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ORIGINAL ARTICLE

BMI distribution/social stratification in Swiss conscripts from 1875 to present

K Staub[1], FJ Rühli[2], U Woitek[3,4] and C Pfister[1]

[1]*Institute of History, University of Bern, Bern, Switzerland;* [2]*Institute of Anatomy, University of Zurich, Zurich, Switzerland;* [3]*Institute for Empirical Research in Economics, University of Zurich, Zurich, Switzerland and* [4]*CESifo, Munich, Germany*

Background/Objectives: We aimed to extend the actual overweight discussion with new unbiased Swiss conscript data from 2005 to 2006, and to present for the first time Swiss data on body mass index (BMI) before 1950 and for the late-nineteenth century.
Subjects/Methods: For this study, 19-year-old Swiss male conscripts (draft army; Cantons Bern, Zurich, Basel-Stadt and Basel-Land) from the census of 1875–1879, 1933–1939 and 2005–2006 ($N = 28\,033$; 2005–2006 census) were included. BMI distribution (World Health Organization (WHO) classification) and social stratification (International Labour Organization classification) were main outcome measures.
Results: Mean BMI of 19-year-old men in Switzerland increased in the 50 years between the 1870s and the 1930s by 0.80 kg/m^2 and between the 1930s and 2005 by 1.45 kg/m^2. The modern BMI sample is much more right skewed and s.d. is higher. Obesity prevalence (according to modern WHO classification) has increased by a factor of 105 from 1870s until present. Over 23% of our representative sample of Swiss men in 2005–2006 had a BMI of over 25 kg/m^2. In 2005–2006, contrary to the nineteenth century, unskilled workers had articulately higher BMI values at the 75th, 90th and 95th percentile than students; 12% of unskilled workers were obese against 2% of students.
Conclusions: It thus seems that BMI relations between the upper and the lower end of the socio-economic strata changed inversely from the late-nineteenth century to 2005–2006. We further propose that the phenomenon of massive right-skewing BMI distribution between the 1930s and 2005–2006 affected the lower socio-economic strata to a far greater extent than the higher socio-economic group.
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Introduction

Overweight and obesity have reached the level of a pandemic in developed countries (WHO, 1998–2004; James, 2001; Henneberg and Veitch, 2005). Because of data limitations (weight measurement and personal scales were uncommon before the 1880s, see Merta, 2003 and Baumann, 2008), there are very few studies assessing long-term trends in body mass index (BMI) distribution. Such historical studies could analyze the timing and social etiology of the onset of this pandemic. Felgal and Troiano (2000) and Komlos *et al*. (2009) explored BMI patterns for the United States since the 1940s. Rasmussen *et al*. (1999) explored BMI patterns for Sweden since the 1970s and Katzmarzyk (2002) for Canada since the 1970s. Vignerova *et al*. (2007) compared percentile changes in BMI-for-age of Czech adolescents between 1951 and 2001. Finally, Helmchen and Henderson (2004) compared the distribution of BMI for Union Army veterans aged 40–69 years in 1890–1900 with participants of a national health survey in the United States (1970–2000), and Komlos *et al*. (2009) showed the rightward skewing in BMI distribution of 18-year-old US military cadets between the 1860s and 1950s.

BMI is a proportional measure that makes it possible to compare modern and historic populations (Riley, 1994). Little is known about BMI in historic populations. In the field of historical anthropometrics, the nutritional status of nineteenth-century populations measured by BMI is a popular topic despite the lack of sources. The number of existing studies is extremely small with data based on

Correspondence: Dr FJ Ruhli, Institute of Anatomy, University of Zurich, Winterthurerstr. 190, CH-8057, Zurich, Switzerland.
E-mail: Frank.ruhli@anatom.uzh.ch
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samples, which reflect BMI values of the lower-class segments of the population, such as Mexican prisoners from 1871 to 1925 (Carson, 2007) and Union Army Veterans from 1861 to 1940 (Cuff, 1993; Costa, 1993; Fogel, 1994; Linares and Su, 2005). The BMI values of historical population were generally much lower than modern ones, obesity was at a low level of 1% and undernutrition was a frequent diagnosis and thus a relevant public health issue. As the u-shaped relationship between BMI and morbidity and mortality (Waaler, 1984) is well documented and extremely low and high BMI values are associated with poor health and greater mortality risk (Cuff, 1993; Fogel, 1994; Murray, 1997; Henderson, 2005; Linares and Su, 2005), it is crucial to know more about the onset, degree and social stratification of such extreme BMI values, relative to the modern pandemic of obesity.

