Kayser

Height and Weight in Human Beings

Autopsy Report

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Autopsy Report

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Preface

Since the publication of ROESSLE and ROULET on "Maß und Zahl in der Pathologie" in 1932 there have been numerous advantages and changes in the field of pathology and in handling large amounts of data. Autopsies being the major source of information at the time of ROESSLE have been decreased in number considerably in the Heidelberg area since 1981. The trend holds on, and is probably caused by modern diagnostic equipments, especially computed tomography and magnetic resonance techniques. Pathology's main duty is now related to diagnostic procedures, i.e. biopsies accompanied by immunohistologic and biochemical supports. On the other hand, data collected during a long period of time showing considerable constancy in the applied methods are rare and may be worth for statistical analysis. Autopsies performed in the Institute of Pathology at the University of Heidelberg since 1841 containing information about height and weight of the patients as well as weight of the major parenchymal organs may be considered to be an important source related to possible changes in the physical appearance of the Heidelberg population. The date of birth of the autopsied persons covers a period of approximately 150 years and includes periods of starvation in the time after the First and Second World War as well as times of abundance of food since 1960. Living habits have changed considerably during the last 150 years as well as the environment. The spectrum of diseases seen in autopsies has changed to a great extent. Infectious diseases being the major cause of death in the middle of the last century – in fact, the first autopsied case was a young man suffering from typhoid fever – have become very rare since 1955 and have been replaced by coronary heart diseases and malignancies. The appearance and the size of the organs being not or only indirectly involved in the main diseases contain information related to the environment and to endogene factors of the human race. Autopsies and the evaluation of the basic data, i.e. height and weight were performed in the same manner since 1900. Knowing the main diseases and the cause of death computations of height, body weight and weights of different organs can be performed using different data sets for the corresponding organs based upon a total of more than 50 000 autopsies.

In this book I want to present basic data of height, body weight and weight of different parenchymal organs of the Heidelberg population. The computation is based on modern computer equipment including the handling of large data bases and including programmes for statistical evaluation. Interpretation of the obtained results is strictly limited in order to preserve the data as momentary standards to be used in autopsies.

The evaluation of the data and their computation needed several years. Both, the evaluation and the statistical computation of the data would not have been possible without the support of the Director of the Institute of Pathology, Professor Dr. Dr. Dres. h. c. W. Doerr and his follower, Professor Dr. H. F. Otto. I am extremely grateful to them giving us their support in some critical situations and the unlimited access to the data. I also wish to express my appreciation and gratitude to Mrs. Adam, Mr. Griesinger, Mr. Kircher, Mr. Lätsch and Mr. Raab supporting us in the evaluation of the data and the corrections of numerical errors. I am also greatly indebted to my publishers for their cooperation and help throughout the production of this book. I am particularly indebted to my family for its patience and tolerance.

I do hope that the data of this book may be used not only as standards in pathology but may also be of influence in giving new access and new perspectives on the development of the human race.

Prof. Dr. Dr. K. Kayser

1. Introduction

Medical information obtained by autopsies can be divided into two categories. The simplest method is to describe macroscopic features of organs, i.e. consistency, color, size, etc. In general, these findings include quantitative measurements of various parameters. More important information is the diagnosis obtained by abstraction of findings. These include statistical computations in view of medical science. While findings of a given case are individual and singular, diagnoses of diseases are valid for all cases suffering from the disease. As long as medicine is considered to belong to natural sciences, a necessity exists to validate findings and to introduce reproducible coordinate systems allowing comparability between different cases. Measurements are mandatory in any kind of medical field due to above mentioned considerations. There is a strong urge in humans that inspires exploration of their environment and of natural laws of the living and dead. This eagerness includes the human himself. Surprisingly limited information is available on simple descriptions of human race, as weight and size of different organs. Although a number of papers describe weights of major organs, no major computation has been made including different organs and detailed differentiation into size, sex, age, etc. since the book of ROESSLE and ROULET (1932).

At first glance, evaluation of weight of major organs and height of humans seems easy. Already rough analysis reveals a number of factors such as social status, nutrition, living habits, congenital factors such as race, inborn errors of metabolism etc. A number of diseases affect weight and size of various organs. For example diseases which may not be known in detail or which no longer exist at the time of death. ROESSLE pointed out that a number of published papers had not considered influences described above in measuring weight of organs. In his explicit book separate computation of weights according to different major diseases was not performed. From the mathematical point of view evaluation of the weight of organs needs a multivariate statistical analysis. This was performed for example by BOYD (1933) for the weight of the liver in a quite simple way. ZSCHOCH and KLEMM (1972) show correlation factors of weights of different organs according to age, height and other parameters. Although their procedure is correct, the value is limited in practice and interpretation is not easy. We will also present correlation factors in this book, but the main purpose of our work can be described as follows: Since 1841 the autopsy material of the Pathological Institute of the University of Heidelberg is available. Only a limited number of autopsies was performed every year at this time. A reliable number of autopsies (more than 100 per month) was performed since 1900. The annual number of autopsies remained nearly unchanged from 1900 to 1981. Autopsy frequencies of different diagnoses are already published (HÖPKER 1976). Additionally, a detailed analysis of the autopsy reports revealed a high percentage of additional documented data such as height and weight. Therefore, we analysed the following question: Is this information useful and, if yes, what can be done with these data? A detailed study of the literature showed that several authors tried to define the weight of organs in respect to different yet special circumstances. Since the majority of these studies was prospective, the number of reported cases was small. The advantage of these studies is an accurate and uniform measurement. At first glance, this can be considered as a necessary condition; on the other hand, various methods weighing organs are used in several Institutes of Pathology. Due to lack of time, weight of organs is usually measured insufficiently. Published data of exact measurements cannot be compared to measurements performed in routine autopsies. In this book we attempt to answer questions as: The average weight and its distribution of major human organs measured under „normal“ conditions in Patho-anatomical Institutes?

The answer reveals an accurate definition of “normal weight”. “Normal data” of weights presented in this book are obtained as follows: Measurements of weight of organs are performed as usual in many Institutes of Pathology. Organs are being weighed independently from amount of blood or edema within the organ. Preparation of organs is performed as described by ROESSLE (1935). Every organ is weighed by separation from the other parts of the body. Preparation is not difficult for organs like lung, liver and kidney. The weight of heart includes epicardial fat but excludes pericardium as measured in the majority of the Institutes of Pathology. All organs are weighed prior to fixation. The procedure ist only useful if internal factors influencing the weight are excluded as far as possible. Cases suffering from diseases with major influence on the weight of the organ considered are excluded from computation. Therefore, the basic population of autopsy cases is different for various organs. Once this population is defined, the weight of a healthy person is known (weight after death). As the autopsy data cover a long period of time, possible changes in human height and weight of various organs can be detected. The length of time leads to following questions: Increased height of autopsy cases during the period considered; if so, what are the quantitative changes? Are there similarities in the distribution of height at present and 80 years ago? Are influences of malnutrition in population (First and Second World War) regarding height and weight detectable?

In the next step, correlation of human height and weight of organs are evaluated. It was noted that human height can be regarded as the most important factor for increase of organs weight (ZSCHOCH and KLEMM, 1972). If this statement holds true, the time dependency of this correlation is of great interest.

The data of this book are presented in figures to allow easy use during autopsies. Detailed correlation coefficients are presented to allow detailed statistical considerations. We are in agreement with ROESSLE and other authors regarding the data of height and weight as useful and necessary for performing autopsies. Knowledge of these data allows a better understanding of changes in the population of the area of Heidelberg (Caucasian race) from 1830-1950 (date of birth).

Nearly every second patient, who died in Heidelberg either at home or in a hospital, had been autopsied in the Institute of Pathology during the period considered. Periods exist with good documentation and accurate diagnoses of autopsies, followed by other periods with increased percentage of missing values. Even in difficult times during First and Second World War height and weight of various major organs were reported accurately. Therefore, autopsy reports are an important and reliable source of information regarding changes in size and body weight of the local population. Data of different populations regarding height and weight of soldiers are already reported. We mention the list of height (scale of measurements) obtained at the “Hohe Carls Schule” at Stuttgart for the period 1772-1794 (cited in HARTMANN, 1970). 155 students were measured with an average height of 167.8 ± 7.7 cm. From 1921 to 1926 the height of students of various universities in Germany are available (München, Tübingen, Leipzig, Freiburg, Gießen, Münster). The observed height in males during this time was already 173 cm at an average. Most of these data were not grouped according to date of birth, but were simply reported as to date of measurements in different areas. The comparability of these data is fairly good and shows good reproducibility. Grouping our data to date of birth made it possible to cover more than 100 years of autopsy reports. We have the unique situation of data collection obtained in one institute, covering a long period of time, and knowledge about the bias of the material. Performing autopsies and measuring the weight ourselves enabled us to estimate systematic errors and quality of the obtained results.

There ist no doubt that the height of Western European population has increased during this century. It is very difficult to obtain exact quantitative values regarding these changes as nearly no data estimating the changes of weight of various major organs are available. Simple questions “Does the weight of brain show a similar increase compared to the height of the body?” “What are the changes in weight of liver or heart?” arise. These questions open new points of view in understanding the development of the human race. Whereas methods of measuring height and weight remained nearly unchanged during the period of time considered, we are now able to perform fairly difficult computations using computers. This was not possible at the time of ROESSLE. The field of medical statistics has changed since that time, and performance of multivariate computations is possible without major difficulties. The handling of statistical methods for evaluation of information from large data pools is simplified. Even in times of cell-dominant morphology, macroscopic findings are still usefull sources in answering questions about different aspects of human beings. The absolute weight of the major organs, height and body weight can be used for these methods.

2. Material and Methods

The first autopsy was performed in the Institute of Pathology, University of Heidelberg, in 1841. Quantitative information about height and weight of body and weight of organs has been documented in a sufficient number of cases since 1900. Weight of organs includes weight of brain, lungs, spleen, liver and kidneys, weight of adrenals was notated since 1970. Weights of thyroid gland, thymus, pancreas and adrenals have not been measured continuously. Autopsy records of the period 1900-1981 of the Institute of Pathology, University of Heidelberg were re-examined and the following parameters were evaluated:

Height and weight of body, weight of brain, heart, right and left lung, liver, spleen, right and left kidney. Observed data were transferred into a small computer and were then combined with the diagnoses. The autopsy frequencies of the diagnoses are already published (HÖPKER, 1976). The diagnoses were coded using a crude 3-digit code (HÖPKER, 1976) which was redefined by the authors in 1976. In all, 47,523 cases were available for computation. As shown in previous papers (KAYSER et al., 1978) no major changes in bias of autopsy material during the period considered were detectable. Bias of autopsy material can be described as follows: Autopsy material favours younger patients (under the age of 60) and males. Sex ratio, average age at death and area of residence of autopsied patients remained unchanged during the period considered. Autopsy frequency of patients with a rare disease has been increased due to high autopsy percentage (40-45%) of all diseased in the area of Heidelberg. Bias of rare diseases has no major importance to our material. Diseased with an average age at death of about 60 years (patients with carcinoma of esophagus or with carcinoma of stomach) show nearly no bias as outlined in detailed studies (KAYSER and BURKHARDT, 1980).

Table 1: Diagnoses excluding cases from computation of body weight

General: collagenosis, cachexia, dystrophy, adiposity, Pickwick syndrome.

Kidneys: transplant, focal gomerulonephritis, renal diabetis (phosphate diabetis, aminoaciduria), dialysis, inflammatory and vascular cirrhosis, tuberculosis.

Liver: cirrhosis (alcoholic, portal, biliary, posthepatic, pigment, hemochromatosis)

Lungs: tuberculosis: florid, pulmonary cavern, recurrence.

Oesophagus: stenosis

Colon: anus praeter

Newborns: virus infection of mother (German measles)

Heart: benign tumours

Tumours: carcinoma, melanoma, sarcoma, lymphoma, etc., i.e. all primary malignant tumours or metastases.

Additional: adults weighing less than 30 kg or more than 150 kg.

Evaluation of autopsy records showed unchanged method of weighed organs from 1900-1981. Organs are being weighed independently from amount of blood or edema without prior fixation. Preparation of organs was performed in most cases in accordance to the method given by ROESSLE (1935). Computation of height was performed in all cases according to date of birth, age and sex of the patients. Date of birth was chosen since it is believed to be the more accurate parameter in showing changes of height than the date of death. For evaluation of normal weight of organs influences of affecting diseases have to be excluded. A so-called control group was established for each organ disregarding cases with a disease influencing the organ considered to a major extent. Explicit information for each organ is given in tables 1-7. Autopsy material was divided into two groups

Table 2: Diagnosis excluding cases from computation of brain weight

Brain and Spinal Cord: malignant und benign tumours of the brain and spinal cord including metastases into the brain and spinal cord.

- congenital defects and developmental disorders: meningocele, encephalocele, meningomyelocele, etc. Teratoid tumours: nasal gliomas, etc., retinal anlage tumours, pilonidal sinuses, dermoid sinuses and choristomas, epidermoid cysts, etc., hydrocephalus (incl. acquired), Arnold Chiari deformity, tuberous sclerosis, syringomyelia.
- vascular diseases and traumatic lesions: anomalies (angiomas, etc.), aneurysms, arterio-venous fistula, occlusion of intra- and extracranial arteries, cerebral arteriosclerosis, infarct, sinus thrombosis, intracranial hermorrhage, subdural hematoma, epidural hematoma, chronic arachnoiditis and arachnoidal cysts.
- inflammatory diseases: encephalitis, meningitis, abscess, granuloma (tuberculoma, fungus, parasites, chronic pachymeningitis, etc.).
  degenerative diseases: atrophy (Alzheimer, Pick, spinal and cerebellar atrophy, Parkinson's disease, amyotrophic lateral sclerosis, Huntington's chorea, and lipid storage.
- deficiency and lipid storage diseases: Wernickes polioencephalopathy, subacute necrotizing encephalomyelopathy (Leigh's disease), posterolateral sclerosis, Gaucher, Niemann-Pick, amaurotic familial idiocy, etc.

Hypophysis: operation, atrophy, specific infiltrations (tuberculosis, lues), insufficiency (diabetis insipidus), Simmond's disease, Sheehan's syndrome, adenoma, hyperactivity (gigantism, acromeglia, Morgagni's syndrome).

Heart: stenosis and insufficiency, combined vitia of aortic, pulmonal, mitral, tricuspid valve, endocarditis lenta (proliferans), rheumatica (verrucosa), exulcerans, rheumatic, cardiomyopathia.

Kidneys: transplant, dialysis, cirrhosis (inflammatory and vascular), uremia.

Liver: coma

Muscle: myopathy, dystrophy (type Duchenne, type Erb), myasthenia gravis, myotony, myositis ossificans, polymyositis, abscess, septic foci.

Veins, Arteries: endarteriitis obliterans Winniwarter-Bürger, thrombangiitis obliterans, periarteriitis nodosa, hypersensitivity angiitis (allergy), giant cell arteriitis (a. temporalis, aortic arch syndrome), rheumatic arteriitis, medionecrosis cystica of aorta (Erdheim-Gsell).

General: psychiatric diseases, status epilepticus, lues, general disturbance of coagulation, Waterhouse-Friedrich's disease.

consisting of children and adolescents (< 20 years of age at time of death) and adults (20 years and older at time of death). Statistical evaluation includes computation of mean weights and multiple regression due to sex, age at death, height, body weight and – if sufficient cases were available – birth cohorts.

Table 3: Diagnosis excluding cases from computation of heart weight

Heart: malignant and benign tumours of the heart including metastases into the heart. tetralogy and pentalogy of Fallot, isolated AVD, VSD, ASD, isolated pulmonary stenosis, aortic stenosis, aortic isthmus stenosis, transposition of large vessels, thrombosis (vestibule and auricular appendix), myocarditis and pericarditis rheumatica, endocarditis (lenta, verrucosa, exulcerans), septic foci, armored heart, hemochromatosis, amyloidosis, papillary muscle rupture, stenosis and insufficiency of aortic, pulmonal, tricuspid, mitral valve, cardiovascular infarction (fresh, old and recurrent), cardiomyopathia, trauma, hypertrophy of right and left heart.

Kidneys: phosphate diabetis, aminoaziduria, transplantation, insufficiency, dialysis, nephrosclerosis, nephritis (interstitial, pyelo-, glomerulo-), uremia, cirrhosis (inflammatory, vascular), glomerulosclerosis, periarteriitis nodosa.

Lungs: asthma bronchiale, status asthematicus, silicosis, pneumoconiosis, bronchiectasis, cysts of lungs, fibrosis.

Muscle: myopathy, dystrophy (type Duchenne, type Erb), myasthenia gravis, spinal muscle atrophy (Kugelberg-Welander, Werding-Hoffmann), myotony, myositis ossificans, polymyositis, abscess.

Thyroid: hyperthyreosis.

Suprarenal Cortex: hyperactivity, hypercorticism (M. Cushing, M. Conn, adrenogenital syndrome).

Pancreas: diabetis mellitus, diabetic coma.

Hypophysis: hyperactivity (gigantism and acromegalia).

Arteries, Veins: medionecrosis, mesaortitis luica, endarteriitis obliterans (Winniwarter-Bürger), thrombangiitis obliterans, periarteriitis nodosa, hypersensitivity angiitis, aneurysm, arteriosclerosis, giant cell arteriits, rheumatic arteriitis, aortic sclerosis, medionecrosis cystica of aorta (Erdheim-Gsell), juvenile coronary arteriosclerosis, coronary arteriosclerosis (severe).

General: gout, rheumatism.

Table 4: Diagnosis excluding cases from computation of lung weight

Lungs, Pleura: malignant and benign tumours of the lung and pleura including metastases into the lung and pleura.
anomalia (of bronchus and of pleura), operation, pneumonia (broncho, lobar, general, virus, influenza), empyema, abscess, aspiration, severe chronic bronchitis, pleuritis, parasites, trauma, asthma bronchiale including status asthmaticus, pneumothorax, anthracosis, silicosis, shock, tuberculosis (florid, recurrent, inactive, cavernous), emphysema, atelectasis, embolism (acute, old, recurrent), infarction, sarcoidosis, mycosis, ornithosis, psittacosis, bronchiectasis, fibrosis, Hamman-Rich-syndrome, fat embolism, pleuritis, hemato- and hydrothorax, pleural cysts, respiratory distress syndrome, granulomatous diseases (Churg-Strauss, Wegener, etc.), rheumatic lung.

General: amyloidosis, shock, collaps, shock symptoms, collagenosis (sclerodermia, lupus erythematosus, dermatomyositis)

Total numbers of autopsied cases for both males and females is given in table 8 and table 9. All in all 18,512 children and 39,012 adults were autopsied. Age distribution of entire autopsy material for children under the age of one year is given in figs. 1 and 2. Age distribution for children and young adults (1-20 years) is shown in figs. 3 and 4. Majority of children was autopsied at the age of one year

Table 5: Diagnosis excluding cases from computation of liver weight

Liver: malignant and benign tumours of the liver including metastases into the liver.
anomalia, operation, atrophy, hepatitis, parasites (echinococcus, etc.), dystrophy, tuberculosis, icterus, coma hepaticum, cirrhosis (alcoholic, atrophic, portal, biliar, posthepatic, pigmental), adipose degeneration, trauma, portal vein thrombosis, leptospirosis, abscess, infarct, hemorrhage.

Gall: cholecystitis, cholangitis, cholangiolitis, empyema, hydrops, cholelithiasis, congenital cystic duct atresia.

Metabolism: hyperbilirubinemia, (inborn and acquired), diabetis mellitus, coma diabeticum, drug addiction, side effects of drugs.

Blood: leukemia (CLL, CML, eosinophile, basophile, megacaryocyte, etc.), agranulocytosis, panmyelopathy, hemorrhagic diathesis, thrombocytopenia, polycythemia vera, erythroblastosis, anemia (hemolytic, pernicious, sickle cell, thalassemia, etc.).

Pancreas: operation, apoplexia, pancreatitis (acute, chronic).

Arteries, Veins: hypersensitivity reaction, periarteriitis nodosa, rheumatic arteriitis, medionecrosis cystica, Wegener's disease (vasculitis of arteries and veins).

Kidneys: glomerulonephritis.

General: collagenosis, (sclerodermia, lupus erythematosus, dermatomyositis), amyloidosis, thyphus, malaria, eclampsia including preeclampsia, cachexia and dystrophy, adiposity, abuse of alcohol, dependency on drugs.

Table 6: Diagnosis excluding cases from computation of kidney weight

Kidneys: malignant and benign tumours of the kidneys including metastases into the kidneys.
transplantation, phosphate diabetis, aminoaziduria, Fanconi's disease, anomalia of renal arteries, hypertrophy, nephrotic syndrome, protein-, paraprotein- and hematuria, nephrosclerosis, shock, hydronephrosis, operation, interstitial nephritis, pyelonephritis, abscess, glomerulonephritis, tuberculosis, cystic kidneys, uremia, cirrhosis (inflammatory and vascular), arterio-arteriolosclerosis, trauma, glomerulosclerosis (Kimmelstiel-Wilson's syndrome), cysts, hemosiderosis, thrombosis of veins, infarction.

Metabolism: defect of metabolism (saccharide, glycogene, galactosis, etc.), electrolyte disturbances, diabetis, coma diabeticum, drug addiction.

Urinary tract: operation, fistula, obstructed secretion, concrements, trauma.

Urinary bladder: cystitis

Arteries veins: embolia, endarteriitis obliterans (Winniwarter-Bürger), periarteriitis nodosa, rheumatic arteriitis, Wegener's disease.

General: amyloidosis, gout, eclampsia and preeclampsia, hypertonia, side effects of drugs

Table 7: Diagnosis excluding cases from computation of spleen weight

Spleen: malignant and benign tumours of the spleen including metastases into the spleen. anomalia, operation, trauma, rupture, tuberculosis, inflammation, amyloidosis, hemosiderosis, splenomegalia, fibrotic casation of pulpa, perisplenitis, hyalinosis, infarction, thrombosis of veins, cysts, atrophy, hemorrhage of pulpa.

Blood: leukemia (CLL, ALL, CML, AML, etc.) agranulocytosis, panmyelopathy, Osler's disease, hemorrhagic diathesis, thrombocytonepia, polycythemia vera, erythroblastosis (A-B-0-incompatibility), anemia (hemolytic, pernicious, sickle cell, thalassemia), exsanguination.

General: amyloidosis, thyphus, malaria.

Table 8: Total number of autopsied children (≤ 20 years) according to date of death

date of death (decade)	males	females	total
1900-09	544	418	962
1910-19	1251	975	2226
1920-29	1238	971	2209
1930-39	1157	815	1972
1940-49	1937	1450	3387
1950-59	1642	1384	3026
1960-69	1501	1161	2662
1970-79	958	821	1779
1980-81	166	122	288
total	10394	8117	18511

Table 9: Total number of autopsied adults (≥ 20 years) according to date of birth

date of birth (decade)	males	females	total
1830-39	66	0065	0131
1840-49	283	0253	0536
1850-59	729	0506	1253
1860-69	1347	0876	2223
1870-79	2343	1502	3845
1880-89	2965	2286	5251
1890-99	4279	3331	7610
1900-09	5301	3278	8579
1910-19	2768	1672	4440
1920-29	1833	1149	2982
1930-39	969	0504	1473
1940-49	358	0215	0573
1950-59	79	0055	0134
1960-69	–	–	–
1970-81	–	–	–
total	23320	15692	39012

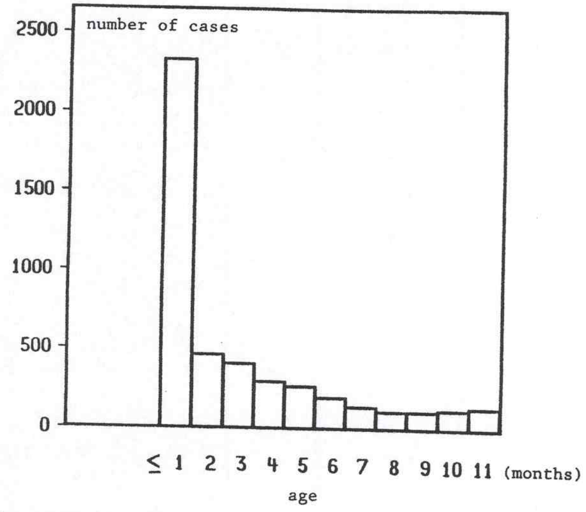


Fig. 1: Age distribution (< 1 year) of autopsied boys, 1900-1981

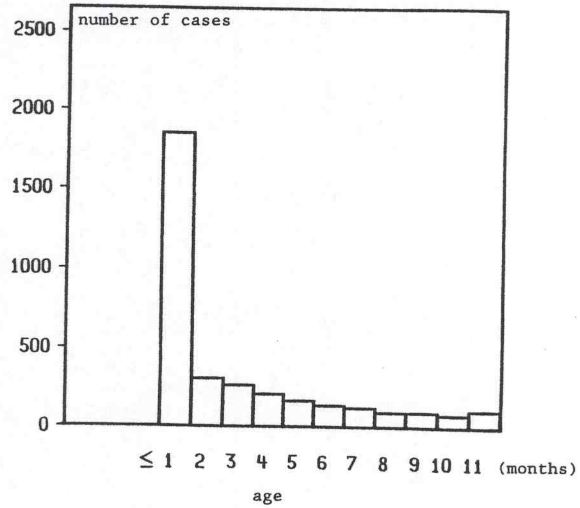


Fig. 2: Age distribution (< 1 year) of autopsied girls, 1900-1981

and younger. Only a small number of cases between the age of 10 years and 15 years is available. The entire number of autopsied children per decade remains nearly constant in 1910-1930 but increases in 1940-1949. There has been a remarkable decrease since 1970. Sex ratio remained constant during the entire period and amounts to 1:0.78 (males: females). Relative number of autopsied stillborns increased up to the year 1969 and has decreased noticeably since 1970 (fig. 5).

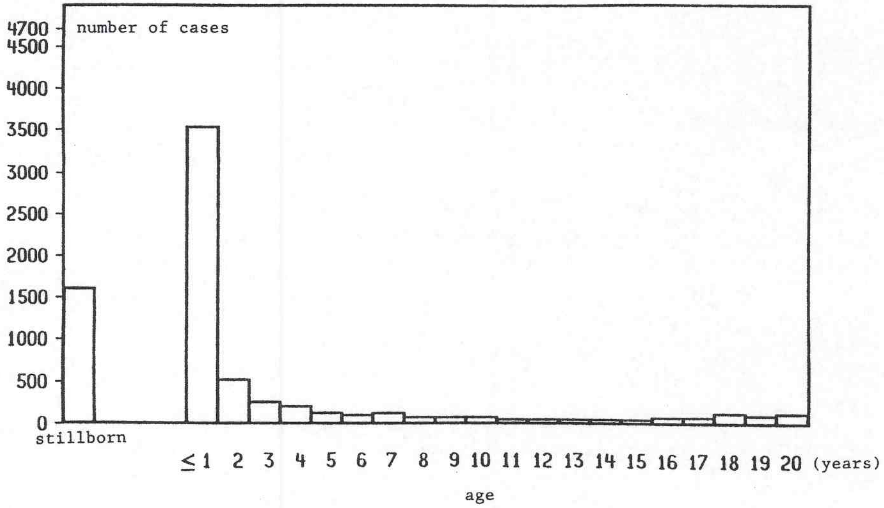


Fig. 3: Age distribution (≤ 20 years of age) of autopsied boys, 1900-1981

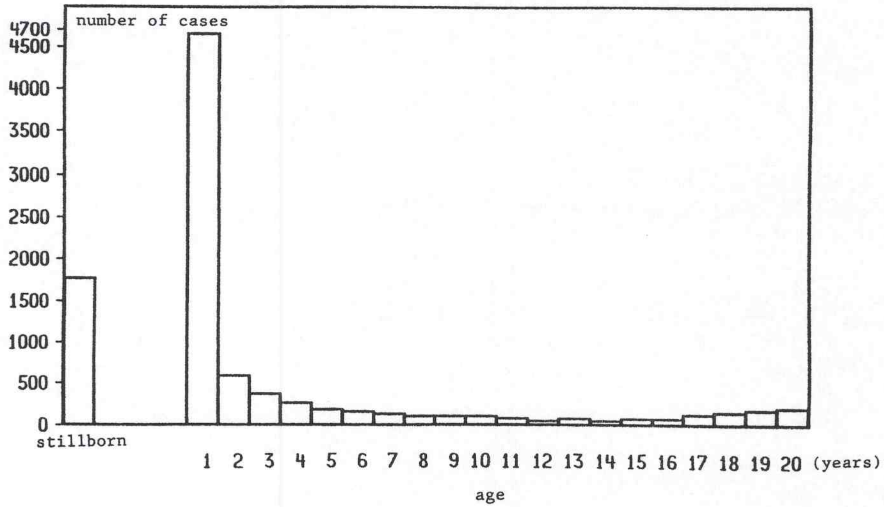


Fig. 4: Age distribution (≤ 20 years of age) of autopsied girls, 1900-1981

As discussed in KAYSER et al. (1978) sex ratio, age distribution, total number of autopsies/decade and percentage of domicile in the area of Heidelberg reflect to bias of autopsy material. Calculation of these factors indicates constancy of bias in the autopsy material during the period considered (fig. 6).

As shown in fig. 7 autopsy frequency according to autopsy decade and sex has been stable from 1910-1939 and from 1940-1979. Distribution of all autopsies

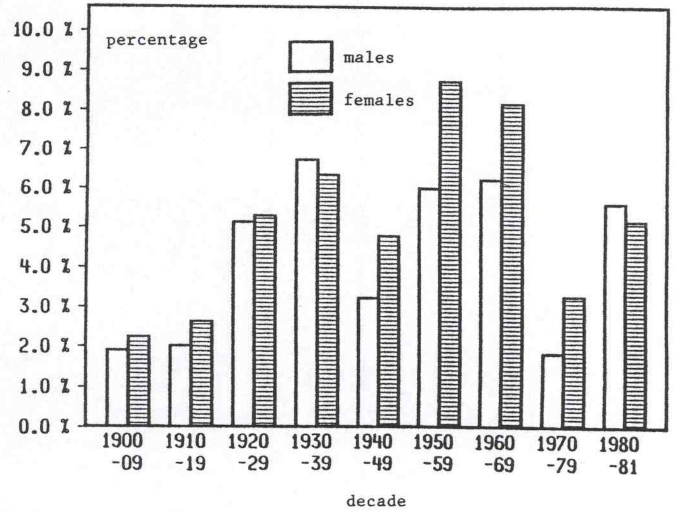
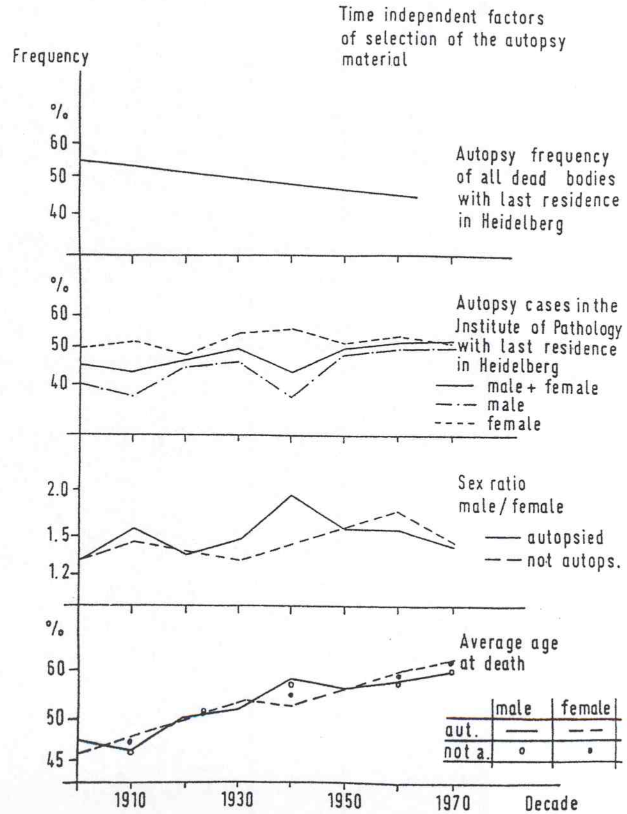


Fig. 5: Relative number of autopsied stillborns according to sex, 1900-1981



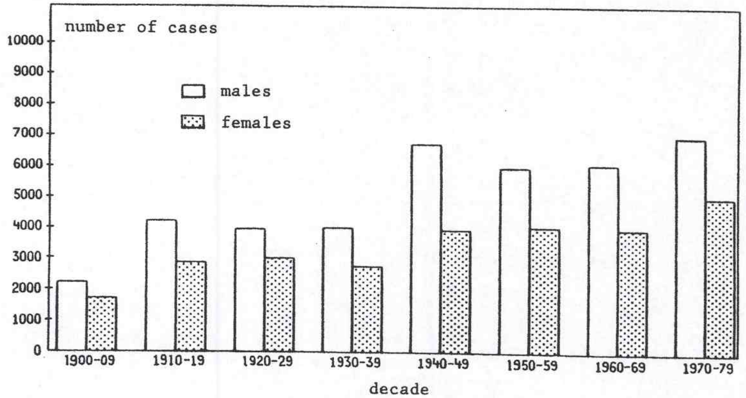


Fig. 7: Total number of adult autopsy cases according to sex, 1900-1981

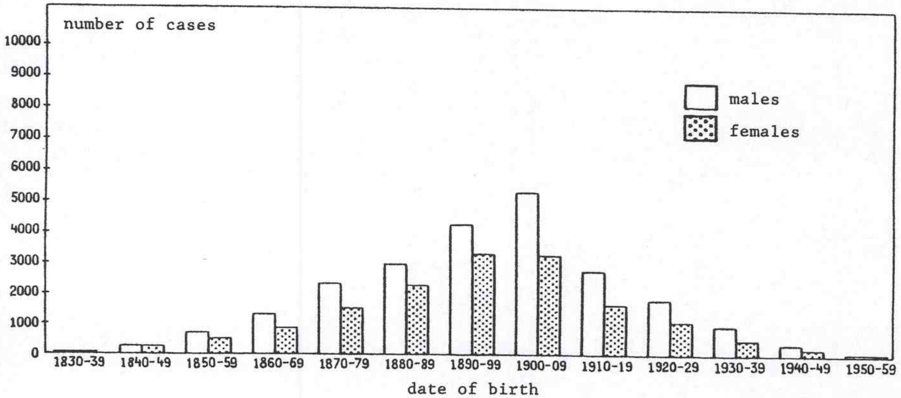


Fig. 8: Total number of adult autopsy cases according to sex and date of birth

according to date of birth is given in fig. 8. The majority of autopsied cases had been born between 1880 and 1919. The sex ratio remained constant for both distributions, average age at death increased remarkably (fig. 9). During the period 1900-1979, in all, 23,320 adult males and 15,692 adult females were autopsied. The age distribution of all autopsied cases is given in fig. 10. The figure shows two peaks, one peak consistant with a high number of autopsied cases below one year of age and the second peak at 60-69 years (age at death). Both groups of autopsied cases (0-19 years) and adults (≥ 20 years) will be discussed separately.

