Tall boys for tall ships?

An exploratory study into the heights and growth of teenage boys in the Netherlands 1791-1939

Björn Quanjer and Jan Kok,
Radboud University, Nijmegen, The Netherlands

Abstract

The rise in adult heights, often called the secular trend in heights, that occurred since the middle of the 19th century is not completely understood. Often, conscription records are used to collect heights of historical populations, but many conscripts had still not reached their adult stature. Therefore this paper tries to understand what the growth pattern looked like in the 19th century to get a better understanding of the secular trend in heights. We used height of students who enrolled in the maritime institute in Amsterdam. Although a series of biases prevent us from generalizing to results for the entire population. We found evidence for a growth spurt, although it occurred at a later age and resulted in a lower growth speed velocity. We also show that it is therefore problematic to use the WHO height-for-age z-scores as a reference. Furthermore we found that the catch up growth of boys in our data is not enough to regain the same height-for-age z-scores at later ages as those that were found for the younger students.

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Introduction

It is often neglected to take the shift in growth patterns into account when the secular trend in adult heights is studied. The rise in adult stature occurred in many western countries from the middle of the 19th century (Hatton & Bray, 2010) and continued on a global scale in the 20th century (Deaton, 2007). There is a large body of literature that tries to find answers to what caused this rise in adult stature (Steckel, 2009), but it is often overlooked that heights are used of persons that had not yet reached their adult height. Historical male heights are frequently derived from conscription records that are seen as the most ideal sources for anthropometric history (Bodenhorn, Guinnane, & Mroz, 2017). The use of these records can be problematic because many boys were still growing (Tanner, 1978). After the age of twenty, Dutch boys living in the 19th century appear to have grown an additional five centimetres on average (Beekink & Kok, 2017; Oppers, 1963). Since height is reflective of the underlying standard of living of a population, the field focusses on changes that might have improved the living standards and as a result caused stature to increase. It remains unclear if these improvements, in e.g. sanitation (Bozzoli, Deaton, & Quintana-Domeque, 2009) or milk consumption (Baten, 2009), caused boys to grow *taller* (referring to full grown adults) or to grow *faster* during their teenage years. If the latter, the secular trend in 'adult heights' may simply result from the accumulation of growth before the age of 19 (thus a shift of growth from the twenties to the teenage years) as a result of improved living conditions. Besides the overestimation of the growth trend, this potential shift in growth velocity implies that the importance of the various explanatory factors will be overestimated, since they capture the effect on both growth speed and fulfilling the genetic adult growth potential. Hence, this article will try to understand the shift in the growth pattern that occurred simultaneously with the secular growth trend in late adolescent heights.

A secondary aim of this article is to contribute to the debate regarding the timing of the impact of living conditions on terminal height. Depauw and Oxley (2018) surmised that living conditions during the teenage years have the strongest impact on height, thereby refuting the Barker (1986) hypothesis that it is the time *in utero* and first few months that matter most. Following Barker, many scholars argue that terminal (adult) height mostly reflects the living conditions of the first years of life because growth velocity is at its fastest during this period (e.g. Chen & Zhou, 2007; Cole, 2003; Schooling et al., 2008). However, do living conditions during the period of higher growth velocity during the adolescence growth spurt have an impact on adult stature as well, or do teenagers, compared to young children, simply have less time to catch up with their peers (Boersma & Wit, 1997) when their growth is hampered by worsening living conditions?

There is evidence in the literature that studying changes in growth velocity over time is important to understand what terminal height represents. For instance, Jacobs and Tassenaar (2004) found a change in the lag pattern for the strongest effects of food prices on heights. This might indicate that there was a shift of the adolescence growth spurt creating this shift in the lag pattern. However for Great Britain unique research by Gao and Schneider (2019) recently showed that the growth spurt was absent until the 1910s. If there was no adolescent peak in growth velocity, worsening living conditions in the 19th century coinciding with specific ages cannot have caused more stunting compared to other ages. Their findings imply that the remaining time to catch up after a period of crisis is crucial for the height that can be reached by adults in times of crises. Since it was found that boys could still grow after they were subject to conscription, understanding this mechanism is important when conscription records are used. Furthermore, the conscription age and therefore the heights recorded in conscription records, might be different across countries and regions, making results tricky to compare across contexts. Therefore, by understanding the growth pattern in the 19th century Netherlands, this article will try to contribute to the understanding of the relation between age at measurement and effect sizes, taking the shift in growth patterns (the remaining time to catch up) into account.

We study the growth spurt because it strongly contributes to terminal height and the absence or late timing of the spurt can influence the secular trend in heights. Furthermore the timing of the growth spurt, reflects living conditions: the earlier the better. For contemporary populations, the WHO assumes, in its growth reference, that the growth spurt takes place around 14 years of age. Based on Jacobs and Tassenaar (2004) we hypothesise that the adolescence spurt in growth velocity took place at a later age than now or was even absent (Gao and Schneider 2019). As a result of the late occurance of the growth spurt, stronger effects of adverse conditions are found for conscription heights because the shift of the growth spurt close to the conscription age gave boys less time to catch up. For adult stature the same reasoning might apply, the occurrence of the growth spurt at a later age might limit the time available between a high growth velocity peak and the time terminal height is reached. The effect on adult stature of this shift in growth pattern will be smaller than on conscription heights none-the-less. Therefore conscription heights can be problematic in anthropometric research.

To study the growth pattern of teenagers in the Netherlands, this paper uses a set of 2879 boys enrolled in the maritime institute of Amsterdam. Their heights were recorded between 1792-1829 and 1852-1916, when the boys entered the institute. The data are not representative for the Dutch population. In the next part this paper will discuss how we navigated our way in a sea of biases. This forms a large part of this paper because the data require a lot of attention. The following part will discuss the growth pattern for the boys we studied by using descriptive statistics and a regression analyses. We claim that for the boys in our data there was a growth spurt in the 19th century, although it occurred later and the peak velocity was lower than for modern populations. Thereafter we will explore what this finding will imply for the relation between growth velocity and effect sizes.

