0.121$), but this could be the effect of the low number of females.

The average statures of the males and females of Klaaskinderkerke were compared to the average statures from Dutch populations in the same time period (1100-1600), which is shown in figure 10 for males and figure 11 for females. For Klaaskinderkerke, the estimations of all methods were averaged to give an overall stature average. For the sites other than Klaaskinderkerke, the method used to estimate stature is given in table three. The actual lengths and periods are summarized in table 3. For some populations, no standard deviation was given in the publication (Dordrecht and Scheemda) or the original publication could not be accessed and the data were obtained through Maat (2005).

For males, the sample from Klaaskinderkerke seems to be slightly taller than contemporary samples, except for Maastricht and Scheemda. The females seem to be more congruent with the other known samples.

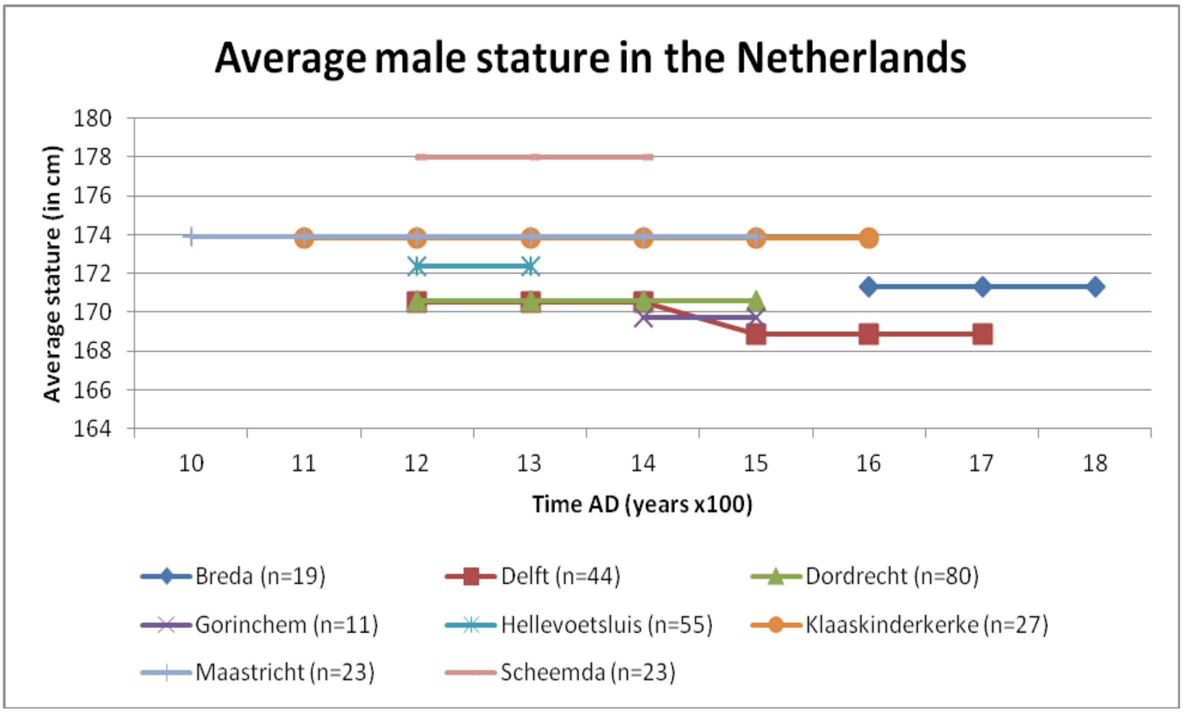

Fig. 10: Comparison of Klaaskinderkerke with seven contemporary sites. Delft represents a younger and an older sample (Carmiggelt et al. 1999; Maat 2005; Maat and Mastwijk 2000).

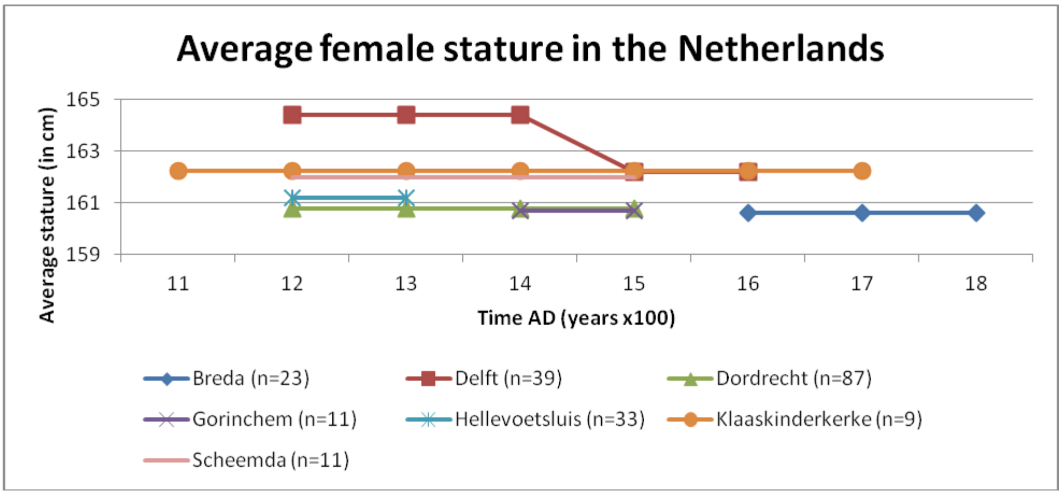

Fig. 11: Comparison of the average stature of the females of Klaaskinderkerke with six contemporary sites. Since Maastricht did not yield any female individuals, Maastricht is not included in this figure (Carmiggelt et al. 1999; Maat 2005; Maat and Mastwijk 2000).