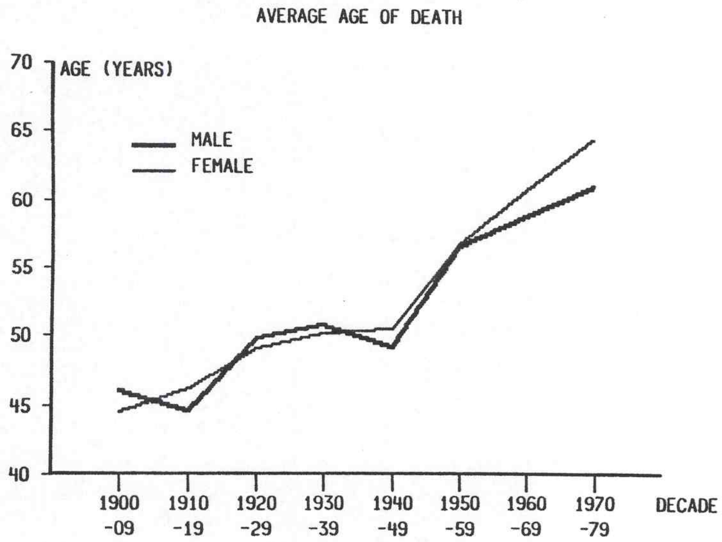
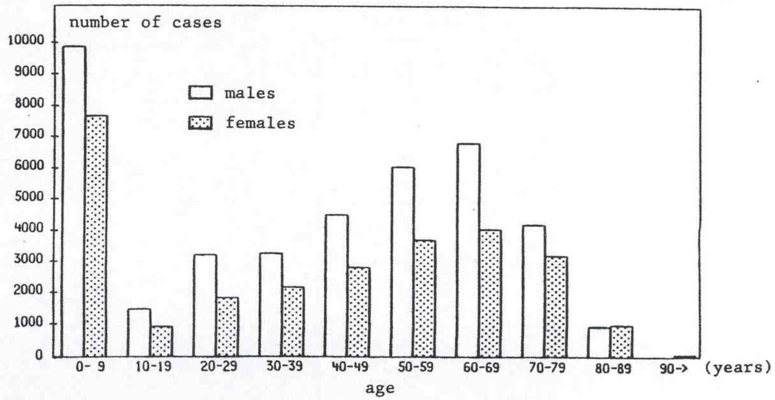


Fig. 9: Average age of death according to sex and decade, 1900-1981



3. Development of height of autopsied children

The height was documented in the autopsy reports of 7,256 boys (70,6%) and 5,823 girls (72,8%). The average height according to age of autopsied boys is given in fig. 11, and that of autopsied girls in fig. 12. The average height at birth measured 41.9 cm for males and 40.6 cm for females; average height of 19-year-old males was 170.8 cm, and 19-year-old females was 158.6 cm. Average height of 17-year-old boys and 15-year-old girls showed significant differences ($p < 0.05$) from average height of 19-year-old boys and girls, respectively. Distribution of

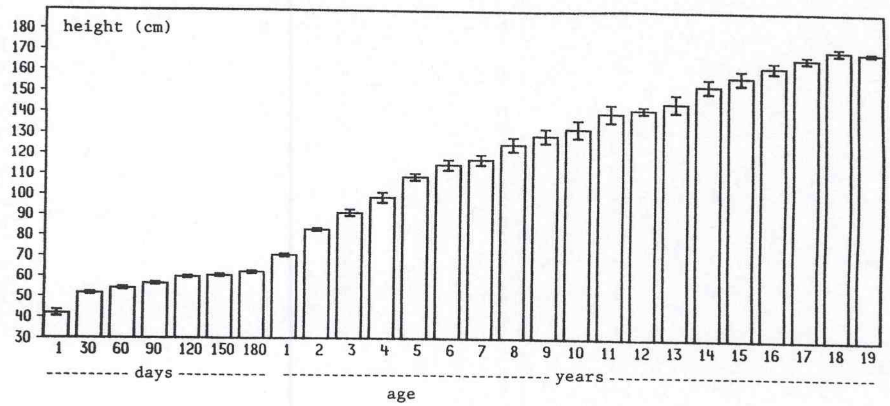


Fig. 11: Mean height (cm) of autopsied boys according to age at death, 1900-1981

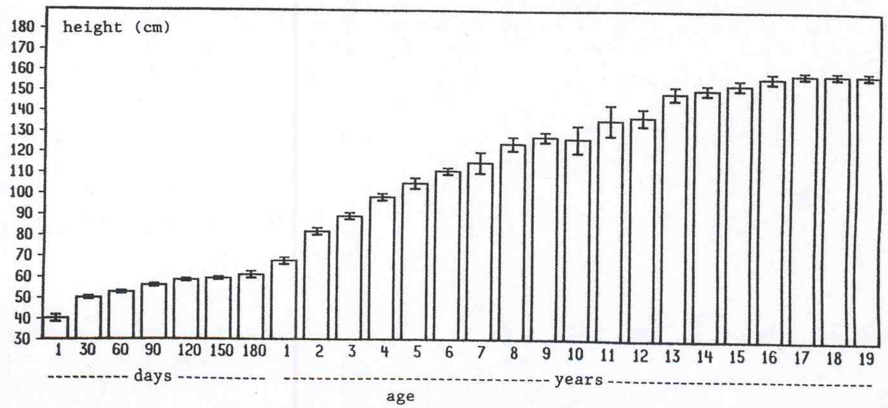


Fig. 12: Mean height (cm) of autopsied girls according to age at death, 1900-1981

height according to age shows a plateau between 8 and 10 years, and a slight increase in girls at 13 years or older. Distribution of height in boys is different and shows linear increase starting at 3 years of age.

It was only possible to separate two collectives for evaluation influence of date of birth to development of height due to small number of autopsied cases. Cases autopsied during the period 1900-1939 (collective I) were compared to cases autopsied during period 1950-1981 (collective II). The results are given in table 10. Statistically significant differences were obtained from the age groups 10 years and older. Boys autopsied in 1950 or later were taller compared to boys autopsied before 1940.

Difference measures 3 cm to 9 cm. Similar results were obtained for girls. Completion of growth for boys shifted from 17 years (collective I) to 18 years (collective II). Height of 17-year-old boys (collective I) revealed no statistically significant difference from the height of 19-years-old boys in both corresponding collectives. Data indicated a delay in development of height for boys born after World War II. For girls the opposite holds true. Termination of growth for girls was computed to be 16 years of age (collective I) and 15 years of age (collective II).

Computation of development of height in both boys and girls according to age revealed differences in both collectives. Two age groups with acceleration of growth were obtained for boys (8-10 years and 12-16 years) in collective II, whereas this is only suggestive in collective I. Data for girls revealed acceleration in growth between 14-15 years in collective I, which was not detectable in collective II.

Table 10: Height in cm

age	1900-1939 n	1900-1939 mean + confidence limits $p \geq 0.95$			1950-1981 n	1950-1981 mean + confidence limits $p \geq 0.95$		
males								
days 1	118	042.9	044.2	045.5	892	038.9	041.5	044.1
2- 30	101	50.3	51.3	52.3	165	50.9	52.1	53.3
31- 60	107	52.9	53.8	54.8	109	53.8	54.8	55.8
61- 90	86	55.1	56.1	57.1	76	58.0	59.0	60.0
91-120	87	58.1	59.5	60.8	64	60.0	61.2	62.4
121-150	73	59.7	60.7	61.8	51	59.7	61.5	63.2
151-180	37	60.1	62.3	64.5	41	62.0	63.6	65.1
years 1	59	69.0	70.8	72.6	46	68.3	71.2	74.2
2	73	81.1	83.0	84.9	50	82.8	85.7	88.5
3	48	88.0	90.5	93.0	55	90.5	93.7	96.9
4	38	93.4	97.4	101.3	33	99.1	102.6	106.1
5	42	103.1	105.4	107.6	37	112.3	115.8	119.4
6	26	105.4	111.0	116.5	35	113.7	116.4	119.1
7	24	116.8	114.1	119.5	29	113.6	118.5	123.3
8	27	115.0	120.6	126.2	30	124.4	129.6	134.7
9	24	117.7	124.0	130.2	26	131.9	134.4	136.9

Table 10: Height in cm (Continuation)

age	n	1900-1939 mean + confidence limits p ≥ 0.95			n	1950-1981 mean + confidence limits p ≥ 0.95		
males								
years 10	25	122.4	129.0	135.7	26	132.2	138.3	144.3
11	15	135.2	138.7	142.1	19	132.5	141.7	150.8
12	26	136.4	139.0	141.5	19	141.7	145.5	149.2
13	29	141.0	145.5	150.0	18	137.8	147.4	157.0
14	37	145.6	150.8	156.0	19	152.0	159.8	167.6
15	34	149.1	153.6	158.2	24	158.3	163.6	169.0
16	49	153.9	158.0	162.1	35	168.3	171.2	174.2
17	63	161.9	164.1	166.3	38	169.6	172.2	174.9
18	65	166.9	169.1	171.2	38	171.2	173.8	176.5
19	63	164.2	166.4	168.6	59	173.8	175.6	177.4
females								
days 1	84	41.4	43.0	44.6	764	37.3	40.1	43.0
2- 30	83	48.4	49.5	50.6	91	49.6	51.3	53.0
31- 60	79	51.7	52.9	54.0	78	51.9	53.2	54.4
61- 90	80	54.2	55.6	57.0	48	55.1	56.9	58.7
91-120	51	55.5	57.0	58.5	49	58.9	60.2	61.5
121-150	44	56.5	58.7	61.0	43	59.4	61.1	62.7
151-180	37	56.1	59.0	61.9	39	61.2	63.2	65.2
years 1	58	66.6	68.4	70.2	36	64.2	67.8	71.5
2	29	76.9	79.8	82.6	34	81.1	84.2	87.4
3	42	85.5	88.1	90.7	31	86.3	91.1	96.0
4	33	92.0	94.6	97.3	26	100.6	102.8	105.0
5	32	98.1	102.6	107.1	25	105.7	108.6	111.5
6	33	105.1	108.6	112.2	36	111.4	114.3	117.2
7	16	103.8	111.3	118.9	24	110.2	117.5	124.7
8	31	115.5	122.0	128.4	23	122.5	127.5	132.4
9	27	123.3	126.7	130.1	16	124.0	128.6	133.2
10	11	110.0	123.0	136.1	12	123.1	130.3	137.5
11	9	125.4	135.0	144.5	12	135.8	142.0	148.3
12	21	127.6	133.4	139.2	9	140.6	147.1	153.6
13	23	141.9	146.5	151.1	17	148.4	153.4	158.4
14	21	148.0	152.4	156.7	11	146.8	152.2	157.6
15	37	147.9	151.7	155.5	19	156.2	158.6	161.1
16	30	151.0	155.6	160.3	19	154.3	158.7	163.1
17	51	153.7	155.9	158.2	32	160.1	162.7	165.3
18	40	153.4	156.0	158.6	15	161.3	165.0	168.6
19	51	153.9	156.9	159.8	23	158.3	162.3	166.4

4. Height of autopsied adults

Height of autopsied adults in relation to age at death for males and females is shown in fig. 13. Average height was measured 170 cm in males (average age at death 57 years) and 159 cm in females (average age at death 58 years). A slight decrease in height between 30 years until 80 years is existent for males and females respectively. Decrease was computed 2.4 cm for males and 3.7 cm for females. Correlation coefficients between height and age are weak and were computed r = 0.13 for males and r = 0.12 for females.

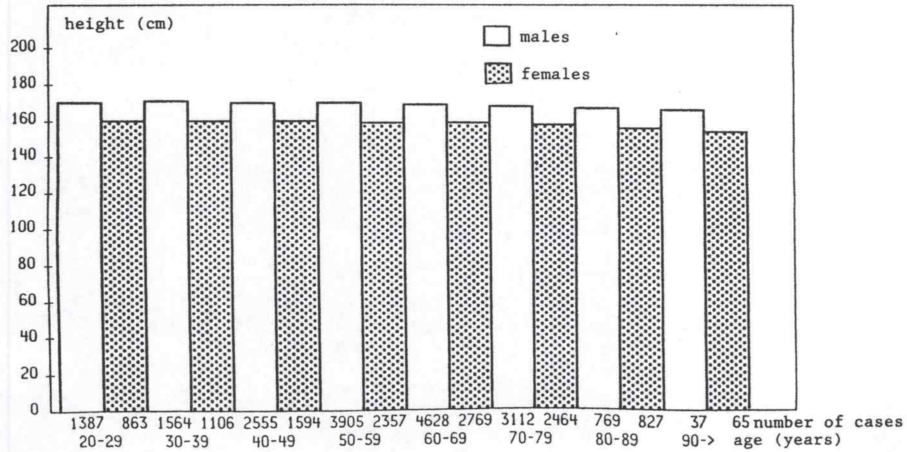


Fig. 13: Mean height (cm) according to sex and age (adults), 1900-1981

A nearly linear increase of height per decade was noted for both males and females (figs. 14 and 15) if cases were grouped according to date of birth (decade); table 11. Average increase of height was computed 1 cm/decade which is in accordance with data reported by AMMON (1893); BOLK (1914) and Ecker (1877). No increase in height of different populations during decade 1700-1850 was found by KENNTNER (1963). However, a nearly linear increase measuring 1 cm/decade was noted in people born during 1850-1950. Autopsy material was grouped into cohorts of two decades and frequency distribution of height among these cohorts was measured (figs. 16 and 17). Obtained curves show at least three peaks in height of autopsied persons born between 1830-1870.

Table 11: Height according to age groups (cm)

age groups	n	date of birth 1830-1879 mean + confidence limits p ≥ 0.95			n	date of birth 1880-1959 mean + confidence limits p ≥ 0.95		
males								
20-29	0	0.0	0.0	0.0	1 387	170.3	170.8	171.3
30-39	70	166.4	168.0	169.6	1 494	171.4	171.9	172.4
40-49	452	166.7	167.7	168.7	2 103	171.2	171.5	171.8
50-59	809	166.6	166.1	168.0	3 096	170.4	170.8	171.2
60-69	898	165.2	165.9	167.0	3 730	170.0	170.3	170.6
70-79	664	164.9	165.6	166.9	2 448	169.1	169.5	170.3
80-89	289	164.4	165.6	167.0	480	167.6	168.2	168.8
90-99	23	163.9	166.0	168.1	14	161.9	167.9	173.9
females								
20-29	0	0.0	0.0	0.0	863	159.8	160.3	160.8
30-39	75	155.9	157.3	158.7	1 031	159.9	160.3	160.7
40-49	263	156.4	157.4	158.4	1 331	160.5	160.9	161.3
50-59	553	156.4	157.1	157.8	1 804	160.2	160.6	161.0
60-69	585	156.1	156.8	157.5	2 184	159.6	160.0	160.4
70-79	456	154.2	155.0	157.5	2 008	158.5	158.9	159.3
80-89	185	152.5	153.6	154.7	642	156.9	157.5	158.1
90-99	31	151.8	153.8	155.8	34	153.9	155.9	157.9

Table 11: Height according to age groups (cm)

age groups	n	date of birth 1830-1959 mean + confidence limits p ≥ 0.95		
males				
20-29	1 378	170.4	170.8	171.2
30-39	1 564	171.3	171.7	172.1
40-49	2 555	170.5	170.8	171.1
50-59	3 905	169.7	170.0	170.3
60-69	4 628	169.2	169.5	169.8
70-79	3 112	168.5	168.8	169.1
80-89	769	166.7	167.2	167.7
90-99	37	164.9	166.7	168.5
females				
20-29	863	159.8	160.3	160.8
30-39	1 106	159.6	160.1	160.6
40-49	1 594	160.6	160.4	160.8
50-59	2 357	159.5	159.8	160.2
60-69	2 769	159.0	159.3	159.6
70-79	2 464	157.8	158.2	158.6
80-89	827	156.2	156.6	157.0
90-99	65	153.3	154.9	156.5

Relative percentage of very tall persons (180 cm - 200 cm) remained nearly constant, whereas percentage of tiny persons (140 cm-150 cm in males and 130 cm-150 cm in females) has decreased considerably. Increase in average height in autopsied adults is mainly caused by decrease of percentage of tiny persons in

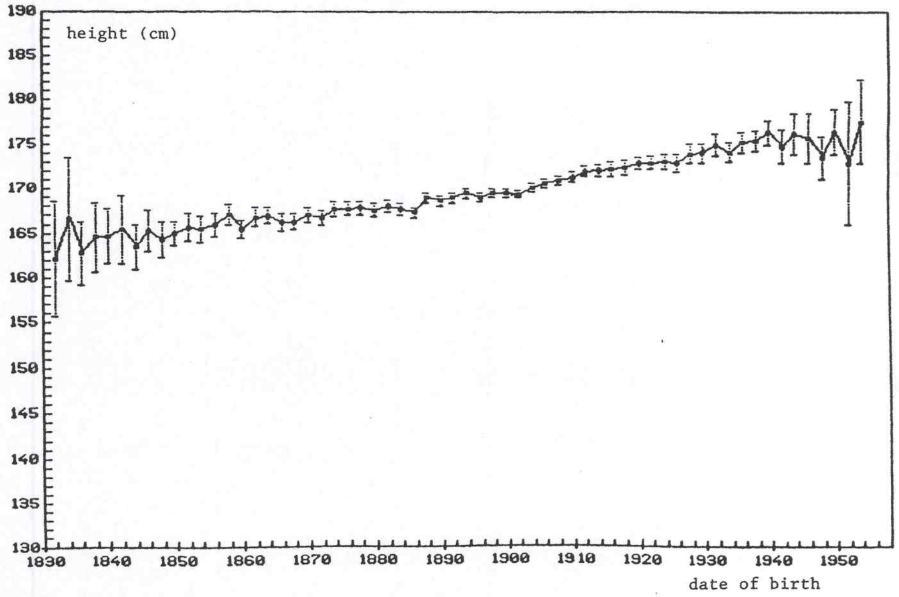


Fig. 14: Mean height (cm) of autopsied males according to date of birth

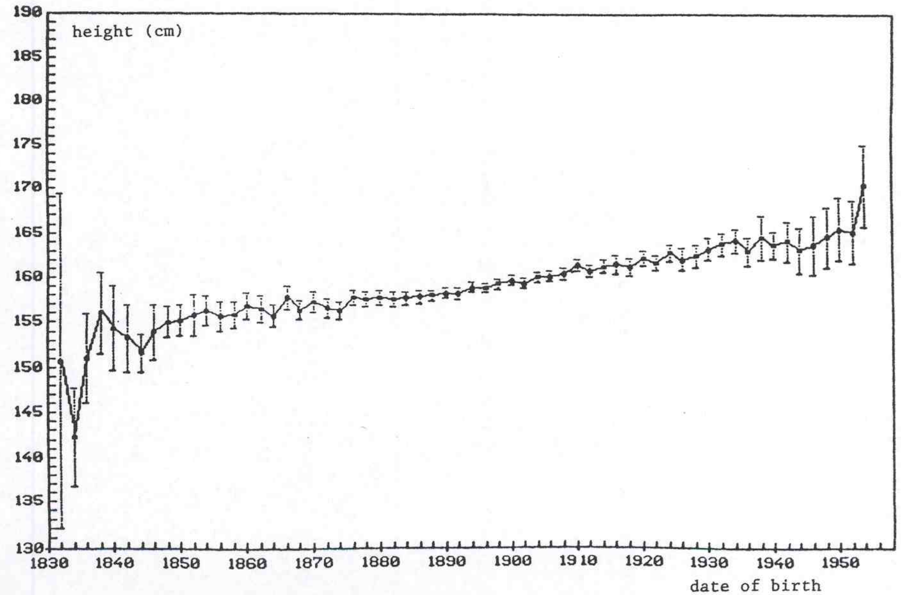


Fig. 15: Mean height (cm) of autopsied females according date of birth

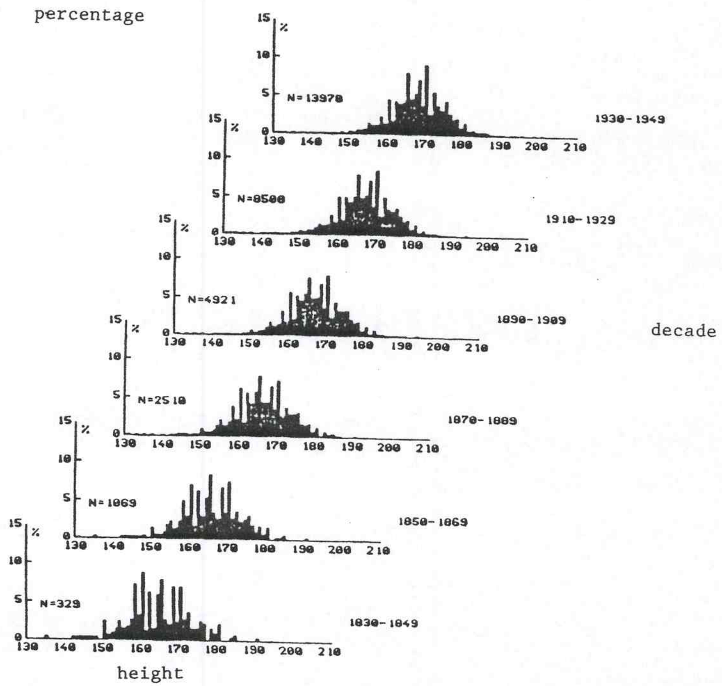
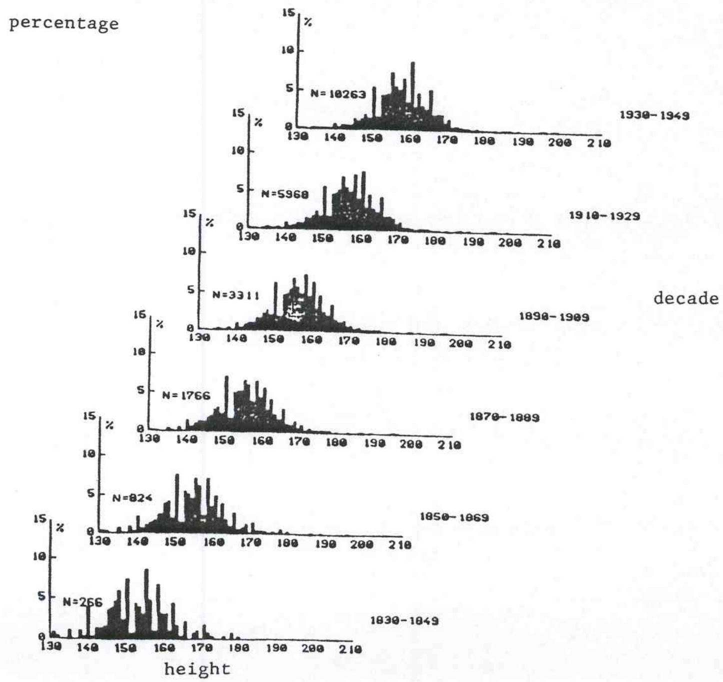


Fig. 16: Distribution of height (cm) of autopsied males according to date of birth



5. Discussion

5.1 Development of height

Velocity of body growth decreases from birth to final height. Development of growth is generally divided into two different growth periods. Acceleration of growth between the age of 6-8 years was called mid-growth spurt (TANNER, 1947). The second acceleration of growth during school age is reported between the ages of 13 and 15 years in boys (12-13 years in girls) and known as adolescent growth spurt (TANNER, 1947). Adolescent growth spurt leads to an increase in height of about 20 cm in both males and females. TANNER (1962) reported similar height of boys and girls before reaching puberty. After the age of 18-20 years, no increase in height is observed (BAWKIN and MCLAUGHLIN, 1964; JOHN and LENZ, 1982; TANNER, 1962).

Our data are in general agreement with the data reported. The period of mid-growth spurt can be seen at the age of eight years in boys and seven years in girls. The second acceleration of growth (adolescent growth) is observed within the age of thirteen to fourteen years in boys and within the age of twelve to fourteen years in girls. Comparing cohorts of patients (collective II) observed differences correlate to secular acceleration in development of height. In boys, the periods of accelerated growth switched from the age eleven, thirteen and seventeen in collective I (1900-1939) to five, eight, fourteen and sixteen in Collective II (1950-1981). Changes of age acceleration growth periods were not observed in girls. Girls show growth spurts at the age of eight, eleven and thirteen in both collectives. Average height of autopsied cases increased remarkably in collective II for boys and girls compared to collective I, starting with the age of fourteen. Boys at the age of 14 years or older in collective II are remarkably taller than corresponding boys in autopsy collective I. Difference in height of boys amounts to 8.1 cm-13.2 cm depending on age, and amounts to 8.7 cm-11.9 cm in girls respectively. Development of height comes to an end at the age of 17 in boys in collective I and at the age of 18 in collective II. Data show delay of body growth in boys correlated to secular acceleration. In girls, the opposite was found. Girls show an ending of growth development at the age of fifteen in collective II compared to the age of sixteen in collective I. In relation to earlier onset of puberty in girls which is reported by several authors (KUNZE, 1976, 1977; KOCH, 1950), earlier onset of adolescent growth spurt is expected. Similar data are reported from other authors (ABRAHMSON and ERNEST, 1954; BOYNE et al., 1957; BROMANN et al., 1942; CLEMENTS, 1953; GREULICH, 1957; HOPKINS, 1947; KIMURA and KITANO, 1959; KOBE and SCHILLER, 1955; SUNDAL, 1957; WEIR, 1952).

5.2 Decrease of height with age

A slight decrease of height in correlation to age was observed by several authors (BÜCHI, 1950; HOLMGREN, 1952; MEIER, 1956; MEYER et al., 1963; PETT, 1955; SALLER, 1956). A decrease of height was mainly reported for elderly persons (70 years and older). BÜCHI noted increasing height (0.5 cm) within the age 24-33. He reported constancy of height between 33-50 years of age. Our data show a slight but constant decrease with increasing age for both males and females, and correlation is weak ($r = 0.13$ for males; $r = 0.12$ for females). Average decrease of height between 20-80 years of age was computed 3 cm in males and 4 cm in females. Decrease is similar in all birth cohorts.

5.3 Secular acceleration

The final height depends on different factors. An increase of height was observed by several authors during the last decades (CLEMENTS, 1953; KOCH, 1935; KÜL, 1939; KUNZE, 1976; MEREDITH, 1944/1955; TANNER; 1964; TOBLER, 1937). An increase of height was reported in western industrialized countries, while a decrease of height was reported from other countries. KENNTNER (1963) observed a decrease of height in the population of Chile within the last 50 years (1920-1964). Similar decreases of height were reported from Turkey and Korea. A slight increase of height was observed in the population of the Iberic Coast and of Sudan, and only limited increase of height was seen in populations of Senegal, Iran and South China. Quantitative measurements of increased height reported from western countries (Lapland, Great Britain, Norway, Sweden, Iceland, Denmark, USSR, Finland, France, Switzerland, Hungary, Italy, Spain, Portugal, Holland, Canada, USA and Japan) amount to 1 cm/decade at an average within the last 50 years (1900-1950). Our data support these general findings. Within the period covered (people born between 1830 and 1950), an average increase of height of 1 cm/decade was observed without major changes during the period. This observation holds true for males and females. Cohorts of height according to date of birth (figs. 16 and 17) reveal at least two different subpopulations in people born between 1830 and 1849. The subpopulations are most distinct in the older cohorts than in cohorts born at a later date. In combination with secular acceleration, several authors (KENNTNER, 1963; KNUSSMANN, 1968; LENZ and KELLNER, 1865; LENZ, 1959; LINZBACH and AKUAMOABOATENG, 1973; TANNER, 1978, 1979) reported additional phenomena as:

a. increased body weight at birth
b. increased height at birth
c. acceleration of puberty
d. acceleration of first and second dentition
e. acceleration of development of speech and walk

f. increasing vitality and intellectuality – circumference of thorax, circumference of head
g. increased development of children born in cities compared to children born in rural areas.

The cause of secular acceleration has been suggested in changes of hormonal status related to absolute hormonal values at a certain age. The value of growth hormone can be altered by increased exposure to sunlight (KOCH, 1935) or increased X-ray radiation (TREIBER, 1941) or to changes in food (LENZ, 1943, 1959, 1961; LENZ und KELLNER, 1965). The theory of LENZ is supported by findings such as increased average height of people living in high social standard compared to average height of people living in low social standard. It is not clear whether increased hormone levels may change the basic genetic potential or not.

Another general theory supported partly by our data is the theory of luxuration of bastards, which was introduced by BOLDRINI (1932); DAHLBERG (1947) and LENZ (1961). Basically, luxuration of bastards can be considered as heterosis, i.e. remitted mixture of different populations showing different genetic potentials with higher amount of genes. Course breeding can lead to a significant increase of vitality, and different expressions of important pictures within the F1 generation compared to parents. Distribution of height in our material in different date of birth cohorts and its diminution in the later cohorts partly support this theory. In addition, influences of changes in food may be present. A slight decrease in height was observed in populations having acceleration spurts in the hunger periods of the First and Second World War. The linearity of increase in height during the period considered is consistant with the theory of heterosis.

6. Body weight of autopsied children

Body weight was documented in 2.997 autopsied boys and 2.276 autopsied girls during the period 1900-1981. The average body weight at birth was measured 1.8 kg in boys and 1.6 kg in girls. In 19-year-old boys it was measured 65.8 kg and 55.3 kg in 19-year-old girls respectively; table 12. Relation to age is shown in figs. 18 and 19. Statistically significant increase of body weight compared to the age of 19 years was observed in boys at 16 years and in girls at 15 years of age ($p < 0.05$). Body weight increased nearly equally in boys between the age 1-19 years; whereas in girls punctual acceleration in development can be noted. Comparison of two cohorts of autopsies (1900-1939, cohort I; and 1950-1981, cohort II) reveals decrease of body weight at birth of boys and girls. Average body weight at birth was computed 2.0 kg in cohort I and 1.8 kg in cohort II. Similar decrease was observed in girls (1.8 kg in cohort I, 1,6 kg in cohort II). Development of body

Table 12: Body weight according to age (kg)

age groups	n	mean + confidence limits $p \geqslant 0.95$			n	mean + confidence limits $p \geqslant 0.95$		
	males				females			
days 1	1 036	1.7	1.8	1.8	884	1.5	1.6	1.7
2- 30	251	2.9	3.0	3.2	177	2.6	2.8	3.0
31- 60	195	3.4	3.6	3.7	139	3.2	3.4	3.6
61- 90	143	3.9	4.1	4.4	101	3.9	4.2	4.5
91-120	113	4.6	4.9	5.2	76	4.4	4.7	5.1
121-150	93	4.7	5.1	5.4	70	4.6	5.1	5.6
151-180	64	5.6	6.0	6.5	68	5.1	5.5	5.9
years 1	90	7.4	8.0	8.6	79	6.1	6.7	7.3
2	98	10.1	10.7	11.3	49	9.8	10.9	11.9
3	96	12.4	13.1	13.8	61	10.5	11.9	13.3
4	64	14.3	15.3	16.3	52	13.7	14.9	16.2
5	62	16.4	17.2	18.0	46	15.5	16.5	17.5
6	52	17.8	19.2	20.6	57	16.4	17.7	19.0
7	47	19.1	20.6	22.1	34	18.7	20.9	23.1
8	47	21.1	23.1	25.1	48	21.0	23.6	26.2
9	42	22.5	24.2	26.0	37	22.1	24.0	25.9
10	41	24.9	27.1	29.4	14	21.4	26.5	31.5
11	24	26.0	30.3	34.6	17	25.0	28.5	32.1
12	32	28.8	31.2	33.7	20	24.4	28.4	32.4
13	33	31.7	34.6	37.6	33	34.5	37.9	41.4
14	44	36.4	39.7	43.0	23	35.6	40.4	45.1
15	45	41.0	44.8	48.5	41	37.0	39.9	42.8
16	64	44.0	46.7	49.4	29	42.0	46.5	50.9
17	66	51.4	54.7	58.1	47	46.1	48.8	51.5
18	66	53.4	56.0	58.6	34	46.1	49.8	53.6
19	89	56.2	58.9	61.5	40	49.1	51.7	54.3

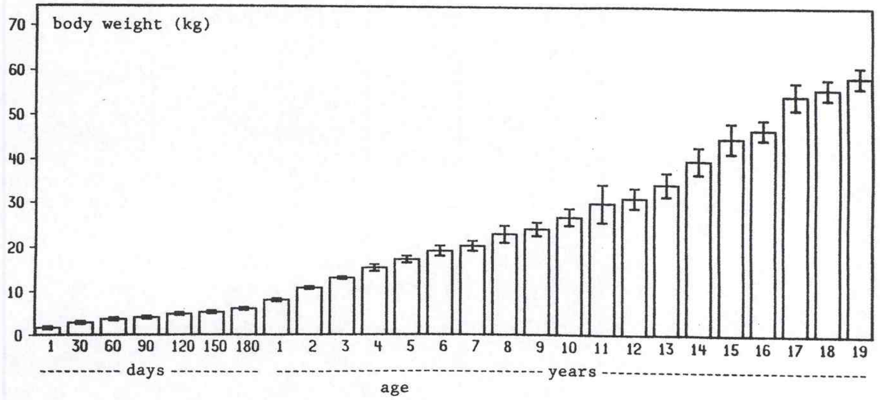


Fig. 18: Mean body weight (kg) of autopsied boys according to age at death, 1900-1981

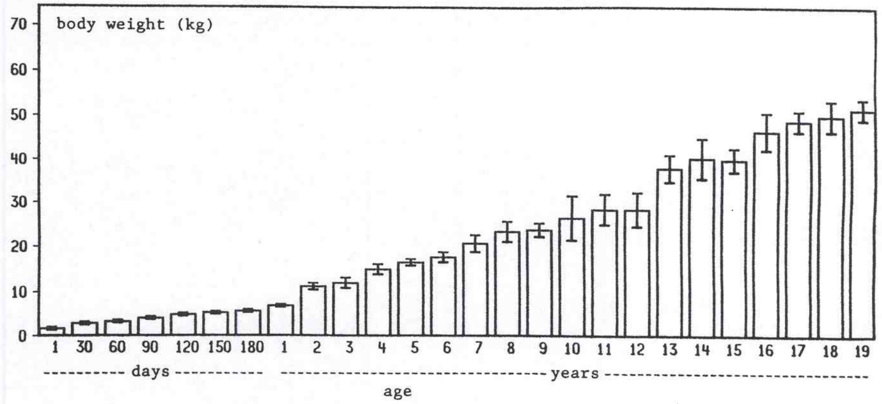


Fig. 19: Mean body weight (kg) of autopsied girls according to age at death, 1900-1981

weight for cohort I and II is given in figs. 20 and 21. Significant differences can be observed for age groups 12 years and older in favour of cohort II. Although boys and girls of cohort I are heavier at birth than boys and girls of cohort II, the relation inverts at the age of 1 year and older. Acceleration in development of weight in both boys and girls (figs. 22 and 23) is similar to observed acceleration of height. In boys, one pre-adolescent acceleration can be noted at the age of 14. In girls, three acceleration peaks exist at the age of 6, 12 and 16 years. Comparison of both cohorts shows significant differences in the development of body weight in boys and girls after the age of 12 years.