Data

In the aftermath of the fourth Anglo-Dutch war, and in particular the Battle of Dogger Bank, the maritime institute in Amsterdam (*Kweekschool voor de Zeevaart*) was founded in 1785 to promote Dutch seafaring on the one hand and to elevate poor boys of the city of Amsterdam on the other. The institute shows similarities with the Marine Society charity that was based in London, used by Floud and Wachter (1982) to study the heights in industrializing England. Therefore this source provides an opportunity to conduct a similar study for the Netherlands, since heights of the Amsterdam' pupils were recorded

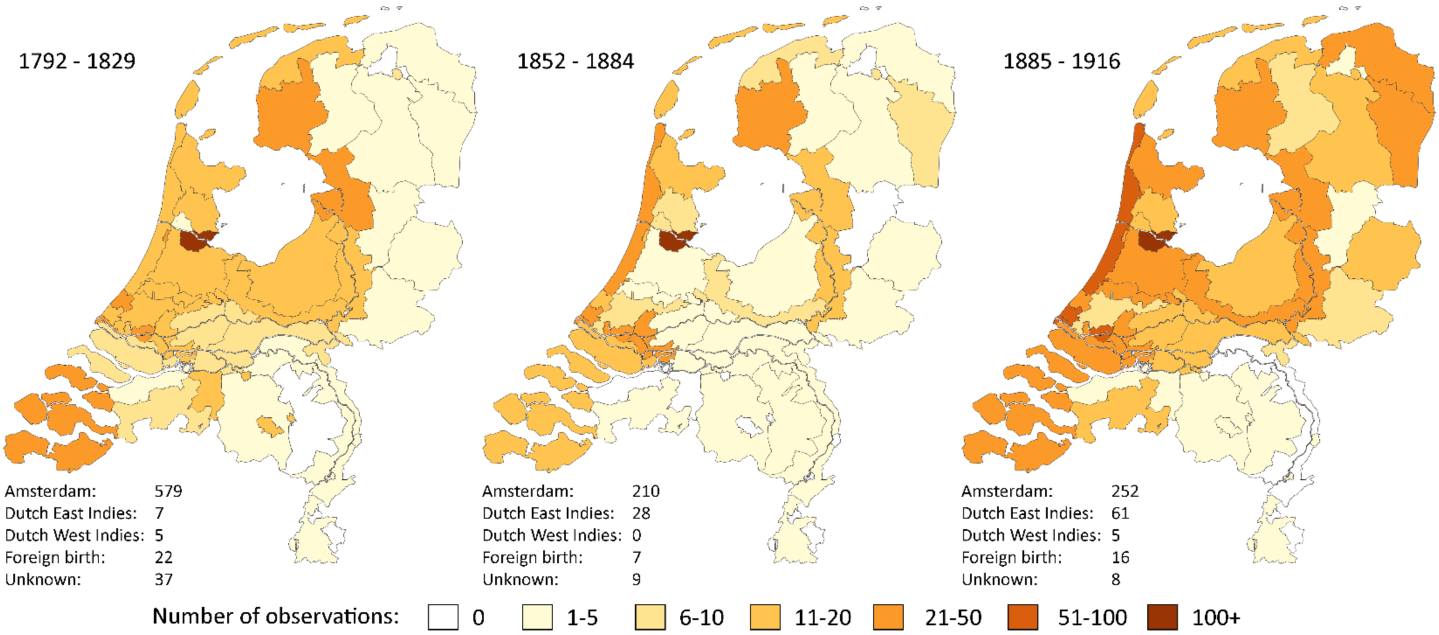
The school existed, with a small interruption in the Napoleonic years (1811-1814), until 2000. During more than two centuries, the students that were attracted changed regarding their background, ages and stature. Although the school started of an institute for the "neatly" poor (boys were required to be literate), the share of students from a higher socioeconomic status (SES) rose over the years. In the earliest period included in our dataset (1892-1829), the share of boys from elite and middleclass families was 34 percent; this share rose to 67 percent during the latest period (1852-1916). In the early period 38 percent of the boys who entered the school had lost one of their parents and 6 percent were full orphan, compared to the respectively 24 and 3 percent for the later period. Therefore, it appears that, over time, the school developed a stronger appeal for higher SES boys. This likely means that our results are largely limited to the healthy and wealthy of society. Often the change in socioeconomic background of a school attending population can bias the results (Schneider, 2018). However, for us, this does not appear to have been an issue. In figure 1, we can see that the rise in height-for-age z-scores for the second part of the 19th century was not caused by a shift in socio-economic status which remain relatively stable after 1870.

Figure 1. *Socioeconomic status based on parental occupations enlisted during enrolment in the institute and the height-for-age z-score of the pupils in the institute*

Source: Comportementsboeken database. Years with less than 10 observations were omitted from the figure. The height-for-age z-scores were calculated using the WHO 2007 growth reference for 5 to 19 year olds (https://www.who.int/growthref/who2007_height_for_age/en/). To determine the socio economic status the HISCO scheme was applied (Van Leeuwen & Maas, 2011) and linked by the HSN Hisco table (Mandemakers et al., 2018)

Next to shifts in socioeconomic background, the regional origin of the students also changed. The institute was founded to support the poor from the cities, which resulted in high enrolment numbers for boys born in Amsterdam, Rotterdam and The Hague. The quest to support seafaring families is also reflected in higher numbers for the region of Zeeland and the North Western part of the Zuiderzee. However, the most significant selection bias was the distance to the institute with a strong focus on Amsterdam and its surroundings. The institute was the first in the Netherlands, but around the second half of the 19th century other cities opened similar schools. Still the institute drew students from all over the Netherlands, as illustrated in figure 2. What also stands out is the high number of boys born in the Dutch East Indies, with which the institute had close relations through the governmental marine. Furthermore the absence of boys from the South East of the country, lacking a seafaring tradition, stands out. This region is known for higher infant mortality and shorter stature thereby creating an upward bias in heights.