Table 3: Period, male and female average stature and stature estimation methods for the populations which are compared with Klaaskinderkerke (Carmiggelt et al.1999, 90; Maat 2005, 278; Maat and Mastwijk 2000, 15).

Population	Period	Males	Females	Method
Breda (n=19:23)	1600-1824	171.3 ± 4.4	160.6	Breitinger 1937; Trotter and Gleser 1952
Delft (n=25:19)	1265-1433	170.5 ± 4.6 171.8 ± 5.7	164.4 ± 7.8	Breitinger 1937; Trotter and Gleser 1952; 1958
Delft (n=19:20)	1433-1652	168.9 ± 3.4 170.8 ± 4.3	162.2 ± 7.1	Breitinger 1937; Trotter and Gleser 1952; 1958
Dordrecht (n=80:87)	1275-1572	170.6 ± 3.8	160.8	Breitinger 1937
Gorinchem (n=11:11)	1455-1572	169.7 ± 3.8	160.7	Breitinger 1937; Trotter and Gleser 1952
Hellevoetsluis (n=55:33)	1250-1300	172.4 ± 6.2	161.2 ± 4.94	Trotter and Gleser 1952; 1958
Klaaskinderkerke (n=27:9)	1100-1600	173.81 ± 4.68	162.26 ± 4.56	Breitinger 1937; Trotter and Gleser 1958; Trotter 1970; Ousley 1995
Maastricht (n=23)	1070-1521	173.9 ± 3.9; 179 ± 5.2	No females	Breitinger 1937; Trotter and Gleser 1958
Scheemda (n=19:11)	1275-1509	178	162	Trotter and Gleser 1958

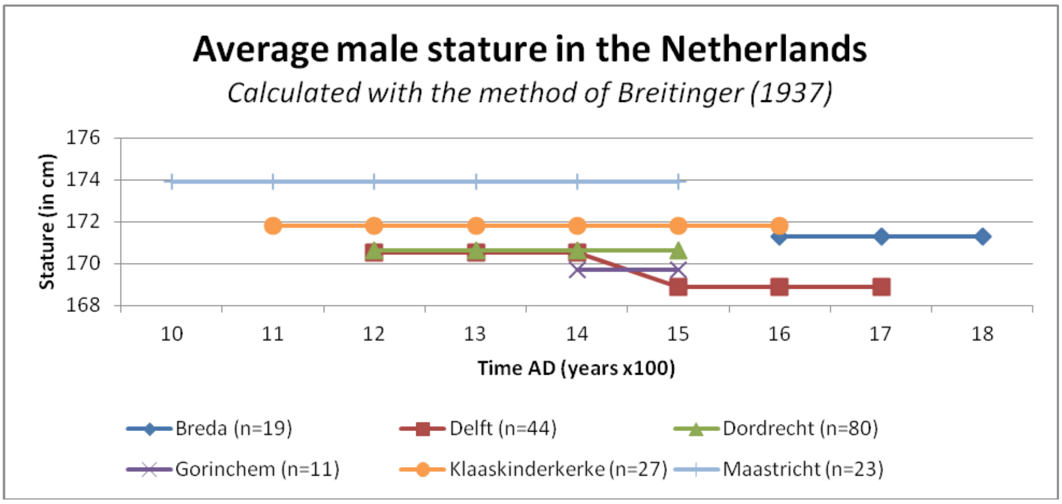

Fig. 12: Klaaskinderkerke in comparison with other sites based on the average stature as calculated by Breitinger (1937).

Some publications used two different methods and gave both estimates. When this was the case, both estimations are given in the table in the same order as the methods. This allowed for two more figures to be made, one based on average statures calculated by using the method of Breitinger (1937) (fig. 12) and one based on average statures calculated by using the method of Trotter and Gleser (1958) (fig. 13).

In figure 12 the men of Klaaskinderkerke still seem taller than their contamporaries, but are smaller than the men from Maastricht. In figure 13, both the males from Maastricht and Scheemda are taller than Klaaskinderkerke, but all other sites possess smaller average statures. Overall the picture does not change much.

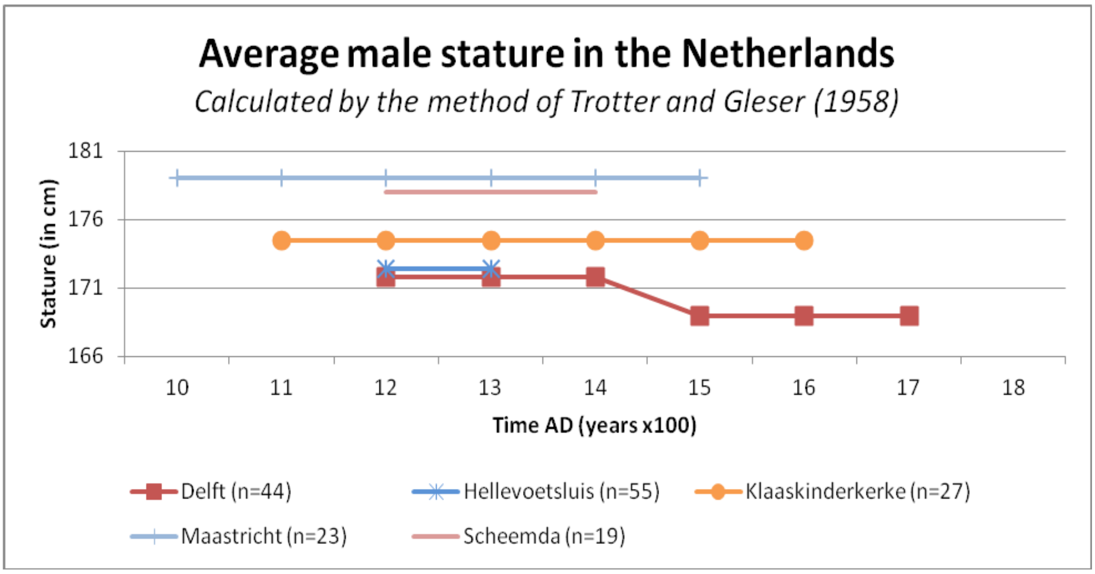

Fig. 13: Klaaskinderkerke in comparison with other sites based on the average stature as calculated by Trotter (1958).