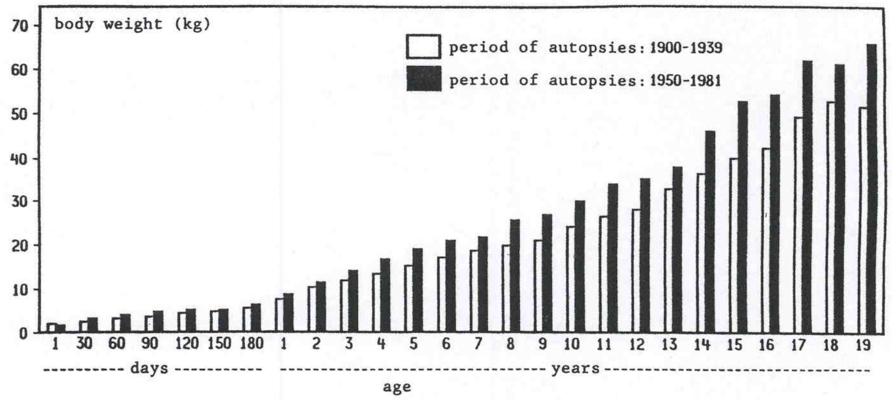


Fig. 20: Mean body weight (kg) of autopsied boys according to age at death and date of birth

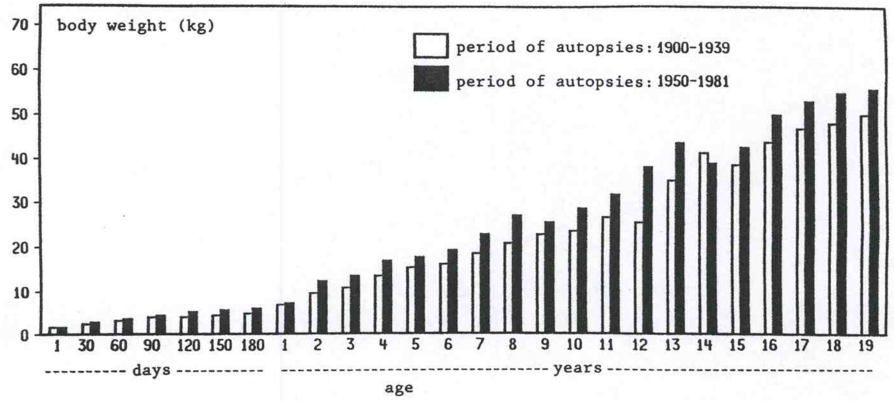


Fig. 21: Mean body weight (kg) of autopsied girls according to age at death and date of birth

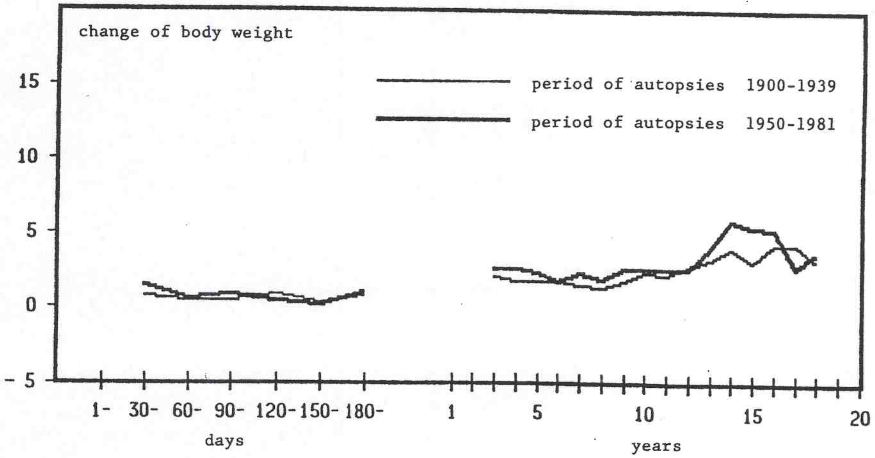


Fig. 22: Absolute increase of body weight (kg) in autopsied boys according to age at death and date of birth

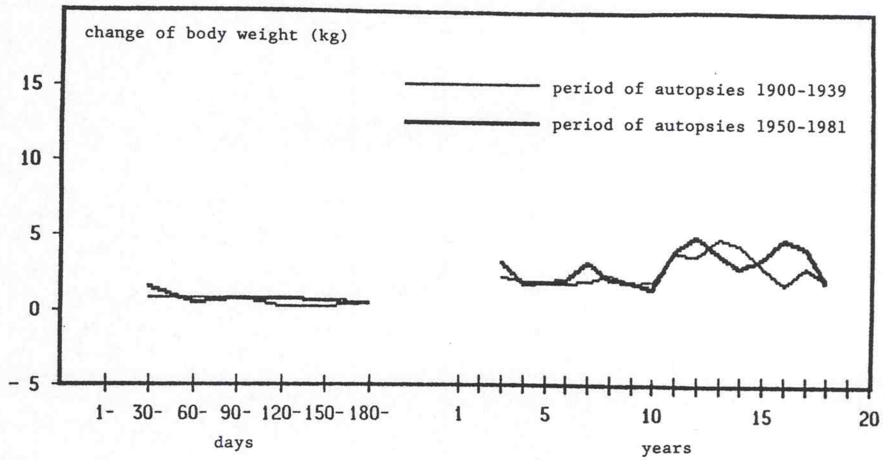


Fig. 23: Absolute increase of body weight (kg) in autopsied girls according to age at death and date of birth

7. Body weight of autopsied adults

Body weight of adults was documented in 7,419 males and 4,804 females; table 13. Autopsy cases with body weight below 30 kg or above 150 kg were excluded. Distribution of body weight in autopsy cases and in normal German distribution (measured in 1980) in relation to the BROCA reference is given in figs. 24 and 25. Autopsy material reveals a noticeable bias in favour of diminished body weight. BROCA reference equal to or below 85% exists in 35% of autopsied males, and in 27% of autopsied females compared to 12% in males, and 16% in females of the living population. Persons with BROCA reference above 105% are underrepresented consequently. Relation of body weight to age for different birth cohorts is given in fig. 26. Slight increase of body weight is observed from the age of 20 to the age of 70 years for both males/females. A slight decrease in body weight can be seen in both cohorts after 70 years of age. Correlation coefficients were weak and were computed r = 0.13 for males, and r = 0.16 for females. Average body weight amounts to 64 kg at the age of 55 in males and 57 kg at the age of 57 in females respectively. Distribution of body weight according to age and BROCA reference is given in figs. 27 and 28 for both males/females. The

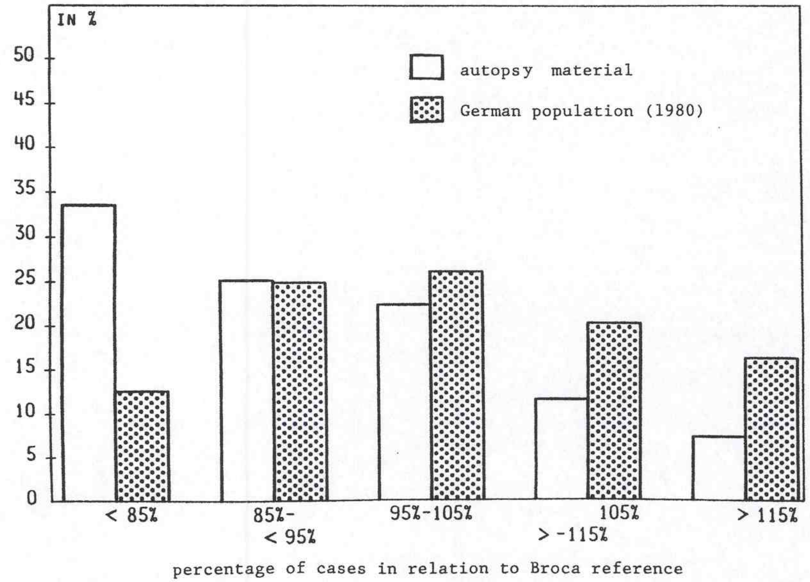


Fig. 24: Distribution of standardized body weight (Brocareference) in living population and in autopsy material, males, 1900-1981

Table 13: Body weight according to age groups (kg)

age groups	n	date of birth 1830-1879 mean + confidence limits p ≥ 0.95			n	date of birth 1880-1959 mean + confidence limits p ≥ 0.95		
males								
20-29	0	0.0	0.0	0.0	760	58.5	60.2	61.7
30-39	29	51.2	57.2	63.3	720	63.7	64.0	65.3
40-49	179	55.2	57.2	59.2	895	65.0	66.4	67.8
50-59	350	58.1	56.9	61.1	1180	65.3	66.4	67.5
60-69	342	57.6	59.1	60.6	1389	65.9	66.9	67.9
70-79	247	56.2	57.8	59.4	980	64.4	65.2	66.0
80-89	132	55.2	58.2	61.2	199	62.3	64.2	66.1
90-99	12	46.3	60.3	76.3	5	0.0	64.6	0.0
females								
20-29	0	0.0	0.0	0.0	492	51.9	53.0	54.1
30-39	39	45.5	50.5	55.5	524	54.4	55.4	56.4
40-49	123	46.3	50.3	54.3	552	56.9	57.9	58.9
50-59	202	51.0	53.3	55.6	620	59.7	60.6	61.5
60-69	196	50.1	53.0	55.9	735	59.3	60.2	61.1
70-79	171	48.7	51.1	53.5	780	58.5	59.3	60.1
80-89	86	46.9	52.3	57.7	253	54.9	56.1	57.3
90-99	15	43.4	51.4	59.4	16	50.5	56.5	62.5

age groups	n	date of birth 1830-1959 mean + confidence limits p ≥ 0.95		
males				
20-29	760	59.2	60.2	61.2
30-39	749	62.8	63.8	64.8
40-49	1074	64.1	64.9	65.7
50-59	1530	64.1	64.8	65.5
60-69	1731	64.8	65.3	65.8
70-79	1227	63.1	63.7	64.3
80-89	331	60.7	61.8	62.9
90-99	17	55.4	61.5	67.9
females				
20-29	492	52.2	53.0	53.8
30-39	563	54.3	55.1	55.9
40-49	675	55.8	56.5	57.2
50-59	822	58.1	58.8	59.5
60-69	931	58.0	58.7	59.4
70-79	951	57.0	57.8	58.6
80-89	339	54.0	55.1	56.2
90-99	31	49.2	54.0	58.8

younger the autopsied person, the higher is the difference compared to living population. Observed differences were noticeable in males and in females. No significant differences compared to the living population could be observed beyond the age of 50 in females.

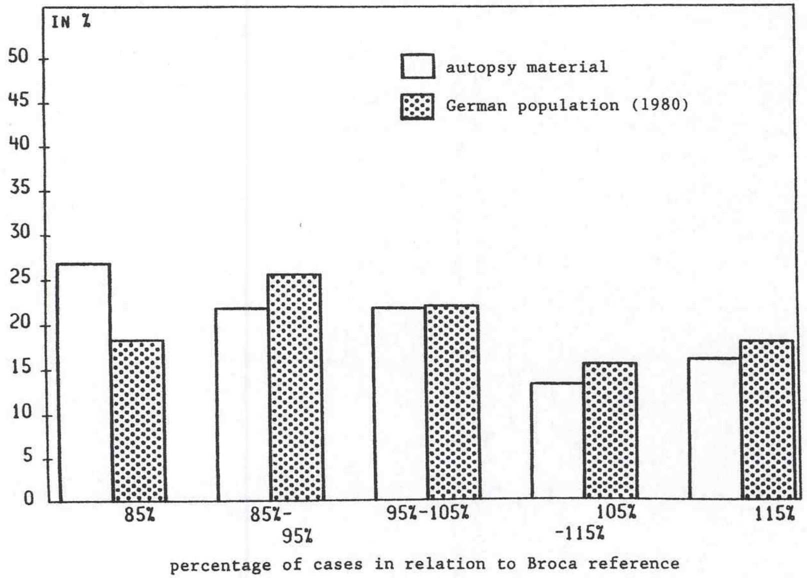


Fig. 25: Distribution of standardized body weight (Brocareference) in living population and in autopsy material, females, 1900-1981

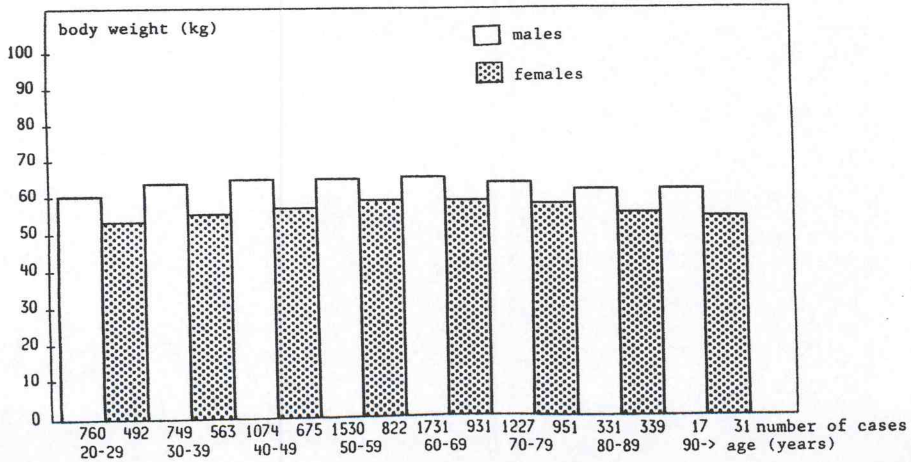


Fig. 26: Mean body weight (kg) according to sex and age at death, 1900-1981

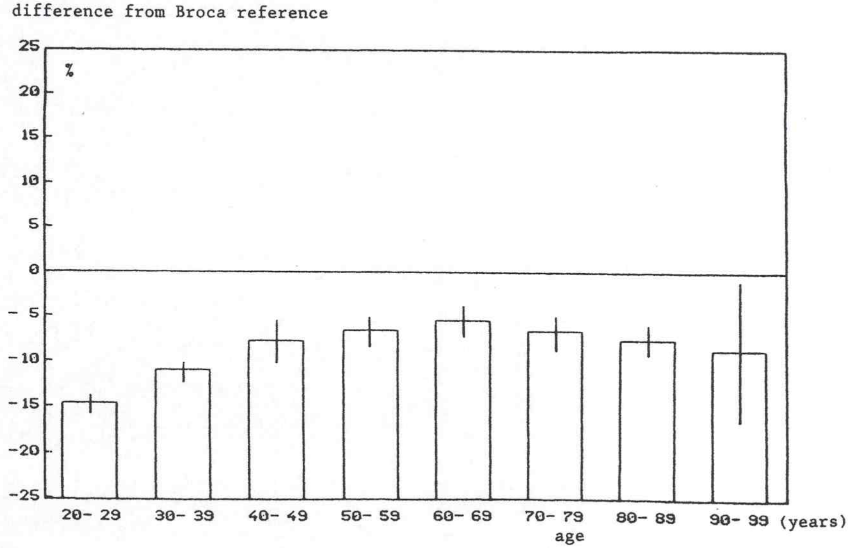


Fig. 27: Difference of standardized body weight (Broca-reference) according to age at death, mean and confidence limits ($p \leq 0.05$), males, 1900-1981

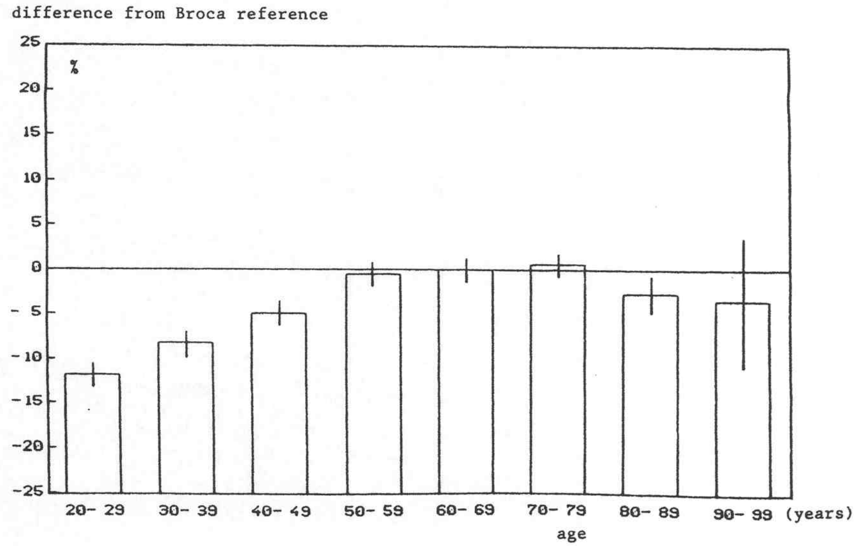


Fig. 28: Difference of standardized body weight (Broca-reference) according to age at death, mean and confidence limits ($p \leq 0.05$), females, 1900-1981

7.1 Secular acceleration of body weight

As already noted, body weight at birth decreased during the period 1900-1981. Opposite to these findings, body weight of adults increased for computed age groups (20-39 years, 40-59 years, 60 years and above) for both males/females (figs. 29 and 30). An increase in body weight is consistant with an increase in height during the period considered. Influence due to hunger periods during or after war time cannot be noted.

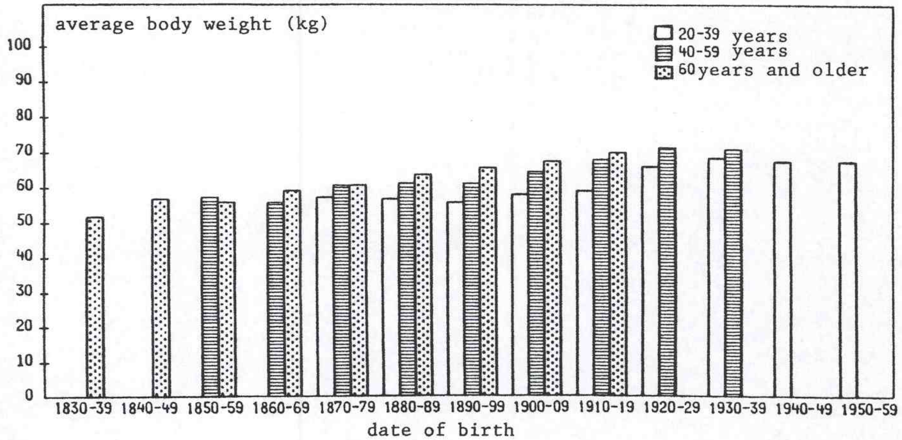


Fig. 29: Mean body weight (kg) in autopsied males according to date of birth and age at death, males, 1900-1981

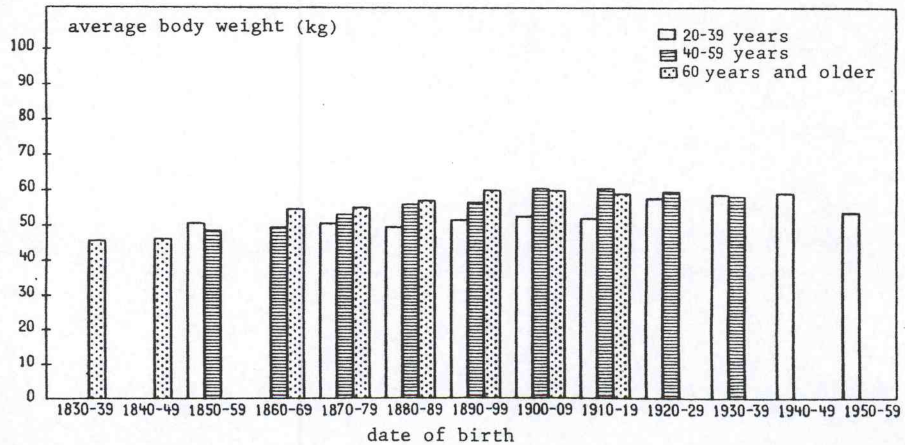


Fig. 30: Mean body weight (kg) in autopsied females according to date of birth and age at death, females, 1900-1981

7.2 Body weight and height

Body weight divided by height (relative body weight), for both boys and girls is shown in fig. 31. Relation for both boys and girls is similar. No major difference can be noted until adulthood. Relation of body weight to height in adults (linear regression curves) is given in figs. 32 and 33. Increase of relative body weight

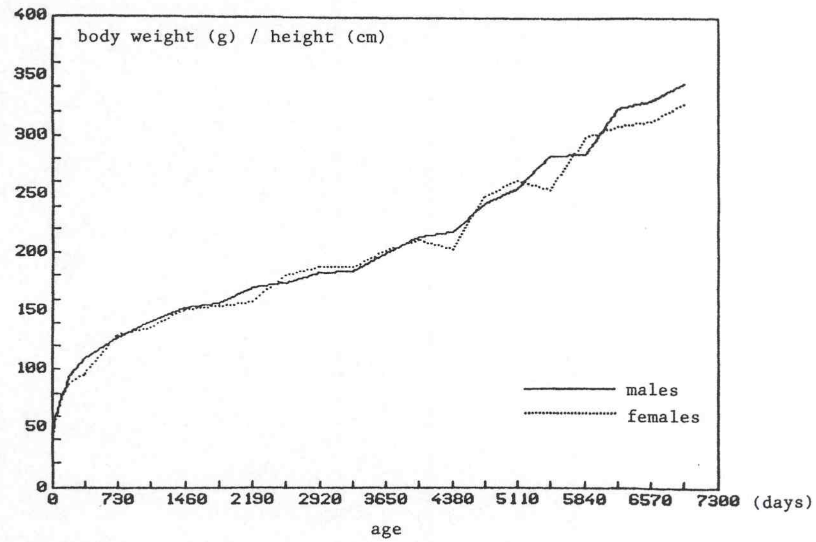


Fig. 31: Relative body weight (kg/cm) according to age at death in autopsied children, 1900-1981

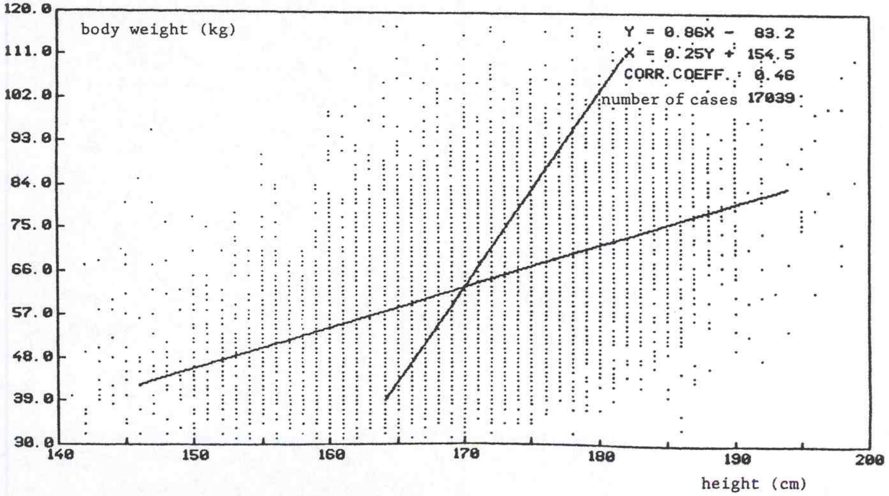


Fig. 32: Body weight (kg) according to height (cm), autopsied males, 1900-1981, linear regression

measuring 8 kg/10 cm can be observed for both males and females. Correlation coefficients (r = 0.46 for males and r = 0.38 for females) result in explicit correlation. Relative body weight for various birth cohorts and various groups of height is given in figs. 34 and 35. Relative body weight reveals constant for all birth cohorts and for all groups of height, except tiny females (height 150-159 cm). In this group of height a slight increase of body weight can be noted in birth cohorts 1840-1890.

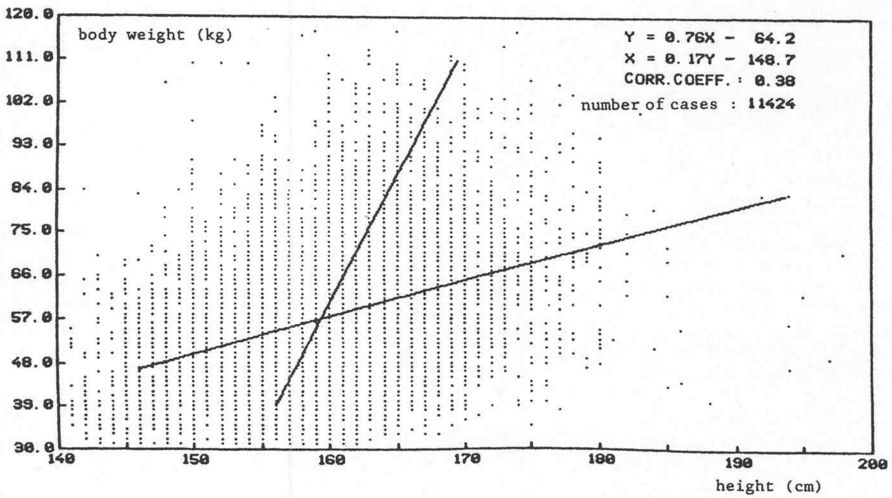


Fig. 33: Body weight (kg) according to height (cm), autopsied females, 1900-1981, linear regression

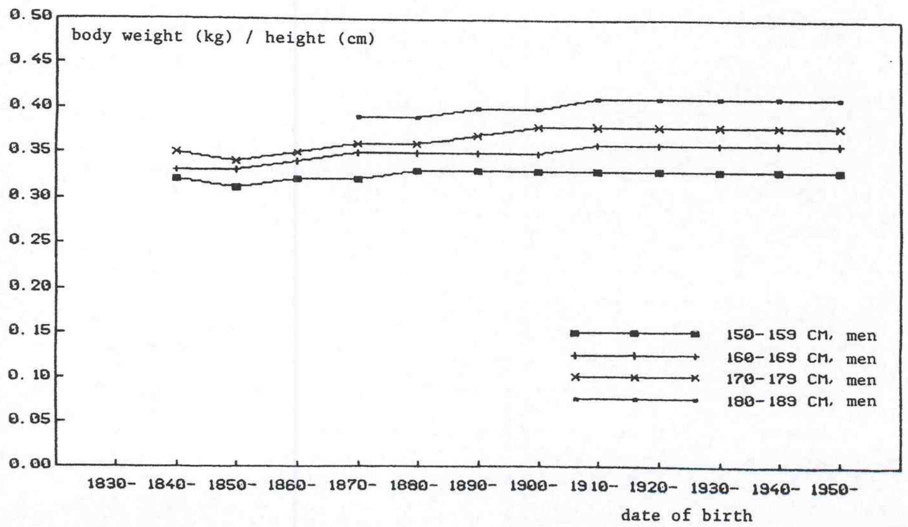


Fig. 34: Relative body weight (kg/cm) in autopsied males according to height and date of birth

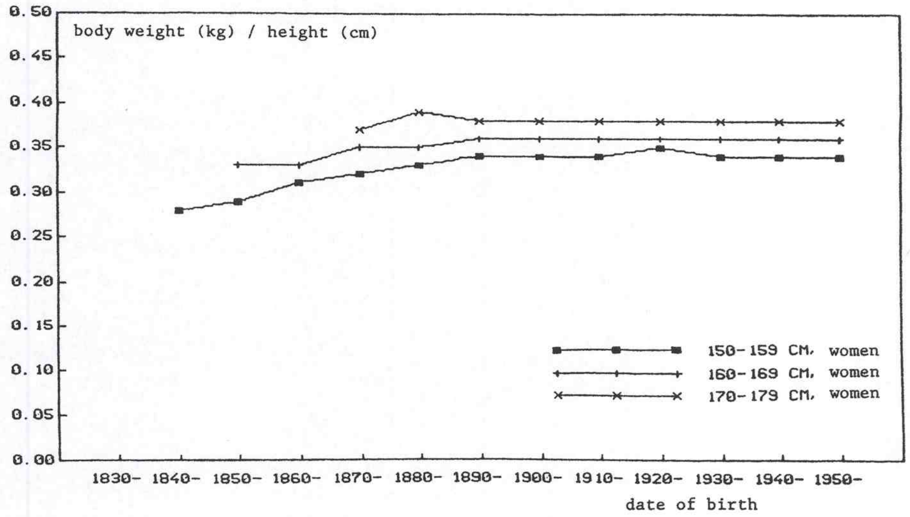


Fig. 35: Relative body weight (kg/cm) in autopsied females according to height and date of birth

8. Discussion

Development of body weight during growth periods revealed similarities to development of height in boys and girls. Relative body weight showed no difference between boys and girls. Major differences of body weight at birth were observed between birth cohorts I and II, i.e. children born during 1900-1939 and 1950-1981. Children born at the earlier period were heavier at birth. In our material, no influence due to hunger periods can be observed. This is in agreement with data published by ACHESON and MCINTYRE, (1958); BARNES et al. (1947); CLARKE and SMITH (1938); OUTHOUSE and MENDEL (1933); QUIMBY (1948); SAXTON and SILBERBERG (1947). According to these authors, influence caused by hunger periods during body development can be compensated by the organism in later periods.

In our material, close relation of body weight to height does exist. Although newborns are not as heavy nowadays as in earlier periods, adults are heavier if born at a later date. This increase of weight is caused by increase of height. Relative body weight remained stable for all groups and for all height cohorts during the period considered.

The final body weight is reached at the age of 17 in girls, and at the age of 19-21 years in boys. These data are in agreement with data from BAYER and BASEY (1959); PETT (1955); SARGENT (1963). Data for later ages differ in literature. MASTER et al. (1960) found a decrease of body weight (10 kg) after 65 years of age in males/females. MEIER (1956) found a slight increase of body weight between the age of 20-65 years, and a slight decrease for older persons.

Our data agree with the data published by MEIER (1956) if compared to the population during hunger period (1946-1948). Average weight in our material is 10 kg lower than that reported from other authors, according to different distribution related to BROCA reference in both data groups. Distribution of body weight in relationship to BROCA reference is similar in autopsy material and in living population, but the mean shifted to lower weight.

Observed increase of body height during the period considered and constancy of relative body weight (body weight divided by height) allows the conclusion that increasing height is probably not accompanied by changes in body shape.

9. Brain weight in autopsied children

Brain weight was documented in 773 autopsied boys and 534 autopsied girls not suffering from diseases affecting weight of brain; table 14. Due to small number of autopsied cases, no cohorts for different decades could be computed. Average weight of brain was measured 1,447 g in boys and 1.288 g in girls at the age of 19 years. At birth the brain weighed 227.1 g in boys and 195.8 g in girls. The difference of 31.3 g is statistically significant ($p < 0.01$). During the whole growth period, the brain weight is higher in boys than in girls. Relation of weight of the brain to age is given in figs. 36 and 37. Highest increase of brain weight was observed up to the age of 6 years in boys and girls. At this age, brain weight was measured to 1,417 g in boys and 1,263 g in girls. Compared to the average, the brain in later life time shows only a slight increase in weight.

Table 14: Brain weight according to age (g)

age	n	mean + confidence limits $p \geq 0.95$			n	mean + confidence limits $p \geq 0.95$		
	males				females			
days 1	218	209.1	227.1	245.0	166	179.4	195.8	212.2
2- 30	63	348.8	383.3	417.8	30	388.7	436.6	484.5
31- 60	47	431.8	474.5	517.1	29	461.8	528.7	595.6
61- 90	43	543.7	595.3	647.0	26	451.4	503.1	554.8
91-120	38	571.2	614.1	657.0	25	512.3	577.9	643.4
121-150	17	587.8	665.2	742.7	25	504.7	571.9	639.1
151-180	30	652.1	713.8	775.5	20	580.4	677.0	773.5
years 1	25	738.2	851.4	964.6	22	655.1	786.8	918.4
2	28	1083.1	1149.2	1215.3	15	1026.5	1090.3	1154.1
3	29	1198.0	1257.4	1316.7	17	1112.4	1211.1	1309.8
4	17	1217.1	1296.4	1375.8	14	1131.3	1204.2	1277.2
5	17	1291.8	1363.5	1435.1	11	1167.1	1260.9	1354.6
6	15	1329.5	1416.6	1503.8	15	1214.3	1263.0	1311.6
7	7	1194.2	1381.4	1568.5	13	1079.3	1211.1	1342.9
8	8	1252.8	1336.2	1419.6	6	1207.2	1295.8	1384.4
9	12	1221.9	1370.0	1518.0	8	1111.8	1235.0	1358.1
10	16	1177.4	1349.6	1521.9	10	1144.3	1299.0	1453.6
11	8	1272.2	1390.6	1508.9	6	1146.8	1232.5	1318.1
12	9	1081.1	1330.5	1579.9	4	1199.1	1337.5	1475.8
13	9	1214.2	1370.5	1526.8	3	1045.3	1296.6	1547.9
14	14	1414.7	1497.1	1579.5	9	1180.3	1292.7	1405.2
15	13	1404.4	1466.1	1527.8	9	1255.2	1379.4	1503.6
16	23	1292.7	1399.8	1506.9	5	1158.9	1266.0	1373.0
17	19	1416.4	1466.3	1516.1	16	1209.0	1274.6	1340.3
18	21	1391.3	1446.0	1500.7	13	1244.9	1291.5	1338.1
19	27	1395.2	1446.6	1498.0	17	1217.1	1288.1	1359.1

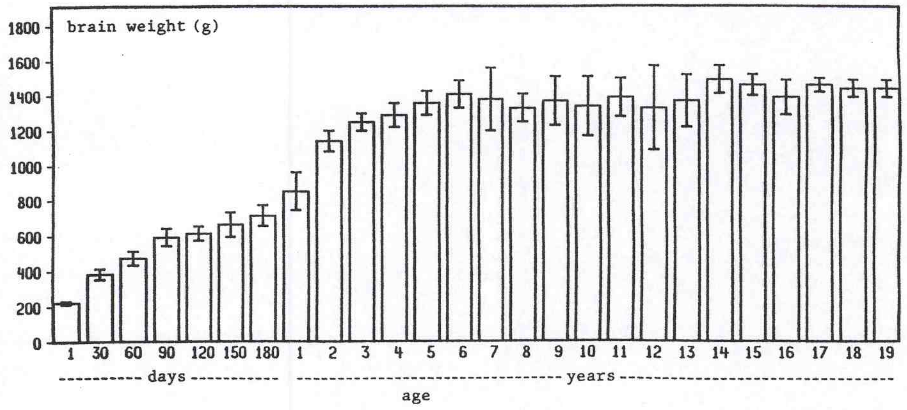


Fig. 36: Brain weight (g) in autopsied boys according to age (mean and confidence limits, ⩾0.95), 1900-1981

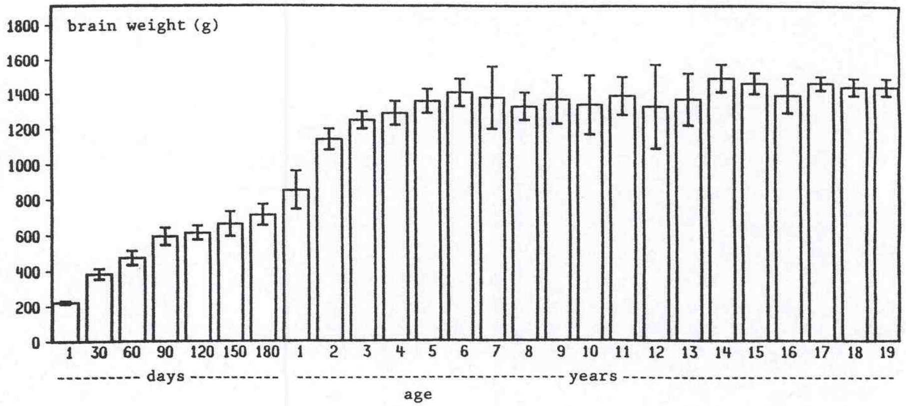


Fig. 37: Brain weight (g) in autopsied girls according to age (mean and confidence limits, p ⩾ 0.95), 1900-1981

10. Brain weigth in autopsied adults

Distribution of brain weight for adults is shown in figs. 38 and 39. It is a normal distribution for both males/females. Its peak amounts to 1,350-1,400 g in males and 1,200-1,250 g in females (figs. 39 and 39). Brain weight decreases slightly with increasing age. The decline measured 20 g in both males and females from 20-40 years, and continued to the age of 60 years. Decline of brain weight is twice as high as in lower ages after 60 years of age. Final weight was measured 1,300 g in males and 1,160 g in females. Difference between males and females remains constant over the life period. Relation between brain weight and age is strong. Correlation coefficients were computed $r = -0.26$ for males, and $r = -0.28$ for females (fig. 40).