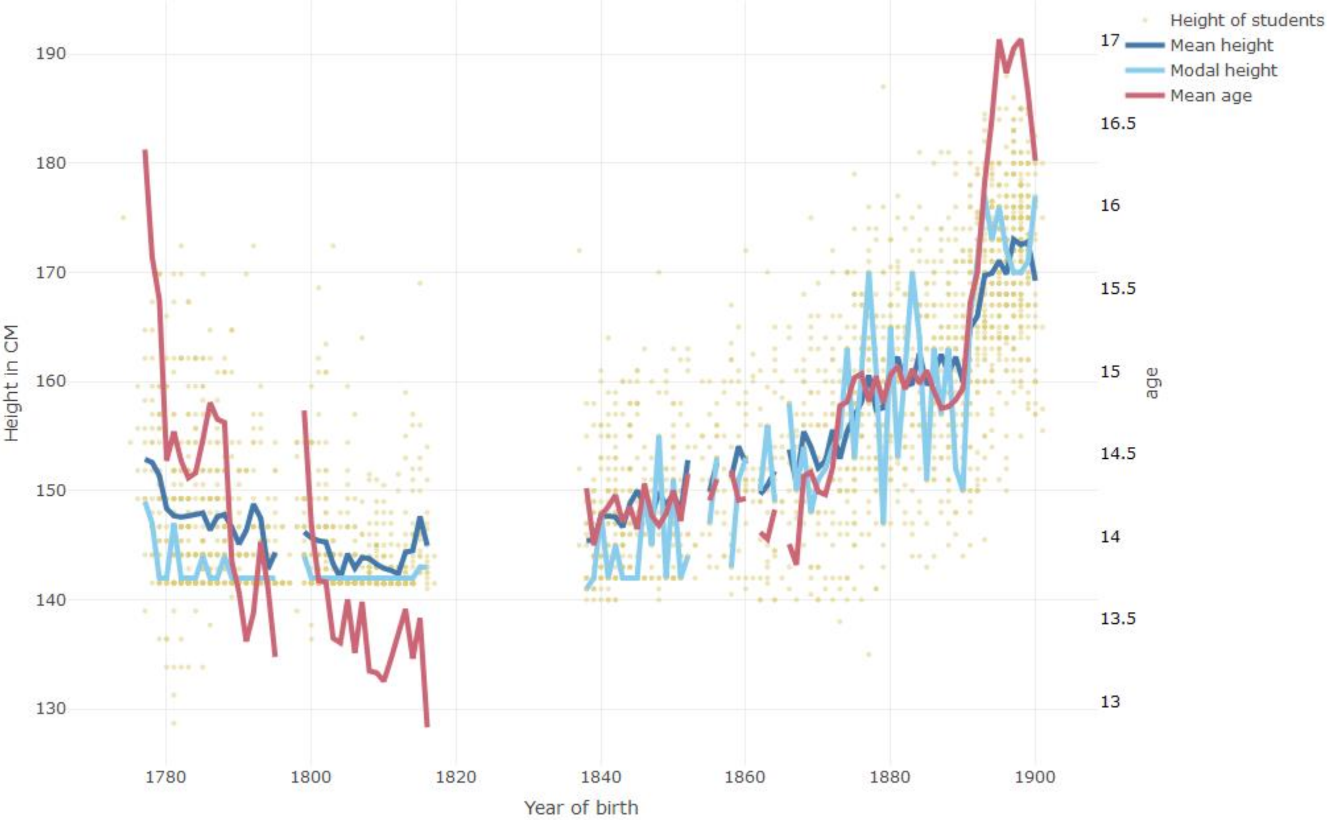
Figure 2. *Place of birth of the students of the maritime institute of Amsterdam per enrolment cohort for different economic regions in the Netherlands.*



Source: Comportementsboeken database. For the regions the economic geographic layout by Van der Bie (2009) is used, because economic borders influence height more strongly than political ones.

The selection biases regarding the background of the students limit the explanatory power of our results to some extent, but what is likely much more problematic are the selection biases regarding age and height. As can be seen in figure 3, a height requirement of 5 feet (141,5 cm) was in place for the majority of the early period. Because there was no age limit, the variation in ages of students provides some variation in overall average heights. However, the modal height covers the height threshold for most of the period. We therefore assumed that often boys who were too short were registered as being the required 5 feet to make sure the classrooms remained full. This might also be the reason why the institute stopped the registration of heights after 1829. The period 1792-1829 (n = 1136) contains both truncated and censored data which made it almost impossible to study and is therefore left out of the analyses.