In developed countries such as Switzerland, overweight is currently the most serious diet-related health risk and public health problem (Eichholzer *et al*., 1999; Eichholzer, 2002; Schneider and Schmid, 2004; Schmid *et al*., 2005). There are only a handful of studies about the increase in the Swiss prevalence of overweight and obesity among young adults and adults since the 1980s (Wietlisbach *et al*., 1997; Bernstein *et al*., 2001; Egger *et al*., 2001; Schütz and Woringer, 2002; Morabia and Constanza 2005;for a literature overview, see Eichholzer, 2002; Schopper, 2005; Mohler-Kuo *et al*., 2006). Groscurth *et al*. (2003) analyzed changes in adult Swiss BMI values since 1950, but the study is only based on life insurance application data. There are significant differences in obesity prevalence between socio-economic groups in Switzerland at the end of the twentieth century, in which people with lower socio-economic status tend to have higher BMI values (Huwiler *et al*., 2002; Galobardes *et al*., 2003).

The aim of this study is to extend the actual overweight discussion with new unbiased data from 2005 to 2006, and to present for the first time Swiss data on BMI before 1950 and for the late-nineteenth century. Furthermore, we aim to show changes in BMI distributions and BMI social stratification between 1876 and present from the same data source, thus adding reliable historical context to the current overweight/obesity discussion. Since 1874, every 19-year-old male Swiss citizen is conscripted for military duty and undergoes a medical examination for military fitness (Kurz, 1985); this examination is based on detailed standardized rules and instructions (Instruction, 1875–1877). The medical commission keeps annual detailed control books containing particular measurements for every conscript (Wolf, 1891). The measurement procedure has remained unchanged over time, which further assures the validity and comparability of our three data sets.

Subjects and methods

The historical data for the 1870s and 1930s were collected from complete annual control books in the public record offices/State archives. Various Swiss Cantons did not archive the control books of the medical examination of conscripts until today, which determined regional selection of our samples. The samples from 1875 to 1879 measurement years included 19-year-old Swiss men living in the Cantons Basel-Stadt (Staatsarchiv Basel-Stadt, www.staatsarchiv.bs.ch) and Basel-Land (Staatsarchiv Basel-Land, www.baselland.ch/Staatsarchiv.273831.0.html), containing nearly complete birth cohorts (Kinkerlin, 1880). The data from 1933 to 1939 measurement years were based on complete transcript control books from the Cantons Bern (Regions Oberland and Seeland, Staatsarchiv Bern, www.sta.be.ch/site/staatsarchiv) and Zurich (Stadtarchiv Zürich, www.stadt-zuerich.ch/prd/de/index/stadtarchiv.html, and Staatsarchiv Zürich, www.staatsarchiv.zh.ch) and also included 19-year-old men. The modern data were provided by the Swiss Armed Forces and consisted of a total of 28 033 samples (Rühli and Woitek, 2007; Rühli *et al*., 2008). For this study, only 19-year-old conscripts from the Cantons Bern, Zurich, Basel-Stadt and Basel-Land were chosen. The regional origin of the sample differs slightly; however, each sample includes rural and urban data. The classification of occupation by nature of task follows the International Standard Classification of Occupation (ISCO-88) from the International Labour Organization (www.ilo.org). As the conscripts in the data set were 19 years old, we added a category for students. To test for occupational differences relative to changes in BMI distribution, we compared unskilled workers and students, which are the two groups at opposite ends of the socio-economic strata.