Three age groups (20-39 years, 40-59 years and 60-79 years) were created to evaluate the changes of brain weight according to decade. The results are given in fig. 41. A slight increase of brain weight according to date of birth can be noted for both males/females. An increase in weight of the brain for each age group amounts to 10 g/decade.

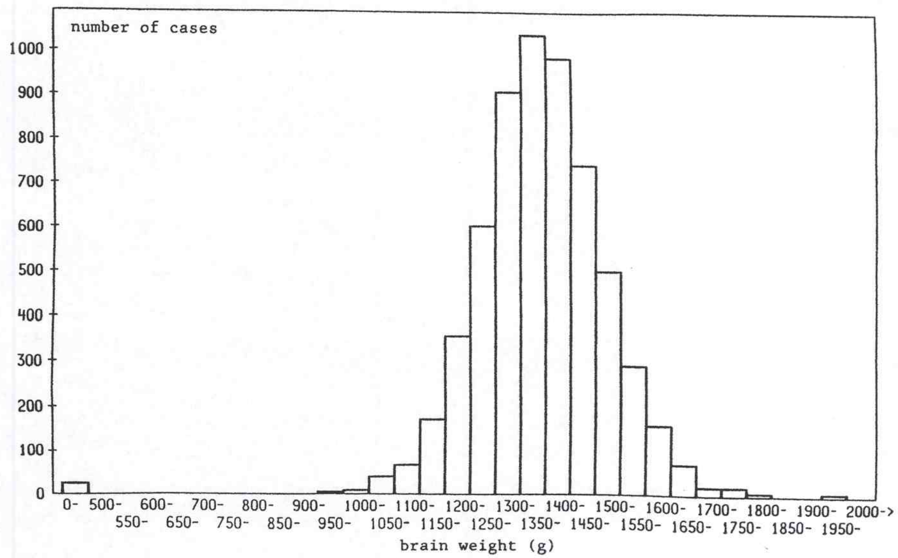


Fig. 38: Distribution of brain weight (g) in autopsied males, 1900-1981

Table 15: Brain weight according to age groups (g)

age groups	n	mean + confidence limits p ≥ 0.95			age groups	n	mean + confidence limits p ≥ 0.95		
males					females				
20-29	337	1 401.3	1 438.0	1 474.7	20-29	157	1 260.4	1 298.9	1 337.4
30-39	350	1 386.2	1 424.2	1 462.2	30-39	249	1 271.2	1 306.0	1 340.8
40-49	737	1 393.1	1 417.8	1 442.2	40-49	381	1 251.6	1 284.8	1 318.0
50-59	1 312	1 380.4	1 403.0	1 425.6	50-59	668	1 242.7	1 274.1	1 305.5
60-69	1 755	1 370.8	1 383.8	1 395.8	60-69	967	1 226.3	1 250.3	1 274.3
70-79	1 200	1 321.2	1 345.5	1 369.8	70-79	902	1 194.6	1 221.7	1 248.2
80-89	335	1 267.6	1 306.4	1 345.2	80-89	307	1 162.0	1 195.3	1 128.5
90-99	19	1 248.9	1 288.9	1 328.9	90-99	24	1 129.3	1 168.9	1 208.5

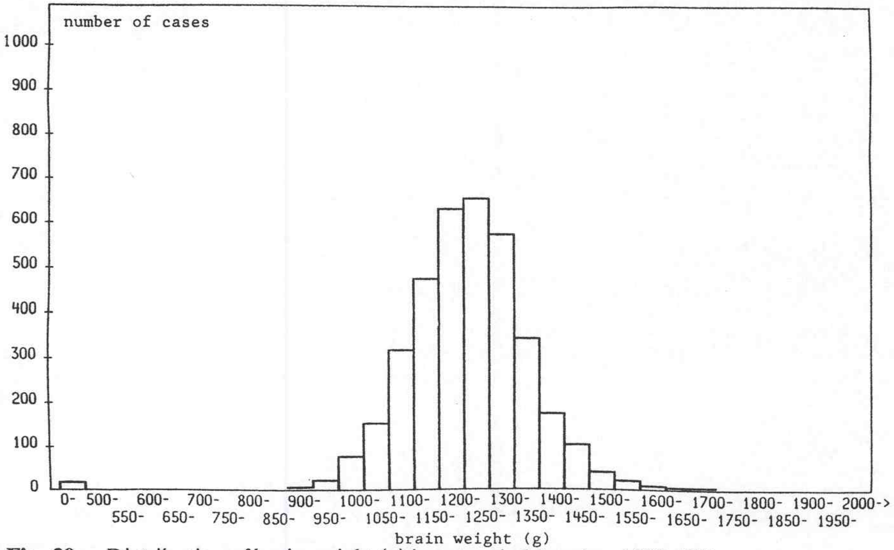
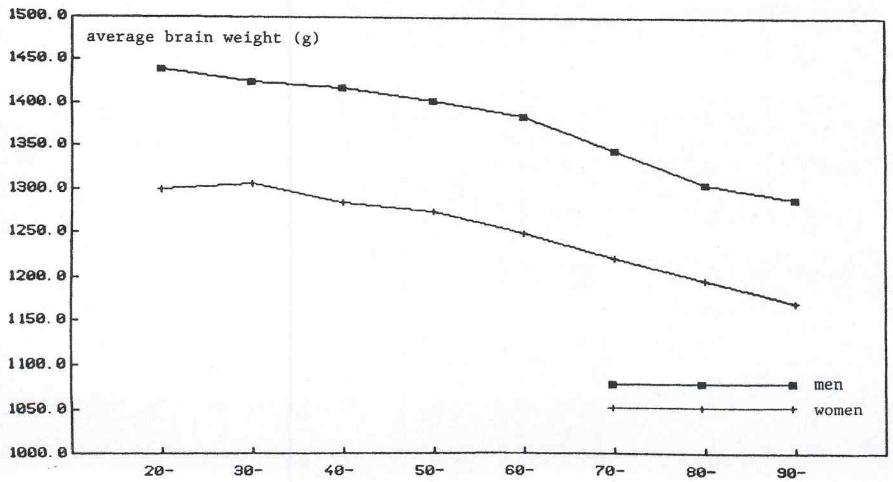


Fig. 39: Distribution of brain weight (g) in autopsied females, 1900-1981



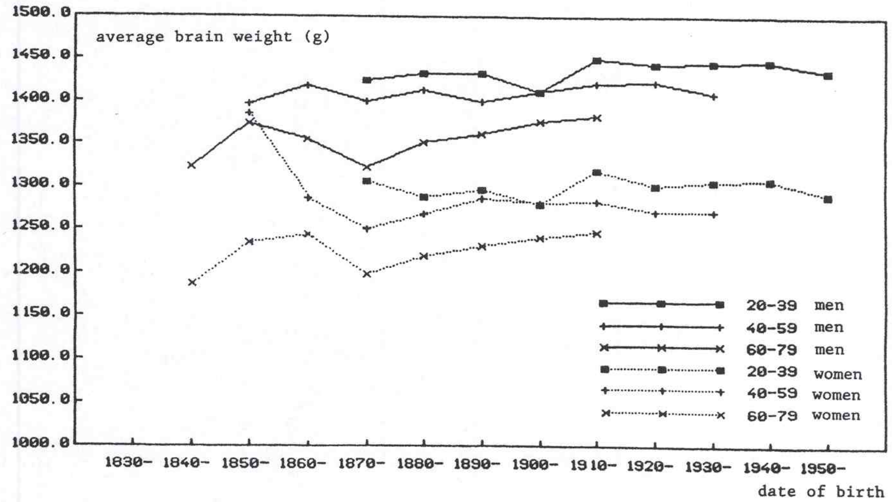


Fig. 41: Mean brain weight (g) according to sex, age at death and date of birth

The dependency of brain weight to height is given in fig. 42. Computed relation of brain weight to body weight revealed similarities as were computed to height (fig. 43). Taller persons showed increased brain weight for body weight. The increase was computed 4.2 g/cm (weight of brain/height) for males, and 4 g/cm for females. Correlation coefficients were computed r = 0,25 for males, and r = 0.24 for females. Decline of brain weight according to age is similar for each group of height (figs. 44 and 45).

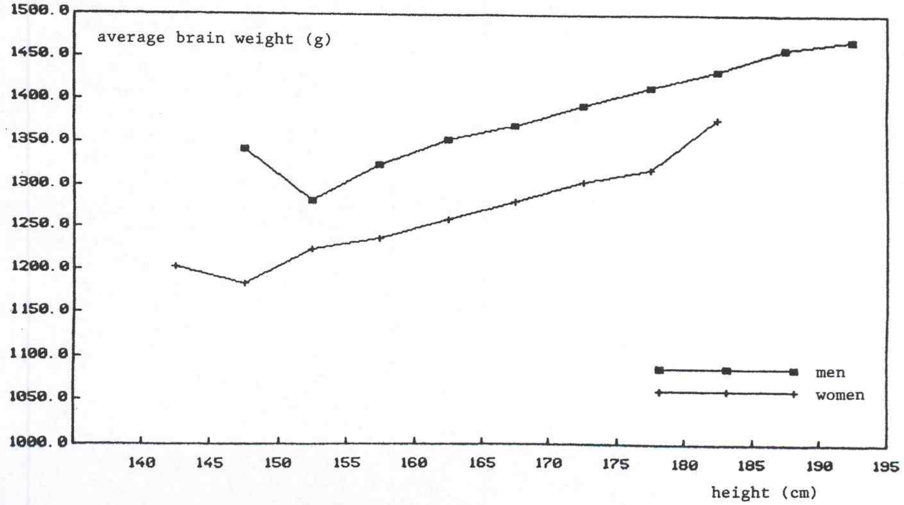


Fig. 42: Mean brain weight (g) according to sex and height, 1900-1981

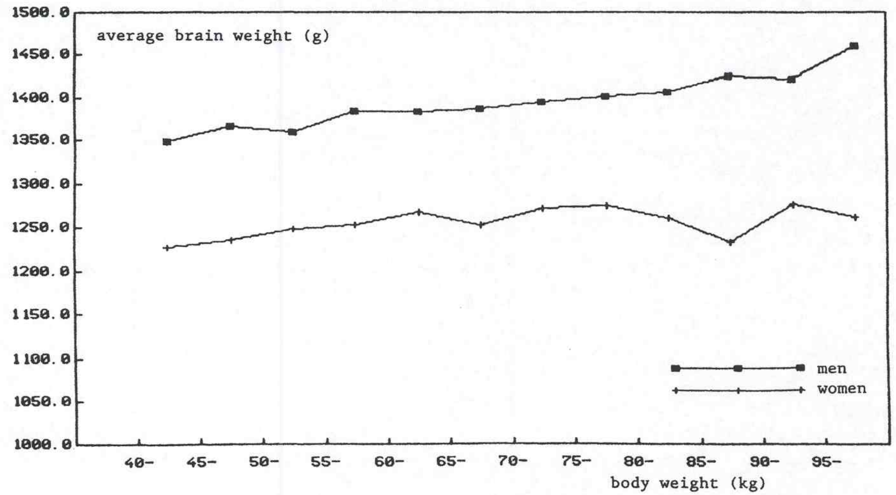


Fig. 43: Mean brain weight (g) according to sex and weight, 1900-1981

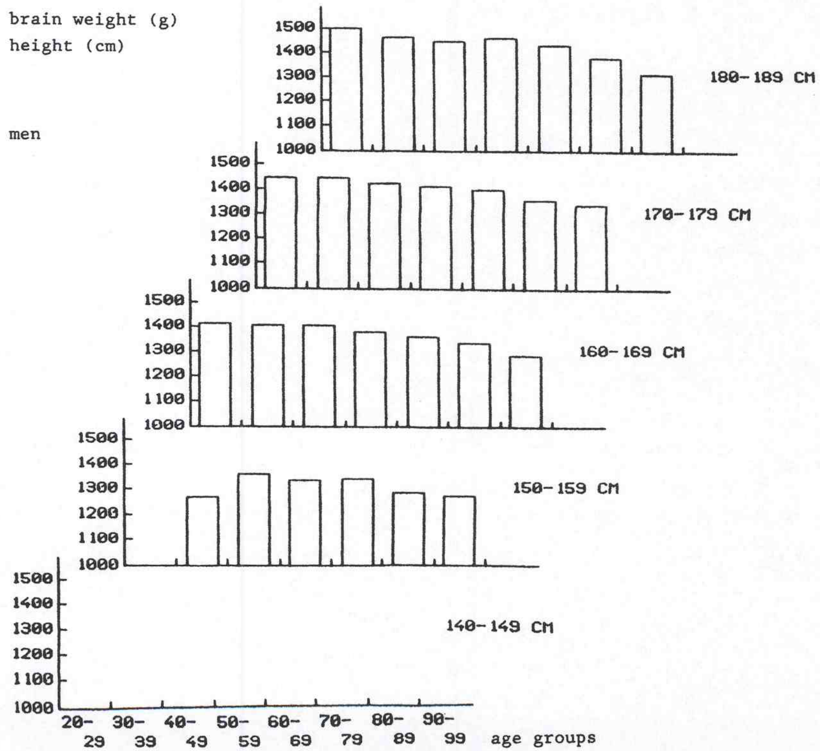


Fig. 44: Mean brain weight (g) according to age and height, males, 1900-1981

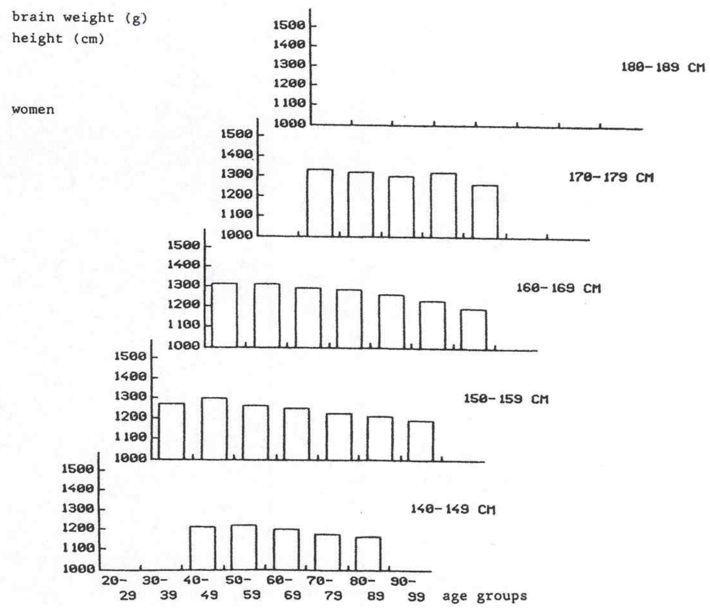


Fig. 45: Mean brain weight (g) according to age and height, females, 1900-1981

Correlation of brain weight divided by height according to age groups and date of birth is given in fig. 46. A decline of relative brain weight can be seen in all age groups. During the period considered, the increase of height is relatively higher than the increase of brain weight. Relative brain weight is independent from height, and was computed 8.2 g/cm for males, and 8.0 g/cm for females.

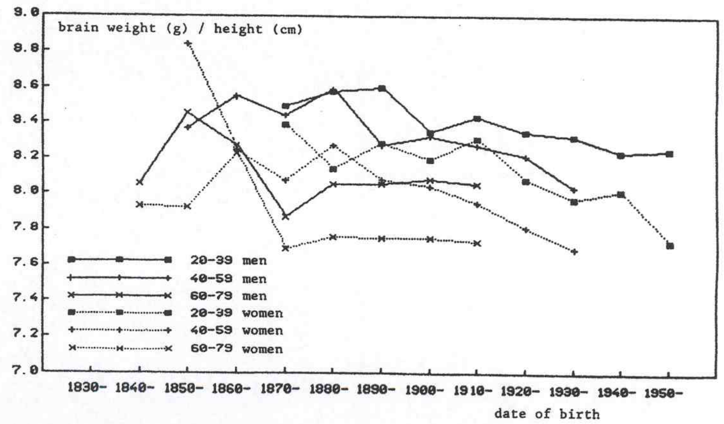


Fig. 46: Relative brain weight (g/cm) according to sex, date of birth and height

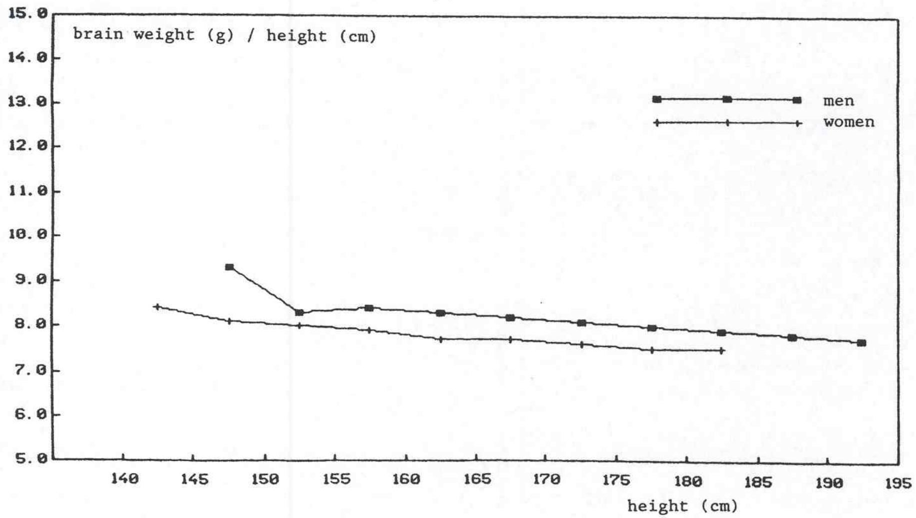


Fig. 47: Relative brain weight (g/cm) according to sex and height, 1900-1981

11. Discussion

Increase of brain weight in children and adoldescents can be noted until the age of 16 in girls and 18 years in boys according to the data reported by ROESSLE and ROULET (1932). Other authors (BOYD, 1876; BUCHSTAB, 1885; BÜRGER, 1957; HANDMANN, 1906; ORTHNER and SENDLER, 1975) showed an increase of brain weight exceeding the age of 20 years. According to our data, the decrease of brain weight after 20 years of age is not questionable. Decrease starts slowly, and measures 20 g/10 years up to the age of 60 years. Later on decrease is more evident, and amounts to 40 g/10 years. The aging of brain includes a decrease in weight and volume, as well as a change in brain surface and increase of ventricle (SAMORAJESKI, 1976). After 60 years of age, a remarkable decrease of weight was reported by HAUG (1975). DELORENZI (1931) and WILCOX (1959) found no decrease of Purkinje cells with increasing age and only after 70 years of age a degeneration of neurons.

Our data clearly show a relationship between brain weight and weight, although correlation coefficients $r = 0.16$ (males) and $r = 0.13$ (females) are not too strong. On the other hand, ZSCHOCH and KLEMM (1972) found correlation coefficients $r = 0.32$ (males) and $r = 0.29$ (females) and PASSINGHAM (1979) correlation coefficents $r = 0.36$ (males and females, age 18-45 years) between brain weight and body weight.

The correlation of brain weight and body weight is probably due to close relation of both parameters to height, although BISCHOFF (1880); MARCHAND (1902) and HANDMANN (1906) did not find a relation beween brain weight and

Table 16: Correlation coefficients brain weight – height (according to nationalities)

Author	males r	females r	nationality
CHRZANOWSKA and KRECHOWIECKI 1975	0.2008	0.263	Polish
RÖTHIG and SCHAARSCHMIDT 1977	0.28	0.3	German
RÜTER 1970	0.3	0.3	German
ZSCHOCH and KLEMM 1972	0.32	0.36	German
PEARL 1905	0.183	0.349	Swedish
	0.182	0.183	Swiss
PASSINGHAM 1979 according to PARKENBERG and VOIGT 1964	0.31	0.2	Danish
own data	0.25	0.24	German

height. On the contrary, our data are in accordance with data of IM OBERSTEG (1952); MATIEGKA (1902); ROESSLE and ROULET (1932); and SPANN (1955). Correlation coefficients of brain weight and height given by different authors, inluding our data, are shown in table 16. The increase of brain weight is 4.2 g/cm in males and 4.0 g/cm in females according to our data and according to data published by CHRZANOWSKA and KRECHOWIECKI (1975); HAUG (1975); RÖTHIG and SCHAARSCHMIDT (1977). The data indicate that the increase of brain weight in males compared to that of females is not only caused by increased height in males, but by constitutional factors. This is in accordance with data published by several authors (CHRZANOWSKA and KRECHOWIECKI, 1975; HAUG, 1975; RÖTHIG and SCHAARSCHMIDT, 1977; SPANN and DUSTMANN, 1965) and can be seen in fig. 47. Relative brain weight (brain weight divided by height) of females measures 0.3 g/cm below that of males. It remains constant for all cohorts grouped to age and height.

During the period considered, a smooth secular acceleration can be noted in brain weight but relative weight of the brain decreased smoothly for all age groups. The observed increase in height due to secular acceleration is not followed by increase of brain weight to the same amount.

12. Heart weight in autopsied children

During period 1900-1981 heart weight was documented in 1,381 autopsied boys and 1,058 autopsied girls; table 17. At birth, average absolute heart weight was measured 12.3 g in boys, and 12.4 g in girls. The difference between both sexes is not statistically significant. Development of absolute heart weight during adolescence is given in figs. 48 and 49. Major differences between heart weight of boys and girls are evident beyond the age of 1 year in favour of boys. Differences ($p < 0.05$) compared to the age of 19 years could be seen in boys at 16 years and in girls at 15 years.

Table 17: Heart weight according to age (g)

age	n	mean + confidence limits $p \geq 0.95$			n	mean + confidence limits $p \geq 0.95$		
		males				females		
days 1	348	12.1	13.2	14.4	312	11.2	12.4	13.5
2- 30	87	20.8	25.4	30.0	63	18.0	20.4	22.8
31- 60	76	21.9	26.4	30.9	49	19.1	29.9	40.8
61- 90	62	24.7	27.4	30.1	57	21.9	26.1	30.4
91-120	58	24.2	30.4	36.6	37	21.1	29.9	38.8
121-150	53	26.1	28.3	30.5	36	23.8	28.2	32.7
151-180	33	31.5	38.0	44.4	33	30.1	39.2	48.2
years 1	48	38.5	48.5	58.5	42	39.8	43.1	46.3
2	49	62.2	66.4	70.7	31	50.3	55.0	59.7
3	52	70.4	75.7	80.9	36	60.0	64.9	69.7
4	26	73.8	83.3	92.9	22	69.5	77.5	85.6
5	40	86.8	94.9	102.9	20	72.1	85.2	98.3
6	26	101.1	115.9	130.8	38	90.3	96.9	103.6
7	21	95.4	106.6	117.8	18	92.2	107.0	121.7
8	30	117.2	131.7	146.1	20	102.4	126.0	149.5
9	22	116.4	131.1	145.7	20	118.0	135.3	152.6
10	28	139.1	158.5	177.9	12	97.3	117.0	136.6
11	18	146.8	170.2	193.7	9	117.3	155.0	192.6
12	25	159.4	178.6	197.7	15	135.5	170.4	205.3
13	19	173.0	195.6	218.2	15	158.2	177.0	195.7
14	27	189.4	213.1	236.8	19	179.1	207.8	236.5
15	24	204.3	232.3	260.3	30	172.8	190.3	207.7
16	39	239.7	258.8	277.9	17	199.8	229.1	258.3
17	56	261.8	278.4	295.1	37	210.5	230.1	249.7
18	62	262.7	279.4	296.0	34	216.5	235.1	253.7
19	54	271.6	294.9	318.2	36	212.1	231.0	249.8

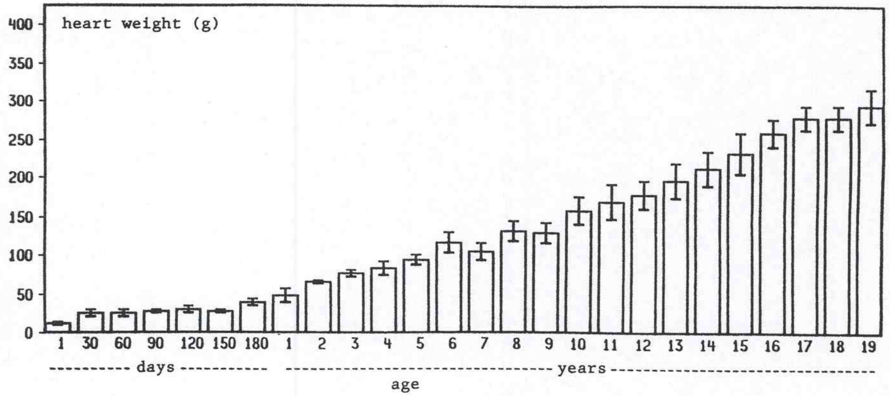


Fig. 48: Mean heart brain (g) in boys, according to age, 1900-1981

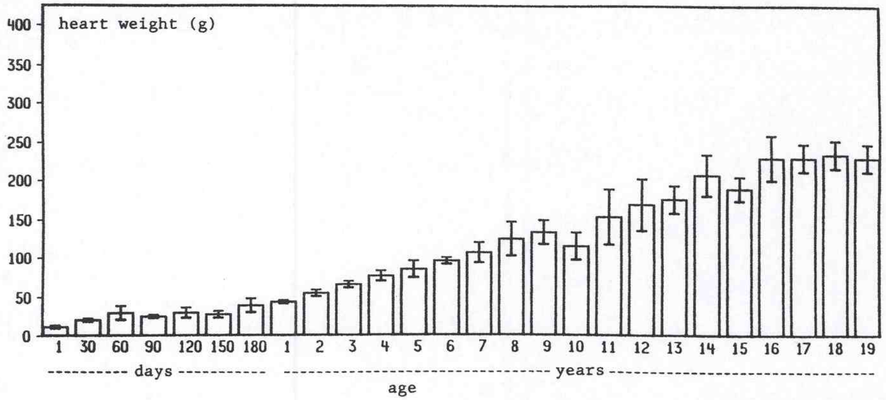


Fig. 49: Mean heart brain (g) in girls, according to age, 1900-1981

Midgrowth spurt and adolescent growth spurt of heart weight exist for boys and girls similar to development of height. Relative heart weight according to height (g/cm) is given in fig. 50 for both boys and girls. Relative heart weight increases constantly up to 20 years. Increase of relative weight of the heart for boys is more remarkable than for girls.

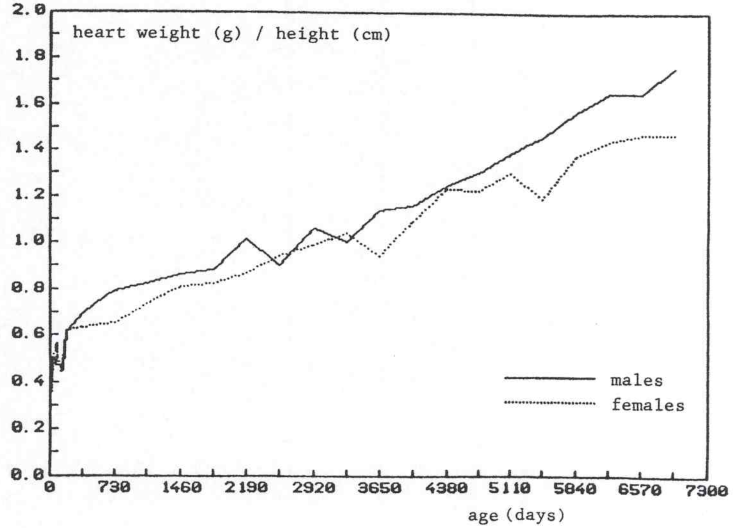


Fig. 50: Relative heart brain (g/cm) according to age and sex, 1900-1981

Strong correlation coefficients of heart weight and body weight suggest computation of relative heart weight according to body weight. Data for boys and girls are given in fig. 51. Relative heart weight according to body weight remained nearly constant after the age of 3 years. The average relative heart weight according to body weight was computed 5.6-5.7 g/kg in males, and 5.2-5.3 g/kg in females.

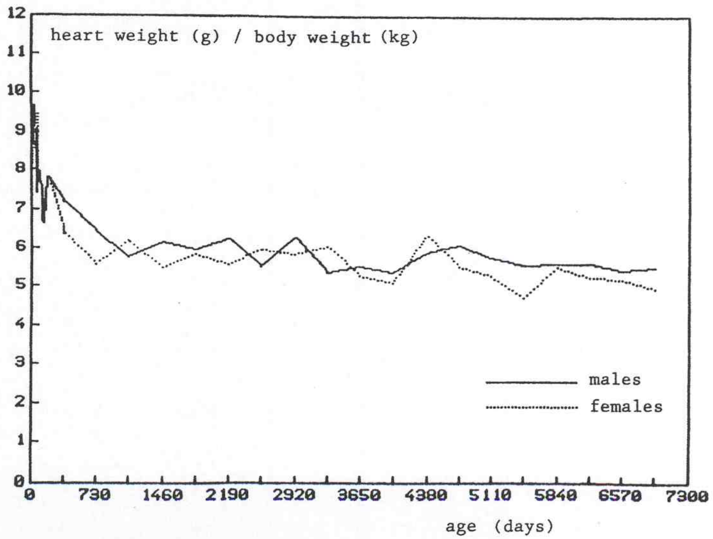


Fig. 51: Relative heart weight (g/kg) according to age and sex, 1900-1981

13. Heart weight in autopsied adults

Frequency distributions of heart weight for males and females are given in figs. 52 and 53. The peak of absolute heart weight amounts to 300-350 g for males, and 250-300 g for females. Lowest heart weight in males was measured 150 g, and 100 g in females respectively. Average heart weight increased slightly with increasing height for males and females (fig. 54; table 18). Table 19 shows average heart weight for males and females and data published by various authors.

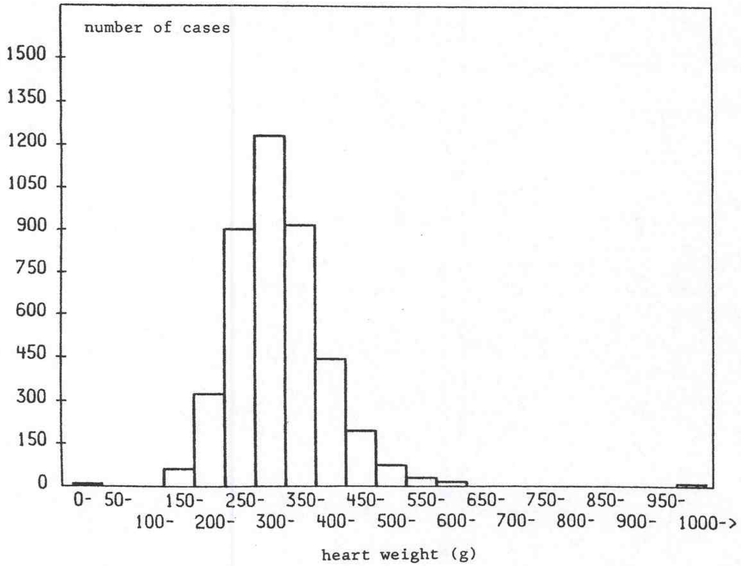


Fig. 52: Frequency distribution of heart weight (g) in males (⩾ 20 years), 1900-1981

Relation between heart weight and age of autopsied patients is given in fig. 55. Heart weight increases slowly but steadily with increasing age up to the age 75. After that age a smooth decrease of weight of heart can be noted. Correlation coefficients were computed r = 0.19 for males, and r = 0.26 for females. Average increase of heart weight according to age amounts to 10 g/10 years for males, and 12 g/10 years for females. Mean heart weight was computed 350 g for males, and 295 g for females (average age at death 53 years).

Average heart weight remained nearly constant for males and females during the period considered (figs. 56 and 57). No increase of heart weight due to secular acceleration was noted. With increasing height, the weight of the heart increased (figs. 58 and 59) for males and females. Dependency of heart weight according to

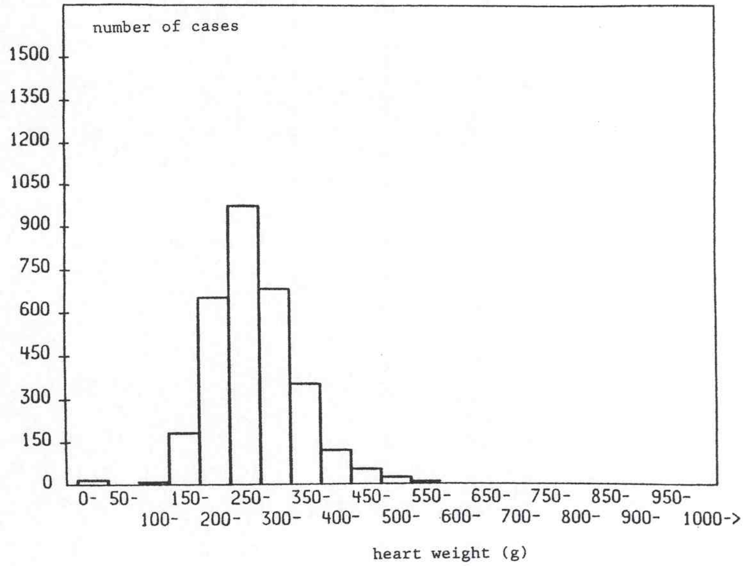


Fig. 53: Frequency distribution of heart weight (g) in females (⩾ 20 years), 1900-1981

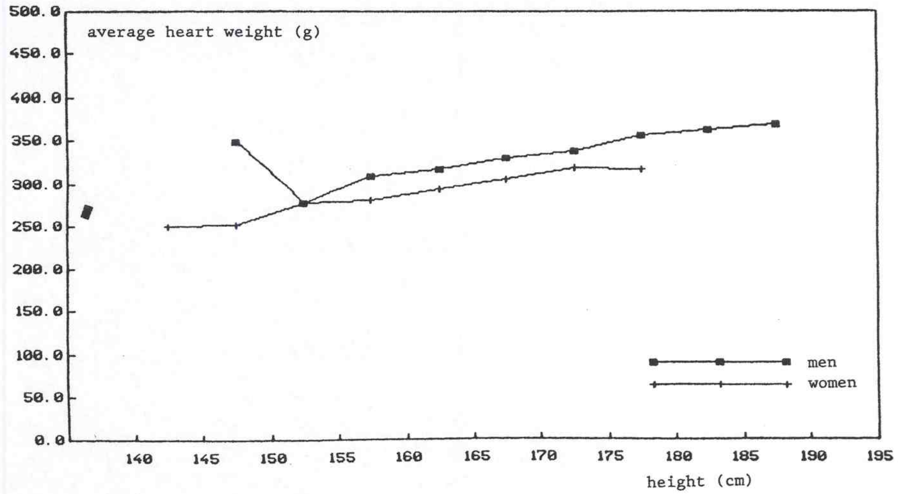


Fig. 54: Mean heart weight (g) according to sex and height, 1900-1981

height is stronger than its dependency on age. Average relative weight of the heart was computed 1.96 g/cm for males, and 1.28 g/cm for females. Correlation coefficients to height were computed r = 0.35 for males, and r = 0.28 for females. Linear regression shows increasing heart weight 3.5 g/cm for males, and 3 g/cm for females. Influence of height on heart weight is similar in all age groups.