Figure 3 *Mean and modal height and mean age of the students of the maritime institute in Amsterdam per year of birth*



Source: *: Comportementsboeken database. Years with less than 10 observations were omitted from the figure. The height-for-age z-scores were calculated using the WHO 2007 growth reference for 5 to 19 year olds (https://www.who.int/growthref/who2007_height_for_age/en/).*

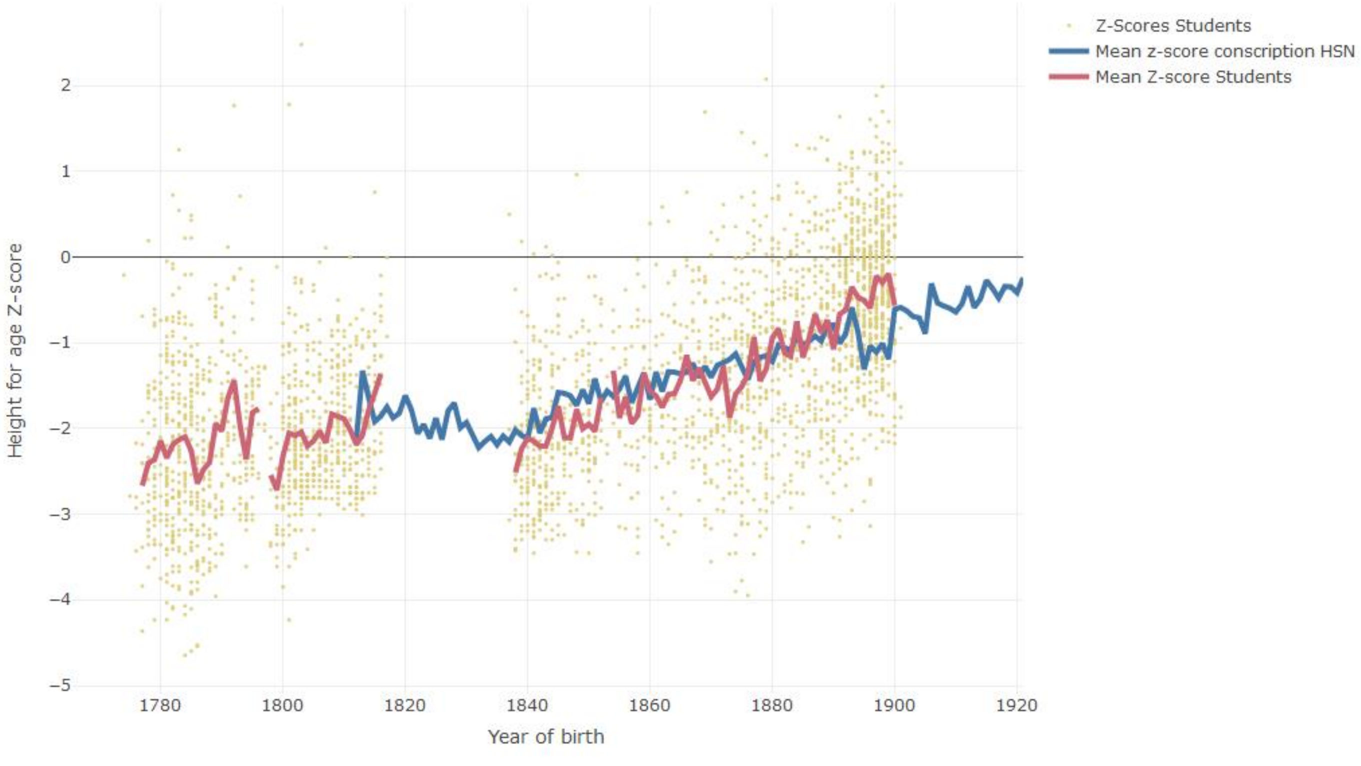
When the height requirement was reinstituted in 1852 it was set at 140 centimetres together with age censoring of boys between 13 and 15 years old, which proved to be far less problematic. In the years 1878 and 1879, boys from the age of 12 were also allowed. From 1887 onwards the upper age limit rose to 16 years and the height limit was lowered to 135 centimetres. In 1908 the age limit was replaced by the condition that students had to have a HBS-background (at least 3 years of high school), and in practice driving up the entry age at the institute.

Figure 3 shows that both height and age increased during the second half of the 19th century. To disentangle the strong influences of age on stature, height-for-age z-scores were calculated which can be found in figure 4. The z-scores of the students closely resemble those of Dutch conscripts which were selected from a random sample of birth certificates called the historical sample of the Netherlands (Mandemakers, 2000) and therefore represent a random sample of Dutch statures (Quanjer & Kok, Forthcoming-a). The WHO growth table that was used as a reference assumes that growth velocity starts to increase from 10,5 years old until it reaches its peak in the 14th year of life. Taking into account the assumption that the growth spurt took place at a later age or was even completely absent in the 19th century, the z-scores between 10 and 15 might be further away from the

WHO reference compared to scores at later ages. The z-scores for higher ages will be closer to 0 because the research persons have caught up on the WHO growth scheme. Therefore the rising age in our sample still causes a stronger upward trend in z-scores. How strong this upward bias is cannot be determined but the fact that the z-scores of students resemble those of Dutch conscripts is an indicator that this is not biasing the results in a problematic fashion.

The height-for-age z-scores for the earlier period vary more than the mean and modal height in figure 3. This has to do with the variance in ages, resulting in different scores although the height of almost all the boys was 5 feet. The institute did want to have students of a respectable height (Bosscher, Raven, Acda, Kuipers, & Habermehl, 1985) and because there was no school year, boys could enrol just after they reached 5 feet. This implies that we do know at which age boys reached 5 feet and which z-score that resulted in. We can therefore assume that living conditions fluctuated around a stable level that was slightly higher than that of the middle of the 19th century.

Figure 4 *Height-for-age z-score for students of the maritime institute in Amsterdam combined with the height-for-age z-scores of Dutch conscripts per birth year.*



Source: *Comportementsboeken database. Years with less than 10 observations were omitted from the figure. The height-for-age z-scores were calculated using the WHO 2007 growth reference for 5 to 19 year olds (https://www.who.int/growthref/who2007_height_for_age/en/). The conscription data: HSN dataset Heights and Life Courses, Release 2018_02*

Next to the height that we collected from the school books, we also took the religion and place and data of birth of the student. The occupations of the father and mother were given together with their place of residence as well. Also the books provided information on the time the pupil was enrolled at school and the grades he received during his training. Further, there was information on how much the parents payed to get the student at the school or whether the parents had died and a guardian paid the school fee. Next to the school books we were able to link a small group of students to their application letters in which their height (rounded to centimetres) was noted a month before they were examined for the institute. A small group of students (n=38) was postponed for one year because of weak results on the math and language tests. For these 38 students we have two height observations 13 months apart.