Results and discussion

Mean BMI of 19-year-old men in Switzerland increased in the 50 years between the 1870s and the 1930s by 0.13 kg/m^2 per decade and between the 1930s and 2005 by 0.21 kg/m^2 per decade (Table 1). Although s.d. and skewness are very similar

Table 1 Descriptive body mass index (BMI) statistics of 19-year-old male Swiss Conscripts in the 1870s, 1930s and 2005–2006

	1875–1879	*1933–1939*	*2005–2006*
N	2781	12 666	8182
Mean	20.62	21.43	22.88
s.d.	1.88	1.97	3.48
Skewness	0.56	0.50	1.70
10% Quantile	18.29	19.05	19.32
25% Quantile	19.43	20.08	20.66
Median	20.57	21.34	22.28
75% Quantile	21.77	22.64	24.26
90% Quantile	22.96	23.88	26.99
$<18.5\,kg/m^2$	11.94%	5.50%	4.42%
$18.5–25\,kg/m^2$	86.55%	90.57%	72.17%
$25–3\,kg/m^2$	1.47%	3.84%	19.19%
$>30\,kg/m^2$	0.04%	0.09%	4.22%

in historical times, the modern BMI sample is much more right skewed and s.d. is higher. Between the late-nineteenth century and the 1930s, the increase in BMI is constant for all percentiles by approximately 0.65–0.92 kg/m^2. From the 1930s to present, a trend was observed especially in the higher percentiles, in which the BMI values in these groups increased by 1.62 kg/m^2 (75th percentile) and 3.11 kg/m^2 (90th percentile), whereas there was little change in the lower percentiles.

We are aware of the difficulty in using modern World Health Organization (WHO) categories for BMI as a framework for historical data, as health-relevant risk cutoff points in BMI may have been shifted over time (Henderson, 2005). When we compare underweight, overweight and obesity in the 1870s, the 1930s and 2005–2006 using modern WHO categories (Table 1), one may analyze body appearance distributions; yet, nothing can be said about morbidity or mortality risks combined with modern BMI categories in such historical samples. Table 1 shows BMI changes over 130 years. In 1875–1879 ca., 12% of the 19-year-old Swiss men were underweight based on modern categories. Until the 1930s, the percentage of underweight decreases clearly to $<6\%$ and the comparison with the 2005–2006 sample shows no more relevant change in this fraction. In contrast, overweight increased slightly from the 1870s to the 1930s by ca. 2.5% and increased markedly by almost 15% between the 1930s and 2005–2006. The same pattern occurs in the percentage of obese young men. In 2005–2006, 4.2% of the young adults had a BMI of over 30 kg/m^2. The view back to the 1930s and to the late-nineteenth century shows that obesity was nearly absent at that time ($<0.1\%$). However, obesity prevalence has increased by a factor of 105 from 1870s until present.

In summary, over 23% of our representative sample of ca. 8000 19-year-old Swiss men in 2005–2006 had a BMI of over 25 kg/m^2 and were thus overweight. In comparison, historical samples show that the problem of overweight/obesity is a very recent population phenomenon. In the 1930s, only approximately 4% had a BMI of over 25 kg/m^2 and it was just 1.5% in the 1870s. Therefore, the percentage of overweight people has increased by a factor of 6 since the 1930s, and by about 15 times since the late-nineteenth century. In contrast, in the 1930s, approximately 5% of the young men were underweight (BMI under 18.5 kg/m^2) and this is nearly as many as were overweight. Unlike obesity, the percentage of underweight young men stayed relatively constant between the 1930s and 2005–2006.

Not only has the prevalence of underweight, overweight and obesity and mean BMI changed over the past 130 years, but also the shape of the BMI distribution has changed. Between the 1870s and the 1930s, an upward shift in the distribution as a whole took place without any important changes in the shape of the curve. However, the form of the BMI distribution has changed in an important and obvious way between the 1930s and 2005–2006 (Figure 1). The difference between the two distributions in the 1930s and in