Table 18: Heart weight according to age (g)

age groups	n	mean + confidence limits p ≥ 0.95		
males				
20-29	614	304.8	309.4	314.0
30-39	573	316.3	321.7	327.1
40-49	783	331.1	335.6	340.1
50-59	980	337.6	342.0	346.4
60-69	848	343.2	347.8	352.4
70-79	374	361.0	366.5	372.0
80-89	69	320.9	349.8	378.7
90-99	4	365.4	390.0	415.6
females				
20-29	346	257.1	261.0	264.9
30-39	470	261.0	264.8	268.6
40-49	529	276.7	281.0	284.6
50-59	695	282.4	285.6	288.8
60-69	620	302.9	306.2	304.5
70-79	338	313.6	317.5	321.4
80-89	100	290.1	307.3	324.5
90-99	2	0.0	345.0	0.0

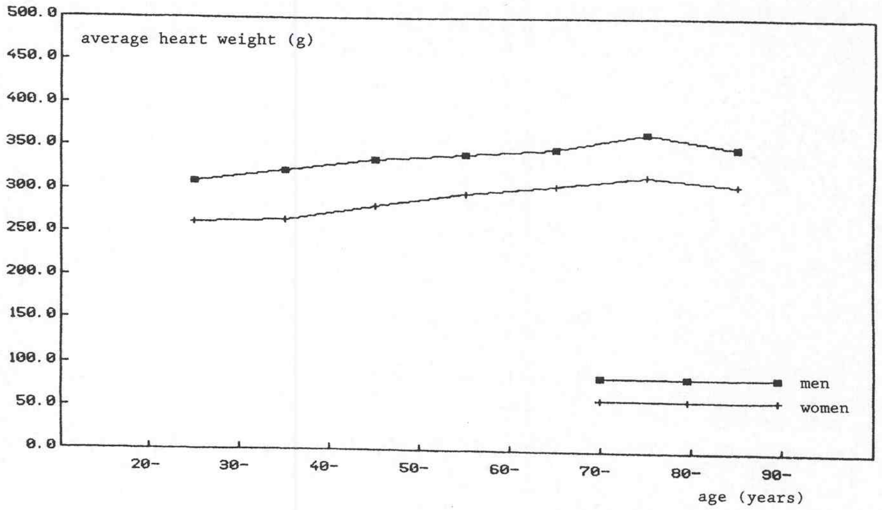


Fig. 55: Mean heart weight (g) according to sex and age, 1900-1981

Strongest relation of heart weight was found to the body weight (figs. 60 and 61). Correlation coefficients were computed r = 0.54 for males, and r = 0.48 for females. Linear regression showed relative increase of heart weight according to increasing body weight (30 g/10 kg for males, and 26 g/10 kg for females).

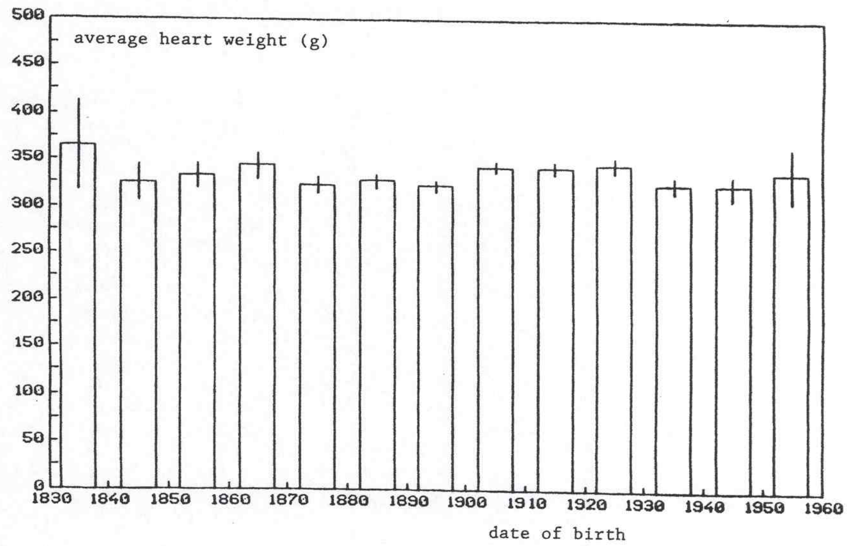


Fig. 56: Mean heart weight (g) in males (≥ 20 years) according to date of birth

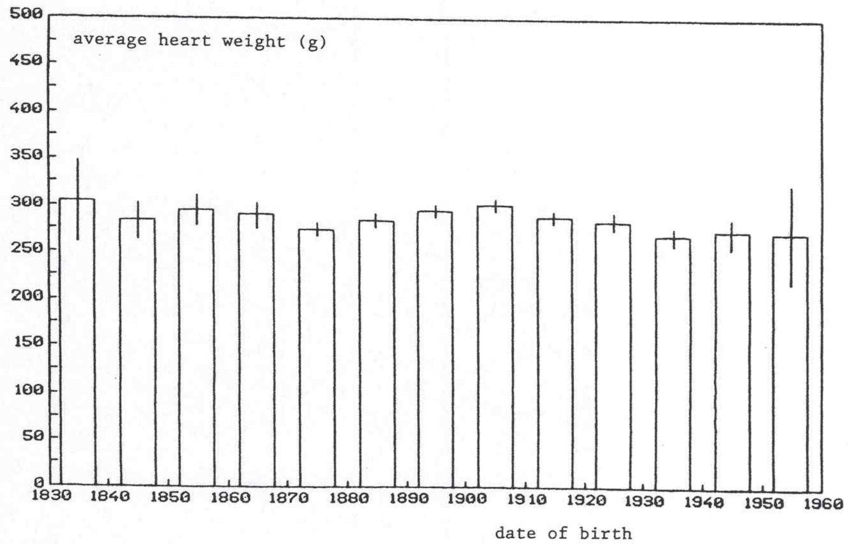


Fig. 57: Mean heart weight (g) in females (≥ 20 years) according to date of birth

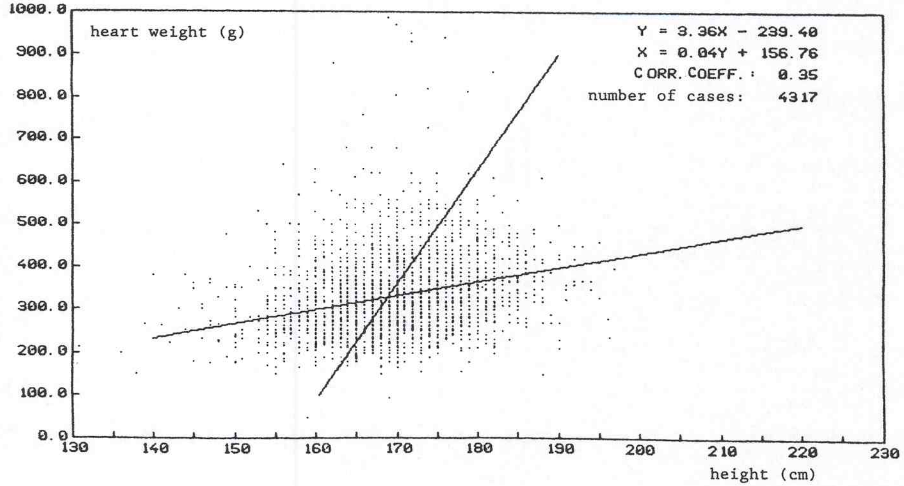


Fig. 58: Heart weight (g) and height (cm), linear regression, males (⩾ 20 years), 1900-1981

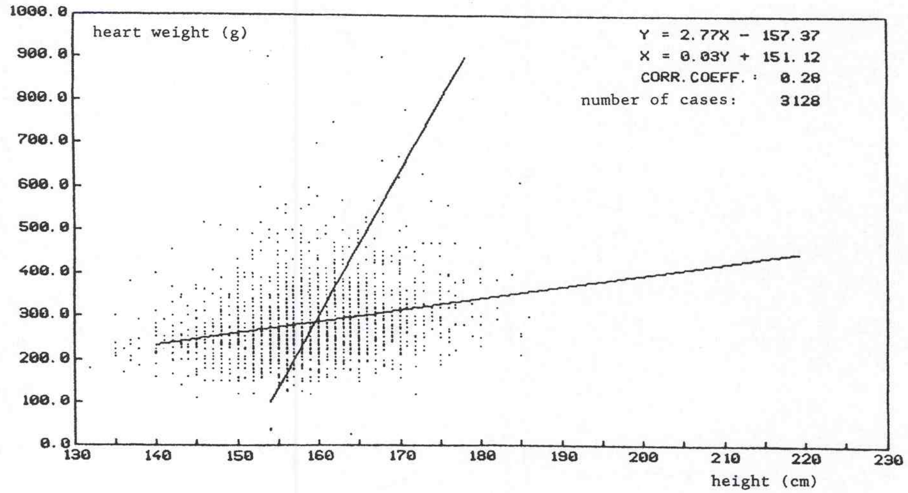


Fig. 59: Heart weight (g) and height (cm), linear regression, females (⩾ 20 years), 1900-1981

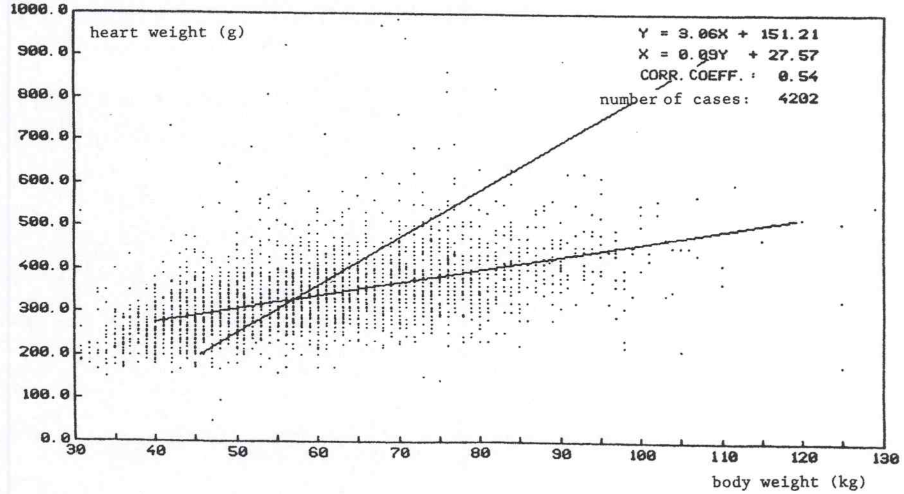


Fig. 60: Heart weight (g) and weight (cm), linear regression, males (⩾ 20 years), 1900-1981

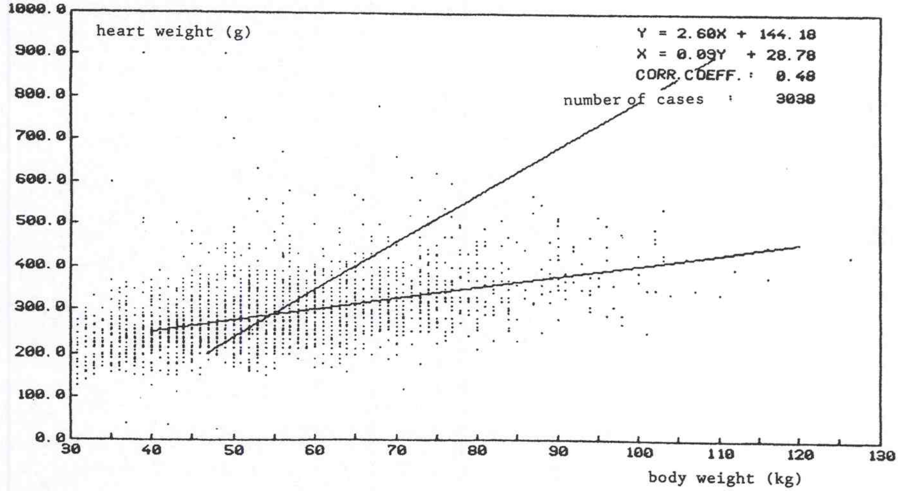


Fig. 61: Heart weight (g) and body weight (cm), linear regression, females (⩾ 20 years), 1900-1981

14. Discussion

The heart was weighed during the period considered without prior fixation and by preparation as described in chapter 2.

End of development of the heart was reported at the age 20 years (ROESSLE and ROULET, 1932). Our data, and data published by GREINING (1968) showed no significant increase in heart weight after 15 years of age. Increasing weight of the heart in later life time for both males and females was observed by several authors. LINZBACH and AKUAMOABOATENG (1973) reported in their detailed material an increase in heart weight of 1 g/year in males, and 1.5 g/year in females until the age 90 years. Similar data were given by GREENWOOD (1904); GREENWOOD and BROWN (1913); MEYER et al. (1963); ROSAHN (1941). Heart weight in females is always reported to be below the heart weight in males.

Table 19: Average heart weight for males and females

	males		females			
Author	number of cases	absolute heart weight (g)	number of cases	absolute heart weight (g)	age years	origin of material
Boyd 1861		334.8		280.2	20-80	data of various authors
Thoma 1882		285.06 m. + f.				autopsy
Müller 1883	466	318.9	378	259.3	20-80	autopsy
Vierordt 1890	214	275.7	218	278.8	15-25	data of various authors
Greenwood 1904	699	345			22-55	autopsy
Gray 1910		280-340		230-280		
Kaufmann 1919		344				soldiers
Fahr 1921		318.7				soldiers
Aschoff 1924	468	321			18-50	soldiers
Busch 1926	1992	285-300			24-45	soldiers
Roessle a. Roulet 1932	384	324.5	108	290.6	21-75	autopsy
Rosahn 1941	187	356			20-70	autopsy
Zeek 1942	354	319	224	267.6	21-70	autopsy

Table 19: Average heart weight for males and females (Continuation)

	males		females			
Author	number of cases	absolute heart weight (g)	number of cases	absolute heart weight (g)	age years	origin of material
Hutchins a. Anaya 1973	456 m. + f.	335 m. + f.			15-89	autopsy
Linzbach 1973	3219	393	2343	329	20-80	autopsy
	472	398	625	349	80-110	
Smith 1921	502	291.4	236	248.8	21-70	autopsy
own data	3798	331.3	2660	279.7	20-69	autopsy
	443	358.1	438	312.4	70-89	

Dependency of heart weight upon blood pressure was reported by several authors (LINZBACH, 1974; ZSCHOCH and ZIPFEL, 1977). The well known fact of increasing heart pressure with increasing age may explain the correlation between heart weight and age. A stronger correlation in heart weight was found as it relates to height; although not as strong as to body weight. MÜLLER (1883) found no relation of heart weight to height. This was also neglected by DADGAR and TYAGE (1979); REINER et al. (1959). Opposite to these authors, BUSCH (1926); GEWERT (1929); KAUP (1926) as well as ZSCHOCH and KLEMM (1972) reported close relation in heart weight to height. Correlation coefficients were computed by ZSCHOCH and KLEMM (1972) $r = 0.36$ in males, and $r = 0.28$ in females; and by ZEEK (1972) $r = 0.30$ in males and $r = 0.29$ in females. The close relationship in heart weight according to body weight was also found by various authors (MEYER et al., 1963; MÜLLER, 1983; ROSAHN, 1941; ZSCHOCH and KLEMM, 1972). Correlation coefficients computed by MEYER et al. (1963); ZSCHOCH and KLEMM (1972) are similar to our data.

Relative heart weight according to body weight shows a linear increase during puberty in boys and girls. These findings were reported by various authors (for example ROESSLE and ROULET, 1932). A synopsis of reported relative heart weight in percent of body weight is given in table 20. Data reported are similar to our data. The decrease of relative heart weight according to body weight over the period considered is of interest (fig. 61a). Constant decrease is seen in all body weight groups (grouped according to BROCA reference), and may be caused by increasing immobility of population. Relationship of heart weight according to increasing height caused by secular acceleration may be of some influence. Whether the amount of decreased heart mass can be tolerated by body function in the near future remains to be seen.

Table 20: Relative heart weight in percent of body weight

Author	males	relative weight of heart in % males + females	females
Thoma 1882	–	0.46	–
Müller 1883	–	0.5	–
Boyd 1876	–	0.7	–
Vierordt 1906	0.54	–	0.48
Greenwood 1904	–	0.57	–
Gray 1910	0.62	–	0.66
Bardeen 1918	0.55	–	0.53
Scammon 1927	–	0.5	–
Smith 1921	0.43	–	0.4
Fahr 1921	0.58	–	–
Gewert 1929	0.5	–	–
Roessle/Roulet 1932	–	0.5	–
Linzbach 1974	0.6	–	0.55
own data			
1900-1910	0.51	0.51	0.51
1930-1940	0.45	0.44	0.42

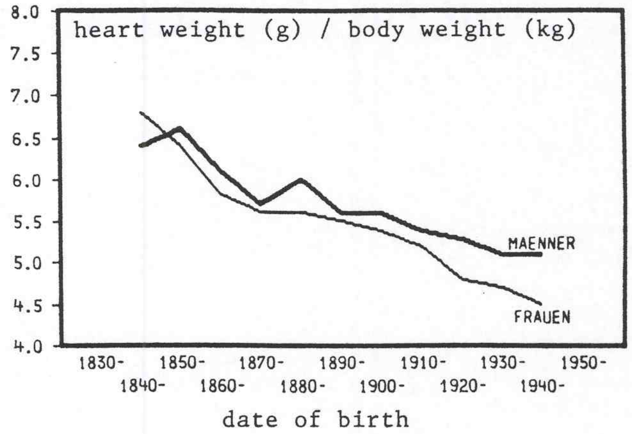


Fig. 61a: Relative heart weight (g/kg) according to sex and date of birth, 1900-1981

15. Liver weight in autopsied children

Liver weight was reported in 1,868 autopsied boys, and 1,322 autopsied girls during the period 1900-1981. At birth, the average absolute weight of the liver measured 68.7 g in boys, and 65,7 g in girls; table 21. Development in liver weight during childhood showed two plateaus between two and five years, and between ten and fourteen years respectively in both boys and girls (figs. 62 and 63). Average absolute liver weight was computed 1,68 g in 19-year-old boys and 1,46 in 19-year-old girls. Difference in liver weight between males and females was significant at the age of 16 years and later ($p < 0.05$). No statistically significant difference in the liver weight at the age 16 years, as compared to autopsied cases at the age 19 years was found in boys and girls respectively. Relative liver weight according to height (g/cm) is shown in fig. 65. A slight decrease in relative liver weight (g/cm) up to the age 19 years can be noted for both, boys and girls.

Table 21: Liver weight according to age (g)

age groups	n	mean + confidence limits p ≥ 0.95			n	mean + confidence limits p ≥ 0.95		
	males				females			
days 1	672	63.7	68.8	73.9	563	61.9	65.7	69.5
2- 30	131	125.0	140.1	155.2	67	104.6	118.6	132.6
31- 60	105	121.2	148.4	175.6	55	126.9	139.0	151.2
61- 90	70	171.4	186.4	201.5	48	136.3	155.6	174.9
91-120	74	159.0	176.1	193.3	44	154.2	183.3	212.4
121-150	49	181.6	215.5	249.4	36	168.7	200.5	232.2
151-180	42	212.9	269.1	325.4	34	187.6	220.0	252.5
1	46	256.5	293.0	329.6	42	252.5	283.0	313.5
2	54	441.0	503.9	566.8	28	303.7	413.7	523.7
3	52	538.8	599.1	659.3	39	449.4	505.3	561.2
4	28	536.2	588.2	640.1	31	474.3	527.4	580.5
5	44	604.1	652.0	699.9	19	475.0	553.4	631.7
6	37	635.6	709.8	784.1	39	556.9	618.7	680.4
7	34	672.3	752.6	832.9	20	534.5	612.0	689.4
8	30	725.3	847.1	968.9	26	670.7	752.3	833.9
9	31	791.8	855.3	918.7	22	796.7	911.8	1 026.8
10	28	861.3	956.9	1 052.5	15	724.1	845.6	967.1
11	17	883.3	1 060.2	1 237.2	10	999.3	1 095.0	1 190.6
12	24	901.6	1 075.2	1 248.7	12	796.5	989.1	1 181.7
13	21	1 062.7	1 201.4	1 340.0	19	913.3	1 050.2	1 187.1
14	28	1 095.3	1 204.2	1 313.2	11	1 081.5	1 194.5	1 307.5
15	30	1 246.8	1 360.6	1 474.5	28	1 197.1	1 307.6	1 418.2
16	40	1 506.4	1 646.9	1 787.4	16	1 134.3	1 347.5	1 560.6
17	56	1 485.8	1 589.0	1 692.2	36	1 250.5	1 398.4	1 546.3
18	56	1 609.7	1 705.7	1 801.6	26	1 350.6	1 504.4	1 658.2
19	69	1 563.0	1 672.9	1 782.8	36	1 350.2	1 456.3	1 562.4

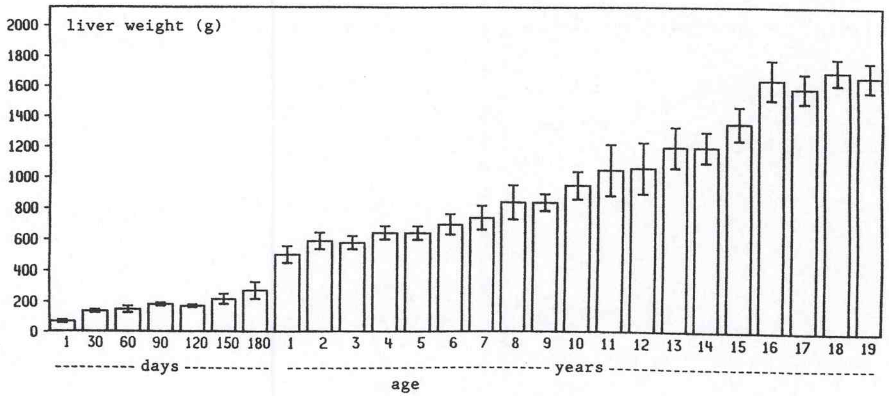


Fig. 62: Mean liver weight (g) in boys, according to age, 1900-1981

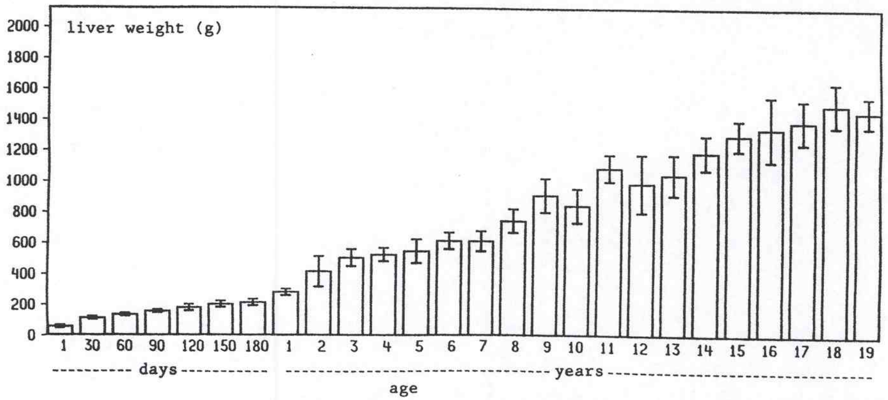


Fig. 63: Mean liver weight (g) in girls, according to age, 1900-1981

Development of relative liver weight compared to body weight (g/kg) was computed 41.75 g/kg for boys, and 43,9 g/kg for girls at birth. As demonstrated in fig. 65, a smooth decrease in relative liver weight in both boys and girls can be seen until grown up.

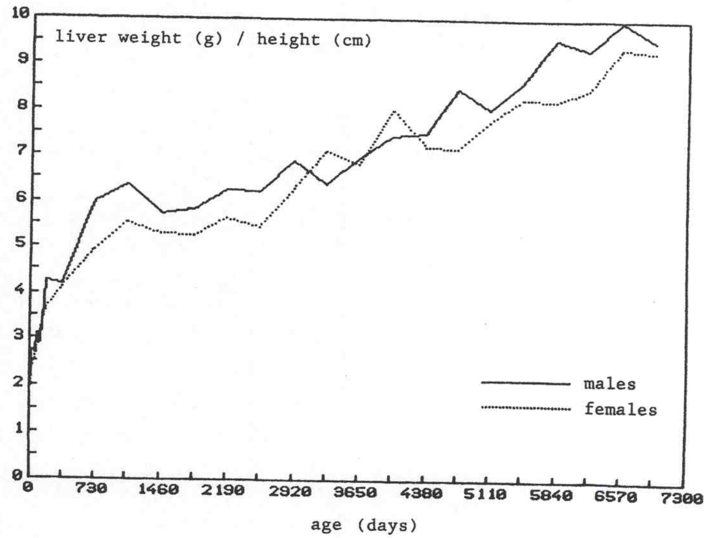


Fig. 64: Relative liver weight (g/cm) according to sex and age, 1900-1981

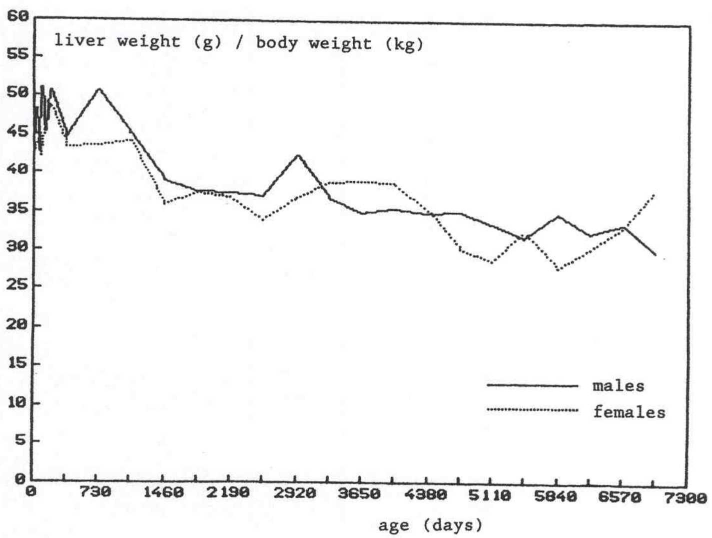


Fig. 65: Relative liver weight (g/kg) according to sex and age, 1900-1981

16. Liver weight in autopsied adults

Liver weight was documented in 4,163 males and 2,226 adult females not suffering from diseases directly affecting the liver; table 22. Distribution of liver weight in males and females (figs. 66 and 67) shows a standard distribution with a broad peak between 1,300-1,700 g in males, and 1,000-1,500 g in females. The remarkably broad frequency distribution may be caused by different amount of blood and edema in liver at time of death. In adults, liver weight increases from 20-40 years of age (fig. 68) in males and females. Later, a constant, smooth decrease was found up to highest age groups. Correlation coefficients between liver weight and age were computed as r = 0.30 for males, and r = 0.33 for females. Average decrease in liver weight after 40 years of age was found to be 68.4 g/10 years in males, and 77.6 g/10 years in females (similar relationship in both sexes). Average weight of the liver at the age 53 years was found to be 1,590 g in males, and 1,380 g in females.

Comparison in liver weight and date of birth (fig. 69) shows a smooth but constant increase for all age groups in males and females.

Average liver weight was found to be increased with increasing height (fig. 70). Correlation coefficients were computed r = 0.37 in males and r = 0.37 in females. Increase of liver weight was measured 19.8 g/cm in males and 16.7 g/cm in females.

Table 22: Liver weight according to age groups (g)

age groups	n	mean + confidence limits p ≥ 0.95		
males				
20-29	486	1 691.1	1 724.8	1 758.5
30-39	463	1 732.1	1 768.3	1 804.5
40-49	657	1 705.6	1 734.5	1 763.3
50-59	856	1 647.3	1 672.6	1 697.8
60-69	939	1 544.2	1 565.4	1 586.5
70-79	580	1 388.8	1 414.3	1 439.7
80-89	168	1 313.4	1 365.7	1 418.0
90-99	14	1 008.2	1 157.8	1 307.4
females				
20-29	250	1 499.2	1 543.4	1 587.7
30-39	329	1 551.9	1 591.6	1 631.3
40-49	363	1 520.9	1 557.9	1 594.9
50-59	411	1 460.0	1 495.2	1 530.5
60-69	407	1 374.9	1 408.5	1 442.1
70-79	358	1 222.8	1 252.3	1 281.7
80-89	142	1 128.6	1 172.7	1 316.8
90-99	6	767.7	1 035.0	1 302.2

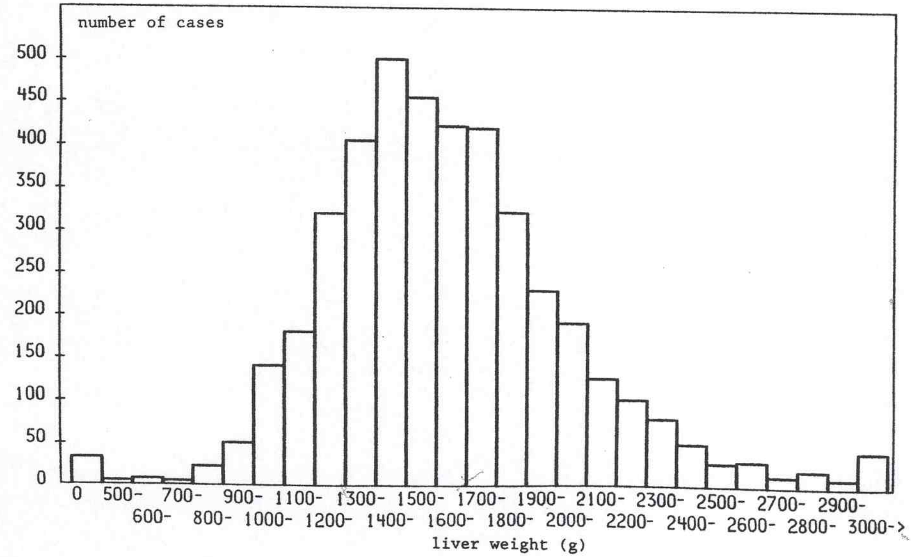


Fig. 66: Frequency distribution of liver weight (g) in males (≥ 20 years), 1900-1981

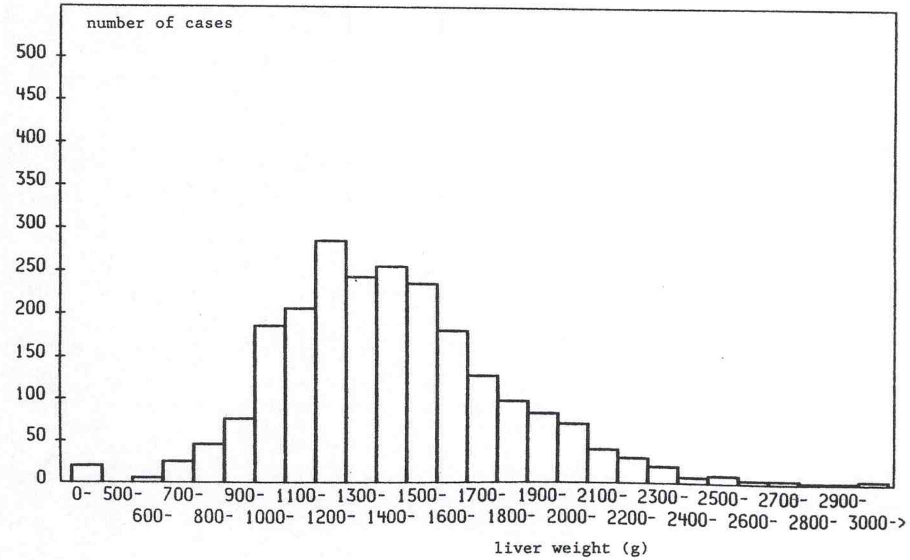


Fig. 67: Frequency distribution of liver weight (g) in females (≥ 20 years), 1900-1981

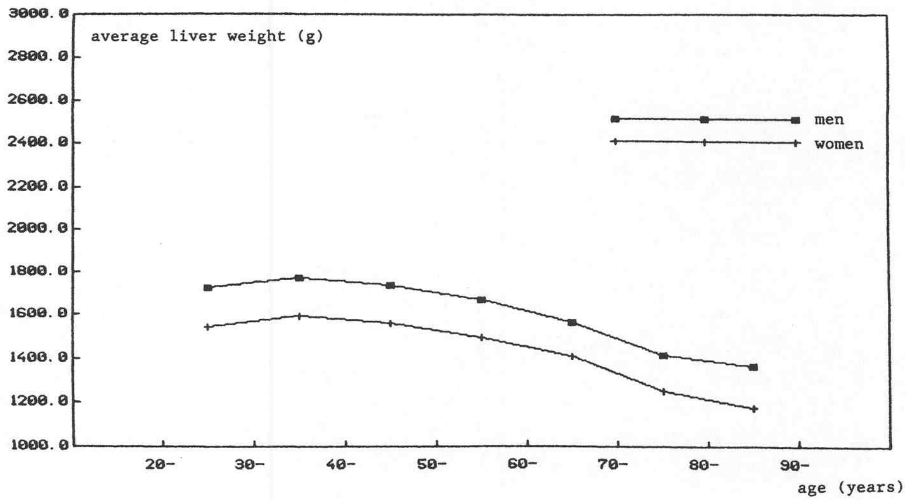


Fig. 68: Mean liver weight (g) according to sex and age, 1900-1981

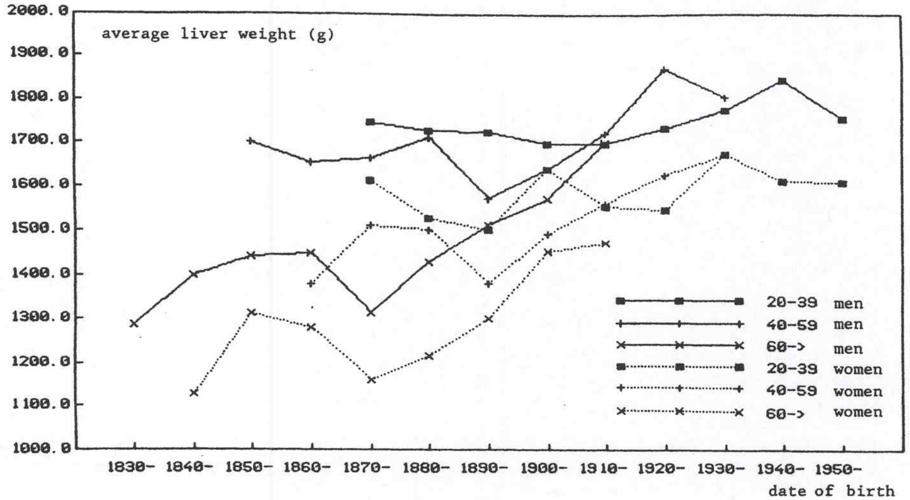


Fig. 69: Mean liver weight (g) according to date of birth and age 1900-1981

The average liver weight as grouped according to age and height is shown in figs. 71 and 72. With increasing age, similar decrease in liver weight was found in all groups of body height.