We also tried to link the students to their conscription records, if these records were available in an online database. We were able to successfully link 714 boys to their conscription records, but this too is not without bias. As was pointed out by Quanjer and Kok (Forthcoming-a), seafaring men were often absent during conscription examinations, and are therefore not measured. Accordingly, we only have conscriptions heights of 40 percent of these successful links. Despite the clear limitation, these links can help us to describe to growth pattern of our research population. In the next section we will use descriptive statistics on the growth curves for all students per cohort. Furthermore, we will used the linked data to get an insight in the growth velocity of these boys and finally we will use regression analyses to get a better understanding of the timing of the growth spurt.

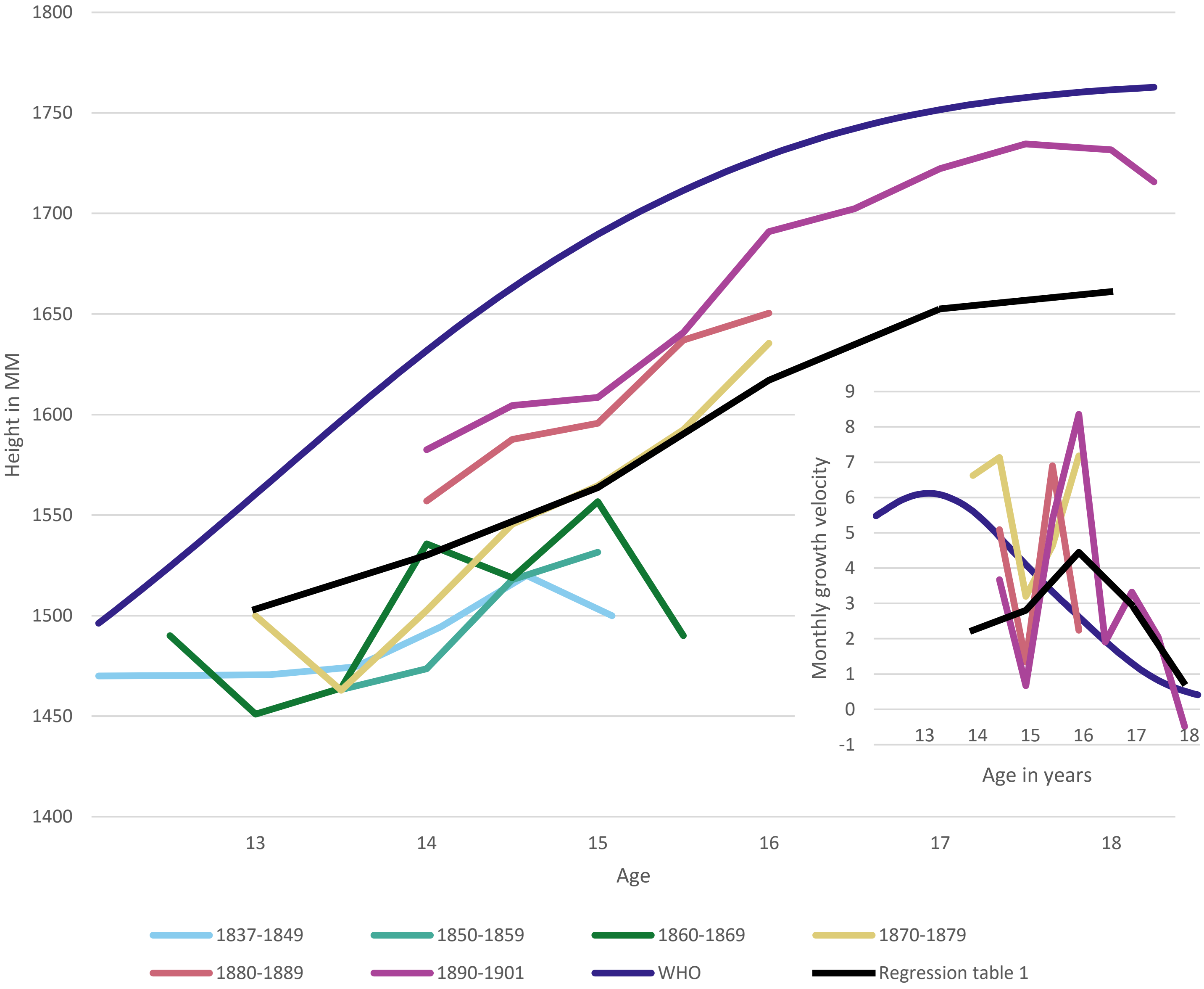
The growth pattern

Both final height and growth velocity are influenced by the environment but especially genetics (Cameron, Preece, & Cole, 2005). The growth spurt cannot be seen as a fixed point in a boys' teenage years, rather it strongly varies in timing and magnitude from boy to boy. Ideally, the growth curve is studied by a cohort study with multiple measurements per research person (Schneider, 2018). Such sources are hard to find for historical populations, so often a period study is conducted instead. Research persons born in different years, but measured in the same year, provide a set of ages and heights from which a growth curve could be distilled. This period method was applied by Floud and Wachter (1982, p. 442) to show that the boys from the London Marine Society experienced their growth spurt at a later age. The problem therein that these people vary in both genes and environment, resulting in growth curves that likely do not truly resemble to growth pattern.