Since the raw data from Scheemda were published, an independent t-test could be used to check the difference between the average male stature of Scheemda and the average male stature of Klaaskinderkerke. This difference is significant (F=0.896; t=-4.08; p=0.00018). In the sample of Scheemda, two definite outliers were present with a length of 191 cm and 188 cm. When these two were excluded from the calculation, the independent t-test yielded no significant difference (F=0.135; t=1.678; p= 0.077). The new average of the stature of the males of Scheemda is then 177.4 cm, which is still remarkably tall.

To test the difference with the other average statures, a Kolmogorov-Smirnov test was executed. The population of Scheemda was left out of this calculation. No significant difference was found (Z=0.469; p=0.980). Even when the population of Scheemda was taken into account with the two outliers, the result remained not significant (Z=0.514; p=0.954).

The same test was done for the female populations. This also yielded no significant difference when Scheemda was included (Z=0.677; p=0.750). A comparison between Scheemda and Klaaskinderkerke was also not significantly different based on a Mann-Whitney U test (Z=-0.826; p=0.442).

Since the estimation of stature has some disadvantages, especially when one wants to compare several sites, the maximum femoral lengths are also compared. The data on the sites other than Klaaskinderkerke were extracted from Maat and summarized in table 4 (2005, 281). The number of femurs used was less than the number of individuals, it was assumed that the measurements from one side was averaged. For Klaaskinderkerke the lengths of the right femurs were averaged (the average for all femoral lengths is nearly identical).

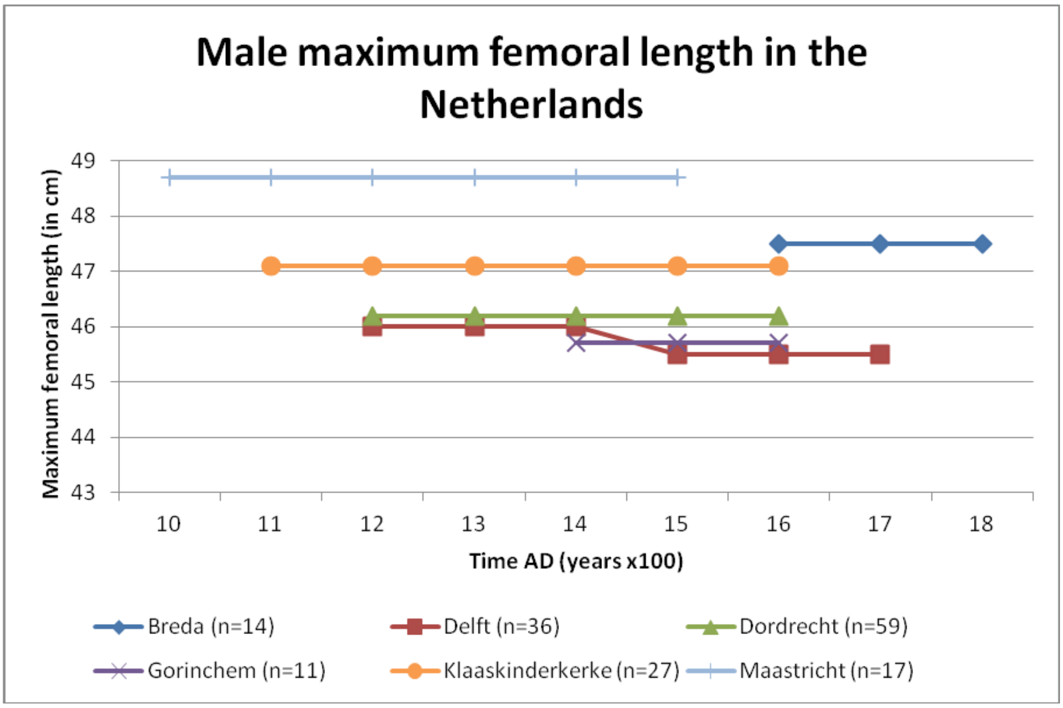

Fig. 14: Average length of the male maximum femoral length in the Netherlands between 1000 AD and 1800 AD.

Again a similar pattern emerges, though with one obvious difference, the males from Breda seem to have a bigger femur on average than the males from Klaaskinderkerke. This did not come through in the average statures. There are no other annomalies present.

Table 4:Average maximum femoral length for the males in the Netherlands.

Population	Period	Average maximum femoral length (in cm)	Number of femurs used
Breda	1600-1824	47.5	14
Delft	1265-1433	46.0	20
Delft	1433-1652	45.5	16
Dordrecht	1275-1572	46.2	59
Gorinchem	1455-1572	45.7	11
Klaaskinderkerke	1100-1600	47.1	27
Maastricht	1070-1521	48.7	17

6. Discussion

6.1 Male-female ratio

Since there are many more males than females (72.9% versus 24.3%), it was checked whether this could be due to differential burial practices, for instance women were buried at one particular place in the cemetery. When this would have been the case, it could be that the female burial place was missed during the excavation, resulting in the skewed distribution. It is expected that this would display itself by a cluster of female graves. The graves analyzed were colored according to sex on the field drawing (fig. 15) to check for the specific distribution of females. It seems that this was not the case, though since the cemetery was only partly excavated, it could be that most women were buried outside the excavated area.