Liver weight as compared to body weight in adults increased constantly with increasing body weight (fig. 73). Correlation coefficients were computed r = 0.39 in males, and r = 0.36 in females. Corresponding increase of liver weight with increasing body weight was computed 112,03 g/kg in males, and 11,29 g/kg in females.

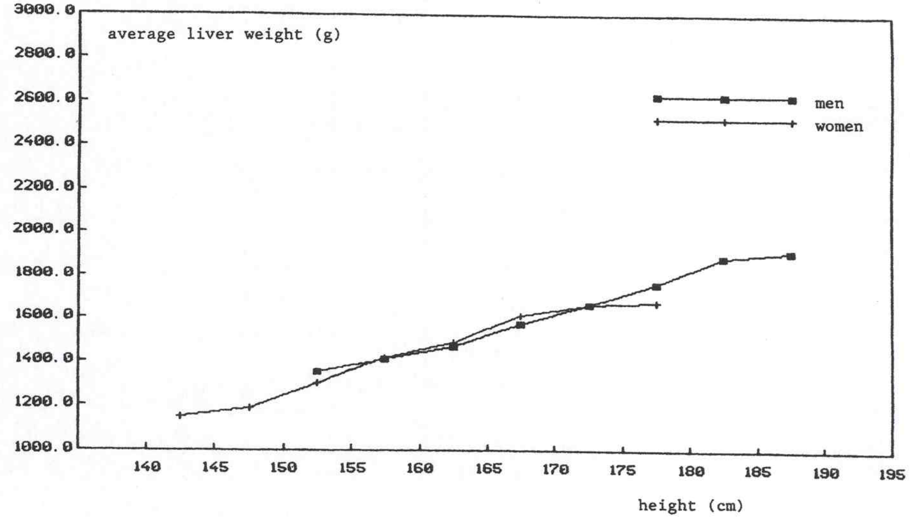


Fig. 70: Mean liver weight (g) according to sex and height, 1900-1981

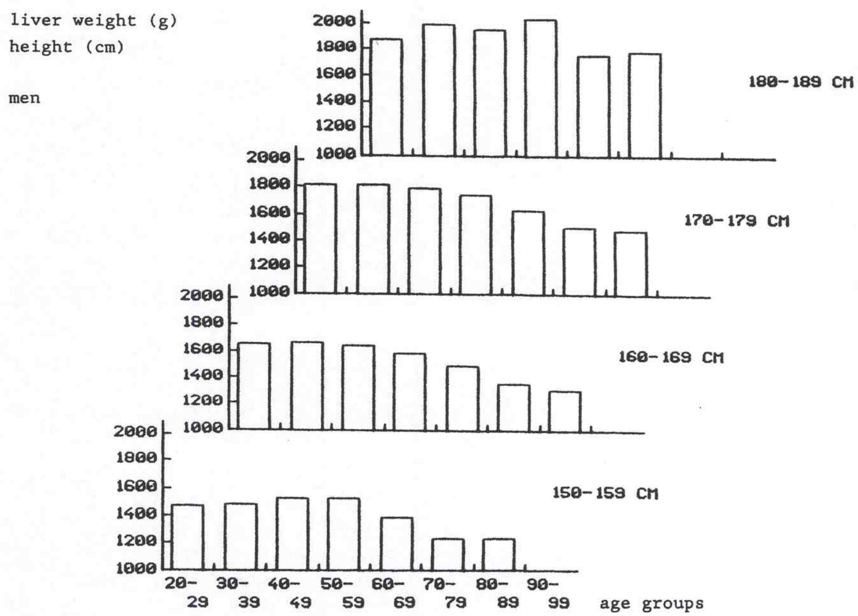


Fig. 71: Mean liver weight (g) in males according to age and height, 1900-1981

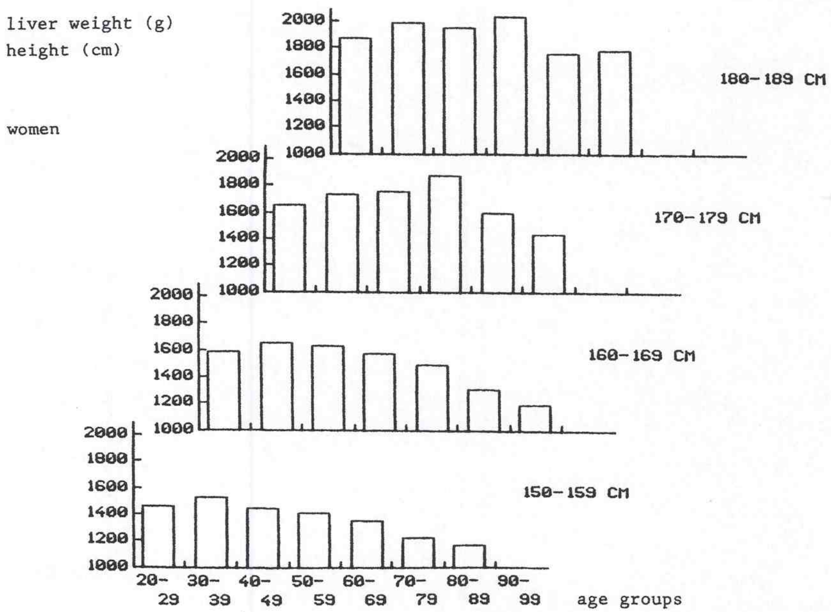


Fig. 72: Mean liver weight (g) in females according to age and height, 1900-1981

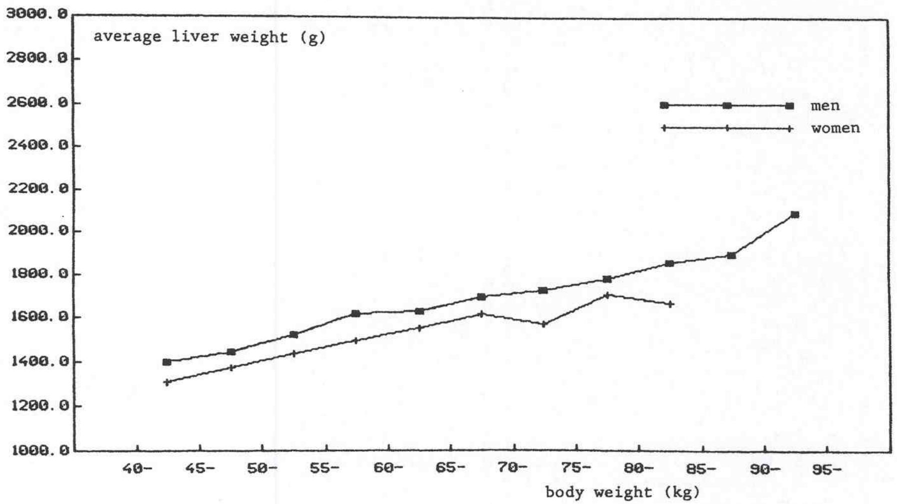


Fig. 73: Mean liver weight (g) according to sex and body weight, 1900-1981

The relative liver weight (liver weight/height) in relation to height is shown in fig. 70. Dependency of relative liver weight upon height is slight but detectable for both, males and females. In small persons (155-160 cm), relative liver weight measured 9.0 g/cm, in tall persons (175-190 cm) relative liver weight measured 10 g/cm. The obtained difference is statistically significant ($p < 0.05$).

17. Discussion

Absolute liver weight is to a high degree influenced by the amount of blood and edema at time of death. RASO and SIQUEIRA (1963) found that liver weight in living people is 500 g heavier than measured at autopsy. According to SCHÜTZ (1925) blood accounts for 50% of the liver weight. Therefore retrospective analysis of liver weight in autopsy material is of limited value and obtained data should be validated by additional prospective studies.

Increase of liver weight during childhood as reported by ROESSLE and ROULET (1932) and VIERORDT (1906) is given in table 23.

DELAND and NORTH (1968) analysed the liver weight using isotopes in living patients and found a percentage of liver weight compared to body weight q = 3.8%. Studies on liver weight using isotopes or ultrasound were also performed by BANEVER and SPENCER (1979); CARR (1976); FRAGERLI and ROKKONES (1980). RAD and WAGNER (1972) computed similar liver weights according to body weight and height. URBAN et al (1977); KARDEL et al. (1971); and ZSCHOCH and KLEMM (1972) found higher correlation coefficients of liver weight according to body weight and height (table 24) as obtained in our material.

All authors reported end of development of liver at 19 years (BEAN, 1920; MEYER et al., 1963; MÜHLMANN, 1927; UOTILA, 1940; ZSCHOCH and KLEMM, 1972; BEAN 1920). Decrease of liver weight with increasing age after 40 years was found by most of the authors. The decrease in liver weight was found to be caused by aging with decreasing amount of liver cells per volume (TAUCHI and MORIKAWA, 1954). The morphometric measurement showed an increase of cells with two nuclei, and increasing nuclear volume of liver cells with increasing age. In correspondence with decrease of liver parenchyma extracellular fluid was increased. Data were explained by existence of an inhibitory factor for cell division of liver cells. In addition, differences between races were found (Hawaiian – Japanese, Caucasian – American). Changes of morphometric aspects of liver cells were found to start at earlier lifetime in Caucasians than in Japanese. However, a decrease in liver weight was more remarkable in Japanese. Differences seemed to be more related to different nutrition than to different genetic factors.

Development of liver weight during growth period is delayed compared to development of body weight. The situation is similar to the development of brain weight. The two known growth spurts in development of height with decrease of growth of height in boys of 13-16 years, and in girls of 12-15 years have similarities in development of liver weight. Two plateaus in growth of liver with consecutive acceleration periods exist during age groups 2-6 years and 13-15 years in boys, and 2-6 years and 11-13 years in girls respectively.

Table 23: Average liver weight up to the age of 25 years according to Vierordt (1906)

	MALES		FEMALES	
age	number of cases	absolute weight (g)	number of cases	absolute weight (g)
months				
00	10	141.7	16	164.0
01	2	100.5	2	108.5
02	–	–	2	122.5
03	3	132.3	–	–
04	–	–	–	–
05	5	148.7	7	161.7
06	–	–	–	–
07	–	–	–	–
08	1	404	2	220.5
09	–	–	–	–
10	11	–	3	239
11	5	333.5	–	–
12	7	–	9	275.5
years				
01.25	–	–	–	–
01.5	2	333.5	3	357.3
01.75	1	412	–	–
02	28	428.5	25	417.5
02.5	–	–	5	473.5
03	17	484.7	19	445
03.5	18	588.5	1	417.2
04	18	596.2	11	555
05	15	538.8	19	566.3
06	5	614.8	10	642
07	11	688	8	680.6
08	2	650	6	734
09	4	701.7	4	795
10	7	836.7	2	850
11	9	870.4	3	902.5
12	3	880	1	807.9
13	6	1036	2	810
14	7	1188.7	5	1025
15	5	1306	6	1420
16	10	1339.2	8	1541
17	12	1481.5	12	1435.7
18	13	1509.6	14	1478
19	15	1644.6	10	1459.7
20	11	1560.8	25	1568.4
21	21	1626.9	19	1568.9
22	20	1675	14	1443.4
23	17	1528.3	17	1514.8
24	22	1847.7	21	1756.6
25	17	1819	18	1664

Table 24: Correlation coefficients of liver weight according to body weight

Author	males	females
Greenwood 1904	0.57	–
Zschoch and Klemm 1972	0.5515	0.5316
Urban 1977	0.58	0.69
Kardel 1971	0.55	0.55
own data	0.38	0.36

Similar data were reported by VIERORDT (1906). BEAN (1926) found three growth acceleration periods between 3-12 months, 2-8 years, and 14-15 years. Our own data indicate cessation of growth periods in liver close to 16 years with slightly increasing liver weight during later life time.

Absolute liver weight remained constant in different birth cohorts if compared within the same groups of height and body weight. Data are in accordance with those previously reported by BOYD (1933); MEYER et al. (1963); MÜHLMANN (1927); UOTILA (1940); ZSCHOCH and KLEMM (1972).

18. Spleen weight in autopsied children

The spleen weight was documented in 1,612 autopsied boys and 1,266 autopsied girls during the period 1900-1981; table 25. Average spleen weight was measured 6,6 g in boys, and 5.8 g in girls at birth, and was measured 195.6 g in males and 156.5 g in females at the age 19 years. The difference of weight of 39.1 between males and females is not statistically significant ($p > 0.05$) g. Development in spleen weight during childhood is given in figs. 74 and 75 for boys and girls. Spleen weight during childhood shows high standard deviation at birth and in all age groups. Maximum spleen weight was computed at the age of 17 years (boys) and 16 years (girls). A smooth decrease of spleen weight in boys was found between the age 7 and 12, and between the age 8 and 12 in girls. This decrease is not statistically significant, but a delay in development of spleen weight exists. Relative spleen weight compared to body weight (g/kg) during childhood is given in fig. 76 for both boys and girls. The curve shows again broad variations and some peaks which are not statistically significant ($p > 0.05$). Relative spleen weight was measured 3.95 g/kg for males, and 3.88 g/kg for females at an average. It was found to be constant after 1 year of age.

Table 25: Spleen weight according to age (g)

age groups	n	mean + confidence limits $p \geq 0.95$			n	mean + confidence limits $p \geq 0.95$		
		males				females		
days 1	488	5.9	6.6	7.3	426	5.1	5.8	6.4
2- 30	126	11.0	12.4	13.8	76	9.6	11.5	13.4
31- 60	113	14.2	16.3	18.4	83	16.4	22.9	29.4
61- 90	80	14.8	17.4	20.0	64	12.3	16.3	20.2
91-120	83	14.8	19.1	23.4	58	12.7	14.6	16.5
121-150	68	17.9	23.0	28.0	49	15.4	19.9	24.4
151-180	47	16.6	20.0	23.4	42	14.8	18.2	21.6
years 1	61	26.6	31.1	35.7	47	19.9	23.5	27.1
2	62	38.2	42.6	47.0	38	34.8	42.0	49.2
3	47	44.7	54.8	64.9	45	36.2	41.8	47.3
4	37	46.3	58.7	71.2	22	40.0	49.3	58.5
5	29	46.9	56.8	66.7	20	41.5	50.7	59.8
6	28	57.2	69.3	81.5	34	56.5	67.2	77.8
7	25	66.5	103.3	140.1	14	48.4	64.2	80.0
8	23	60.8	73.1	85.3	23	66.9	94.3	121.6
9	23	61.9	90.9	119.9	21	66.9	80.9	94.9
10	29	82.7	111.3	139.9	8	60.7	90.0	119.2
11	14	62.0	90.0	117.9	6	62.8	87.5	112.1
12	23	90.6	114.7	138.8	11	68.8	89.0	109.3
13	12	83.3	138.7	194.1	19	98.3	129.0	159.6
14	24	111.1	151.2	191.3	18	110.8	162.8	214.9
15	24	119.2	155.3	191.4	22	97.3	129.2	161.0
16	30	135.4	165.1	194.8	21	160.0	219.0	277.9
17	33	164.5	212.7	260.9	40	140.7	158.0	175.3
18	37	155.9	181.0	206.2	25	121.3	146.4	171.5
19	46	166.6	195.6	224.6	34	116.5	156.5	196.4

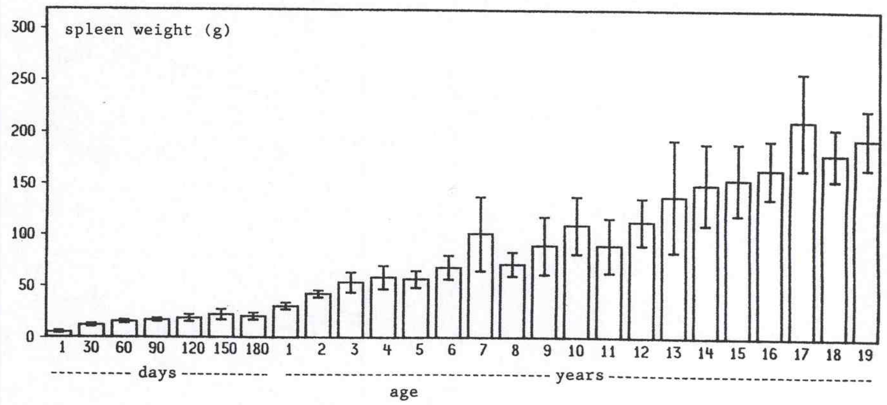


Fig. 74: Mean spleen weight (g) in boys according to age, 1900-1981

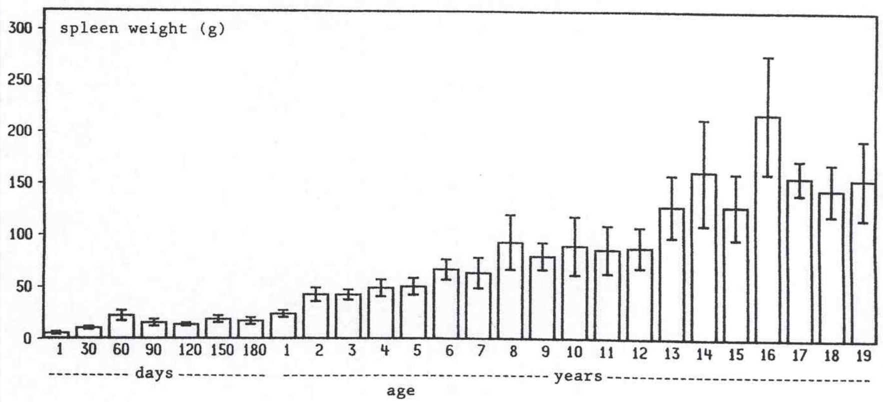


Fig. 75: Mean spleen weight in girls according to age, 1900-1981

The relative weight of the spleen as compared to height (g/cm) is given in fig. 77. Besides the variations already noted, a nearly linear increase of relative spleen weight compared to height can be seen. The peaks observed are not statistically significant ($p > 0.05$).

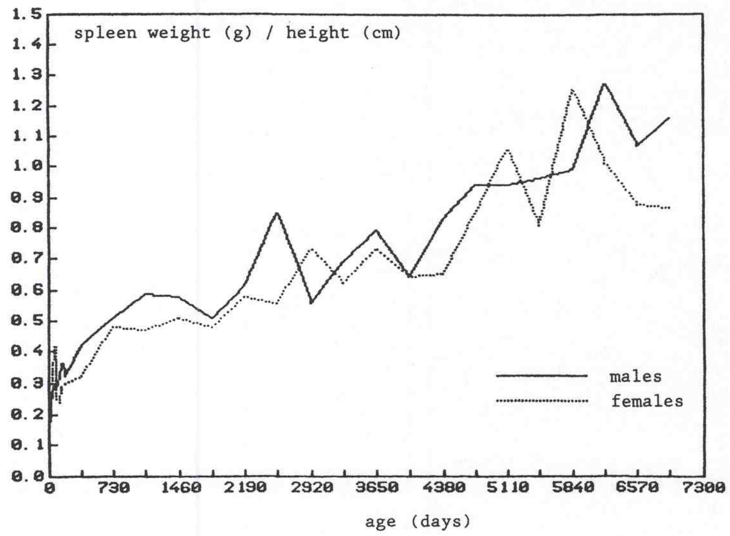


Fig. 76: Relative spleen weight (g/cm) according to sex and age, 1900-1981

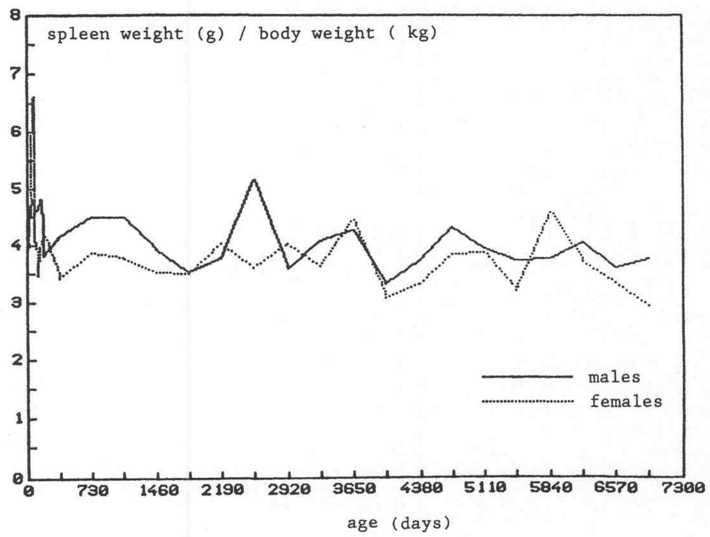


Fig. 77: Relative spleen weight (g/kg) according to sex and age, 1900-1981

19. Spleen weight in autopsied adults

Greater variations in spleen weight found in children were also noted in adults. Frequency distributions of spleen weight in males (fig. 78) and females (fig. 79) computed from 5,708 autopsied males and 4,199 autopsied females show a broad but bisymmetric curve. Maximum spleen weight was found to be 126-150 g in males and 126-150 g in females, respectively.

A smooth increase in spleen weight from 20 to 40 years can be noted in adults (fig. 80; table 26). After this age, a steady decrease in spleen weight up to highest age groups was found. Regression coefficients were small and computed $r = 0.16$ in males, and $r = 0.18$ in females. Average weight of the spleen was measured 165 g in males and 150 g in females, at an average age of 58 years in both males and females.

Development in spleen weight for different birth cohorts is given in fig. 81. A steady increase in spleen weight was noted for all age groups in both, males and females during the period considered. Average increase was computed 20-25 g/decade in younger age groups, and 40 g/decade in higher age groups. Average spleen weight as compared to body weight (g/kg) is shown in fig. 82 for both, males and females. A smooth but constant increase of spleen weight with

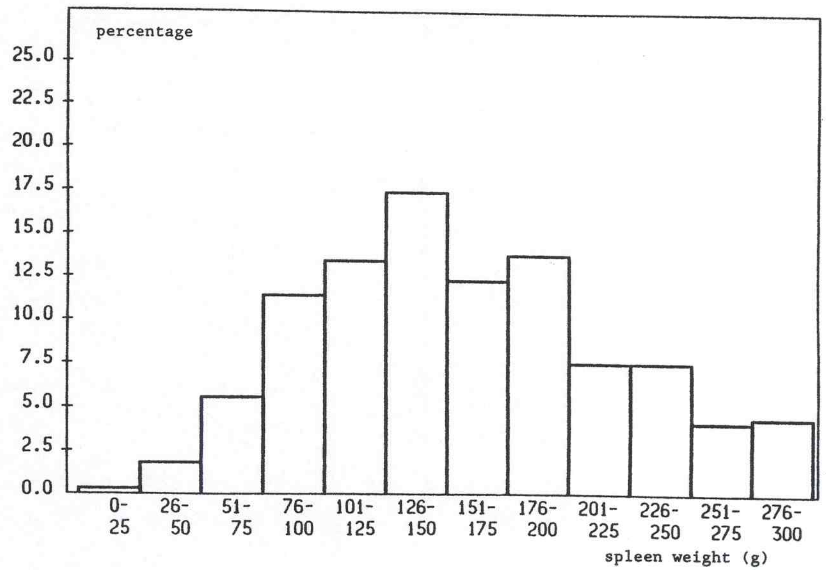


Fig. 78: Frequency distribution of spleen weight (g) in males, 1900-1981

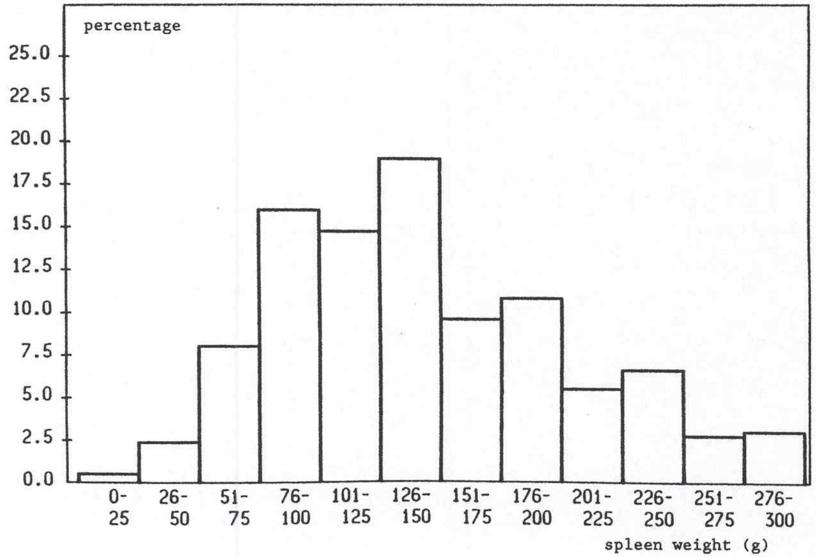


Fig. 79: Frequency distribution of spleen weight (g) in females (≥ 20 years), 1900-1981

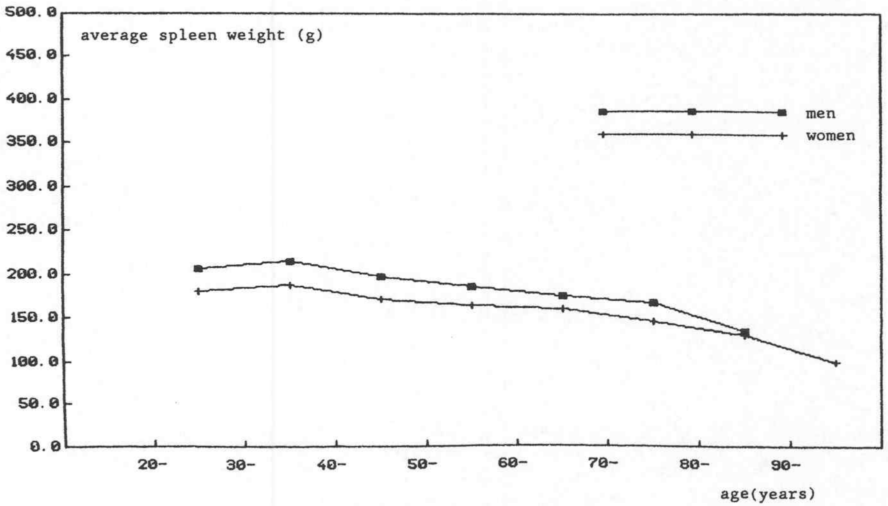


Fig. 80: Mean spleen weight (g) according to sex and age, 1900-1981

increasing body weight can be noted. Correlation coefficients were computed r = 0.26 in males, and r = 0.24 in females. Average increase in spleen weight was found to be 1.17 g/kg in males, and 1.07 g/kg in females. Dependency of spleen weight upon body weight is more remarkable than upon age.

Table 26: Spleen weight according to age groups (g)

age groups	n	mean + confidence limits p ≥ 0.95		
males				
20-29	482	197.4	205.5	213.7
30-39	550	205.3	213.3	221.3
40-49	888	189.7	196.0	202.2
50-59	1337	179.9	184.6	189.3
60-69	1385	170.5	175.2	179.8
70-79	849	160.9	166.5	172.2
80-89	206	124.3	133.0	141.6
90-99	11	88.1	125.0	161.8
females				
20-29	311	170.3	179.1	188.0
30-39	420	177.7	186.1	194.6
40-49	600	162.9	169.5	176.1
50-59	862	158.2	163.7	169.2
60-69	941	154.3	159.5	164.7
70-79	800	139.7	144.7	149.7
80-90	244	120.1	128.9	137.6
90-99	21	75.3	98.2	121.0

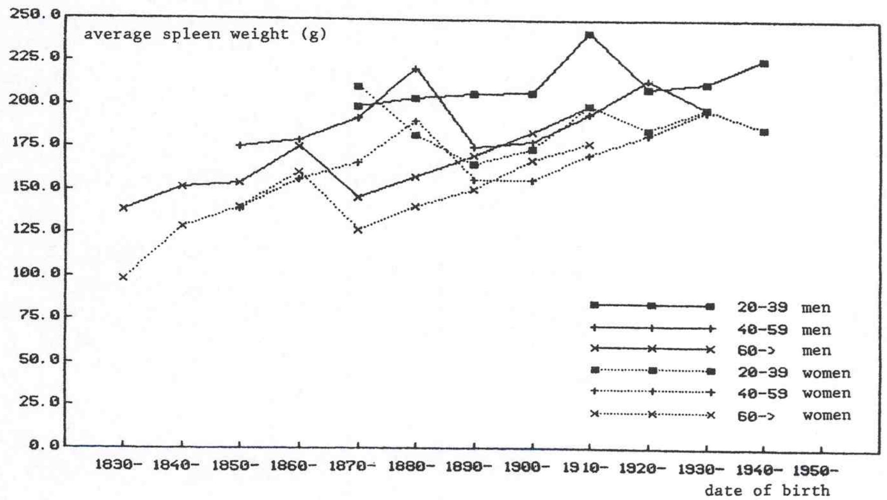


Fig. 81: Mean spleen weight (g) according to sex, age and date of birth

Similar increases in the spleen weight was found with increasing height (fig. 83). Correlation coefficients were similar to those obtained for weight, and were computed r = 0.21 in males and females. Increase in spleen weight with increasing height was found to be 1.77 g/cm in males and 1.73 g/cm in females, respectively. A similar decrease in weight of the spleen with increasing age was found in males and females (figs. 84 and 85) for all groups of height.

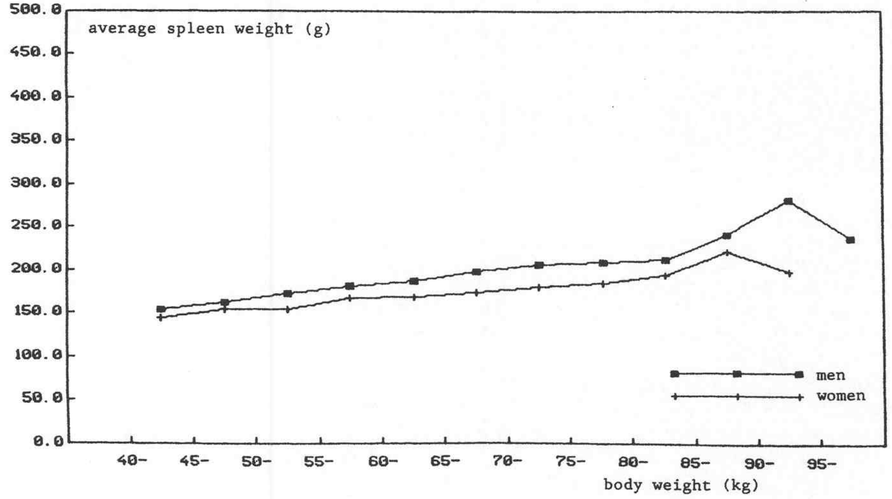


Fig. 82: Mean spleen weight (g) according to sex and body weight (kg), 1900-1981

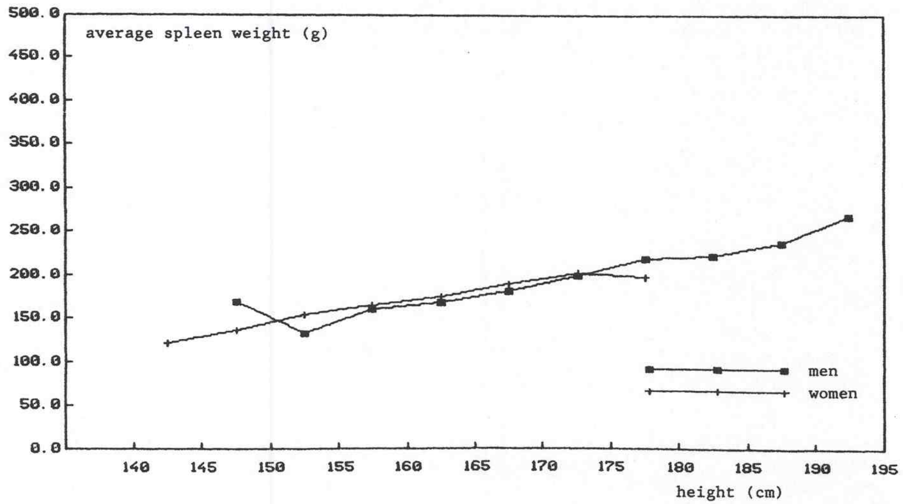


Fig. 83: Mean spleen weight (g) according to sex and height (cm), 1900-1981

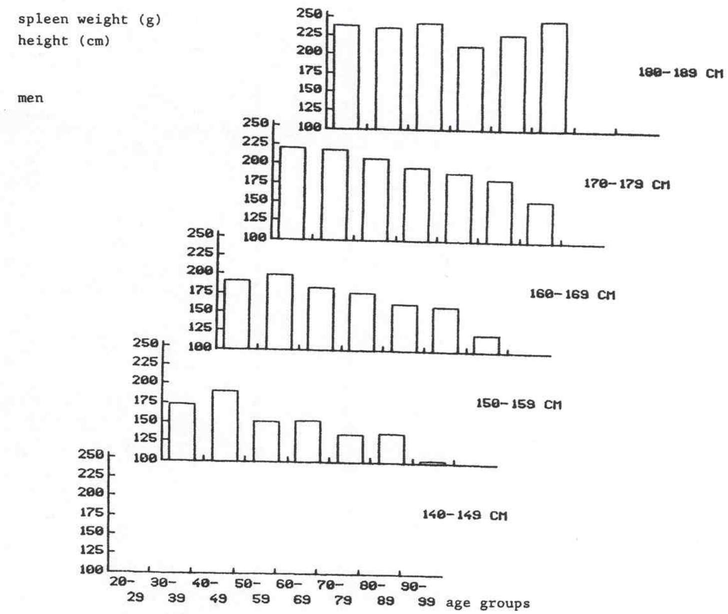


Fig. 84: Mean spleen weight (g) in males according to age and height, 1900-1981

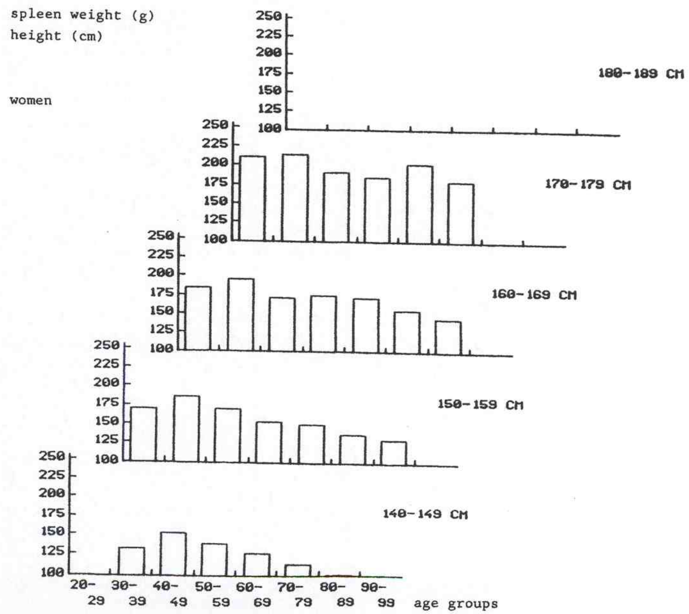


Fig. 85: Mean spleen weight (g) in females according to age and height, 1900-1981

20. Discussion

Exact measurements of spleen weight are difficult due to the various amount of blood and acute reaction of lymphatic tissue to harmless infections. In literature, spleen weight was reported to be 10-12 g at birth in boys and girls (BEAN, 1920; JACOBS, 1934; KRESS, 1902; OPPENHEIMER, 1888; UOTILA, 1940; VIERORDT, 1906) which is slightly higher than our data. The maximum spleen weight was found at the age of 20 years in males, (265 g) and 18-19 years (220 g) in females, respectively (BEAN, 1920; BOYD, 1933; KRUMBHAAR and LIPPINCOTT, 1939). Most authors reported a decrease in spleen weight reaching the final weight 90-110 g at the age of 90 years (BEAN, 1920; BOYD 1933; DELAND, 1970; MÜHLMANN, 1927; ROESSLE and ROULET, 1932; UOTILA, 1940). MOON (1928) reported a lower spleen weight in Blacks than in Whites for both males and females at all age groups. DE LEON et al (1933) reported a small increase of the spleen weight until the age of 40, according to data from MOON (1928), and concurring with our data. The spleen was found to be heavier in males than in females which is in accordance with data of all authors except NEUGARTEN (1921) who found a higher spleen weight in females (140 g) than in males (113.3 g). Dependency in spleen weight according to age is weak according to low correlation coefficients. Correlation coefficients similar to those obtained by us were reported by LINDSAY (1979); MEYER et al. (1963); and ZSCHOCH and KLEMM (1972). Low correlation coefficients may indicate that decrease in spleen weight with increasing age is not directly caused by age factors. Lower spleen weight was reported in different races as in Blacks (BEAN, 1920; MOON, 1928), Japanese (SALLER, 1956) and Filippinos (DE JESUS et al, 1934; and DE LEON et al., 1933), compared to Caucasians.