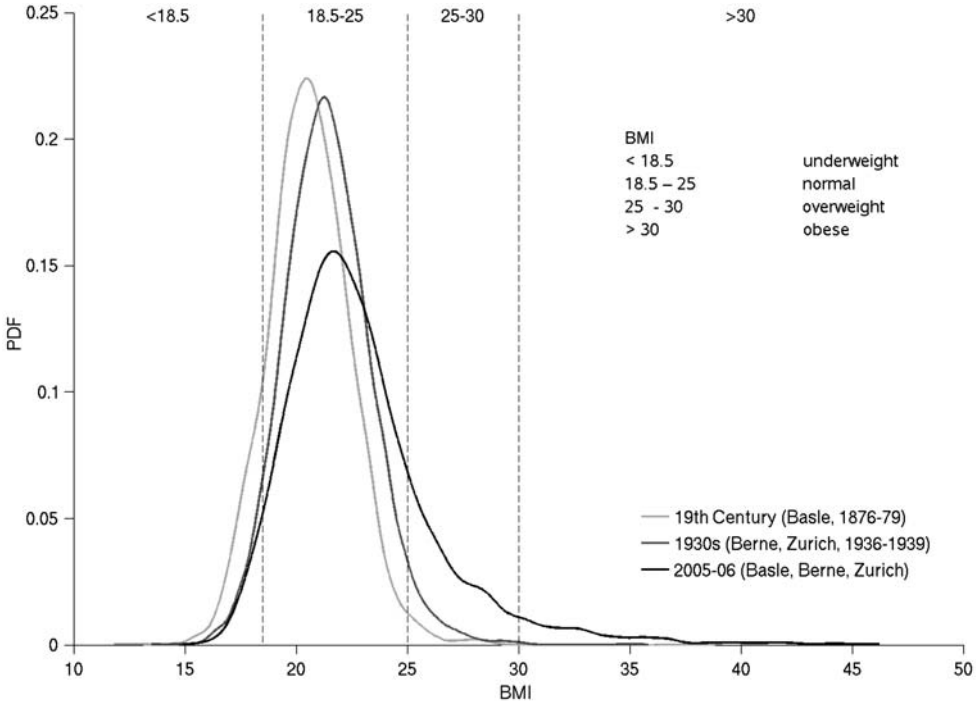

Figure 1 BMI distribution in Swiss conscripts.

2005 is close to zero at the lower percentiles and increases progressively at the higher percentiles, resulting in a clearly increased skewness in 2005–2006. Similar to Felgal and Troiano (2000), we observed for Switzerland a mixed change in distribution shapes by both an upward shift and an increased skewness between the 1930s and 2005–2006. The clearly right-skewed BMI distribution in 2005–2006 was an unknown phenomenon before the 1930s. Groscurth *et al*. (2003) and Statistisches Amt Basel Stadt (2009) suggest that this skewing phenomenon has been taking place from 1980 onward in the case of Switzerland. We were not able to test that point in time, but we confirm the general pattern that has been observed in other countries (Rasmussen *et al*., 1999; Felgal and Troiano, 2000; Katzmarzyk, 2002; Penman and Johnson, 2006; Komlos *et al*., 2009; Hiermeyer 2009). The BMI distribution in Switzerland has become increasingly skewed in the second half of the twentieth century by a distribution shift more to the upper end of the curve than to the lower end.

Table 2 shows BMI percentiles and WHO categories distribution for both occupational groups in all three samples. In the 1870s, both distributions are quite equal at lower percentiles, whereas the BMI values of students were clearly higher at 90th and 95th percentiles; that is, 4.7% of the students were overweight (BMI $>25\,kg/m^2$) compared with 0% of the unskilled workers. This finding confirms the literature on historic body stereotypes that until the end of the nineteenth century socio-economic wealth was expressed not only by higher material status but also by higher corpulence (Thoms, 2000; Merta, 2003), which was also the case in underdeveloped countries until recently. In the 1930s, BMI distributions showed no important differences regarding occupation and thus socio-economic status. Again, in 2005–2006, the lower percentiles showed no important differences, but contrary to the nineteenth century, unskilled workers had articulately higher BMI values at the 75th, 90th and 95th percentile than students. This is reflected by contrasting the prevalence of overweight and obesity: 26% of unskilled workers were overweight versus 13% of students, and 12% of unskilled workers were obese against 2% of students. This finding is in general congruous with Huwiler *et al*. (2002) and Galobardes *et al*. (2003). It thus seems that BMI relations between the upper and the lower end of the socio-economic strata changed inversely from the late-nineteenth century to 2005–2006. We further propose that the phenomenon of right-skewing BMI distribution between the 1930s and 2005–2006 affected the lower socio-economic strata to a far greater extent than the higher socio-economic group.