It was also suggested by dr. F. Theuws (personal correspondence) that there was a difference in burial depth between males and females, and since the top layers of the cemetery were washed away, the females could have washed away. It is assumed that the little numbers in the field drawing are the depth of the burial in centimeters (appendix 1), which is used to check this theory. The burial depth for the females varies between 6 cm and 109 cm, which is a wide enough range to say that there was no difference in burial depth between male and females.

In Hellevoetsluis there were also considerably more males than females excavated (55 males and 33 females) (Carmiggelt *et al*. 1999, 90). They explained the surplus of males in the cemetery by journeymen and the presence of an “uithof”, a large farmstead run by monks, in its vicinity (ibid.). It is not known if such a farmstead existed in the vicinity of Klaaskinderkerke. Even if it was present, in the fourteenth century the function of these farmsteads was changed and they became part of the lease system (Brusse and Henderikx 2012, 271). There is a convent known west from Klaaskinderkerke, called Bethlehem. However, this convent held women rather than men (Brusse and Henderikx 2012, 128)

Another explanation given by Huizinga and Trimpe Burger in 1963, is the burial of the victims of the battle of Brouwershaven in 1426 (1963, 563). One has to wonder why these men would be buried in Klaaskinderkerke, when Brouwershaven had a cemetery for itself and several other village cemeteries nearby could also have served this purpose (fig. 3). Moreover, during the examination of the material, very little evidence of violence was found. It is thus unlikely, but not impossible, that the sample was enriched in men because of the battle of Brouwershaven.

A last possible explanation could lie in the topographical location of Klaaskinderkerke. Its proximity to the dyke and water could have caused drowned fishermen to have washed ashore near the village, where their bodies could have been buried. This is not mentioned in historical sources, except for a memory mentioned by a local who stated that he remembered that his grandfather once buried a drowned man on the cemetery (Huizinga and Trimpe Burger 1963, 563). However, many fishermen need to have drowned in the vicinity of Klaaskinderkerke to have created such a skewed distribution.

These are several explanations of many possible reasons for the male-female ratio in Klaaskinderkerke. Although some seem more likely than others, one has to keep in mind that the cemetery was not excavated as a whole and that it had suffered from several floods over the centuries (Huizinga and Trimpe Burger 1963, 559). It may well be possible that this phenomenon is purely the result from these two factors.