Increase of spleen weight with increasing body weight was found by several authors (MEYER et al., 1963; MOON, 1928; ZSCHOCH and KLEMM, 1972). MEYER et al. (1963) reported high correlation coefficients between spleen weight and body weight in females (r = 0.68), but low correlation coefficients in males (r = 0.18). ZSCHOCH and KLEMM (1972) reported moderate high correlation coefficients (r = 0.39 in males and r = 0.42 in females). MOON (1928) found a diminished relative spleen weight in Blacks compared to that in Whites. In contrast to the data reported, we were not able to obtain differences in correlation coefficients in males and females. However, we must indicate that our data are biased, and all patients suffering from diseases which may affect the spleen were neglected. Similar data as ours were reported by DE JESUS et al. (1933). Dependence of spleen weight to height is not as strong as to body weight. The findings are in agreement with data reported by DE JESUS et al. (1933); DELAND (1970); ZSCHOCH and KLEMM (1972).

21. Lung weight in autopsied children

The weight of the right lung could be evaluated in 686 autopsied boys and 536 autopsied girls; the weight of the left lung in 684 autopsied boys and 540 autopsied girls, respectively. The right lung measured 17.4 g at birth in boys, and 15.8 g at birth in girls; table 27. The left lung measured 14.8 g in boys, and 13.4 g in girls. Absolute average weight of the right lung was computed 594 g in boys, and 456 g in girls at 19 years of age. The average weight of the left lung measured 497 g in boys, and 377 g in girls. Development of weight of the right and left lung in boys and girls during childhood is shown in figs. 86 and 87. Standard deviations are high according to data reporting various amounts of blood at death (JOACHIM

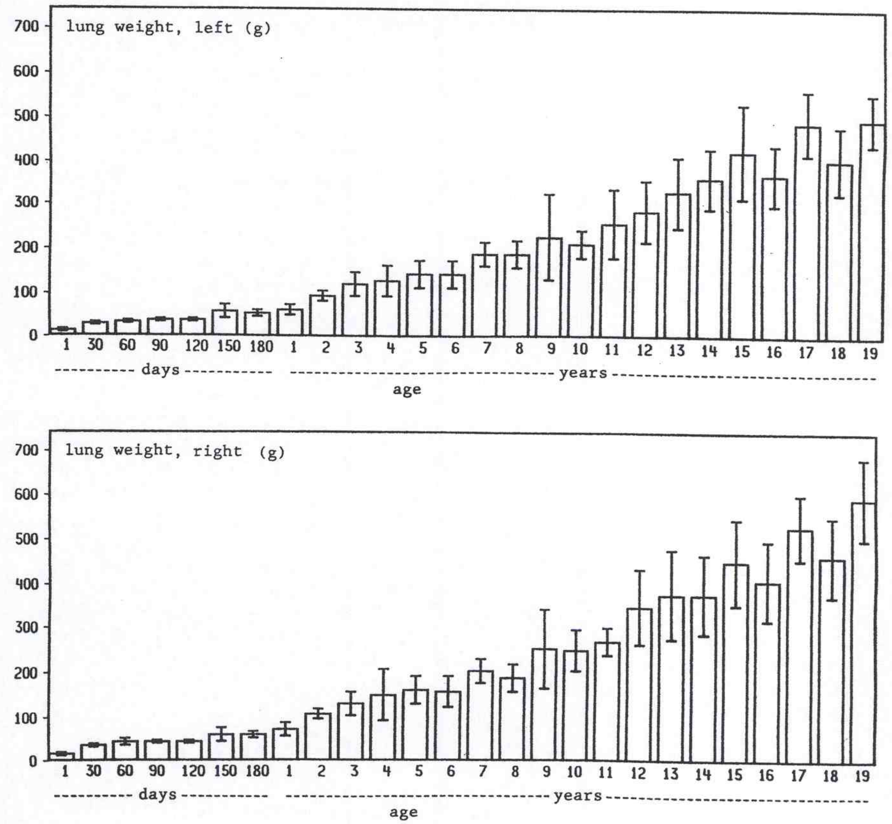


Fig. 86: Mean weight of left lung (g) in boys according to age, 1900-1981

Table 27: Lung weight according to age (g)

age groups	right lung n	mean + confidence limits p ≥ 0.95			left lung n	mean + confidence limits p ≥ 0.95		
males								
day 1	238	16.0	17.4	18.7	237	13.7	14.8	15.9
2- 30	40	31.8	35.9	39.9	41	26.9	31.0	35.0
31- 60	39	34.4	44.1	53.8	39	28.4	34.6	40.8
61- 90	25	40.7	46.4	52.0	25	33.0	37.8	42.5
91-120	31	38.1	43.6	49.0	31	33.2	38.5	43.8
121-150	28	42.0	58.9	75.8	28	36.6	55.0	73.3
151-180	17	49.5	61.0	72.5	17	44.9	52.8	60.8
years 1	16	54.4	73.1	91.7	16	44.7	60.2	75.7
2	28	92.9	107.6	122.4	27	78.1	90.5	103.0
3	20	100.1	128.5	156.8	20	88.4	118.4	148.3
4	12	90.9	150.5	210.0	12	86.1	125.0	163.8
5	14	125.8	160.6	195.3	14	106.8	141.5	176.1
6	13	120.5	159.3	198.2	13	108.6	141.4	174.2
7	12	174.6	203.1	231.7	12	160.7	189.6	218.5
8	9	155.8	187.7	219.7	9	154.8	187.2	219.5
9	8	162.5	253.7	344.9	8	129.6	228.1	326.5
10	17	202.2	250.4	298.6	17	179.0	213.2	247.5
11	7	238.6	270.8	303.0	7	177.9	257.2	336.6
12	15	263.5	349.6	435.7	15	212.3	286.0	359.6
13	9	272.3	375.5	478.7	9	244.8	328.8	412.8
14	12	285.1	375.8	466.5	12	287.9	361.2	434.5
15	15	347.9	448.0	548.0	15	309.8	420.0	530.1
16	15	316.9	406.6	496.3	15	291.8	365.6	439.4
17	18	450.7	527.5	604.3	18	411.3	487.7	564.2
18	10	370.0	460.0	549.9	10	323.1	403.2	483.2
19	18	498.3	593.8	689.3	17	435.7	497.0	558.3
females								
days 1	200	14.5	15.8	17.1	203	12.3	13.5	14.7
2- 30	29	23.4	39.6	55.7	29	20.1	34.3	48.5
31- 60	31	32.7	37.9	43.0	32	29.2	34.5	39.7
61- 90	27	36.1	40.8	45.5	27	30.9	35.2	39.5
91-120	17	35.2	43.5	51.8	17	31.6	39.8	48.0
121-150	19	34.8	44.2	53.6	19	30.6	38.2	45.7
151-180	17	40.9	48.4	56.0	17	37.1	43.8	50.4
years 1	13	38.3	54.9	71.5	13	32.5	49.9	67.3
2	13	88.5	116.4	144.4	13	83.1	103.0	122.9
3	13	107.9	121.9	135.9	13	86.5	104.3	122.0
4	10	111.3	132.4	153.4	10	100.1	115.7	131.2
5	6	106.1	156.1	206.1	6	101.9	142.0	182.0
6	20	151.0	178.7	206.4	20	140.5	169.7	198.9
7	10	145.0	211.0	276.9	10	124.4	159.8	195.1
8	14	156.3	232.7	309.1	14	155.9	204.2	252.6
9	9	165.3	212.2	259.0	9	136.4	175.5	214.6
10	5	82.8	251.0	419.1	5	65.0	218.0	370.9
11	6	214.6	247.5	280.3	6	196.7	232.5	268.2
12	6	121.0	205.0	288.9	6	110.4	182.5	254.5
13	12	286.3	345.8	405.2	12	253.1	297.0	340.9
14	7	178.1	263.5	348.9	7	151.0	237.1	323.1
15	11	299.9	363.1	426.3	11	237.4	282.7	327.9
16	6	233.2	464.1	695.0	6	193.8	430.8	667.7
17	14	360.3	475.0	589.6	14	305.2	391.4	477.6
18	8	287.6	415.0	542.3	8	227.2	326.2	425.2
19	13	327.7	456.1	584.5	13	290.7	377.3	463.9

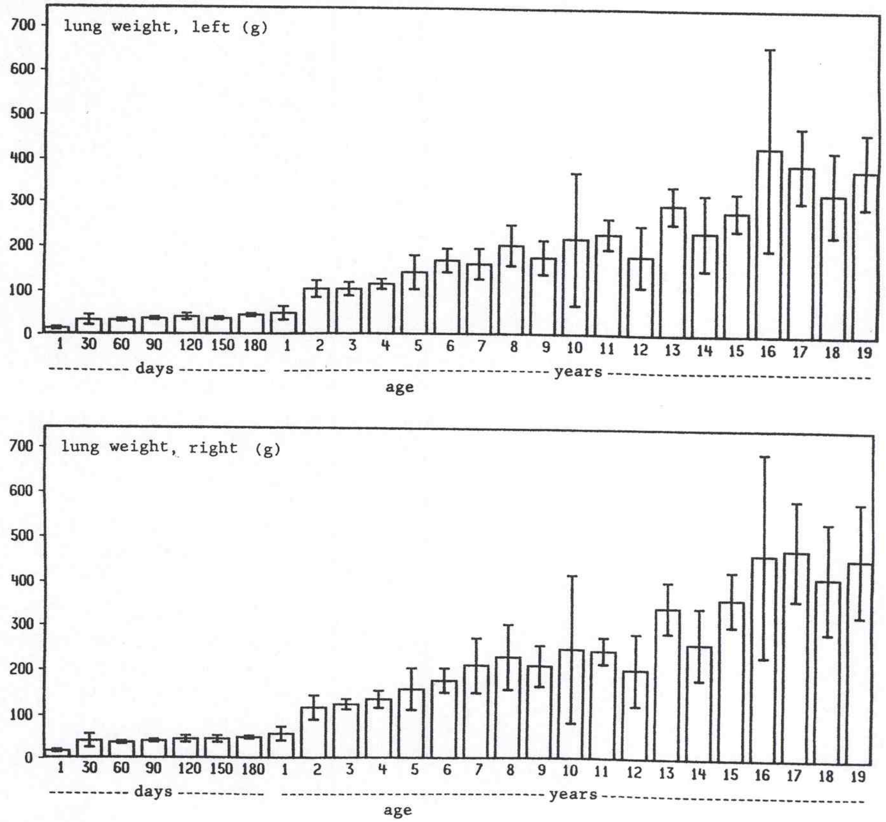


Fig. 87: Mean weight of left lung (g) in girls according to age, 1900-1981

et al., 1978; KRESS, 1902; ROESSLE and ROULET, 1932). Significant differences of lung weight measured in boys and girls were observed at the age 12 years and older ($p < 0.05$). Average difference of lung weight between males and females measured 140 g for the right lung and 120 g for the left lung. Development of absolute weight of the lungs showed diminished acceleration between 4 years and 9 years in boys, and between 6 years and 12 years in girls.

Relative lung weight compared to body weight (g/kg) is similar for right and left lung, and remains constant for all age classes older than two years in boys and girls. Relative weight of the right lung was computed 11.3 g/kg in 19-year-old boys, and 9.45 g/kg in 19-year-old girls. Relative weight of the left lung measured 9.33 g/kg in 19-year-old boys, and 7.72 g/kg in 19-year-old girls, respectively.

Relative lung weight compared to height (g/cm) is given in figs. 88 and 89. A constant increase of relative weight of the right and left lung for both males and females can be noted. Relative weight of the right lung was computed 3.71 g/cm in 19-year-old boys, and 3.03 g/kg in 19-year-old girls. Relative weight of the left lung measured 3.01 g/cm in males and 2.53 g/cm in females, respectively.

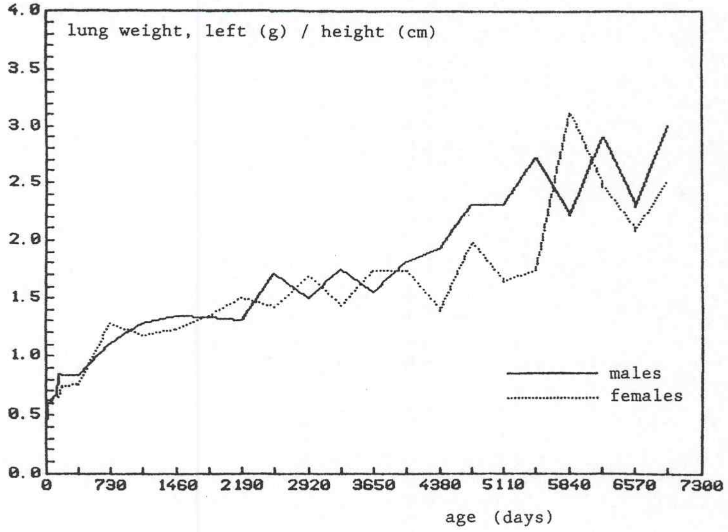


Fig. 88: Relative weight of left lung (g/cm) according to sex and age, 1900-1981

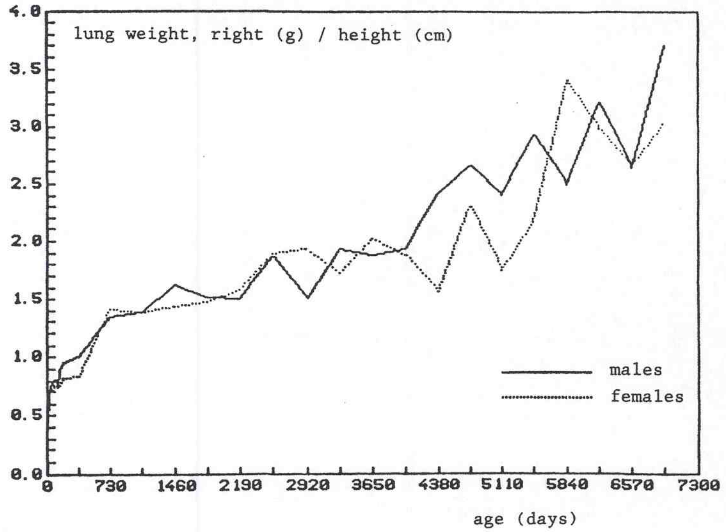


Fig. 89: Relative weight of right lung (g/cm) according to sex and age, 1900-1981

22. Lung weight in autopsied adults

The absolute weight of the right (left) lungs was documented 1,060 (1,062) autopsied males, and 1,041 (1,042) autopsied females not being affected by diseases to a major extent; table 28. Frequency distribution of absolute weight of the right and left lungs for males and females is given in figs. 90. 91, 92, 93. Frequency distribution of weight of both lungs is similar to normal distribution, whereas standard deviation of absolute weight of both lungs is high. Mean weight was noted in the right lung between 550-600 g in males, and 450-500 g in females, and 450-500 g in males, 350-400 g in females for the left lung respectively. Relationship of right and left lung according to age at death is given in figs. 94 und 95. A smooth increase in weight of right and left lung is given between 20-35 years. Weight of both lungs remains constant in higher age groups. Average weight of the right lung was computed 655 g in males at average age at death 57 years, and 500 g in females at an average age at death of 51 years. Average weight of the left lung was computed 570 g in males and 415 g in females at same ages at death. All lung weights were obtained with high standard deviations. Correlation coefficients according to age at death were weak and computed $r = 0.05$ for right and left lung in males, and $r = 0.03$ for right and left lung in females, i.e. no relations could be obtained.

Table 28: Lung weight according to age groups (g)

age groups	right lung n	mean + confidence limits $p \geqslant 0.95$			left lung n	mean + confidence limits $p \geqslant 0.95$		
males								
20-29	186	567.8	594.8	621.7	187	514.3	541.3	568.4
20-39	179	617.3	648.7	680.2	180	520.4	547.8	575.1
40-49	211	638.2	666.1	194.0	211	544.9	568.9	592.8
50-59	175	647.0	673.3	699.7	174	540.9	564.3	587.6
60-69	190	645.0	673.5	701.9	191	551.5	575.1	598.6
70-79	99	597.1	630.8	664.5	99	522.3	550.7	579.1
80-89	18	455.9	521.1	586.2	18	381.0	445.5	510.0
90-99	2	532.4	675.0	1 882.4	2	23.0	575.0	1 166.9
females								
20-29	139	443.3	468.5	493.7	139	368.8	390.7	412.6
30-39	150	466.5	493.3	520.1	150	402.2	425.8	449.5
40-49	196	482.1	505.8	529.5	197	387.6	405.6	423.7
50-59	217	493.8	513.1	533.4	218	415.6	433.2	450.8
60-69	168	483.0	506.2	529.5	167	408.0	426.7	445.3
70-79	135	490.5	514.1	537.7	135	380.8	402.6	424.4
80-89	34	387.5	439.5	491.5	34	316.7	354.2	391.7
90-99	2	632.4	575.0	1 782.4	2	1 143.7	445.0	2 033.7

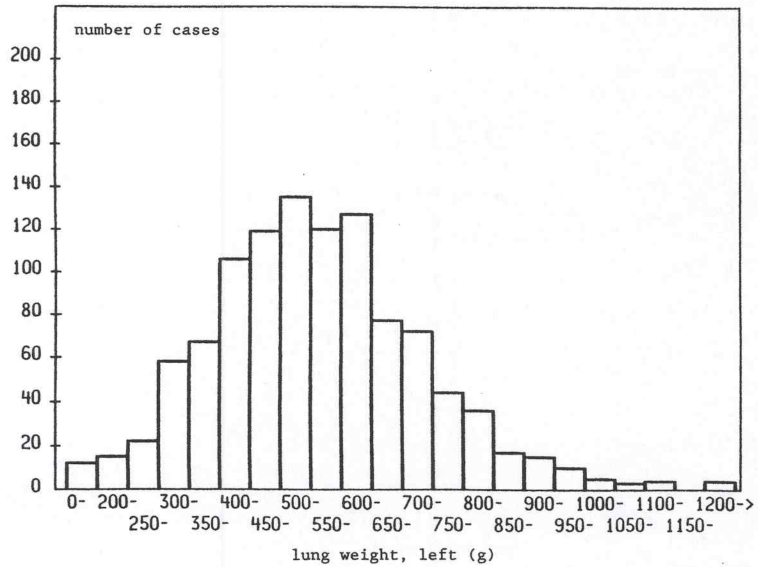


Fig. 90: Frequency distribution of weight of left lung (g) in males (≥ 20 years), 1900-1981

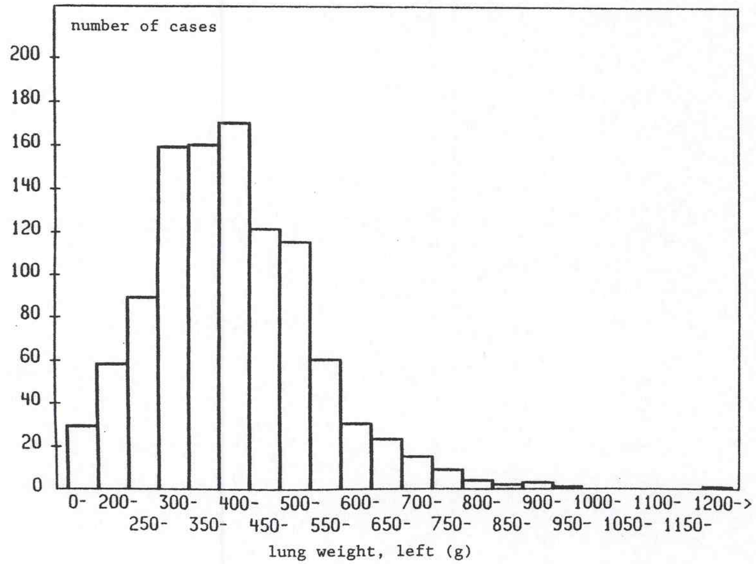


Fig. 91: Frequency distribution of weight of left lung (g) in females (≥ 20 years), 1900-1981

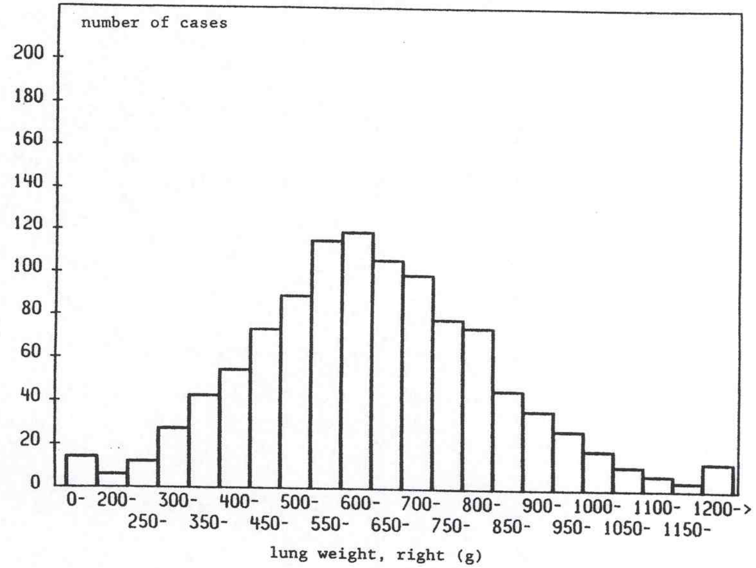


Fig. 92: Frequency distribution of weight of right lung (g) in males (≥ 20 years), 1900-1981

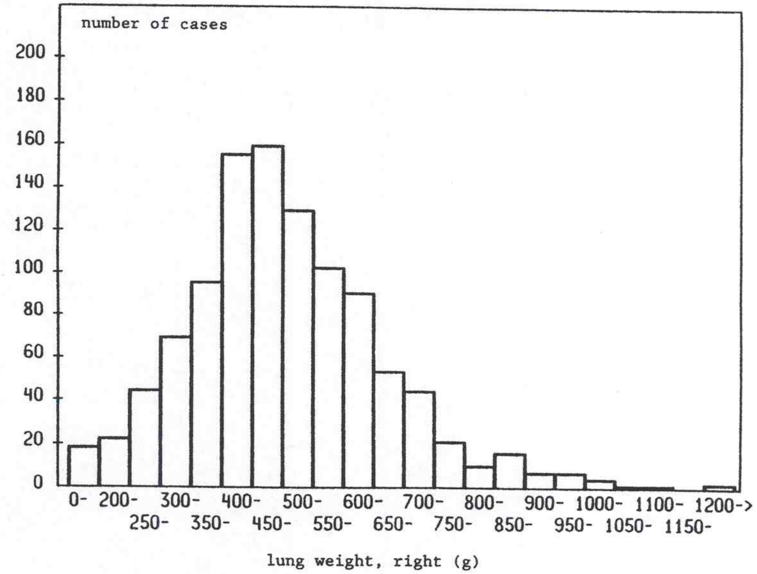


Fig. 93: Frequency distribution of weight of right lung (g) in females (≥ 20 years), 1900-1981

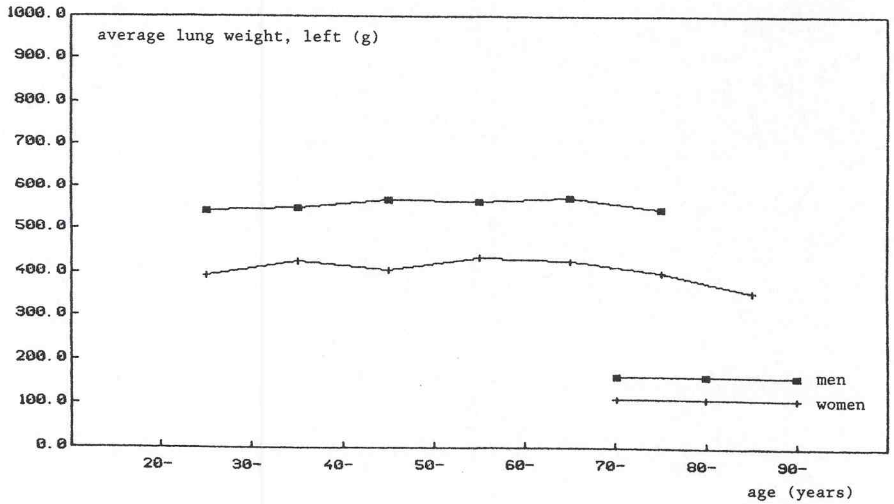


Fig. 94: Mean weight of left lung (g) according to sex and age, 1900-1981

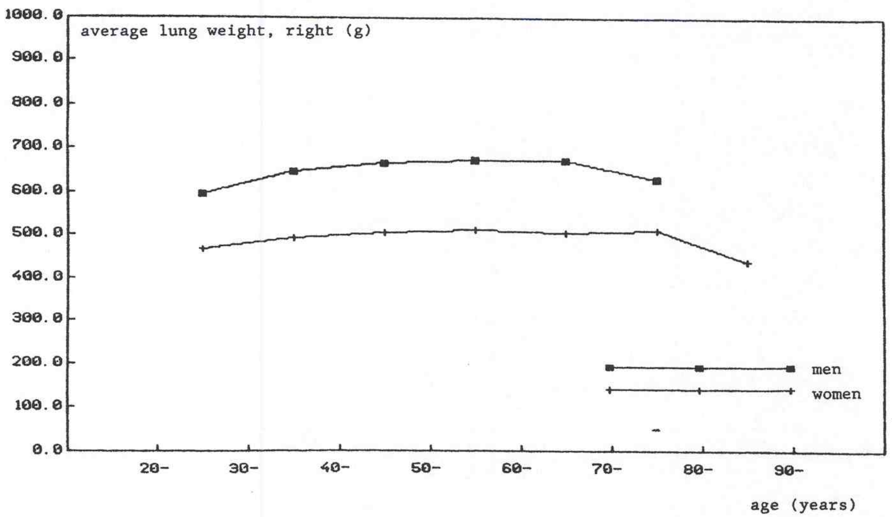


Fig. 95: Mean weight of right lung (g) according to sex and age, 1900-1981

Weight of right and left lungs rose with increasing body weight (figs. 96 and 97). Again the increase of lung weight is small, and was computed for males 2.0 g/g in the right lung (1.1 g/kg in females), and 1.8 g/kg for males in left lung (0.89 g/kg for females), respectively. Correlation coefficients were weak and were found r = 0.15 in males, and r = 0.11 in females for both lungs, i.e. insignificant dependence of lung weight upon body weight.

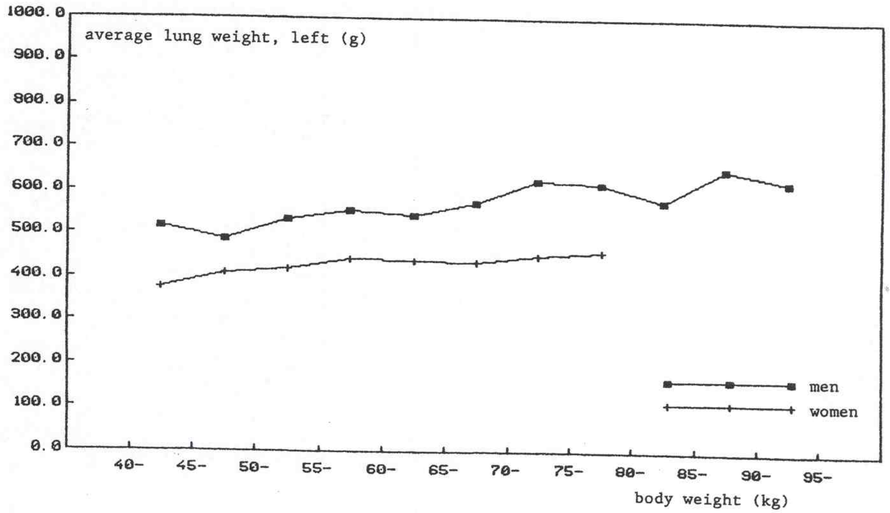


Fig. 96: Mean weight of left lung (g) according to sex and body weight (kg), 1900-1981

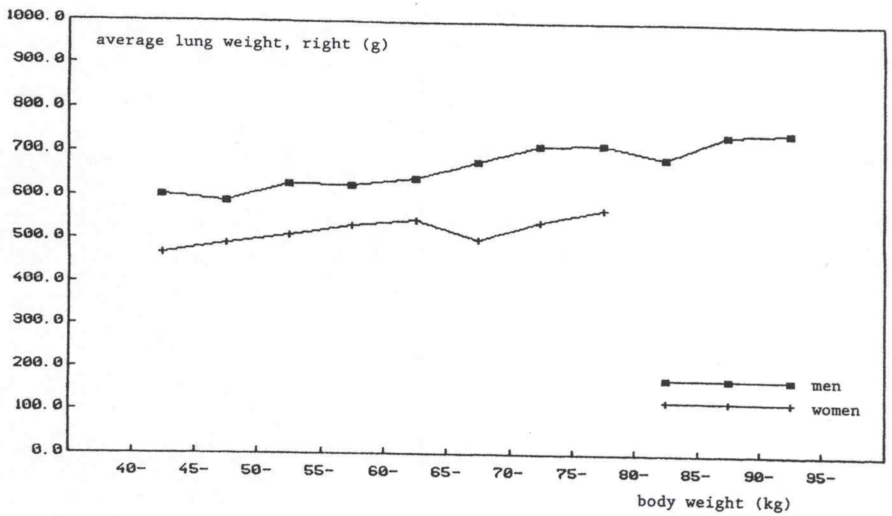


Fig. 97: Mean weight of right lung (g) according to sex and body weight (kg), 1900-1981

Similar situations were found regarding relationships between lung weight and height (figs. 98 and 99). The increase of lung weight with increasing height was computed 6.2 g/cm (males, right lung), and 5.55 g/cm (females, right lung). The left lung showed a rise with increasing height (5.8 g/cm in males and 5.0 g/cm in females). Correlation coefficients were computed r = 0.25 in males, and r = 0.24 in females for right and left lung. Dependence of lung weight upon height is more significant than upon body weight.

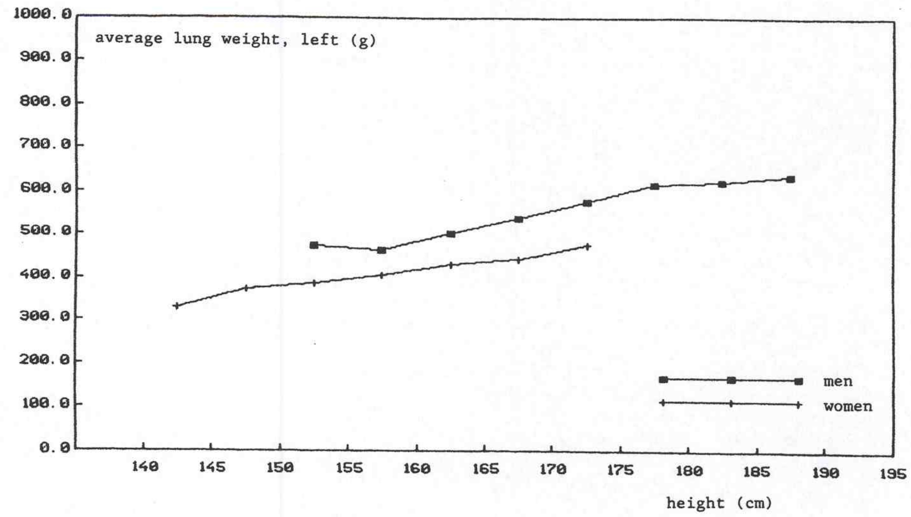


Fig. 98: Mean weight of left lung (g) according to sex and height (cm), 1900-1981

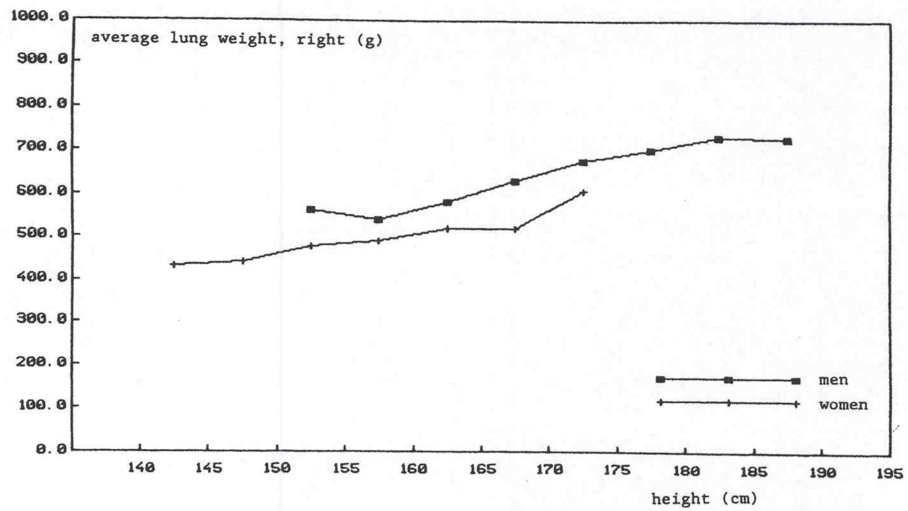


Fig. 99: Mean weight of right lung (g) according to sex and height (cm), 1900-1981

23. Discussion

WIESENER (1964) showed good correlation of lung function measurements to body weight and height in children. Correlation coefficients computed were found to be higher in boys than in girls.