BMI reflects the current nutritional status and thus the nutritional, hygienic, disease and stress environment of a population. People in the late-nineteenth century lived under totally different health conditions, were housed under worse conditions, worked physically harder on the job and walked long distances to the place of employment (Gubéran, 1980; Gruner and Wiedmer, 1987; Trevisan, 1989; Ritzmann-Blickenstorfer, 1996). A cumulative effect has been ascribed to the close interrelation between nutrition, infection and immunity (Lunn, 1991). All these factors influenced the poor more negatively. In the late-nineteenth century, underweight was a major health issue, considering that approximately 12% of the 19-year-old young men in Switzerland were underweight. Exemplary, physical immaturity (deficient height, narrow chest and weakness) was the most important reason for unfitness for military service between 1875 and 1879 in all over Switzerland (Hürlimann, 1880).

At the beginning of the twenty-first century, the population changed from being rather underweight to being overweight. The reason for this modern obesity pandemic remains quite enigmatic. Komlos *et al*. (2009) found that the raising obesity pandemic among US-born children and youth since the 1920s and especially between 1950 and

Table 2 Occupational differences in body mass index (BMI) between 19-year-old male Swiss students and unskilled workers in the 1870s, 1930s and 2005–2006

	1875–1879		*1933–1939*		*2005–2006*	
	Unskilled workers	*Students*	*Unskilled workers*	*Students*	*Unskilled workers*	*Students*
N	145	64	1908	384	50	2313
5% Quantile	17.47	17.92	18.44	18.41	18.59	18.31
10% Quantile	18.25	18.29	19.1	18.9	18.81	19.08
25% Quantile	19.38	19.27	20.16	19.93	20.52	20.29
Median	20.28	20.48	21.43	21.07	22.66	21.80
75% Quantile	21.26	21.87	22.72	22.46	25.10	23.57
90% Quantile	21.87	23.44	23.88	23.67	32.18	25.71
95% Quantile	22.95	24.96	24.49	24.48	32.91	27.69
$<18.5\,kg/m^2$	12.41%	14.06%	5.14%	5.73%	4.00%	5.75%
$18–25\,kg/m^2$	87.59%	81.25%	91.67%	91.67%	70.00%	81.11%
$>25\,kg/m^2$	0.00%	4.69%	3.20%	2.60%	26.00%	13.14%
$>30\,kg/m^2$	0.00%	0.00%	0.05%	0.26%	12.00%	2.16%

1970 can be observed as the outcome of the combined effects of continuous and multifaceted technological, cultural and nutritional lifestyle changes in the twentieth century (TV consumption, short-distance use of automobiles, information technology revolution, fast-food culture, sedentary lifestyle and so on). We suggest that a positive energy balance (decreased energy expenditure by low level of physical activity and/or increased dietary energy intake by relative cheapness of processed foods, large portion sizes, immediate availability of fast foods, high-fat or high-energy diet and so on) is also a major reason for the increased prevalence of overweight Swiss from the 1980s until today; however, the phenomenon has been delayed by at least 30 years compared with the United States (Groscurth *et al*., 2003; Komlos *et al*., 2009; Statistisches Amt Basel Stadt, 2009). Although Henneberg and Veitch (2005) found that variance in BMI is strongly influenced by the components of the lean body mass (size of the musclo-skeletal system and the intra-abdominal contents) and not only by the amount of subcutaneous adipose tissue, genetic factors may also be another reason for this variance (James, 2001; Gutiérrez-Fisac *et al*., 2002; Katzmarzyk, 2002; Dina *et al*., 2007). However, our historical study shows that only genetic factors became effective in combination with profound changes in lifestyle, which are unique in the history of mankind. Being overweight or obese as an adult or adolescent is related to disadvantages regarding family income or marriage possibilities, school performance or total school years, college acceptance, psychosocial functioning or the rate of household poverty (Averett and Korenman, 1996; Gortmaker *et al*., 1993). There are also relations to rising medical costs as well as lower wealth (Zagorsky, 2005). Thus, studies revealing changing patterns of obesity through time and space (including socio-economic factors) have important policy implications (Harper, 2000; Cawley, 2004; Finkelstein *et al*., 2005).

Conflict of interest

The authors declare no conflict of interest.

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