In figure 5 we applied the same method as Floud and Wachter to study the growth curve for six birth cohorts using the WHO growth curve as a reference. Although the lines even show some shrinking for the reason that we do not have multiple observations per person, a general picture emerges. The growth velocity appears to be lower for 13 and 14 year olds yet there appears to be a growth spurt reaching its peak around the age of 16. Furthermore the heights before the spurt also appear to be higher for the later cohorts.

We conducted regression analysis that can be found in table 1. In this analysis we explored the growth curve while controlling for socioeconomic status, birth regions, orphan status and birth cohort. The results show a growth curve that was close to the WHO reference for the younger teenage boys, started rising at a later age to catch up part of the ground that was lost. The growth velocity peak of the regressed curve was also at age 16. The curve ended at a lower point which is the result of controlling for socioeconomic status. Therefore we can assume that boys from a higher status experienced a higher peak, but still at a later age than is the case in contemporary societies. This suggest that the adolescent growth spurt was not absent for the wealthier boys in the Netherlands in the late 19th century.

Figure 5 *Growth curves and growth velocity based on a period study of mean heights of students of the maritime institute in Amsterdam for six birth cohorts.*



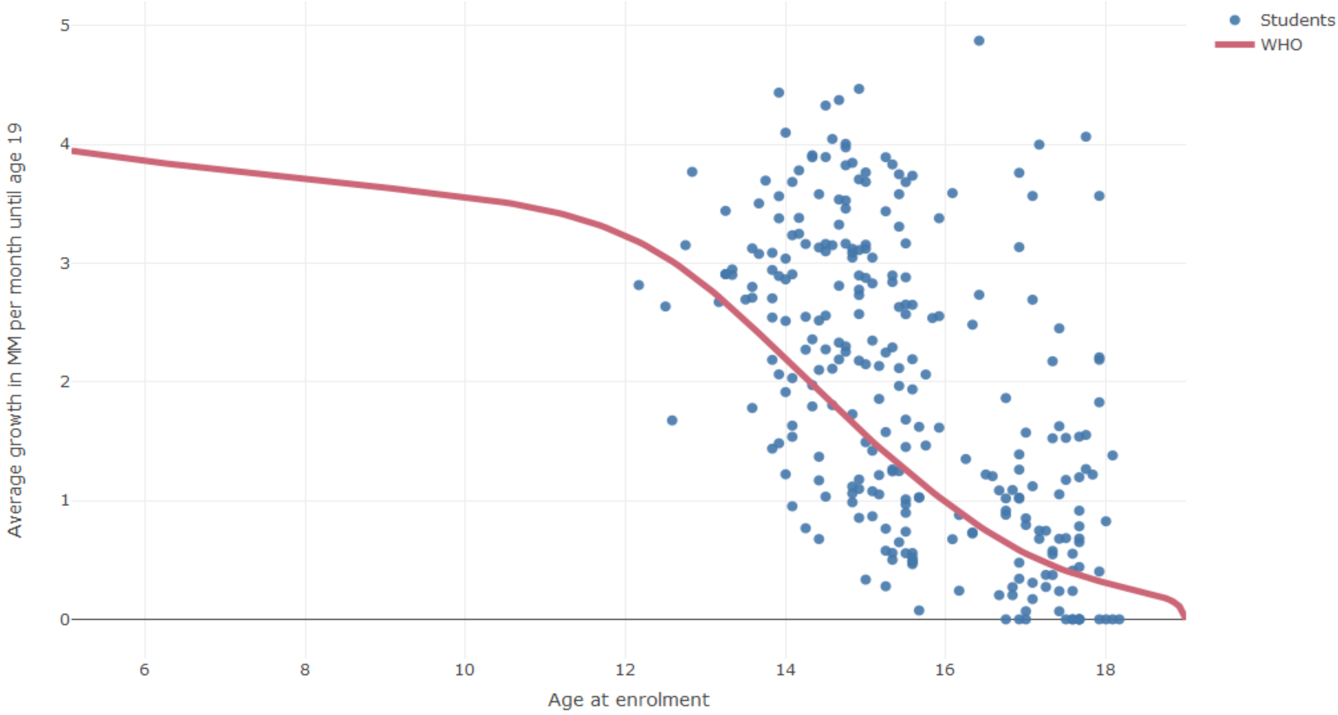
Source: *Comportementsboeken database, the regressed growth curve is taken from table 1. The curve is based on elite boys from Amsterdam born between 1860 and 1869 with both parents still alive as those were the reference categories used in the regression of table 1.*

As noted above, for a small part of the dataset we were able to collect heights from the conscription records, resulting in two height observations per research person. This allows us to calculate an average monthly growth velocity between the moment the boy was measured at the institute and moment he was subject to conscription. These scores can be found in figure 6 together with the WHO growth reference which was recalculated to a monthly average growth velocity based on total height increase between only two points in time divided by this period.

A large part of the points in figure 6 are above the WHO reference which implies that these boys had a higher average monthly growth velocity. This has to do with the fact that the growth spurt occurred at a later age together with a starting point that was farther below the WHO reference. This means that boys caught up with a higher growth velocity during their older teenage years.

Were these boys able to catch up because of conditions within the institute? The institute was known to be a clean place in the second half in the 19th century. During the large outbreak of cholera in 1866 the institute did not suffer any casualties (Bosscher et al., 1985, p. 157), so it might have been a relatively healthy place. However, we can zoom in on a deeper layer to ask the question of why we found the heights of these boys at conscription in the first place. A large share of the boys were at sea and were never measured for conscription (which does not imply that they were exempted). There are two explanations, the first being that the students who were subject to conscription were not at sea during the first world war and therefore we were able to trace them in the conscription records. This reason is only applicable on a small part of the data, but for this short time period a rise registered heights was found. The second reason is that the boys we found were dropouts from the school. We conducted a logistic regression (not shown here) on the population at risk (the 714 boys that were found in the conscription records of which 40 percent with heights measured). We used time at the institute as an independent variable, controlling for the year of birth because over time the curriculum took less time to complete. We found a significant odds ratio of 0,77 (p=0,00) which means that the longer a students was at the institute the smaller the likelihood was of being measured for conscription. The reasons to drop out of the school varied to a great extent. Boys were expelled for a variety of reasons, ranging from bad conduct, poor results or bad health. Some were withdrawn by their parents, who forfeited part of the paid fees. From the 279 boys in figure 6, 40 left the school within the first two years and 16 within the third year. Figure 6 therefore reflects growth velocity of both boys within and outside of the school. There was no significant difference in growth velocity (based on a regression analysis: -0,06, p = 0,27) for boys that left het school early.