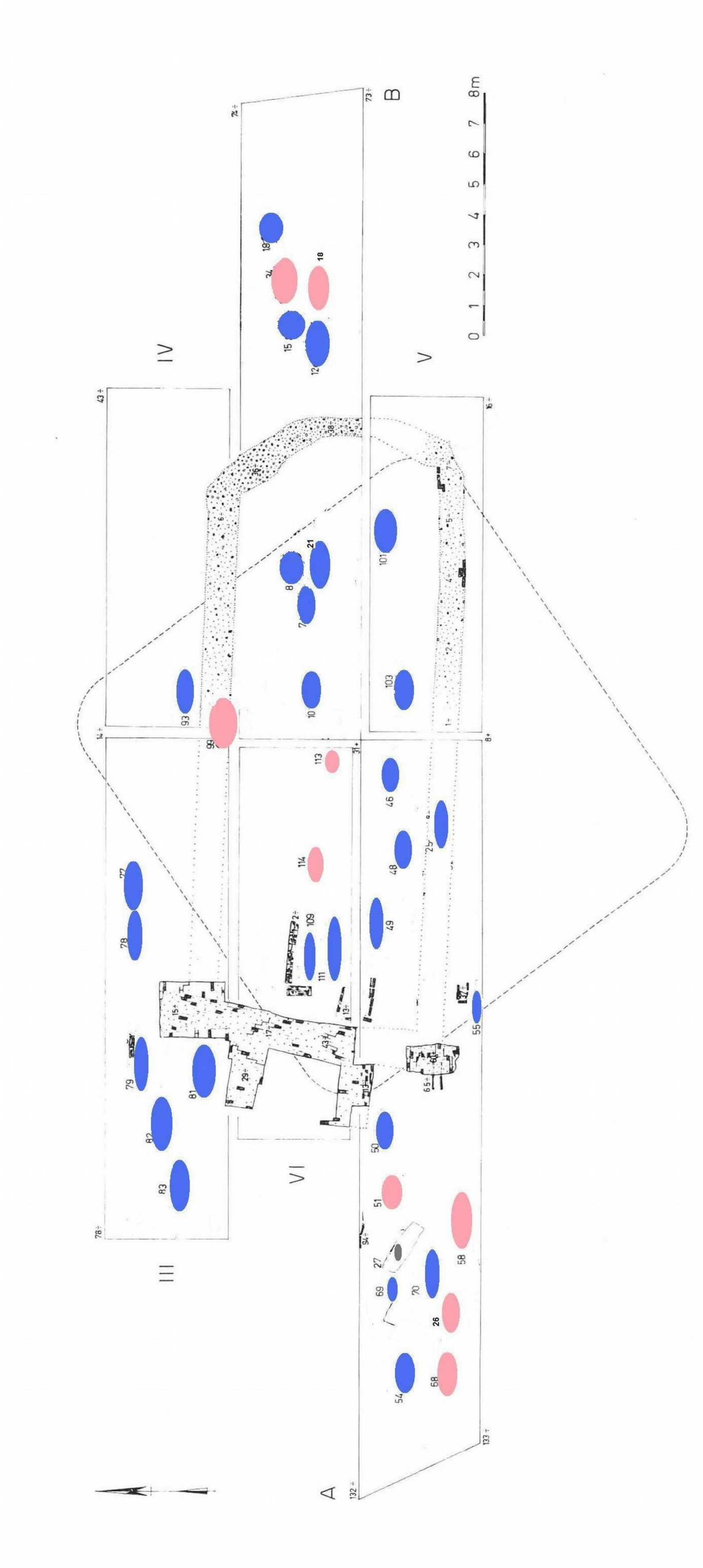

Fig. 15: Excavation map with the sexes coloured (females pink, males blue) (after Huizinga and Trimpe Burger 1963).

6.2 Differences between methods of stature estimation

As is shown by the several statistical analyses, there is a significant difference between the method of Breitinger and the method of Ousley when looked at all the estimations. No significant difference was found in the other combinations. When the sample was divided into two different groups according to the average stature (group 1 being under 175 cm and group 2 being 175 cm or over), Breitinger showed significant differences with all other methods in the statures estimated over 175 cm. This has major implications for the use of this method. As there were already reservations based on the original measuring by palpating the landmarks, now it seems that it systematically underestimates the higher statures when compared to other methods.

This is also visible in fig. 8, where the regression line based on the maximum femoral length from Breitinger (1937) is not as steep as those from Trotter and Gleser (1958), Trotter (1970) and Ousley (1995). There are several mechanisms at work here: difference in reference sample, difference in measuring and difference in time. The difference in measuring has already been discussed in chapter 2, so will not be elaborated on, but the effect of the reference sample is summarized and the element of time is more thoroughly discussed.

The reference sample used by Breitinger consisted of Germans, while the other authors based their methods on the American population (Breitinger 1937; Ousley 1995; Trotter 1970; Gleser and Trotter 1958). Although the American population is partly European in descent, it could be argued that the difference in the regression lines is caused by differences between the German and the American population.

The positive secular trend of stature in the last century is not only present in the Netherlands, but also in the other Western countries and, to a lesser extent, in the rest of the world (Shin *et al*. 2012, 438-439; Steckel 1995, 1919). In some cases it meant that each new generation grew taller than the one before (Maat 2005, 286-287). The reference populations used to develop the stature estimation methods all date to the last century and thus were influenced by the secular trend occurring during this period.

The element of time is thus important when one looks at the different methods and their regression lines. It has already been mentioned several times that the method is the result of the reference population, and this point cannot be stressed enough (Ousley 1995, 769; Pearson in Gleser and Trotter 1952, 465). The different methods span a considerable amount of time, as Breitinger measured his subjects between 1926 and 1932 (1937, 253), Trotter and Gleser measured both victims from the Second World War and the Korean War (1958, 80), Trotter used subjects with the same origin as Trotter and Gleser (Trotter 1970, 72) and Ousley used data from the Forensic Data Bank (FDB) (Ousley 1995, 772). The data are summarized in table 5.

Table 5: Reference collections for the male stature estimation methods. Ousley did not provide the necessary data to fill in this table (Breitinger 1937, 253; Trotter and Gleser 1958, 80; Trotter 1970, 72; Ousley 1995;772).

Method	Number of individuals	Time of measurement	Estimated time of birth
Breitinger	2400	1926-1932	1890-1914
Trotter and Gleser	4672	1943-1950	1920-1932
Trotter	3845	1943-1955	1920-1937
Ousley	???	??-1995	??-1977

The different reference populations represent different generations and if each generation grew taller than the last, the formulas may be influenced by this trend. As can be deduced from table 5, the reference population used by Breitinger represents the oldest generation, hence probably also the smallest population. The reference populations used by Trotter and Gleser and Trotter are very similar, thus resulting in very similar regression lines. And although the subjects used by

Ousley are not described in detail, they came from the forensic database and the formulas work better on modern populations, so one can assume that these subjects were again some generations younger than those measured by Trotter and Trotter and Gleser (Ousley 1995, 772). Since the positive secular trend is very steep during this period, it is argued that the older the reference sample, the smaller the average stature was for this sample. This is then reflected in the formulas based on these reference samples, causing (part of) the differences observed here.

What does this mean in relation to the comparison between the different sites? As shown by figures 10, 12 and 13, there is no difference in the order from small to tall populations, although some samples could not be included in all figures. Therefore statures estimated by different methods could still be used to get an overall picture, but care should be taken and differences and similarities cannot be taken for granted. Figure 14 does show some differences with the initial figures. This is the figure based on the maximum femoral length and the effect of the equations used to estimate stature is clear. As explained above, not all individuals have all elements present, which creates another error to be taken into account (Maat 2005, 278;281). It is therefore argued that in future studies the raw data should at least be included, and comparisons based on raw data, like the measurements of the femur, are preferred.

6.3 The average stature of Klaaskinderkerke compared

The significant difference between the males buried inside the church and those buried outside it, can be easily explained historically. Burial within the walls of the church was reserved for the clergy and people of a nobel descent since the tenth century. From the twelfth century onwards, wealthy laymen were also allowed such a desirable burialplace (Brusse and Henderikx 2012, 182). These people were brought up surrounded by wealth and their living standards were thus superior to the living standards of the people buried outside the church, resulting in a significant difference in average stature.