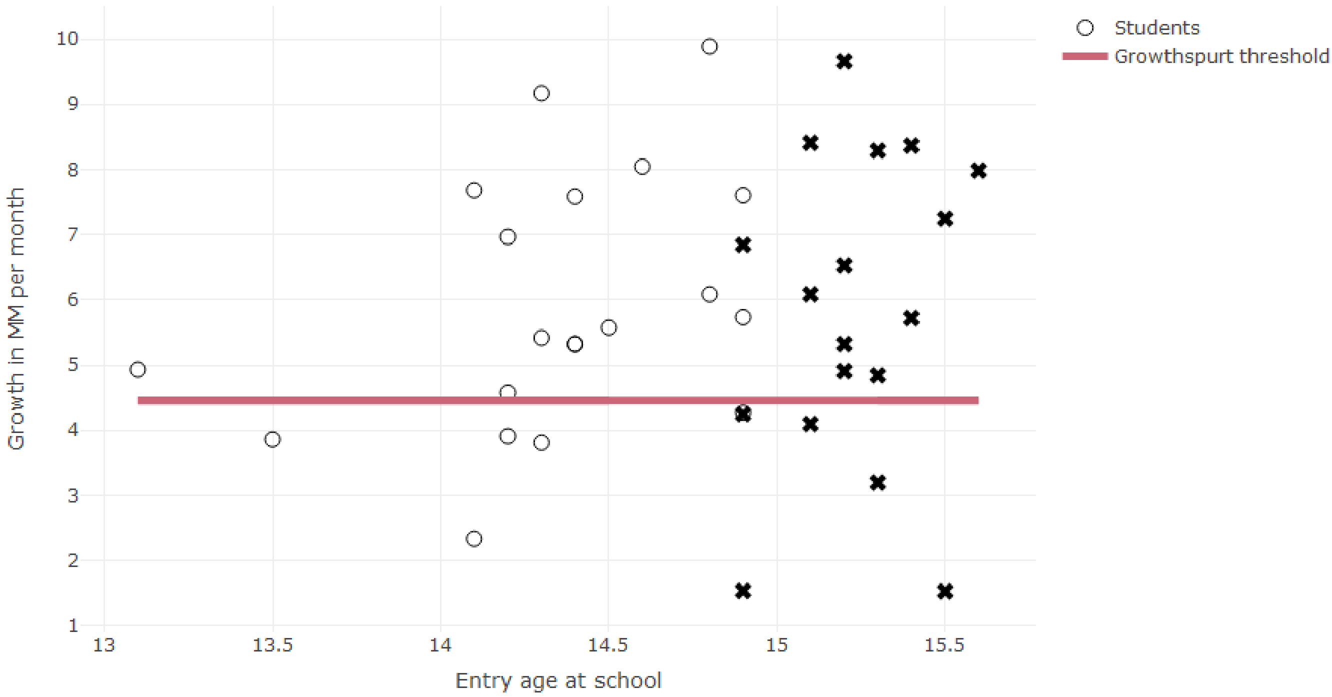
Figure 6 *Average monthly growth velocity over the interval between intake in the institute and conscription referenced to the WHO monthly growth velocity calculated of the interval between adult height and height-for-age scores*



Source: *Comportementsboeken database; the WHO 2007 growth reference for 5 to 19 year olds (https://www.who.int/growthref/who2007_height_for_age/en/).*

The growth velocity in figure 6 is an average calculated over multiple years that flattens the growth curve, but since we are interested in peak velocity we can turn to another form of record linkage. The first step in applying for the institute was to visit one of the local gatherings of the commissioners of the institute in the first week of May. Here the boy and his parents had to fill in an enrolment form to get invited for the entry examination that took place in the first week of June. During this process the boy was measured to check if he could reach the required height by June. This was done at the local city hall and according to the regulations had to be done without shoes. Still, personal recollections of aspirant pupils indicate that this happened with shoes as well (Bosscher et al., 1985, p. 140). We were able to retrieve 193 of these enrolment letters and link them to the heights of the students measured in June. Because of the unclear measurement procedures, 29 of these boys reported shrinking of which 11 shrunk more than a centimetre. The other problem is that the reported heights were rounded to centimetres, therefore the change in heights between May and June is absent or too large. Still there is one group that can be examined. The pupils were not only tested for their heights in June but they had to complete a language and math exam. The results played a role in the selection of students as well. Boys that were rejected on their scores could apply to be enrolled the next year. This implies that we have two heights, 13 months apart. Although we should be careful with both measurements, we were able to calculate an average monthly growth speed displayed in figure 7. The majority of the observations was above the growth spurt threshold that we took from Gao and Schneider (2019, p. 75). This supports the observation that there was a growth spurt for the boys in our dataset.

Figure 7 *Average monthly growth velocity of the students which were postponed from entering the institute by 1 year*



Source: *Comportementsboeken database and the growth spurt threshold is calculated using Gao and Schneider (2019, p.75)*

In figure 5 we already showed the growth curve that was calculated by a regression analysis in which we controlled for socioeconomic status, orphan status, birth region and birth cohort. The results of this regression can be found in table 1. The high adjusted R^2 for the model that used height as a dependent variable is caused by the age variable and shows how important age is to predict height. This should be a warning when conscription heights are used of draftees that are still growing.