When one compares the figures 10 and 11, the difference is striking. Apparently it is not necessarily the case that when the males are relatively tall, the females are tall in the same proportion. The difference between males and females stature means is shown in table 4. Normally the size of this sex difference is between 9.9 to 13 cm, but the degree is generally higher in better nourished populations (Eveleth 1975, 35; Maat *et al*. 1998, 15). In addition, the difference tends to increase with increasing height (Eveleth 1975, 37). Preferential treatments of either sex could also influence the degree of sexual dimorphism in stature (ibid.).

Four out of eight populations fall within the normal range of the degree of sexual dimorphism (Maat *et al.* 1998, 15). The populations from Delft and Gorinchem have a smaller degree of sexual dimorphism, while the female population of Scheemda is on average 16 cm smaller than their counterparts. In Scheemda all three of the above mentioned processes could be at work to create this large difference between the males and females of the population. Although the difference between the males and females of Klaaskinderkerke falls within the expected range, it is at the high end of the spectrum. Since the males from Klaaskinderkerke seem to be slightly taller than most of the other populations, it can be suggested that this slightly higher sexual difference is caused by the increasing height (Eveleth 1975, 37).

With the compared average statures, males of Klaaskinderkerke seem slightly taller than the other populations. The exceptions are the males from Maastricht with a nearly identical average stature and the males from Scheemda, which are exceptionally tall (Janssen and Maat 1999; Uytterschaut 1990). The female average stature of Klaaskinderkerke corresponds well with the data from the other sites.

Table 6: Difference between male and female average stature.

Site	Male average	Female average	Difference (in cm)

	stature (in cm)	stature (in cm)	
Breda	171.3 ± 4.4	160.6	10.7
Delft (until 1433)	170.5 ± 4.6	164.4 ± 7.8	6.1
Delft (after 1433)	168.9 ± 3.4	162.2 ± 7.1	6.7
Dordrecht	170.6 ± 3.8	160.8	9.8
Gorinchem	169.7 ± 3.8	160.7	9
Hellevoetsluis	172.4 ± 6.2	161.2 ± 4.92	11.2
Klaaskinderkerke	173.8 ± 4.68	162.26 ± 4.56	12.5
Scheemda	178	162	16

The high statures from Maastricht can be explained by the background of these men (Maat 2005, 286). They were the canons of the Saint Servaas Basilica in Maastricht and historical literature suggests that they were from prosperous descent (Janssen and Maat 1999, 11). In addition they were known for their excessive life-style at the convent itself (Maat 2005, 286). This was supported by the presence of DISH (diffuse idiopathic skeletal hyperostosis is a disease of which is thought to be linked to obesity and type 2 diabetes (Roberts and Manchester 2010, 159)) and many soft tissue ossifications in all of their skeletons (Maat 2005, 286).

The high statures from Scheemda are more difficult to explain. Between 1175 and 1300 a period of high prosperity is indicated by a high frequency of building activities in the area and in Scheemda two large churches were built in a time span of several decades (Molema 1990, 268). Texts from the thirteenth century indicate that the main crop is rye and that the yield could be quite substantial (Molema 1990, 265). This seems to be the case until a great flood in 1509, which had a devastating effect on the village (Molema 1990, 265). There seems to be enough evidence to state that the people of Scheemda were prosperous, but it is hard to believe that this is the sole cause of the large difference in stature with the other populations in the Netherlands, for even when the two outliers are excluded, the males from Scheemda had an average stature of 177,4 cm.

When the maximum femoral lengths are compared, Scheemda cannot be included, but Maastricht still delivers the tallest measurements. However, it is interesting to see that although the males from Breda were not taller than the males from Klaaskinderkerke in average stature, the maximum femoral length is taller on average (fig. 14). This could be caused by the way the stature for Breda was estimated, which is the method of Breitinger. To calculate the stature, Breitinger offers four regression formulas, one each for the humerus, radius, femur and tibia. The final stature estimation is an average of these four outcomes (Breitinger 1937, 269). It seems that out of 19 individuals only 14 had their right femur present, which means that the stature of five individuals was calculated without the femur, perhaps causing the lower average stature.

Can the relatively high male stature in Klaaskinderkerke be explained in a similar way as for Scheemda and Maastricht? The average of the males buried within the church most certainly can be explained by a healthy life style, as it is historically known that they represent the nobility. When we consider the average of the males buried outside the church (171.8 cm) in relation to the other sites, it is more comparable with the other sites and it is no longer considered to be relatively tall. This becomes clear in figure 16, where the two groups from Klaaskinderkerke are displayed. Two separate groups appear, one with relatively tall individuals (Scheemda, Maastricht and Klaaskinderkerke inside the church) and a larger group with some smaller individuals (Delft, Dordrecht, Gorinchem, Hellevoetsluis and Klaaskinderkerke outside the church). For Maastricht and Klaaskinderkerke inside the church and to some extent for Scheemda historical evidence mention these populations as being the more wealthy than average, which is expressed in a taller stature than average.

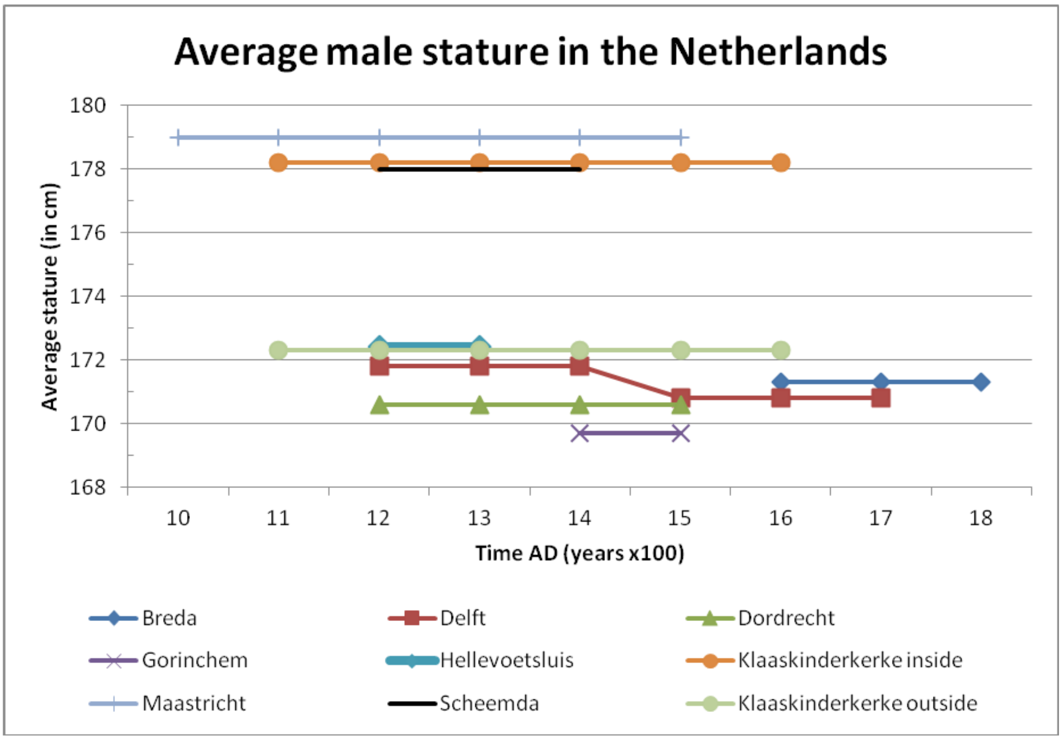

Fig. 16: Comparison of the average stature of the males from Klaaskinderkerke buried inside the church and those buried outside the church with the average stature of several contemporary sites. When possible, the average calculated by the method of Trotter and Gleser (1958) was used.

The average stature of the people buried outside the church is very similar to the average stature of Hellevoetsluis, as was expected, and to the early population of Delft. It still is at the top end of the lower average cluster, but since the other sites all are urban (except for Hellevoetsluis, which consists of a rural population), this was to be expected.

7. Conclusions

The material of Klaaskinderkerke was assessed and compared to previous research published on the stature of Dutch populations of the late middle ages. The data obtained did not differ much from the original publication of 1963, though the data are now recorded for future research as well as compared to other data (Huizinga and Trimpe Burger 1963).

The sample consisted mainly of male individuals: 27 out of 36 were either male or probable male and 9 were female or probable female. No specific distribution pattern which could have caused the skewed distribution was found when the sexes were plotted on the excavation drawing. It was suggested that males were perhaps buried at a different level than females, but this was also excluded based on the depths recorded on the excavation plan (appendix 1). The lack of evidence of violence made the presence of victims of the battle of Brouwershaven unlikely, which was suggested by Huizinga and Trimpe Burger (1963, 563). The presence of journeymen or monks working on a farmstead could also explain the sex distribution, as it did in Hellevoetsluis (Carmiggelt *et al*. 1999, 90). There is no historical evidence for the presence of such a farmstead and had it been present, it most likely disappeared in the fourteenth century (Brusse and Henderikx 2012, 271). No satisfactory explanation could be found for the skewed sex distribution in Klaaskinderkerke and one has to keep in mind that what is observed could be the result of both water damage over the centuries and the partial excavation method.

Overall, the only significant difference was found between Breitinger and Ousley, but when the individuals were grouped into two groups according to average estimated stature, all methods were significantly different from Breitinger in the group of 175 cm or taller. This is made visible in fig. 8, where the regression lines of the four methods are given for the maximum femoral length. The date of conception of the regression formulas could be of influence here. The positive secular trend of the last century affected the subjects measured to calculate the formulas, and the formulas represent their source population best (Ousley 1995, 769; Pearson in Gleser and Trotter 1952, 465).

The presence of significant differences between the methods implies that they cannot be compared without further reference. Especially the method devised by Breitinger is problematic based on the statistical results presented in this study and on the original procurement of the formulas. It would therefore be better to compare direct measurements without the interference of formulas. This is however more difficult to realize, as these measurements are rarely given in publications.

Overall the average stature of the males of Klaaskinderkerke was slightly taller than the average statures of the contemporary populations, except two (Maastricht and Scheemda). The difference became more pronounced when a distinction was made between the men buried inside the church and those buried outside the church. This could not be compared among the females, since there were few females examined.

The males buried inside the church were significantly taller than the males buried outside the church, and it is assumed this difference occurred because of a difference in living standards. This is supported by historical evidence, saying that burials within the church walls were only allowed for the clergy, the nobility and wealthy laymen (Brusse and Hendrikx 2012, 182). The average stature of these males is similar to that of both the males from Scheemda and the males from Maastricht, both relatively tall populations of which historical background confirms a wealthy lifestyle (Maat 2005, 286; Molema 1990, 268).

The average stature of the males outside the church was very similar to the average stature of Hellevoetsluis, as expected (Carmiggelt *et al*. 1999; Maat 2005, 278). The female average stature is even nearly identical to the female average stature of Hellevoetsluis. As expected, both rural populations (Hellevoetsluis and Klaaskinderkerke) are slightly taller than the urban populations. Breda could also be considered an exception, based on the maximum femoral length, but as this excavation included a church, it could be that something similar is going on in Breda as in Klaaskinderkerke (Maat and Mastwijk 2000, 123).