We found that boys at the top of the social ladder were also the tallest, followed by middle class, skilled and unskilled families, respectively. The other SES groups' influence on height was not significant, although the variables moved in the expected direction. Further, we found that boys who lost their mother were significantly shorter opposed to boys who lost their father. These health implications of the absence of the mother who was assigned the important homemaker role were also found in an earlier paper (Quanjer & Kok, Forthcoming-b). With regard to the region of birth we found that boys born in the south, although their number was small, still reflect the negative height difference with the rest of the country that was also found in other research (Rutten, 1995; Tassenaar, 2019). Finally the cohort effect was added to control for the different enrolment conditions that resulted in height differences.

Comparing the second to the third model, both regressing all control variables on height-for-age z-scores, adding the age dummy does not cause major changes in the effect sizes of the other variables. Still when the age dummies are added in the third model there are significant changes in z-scores for different age groups with the boys aged 13 as a reference. This is a notable effect because height-for-age z-scores should cancel out the differences in height so the amount of stunting can be compared for differed research persons regardless of their ages. This is also reflected in the lower adjusted R^2 that was found for these models. That we still found a significant difference in z-scores for the ages 14,15 and 16 compared those at age 13 has to do with the WHO reference. This reference does not reflect the growth curve of the 19th century. The 13 year old boys are relatively close the reference, their older peers lose ground when the growth velocity of the WHO reference peaks for 14 and 15 year olds. When the peak in growth velocity occurs for 16 year olds in the 19th century, these boys catch up on the WHO reference, but seem to never fully catch up their lost growth, although the results are not significant.

Table 1. OLS Regression models on height in millimetres and height-for-age z-scores based on the WHO reference for boys enrolled in the maritime institute in Amsterdam born between 1837-1901.

Dependent variable:	*Height in mm*	*Z-score*	*Z-score*
Age			
13	Ref.		Ref.
14	26,863 **		-0,391 ***
15	60,478 ***		-0,521 ***
16	113,848 ***		-0,242 ‘
17	149,294 ***		-0,091
18	157,909 ***		-0,092
HISCLASS parents			
Elite	Ref.	Ref.	Ref.
Middle Class	-13,263 **	-0,196 ***	-0,187 **
Skilled Workers	-17,862 **	-0,277 ***	-0,245 **
Farmers	-9,681	-0,127	-0,117
Unskilled workers	-20,448 ‘	-0,301 *	-0,295 *
No Occupation	5,005	0,074	0,085
Occupation unknown	-20,061	-0,164	-0,170
Orphan			
Father alive	Ref.	Ref.	Ref.
Father died	0,794	0,023	0,029
Mother alive	Ref.	Ref.	Ref.
Mother died	-13,631 **	-0,173 *	-0,189 **

Birth region			
Amsterdam	Ref.	Ref.	Ref.
East	0,924	-0,009	-0,007
North-West	3,748	0,041	0,037
South-West	0,575	-0,010	-0,013
South	-26,090 *	-0,316 *	-0,361 *
Overseas	5,056	0,041	0,053
Birth Cohort			
1837-1849	-41,586 ***	-0,553 ***	-0,528 ***
1850-1859	-19,564 *	-0,311 **	-0,259 *
1860-1869	Ref.	Ref.	Ref.
1870-1879	17,018 *	0,054	0,143
1880-1889	57,105 ***	0,562 ***	0,659 ***
1890-1901	83,241 ***	1,016 ***	0,878 ***
Intercept	1503,219 ***	-1,310 ***	-0,969 ***
Adjusted R^2	0,6247	0,3218	0,3381

Signif. codes: 0 *** 0.001 ** 0.01 * 0.05 ’ 0.1, Source: Comportementsboeken database

Discussion and conclusion

The data show that the use of the WHO height-for-age reference can be problematic when used for historical data. Especially when heights for different ages are compared this can lead to biased results with stronger effects for boys around the age of 15. Therefore this might call for an historical growth reference that, although strong differences in the growth pattern between regions and periods can be expected, will result in a better comparison of still growing adolescents. The regressed growth curve of this paper might be a first step, but biases for region, age and socioeconomic backgrounds call for further investigation. Furthermore this can also help to derive at a clear definition of when we can call peak growth velocity an actual growth spurt.

From the data in figure 5 and table 1 we can also observe that the large divergence between historical and present day stature seems to occur largely in the teenage years. If this is truly the case, then we can conclude that the secular trend in heights is mainly caused by an acceleration of growth velocity during the adolescence. Might the body be more willing to make concessions in growth during this period of life when living conditions force it to? That could explain why Depauw and Oxley (2018) found such a strong effect for food prices on height during the teenage years. Since the current data represents boys from a relative wealthy background, the change in the growth pattern might be even stronger for the lower classes as height differences converged alongside the increase in heights (Alter, Neven, & Oris, 2004). Therefore a better understanding of the difference in growth for also the younger ages is key to understand the secular trend in heights.

For now, we have showed that the students of the maritime institute in Amsterdam followed a similar trend in z-scores as conscripts in the Netherlands. Based on the z-scores for the early period we can assume that living standards were slightly better for the 1780-1810 period compared to the worst period in the middle of the 19th century. From the linked records we could establish that boys experienced high average growth velocities, hinting at the existence of a growth spurt. This was supported by the results of the regression analyses. Still the growth spurt occurred at a later age and the highest growth velocity reached was lower than for modern populations. Furthermore the growth curve appears to have moved upwards based on the period study we conducted using the individual observations. In this way, we added some information to our understanding of the growth curve of the 19th century, but there is still a sea full of questions to explore.

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