To conclude one can say that the average stature of the population of Klaaskinderkerke revealed two social classes, the wealthy nobles, buried inside the church, and presumably the working class, buried outside the church. The upper class compares well to other contemporary known wealthy populations, while the lower class compares well to the contemporary rural population of Hellevoetsluis. Even today the difference between the two can be deduced based on their burial location and their length, which confirms the idea that stature is influenced by living standards and wealth.

Abstract

It is generally known that the Dutch are tall. However, this has not always been the case. In 2005 Maat published an article tracing back trends in average Dutch male stature. In this article data from 21 different samples were included, of which only one came from a rural population. This study introduces a second rural population into the mix. The stature of both the males and females of Klaaskinderkerke is assessed and compared to the available material. In addition the different stature estimation methods are compared to each other.

The material consists of 37 individuals excavated in 1959 at the site of the cemetery of the former village Klaaskinderkerke. The cemetery roughly dates to 1100 to 1600 and was hit repeatedly by floods. Sex was estimated, as well as age and stature. There were more males than females (27 males, 9 females, 1 indeterminate), which is difficult to explain. Probably the damage caused by the floods and the excavation technique affected the male-female distribution.

The stature estimation method published by Breitinger (1937) yielded significantly different results from the method published by Ousley (1995). Breitinger (1937) differed significantly from all methods where the higher statures were concerned. In the female methods, no significant different results were found. The average stature from the males from Klaaskinderkerke was slightly higher than the average statures from the other sites, except for the site of Maastricht and Scheemde, which both delivered exceptionally tall men. This can be explained by the social background of both populations. When the statures of Klaaskinderkerke were separated based on burial location (inside versus outside church), it was found that these two groups differed significantly in average stature. The average stature from the men within the church compared well to the men from Maastricht and Scheemda, while the average stature from the men outside the church compared well to the men from the only other rural site, Hellevoetsluis.

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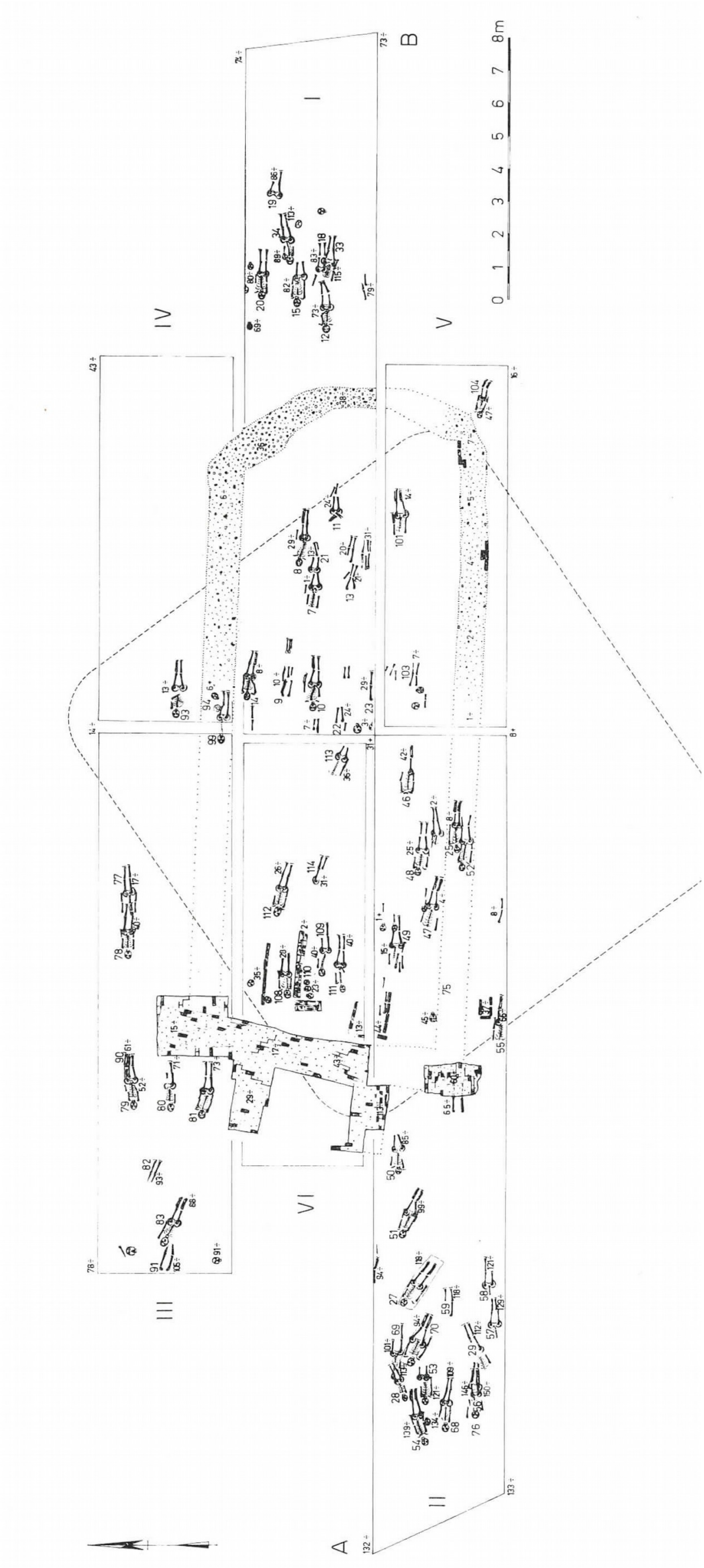

Appendix 1: Excavation drawing (Huizinga and Trimpe Burger 1963, 561).