According to our data, and data published by these authors, development of the lung during childhood is terminated at the age of 20 years. Similar data in development of the lungs measured by weight were reported by KRESS (1902); OPPENHEIMER (1888) as well as by ROESSLE and ROULET (1932) and VIERORDT (1906).

Lung weight divided by body weight (weight of lung/body weight, g/kg) remained nearly constant during childhood opposite to relative weight of lung (lung weight/height, g/cm), which increases constantly up to the age 20 years. Lung weight was found to be heavier in boys than in girls at the age 12 years and older. Our data are in accordance with data published by ROESSLE and ROULET (1932), WHIMSTER (1971), WHIMSTER and MCFARLANE (1974). Growth acceleration as noted in development of body weight and height exists in corresponding age groups for boys and girls. Data are not statistically significant because of high standard deviation of lung weight related to various amount of blood at death.

Due to different mechanisms of death affecting distribution of blood in the lungs, it is difficult to measure the exact weight of the lungs as reported by BISCHOFF (1863), ENGEL (1869), OPPENHEIMER (1888), and ROESSLE and ROULET (1932). Our data support these findings. Frequency distributions of lung weights in adults not suffering from diseases directly affecting the lung show broad, yet standard deviations. Recently, JOACHIM et al. (1978) published exact measurements of the weight of the lungs in acute death. Lung edema, perfusion and proliferative changes were measured due to amount of water, hemoglobin and DNA. JOACHIM et al. (1978) found an average weight of the right lung 251 g in males (6 cases), and 200 g in females (2 cases) in peracute trauma. The left lung was measured in males at 187 g (2 cases). However, lung weight increased remarkably and was measured 469 g if patients survived one hour or longer after acute trauma. After complete development of shock alterations, lung weight increased up to 1,124 g. The same weight was measured if patients survived one week or longer after the acute trauma. Similar observations were made by various authors (FORBES et al., 1953; JENKINS et al., 1950; MITCHEL et al., 1974). Synopsis of measured lung weight is given in table 29.

Weight of the right lung varies from 251 g - 1,437 g in males, and 200 g - 522 g in females. Similar situations can be noted in the left lung. Lung weight in children and adults depends upon circumstances at death, time of autopsy, and time of

Table 29: Lung weight in males and females according to various authors

AUTHOR	NUMBER OF CASES MALES	FE-MALES	MALES weight of right lung (g)	MALES weight of left lung (g)	FEMALES weight of right lung (g)	FEMALES weight of left lung (g)	AGE
BISCHOFF 1863	71		247	228			20
ENGEL 1869	95		813.3	738.2			20-30
			683	620.7			30-50
OPPENHEIMER 1888	58	87	506.1	443.3	450.4	448.4	20-25
VIERORDT 1906	101	100	512.2	455.7	455.5	390.8	20-25
SPITZKA 1904	6	281	253				23-41
MÜHLMANN 1927			967.9		843.6		20-25
			1437.2				25-42
			1144.7				60-73
ROESSLE and	13	12	379	291	322.7	297.6	15-20
ROULET 1932	58	60	433	367.6	352.7	296.1	21-60
	21	28	394.1	357.8	356.1	268.2	61-90
REID 1843	29	21	720	630	510	450	
MILLER 1947			488.8	568.7	500	450	
SUNDERMANN and BOERNER 1949	77	91	455	402	401	345	20
WHIMSTER and MCFARLAINE 1974	77	91	455	402	401	345	20
URBAN, STREJC and TATICOVA 1977	1598		684.2	596.6	522.1	451.3	21-75
JOACHIM, RIEDE and MITTERMAYER 1978	6	2	251	187	200		
OWN DATA	365	289	621.7	544.5	480.9	408.2	20-39
	385	415	669.8	566.6	509.4	419.4	40-59
	307	336	625.1	541.6	508.6	407.1	60-89

survival. These data are difficult to classify, and were only partly known at time of autopsy. Therefore, lung weight is not easy to measure in autopsies. In addition, the lung is affected by nearly all diseases leading to death. Selection of cases showing unaltered lung weight is difficult. This fact explains the small number of cases being selected for lung weight in our material. Correlation coefficients of lung weight related to body weight and height are small compared to those of other organs. Again,large variations in lung weight render more difficult computation of relationship. The best correlation of lung weight was found to height in our material and by other authors (URBAN et al, 1977; WHIMSTER, 1971; WHIMSTER and MCFARLANE, 1974).

Race may influence lung weight. However, data reported by WHIMSTER (1971) and by WHIMSTER and MCFARLANE (1974) could not indicate differences related to race. The authors computed lung weight in Blacks. Major differences between the Black and Caucasian population in Jamaica were not found. Correlation coefficients computed were similar to ours.

24. Kidney weight in autopsied children

The weight of the left kidney was documented in 2,028 boys and in 1,545 girls, additionally, the weight of the right kidney in 2,025 boys and 1,542 girls, respectively; table 30. The weight of the left kidney measured 7.5 g in boys, and 6.8 g in girls at birth; that of right kidney 7.7 g in boys, and 6.8 g in girls, respectively. Average weight of the right kidney was computed 147.5 g in boys, and 129.0 g in girls; weight of the left kidney 152.0 g in boys, and 130.6 g in girls at 19 years of age. Development of weight of left and right kidney during childhood is given in figs. 100, 101, 102, 103. Statistically significant differences ($p < 0.05$) in

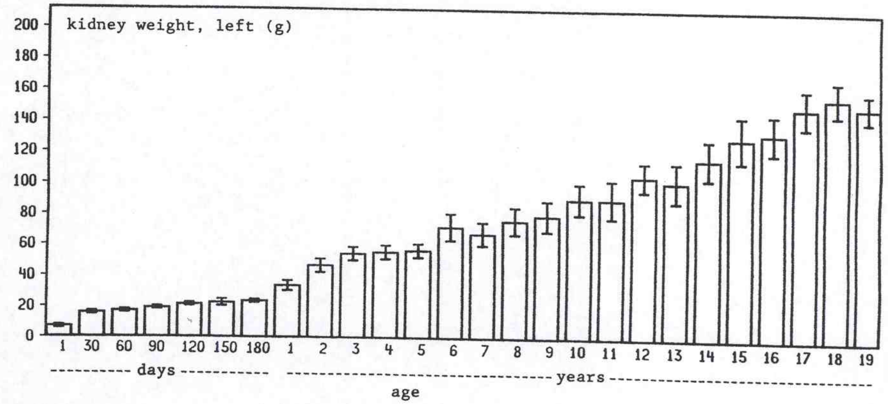


Fig. 100: Mean weight of left kidney (g) in boys, according to age, 1900-1981

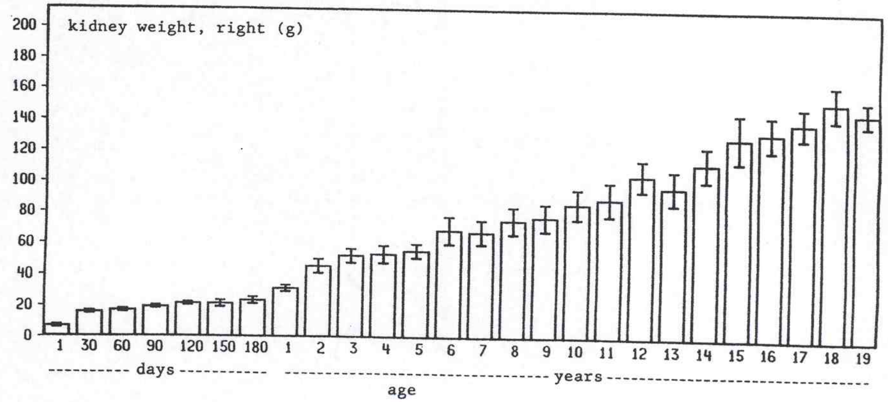


Fig. 101: Mean weight of left kidney (g) in girls, according to age, 1900-1981

Table 30: Kidney weight according to age (g)

age groups	right kidney n	right kidney mean + confidence limits p ≥ 0.95			left kidney n	left kidney mean + confidence limits p ≥ 0.95		
males								
days 1	662	7.1	7.5	7.9	662	7.3	7.7	8.1
2- 30	137	14.6	16.2	17.8	137	14.4	15.9	17.5
31- 60	110	16.0	17.4	18.8	110	15.9	17.4	18.8
61- 90	93	17.7	19.4	21.1	93	18.0	19.8	21.5
91-120	87	19.6	21.5	23.4	87	19.5	21.3	23.0
121-150	74	19.6	21.8	24.1	74	20.4	22.7	25.0
151-180	56	20.9	23.8	26.6	56	21.3	23.5	25.6
years 1	62	29.0	31.9	34.8	62	29.8	33.6	37.4
2	70	40.6	45.7	50.9	73	42.2	47.3	52.5
3	65	47.7	53.2	58.7	65	49.5	55.0	60.5
4	37	47.9	53.8	59.8	37	50.7	55.9	61.1
5	45	51.0	56.1	61.2	45	52.6	57.6	62.7
6	40	59.5	69.4	79.3	40	62.4	72.3	82.1
7	27	59.6	68.4	77.1	27	59.9	67.8	75.7
8	38	66.9	76.3	85.8	38	68.2	77.7	87.1
9	29	68.7	78.7	88.6	29	70.1	80.7	91.3
10	40	76.7	87.2	97.7	41	80.3	91.2	102.2
11	21	78.9	90.0	101.2	20	78.8	91.3	103.8
12	32	95.9	106.1	116.4	32	97.0	106.6	116.2
13	24	86.8	98.0	109.1	24	90.5	103.2	115.9
14	29	102.2	113.4	124.6	30	103.8	116.8	129.7
15	31	114.3	130.2	146.1	30	115.6	130.7	145.8
16	43	122.7	134.0	145.2	42	121.3	133.8	146.3
17	52	129.9	140.3	150.6	54	138.2	150.6	163.0
18	57	141.3	153.4	165.6	56	145.3	156.9	168.5
19	64	139.4	147.5	155.7	64	142.5	152.0	161.4
females								
days 1	561	6.4	6.8	7.2	560	6.4	6.8	7.2
2- 30	91	13.1	14.7	16.2	91	13.2	14.7	16.1
31- 60	78	14.5	16.7	18.9	78	14.7	17.1	19.4
61- 90	72	16.0	17.7	19.4	72	16.1	17.8	19.4
91-120	49	16.8	19.5	22.1	48	17.3	19.9	22.6
121-150	50	19.5	22.8	26.0	51	19.8	23.0	26.2
151-180	46	20.6	23.2	25.8	46	21.3	23.9	26.5
years 1	62	23.1	25.6	28.0	63	24.2	26.7	29.3
2	36	34.2	37.4	40.5	37	36.1	39.5	42.9
3	50	43.3	47.5	51.6	50	44.6	48.4	52.2
4	34	46.3	51.1	55.9	34	47.2	52.8	58.4
5	30	48.6	54.7	60.7	30	49.8	54.7	59.6
6	46	54.9	62.3	69.8	46	56.6	64.2	71.8
7	27	60.5	72.6	84.6	28	62.4	74.3	86.3
8	29	63.1	76.3	89.6	29	63.4	81.2	99.0
9	19	66.6	73.8	81.1	20	70.9	81.2	91.5
10	15	65.4	89.3	113.2	15	64.4	88.6	112.9
11	15	77.9	93.3	108.7	15	77.1	93.2	109.2
12	12	67.9	91.5	115.0	12	68.8	93.0	117.3
13	27	90.4	101.5	112.7	27	96.9	108.2	119.6
14	16	97.0	105.2	113.4	17	104.0	113.8	123.7
15	33	100.7	113.2	125.6	33	108.3	118.4	128.6
16	18	105.0	122.3	139.7	18	111.0	127.6	144.1
17	47	119.4	129.2	139.0	46	123.2	134.8	146.5
18	37	116.6	123.9	131.3	37	121.3	129.3	137.7
19	42	119.4	129.0	138.6	42	119.5	130.6	141.6

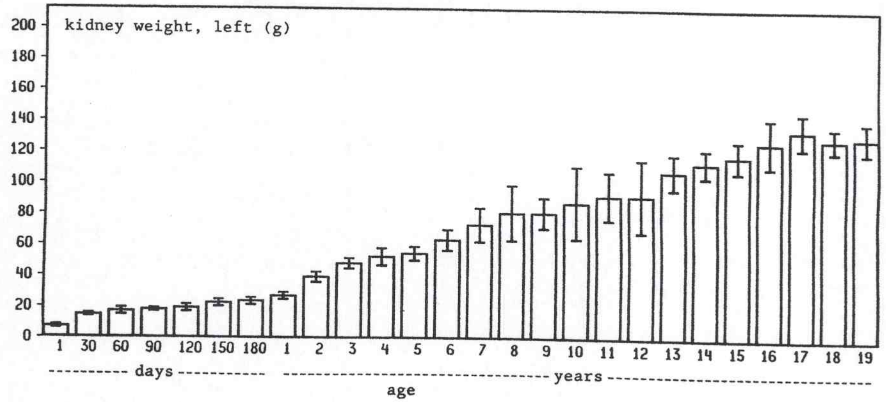


Fig. 102: Mean weight of right kidney (g) in boys, according to age, 1900-1981

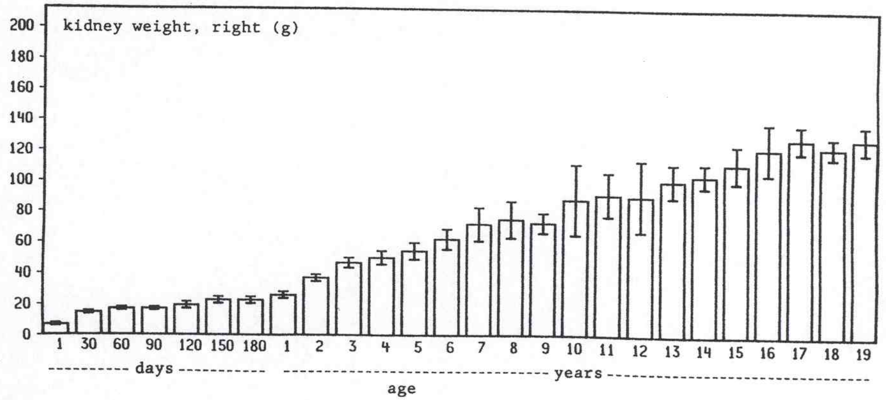


Fig. 103: Mean weight of right kidney (g) in girls, according to age, 1900-1981

the weight of the right and left kidney between 19-year-old boys and 16-year-old boys and younger were found. Similar data were obtained between 19-year-old girls and 15-year-old girls and younger ($p < 0.05$). Development of kidney weight showed acceleration periods in boys between 9-12 years, and between 14-17 years; in girls between 9-21 yeas, and 14-16 years, respectively.

Relative weight of the right and left kidney (compared to body weight g/kg) is shown in figs. 104 and 105 for boys and girls. It remains nearly constant after the age of 5 years. It was computed as 2.72 g/kg (right) and 2.81 g/kg (left) in 19-year-old-autopsied boys, and 2.67 g/kg (right) and 2.71 g/kg (left) in 19-year-old autopsied girls. Major differences between males and females, and between right and left kidney could not be found, except that the left kidney is somewhat heavier than the right.

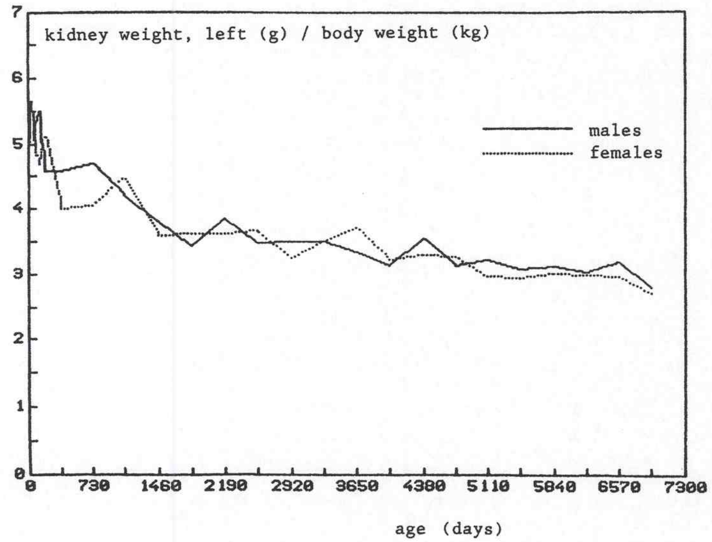


Fig. 104: Relative weight of left kidney (g/kg), according to sex and age, 1900-1981

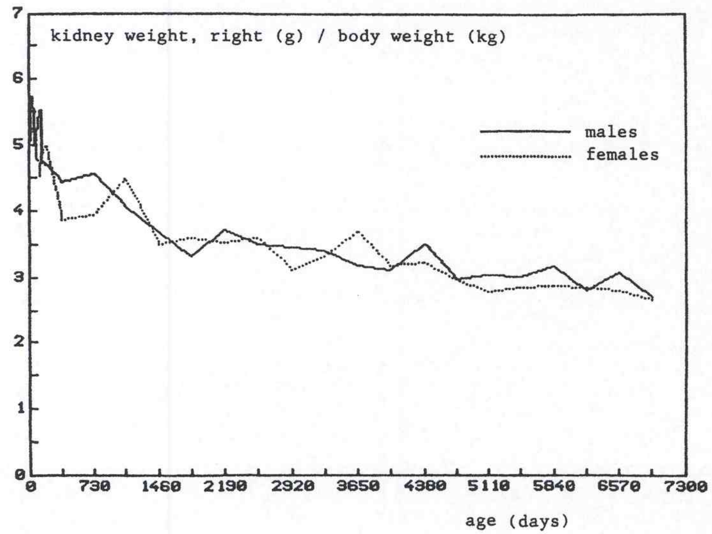


Fig. 105: Relative weight of right kidney (g/kg), according to sex and age, 1900-1981

The relative weight of the right and the left kidney compared to height (g/cm) is given in figs. 106 and 107. After a steep decrease until 2 years of age, a constant increase of relative kidney weight for both males and females is given with two acceleration peaks. These are the ages 7 years and 12 years in boys, and 8 years and 11 years in girls. After the age 11 years the relative weight of both kidneys compared to height in girls remained below that of boys.

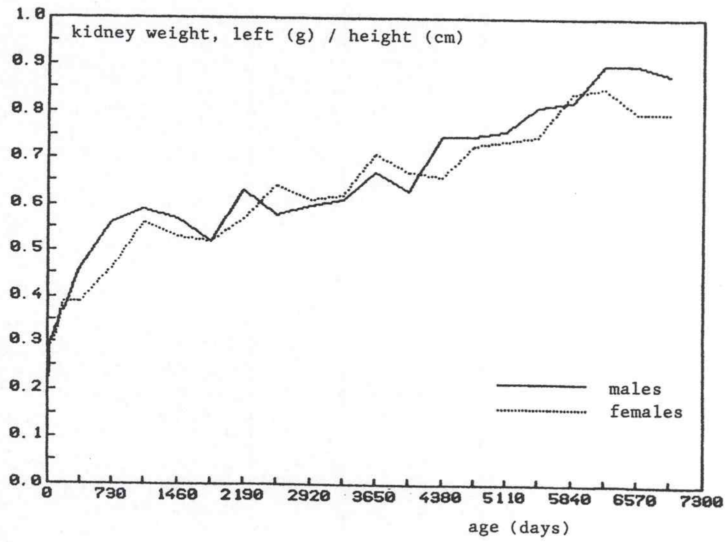


Fig. 106: Relative weight of left kidney (g/cm), according to sex and age, 1900-1981

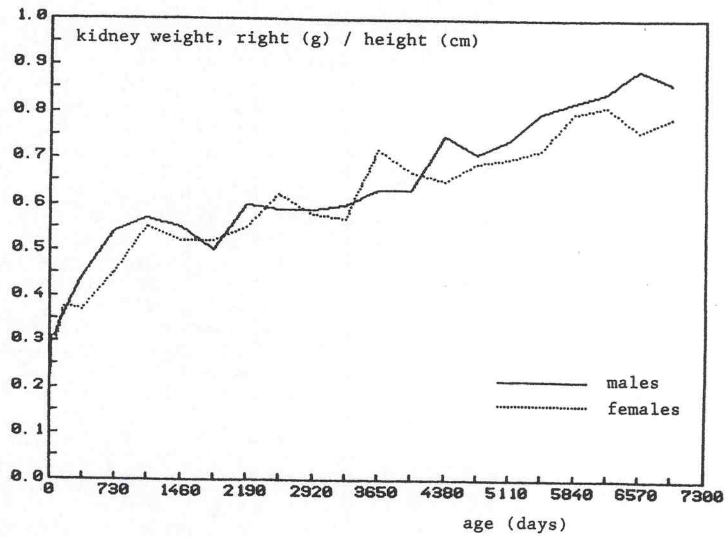


Fig. 107: Relative weight of right kidney (g/cm), according to sex and age, 1900-1981

25. Kidney weight in autopsied adults

Weight of right (left) kidney was reported in 7,500 (7,484) autopsied males, and 4,507 (4,511) autopsied females. This showed a nearly bisymmetric frequency distribution of absolute kidney weight (figs. 108, 109, 110, 111). Maximum weight of right and left kidneys was found between 150-160 g in males, and between 110-120 g in females respectively.

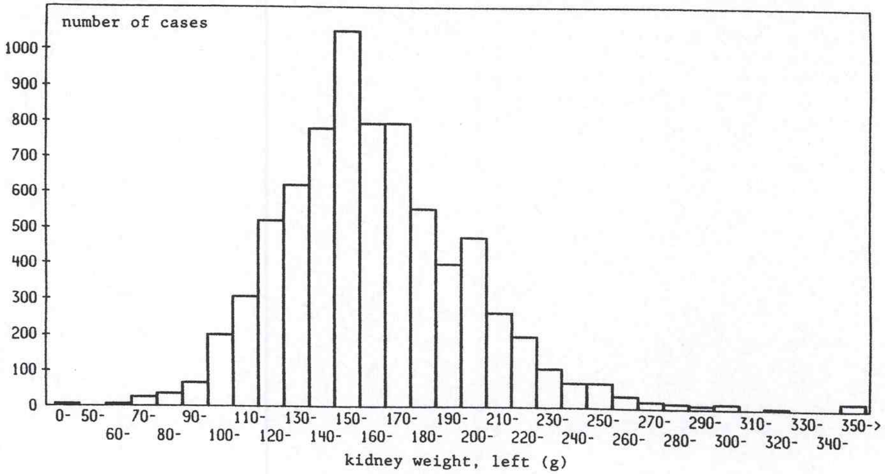


Fig. 108: Frequency distribution of weight of left kidney (g) in males (⩾ 20 years), 1900-1981

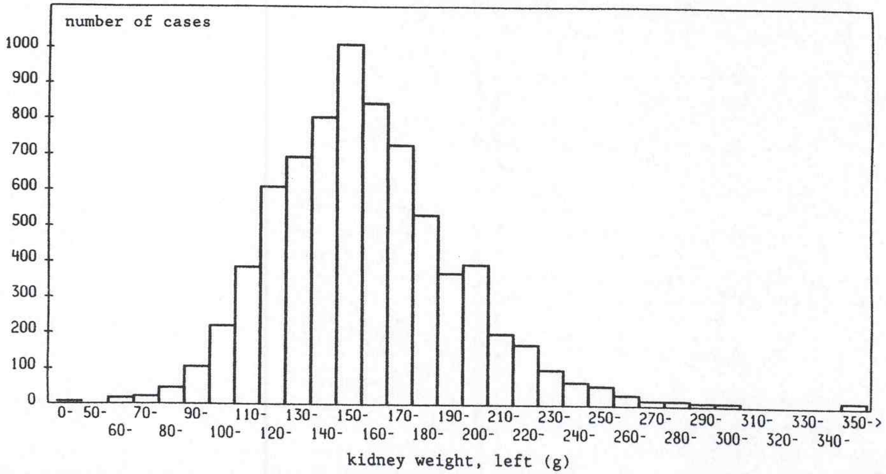


Fig. 109: Frequency distribution of weight of left kidney (g) in females (⩾ 20 years), 1900-1981

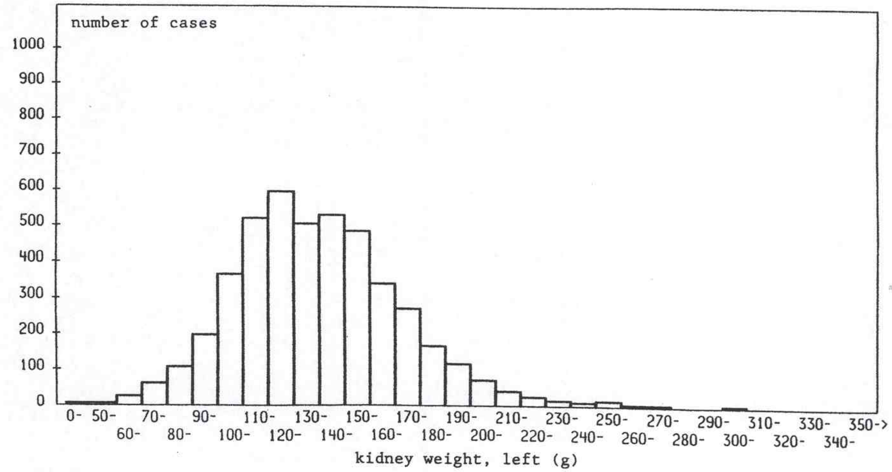


Fig. 110: Frequency distribution of weight of right kidney (g) in males (⩾ 20 years), 1900-1981

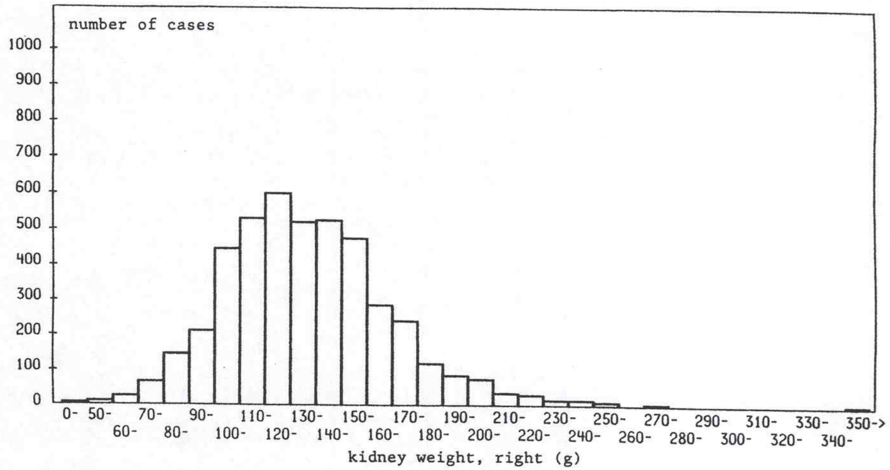


Fig. 111: Frequency distribution of weight of right kidney (g) in females (⩾ 20 years), 1900-1981

Dependency of weight in right and left kidney upon age is given in figs. 112 and 113. Similar to other organs, a smooth increase of absolute kidney weight can be noted up to the age class 30-40 years. Beyond that age, a smooth but constant decrease of absolute kidney weight is given. In the highest age class (90-99 years), average kidney weight was computed 130.4 g and that of left kidney 126.3 g in males, and 105.8 g (right) and 109.7 g (left) in females. Exact data are given in table 31 and 32. Correlation coefficients were computed r = −0.09 (right) and r = −0.11 (left) in males, and r = −0.14 (right) and r = −0.15 (left) in females. A

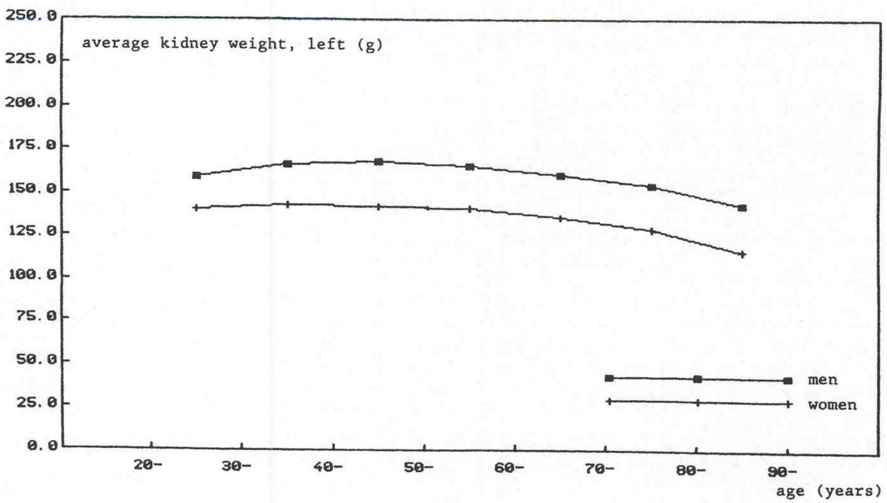


Fig. 112: Mean weight of left kidney (g) according to sex and age, 1900-1981

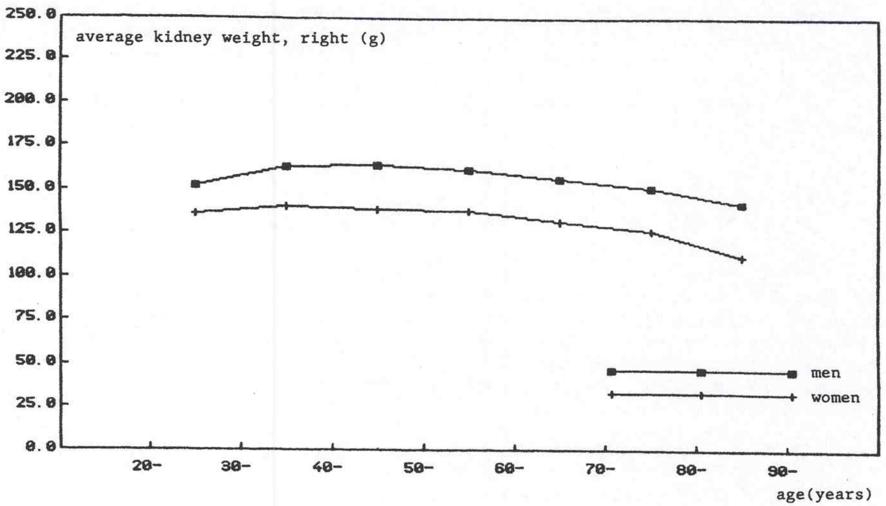


Fig. 113: Mean weight of right kidney (g) according to sex and age, 1900-1981

decrease was found 2.3-3 g/10 years in males, and 3.3-3.5g/10 years in females. The relationship of weight between right and left kidney according to age and birth cohorts is given in figs. 114 and 115. A constant increase of absolute weight of the right and left kidneys in relation to younger birth cohorts can be noted. An increase exists for all age groups and was computed 10 g/decade at an average.

Table 31: Average weight of right and left kidneys according to age groups

Males (right kidney)			
age groups in years	number of cases	mean weight (g)	confidence limits p ≥ 0.95
20-29	737	152.0	149.6-154.4
30-39	765	162.3	159.6-165.0
40-49	1228	163.5	161.5-165.5
50-59	1759	161.2	159.5-162.9
60-69	1810	156.1	154.5-157.7
70-79	968	150.9	148.7-153.1
80-89	222	142.4	137.9-146.9
90-99	11	130.4	104.8-156.0
Males (left kidney)			
age groups in years	number of cases	mean weight (g)	confidence limits p ≥ 0.95
20-29	737	158.6	156.0-161.3
30-39	764	139.4	163.7-169.0
40-49	1225	167.8	165.7-169.8
50-59	1754	164.8	163.1-166.6
60-69	1803	159.9	158.3-161.6
70-79	970	154.2	138.7-147.0
80-89	220	142.8	97.6-155.0
90-99	11	126.3	97.6-155.0

Table 32: Average weight of right and left kidneys according to age groups

Females (right kidney)			
age groups in years	number of cases	mean weight (g)	confidence limits p ≥ 0.95
20-29	376	135.3	132.1-138.5
30-39	529	139.4	136.5-142.4
40-49	695	138.4	135.8-140.9
50-59	1013	137.6	135.5-139.7
60-69	956	131.8	129.8-133.8
70-79	686	126.4	124.1-128.6
80-89	235	111.8	108.1-115.5
90-99	17	105.8	93.6-118.1
Females (left kidney)			
age groups in years	number of cases	mean weight (g)	confidence limits p ≥ 0.95
20-29	378	139.9	136.7-143.1
30-39	530	142.4	139.4-145.4
40-49	695	141.3	138.8-143.8
50-59	1014	140.9	138.7-143.1
60-69	958	135.8	133.7-137.8
70-79	685	129.2	126.9-131.5
80-89	234	116.2	112.3-120.0
90-99	17	109.7	95.6-123.7

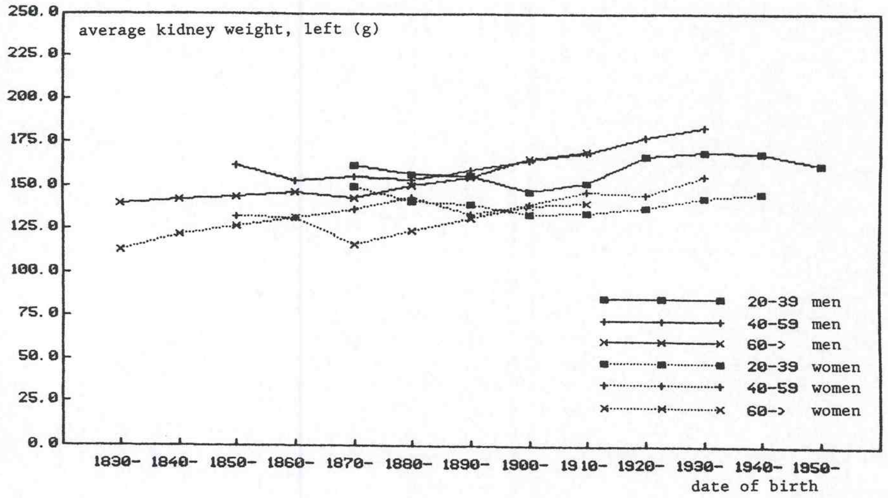


Fig. 114: Mean weight of left kidney (g) according to sex, age and date of birth

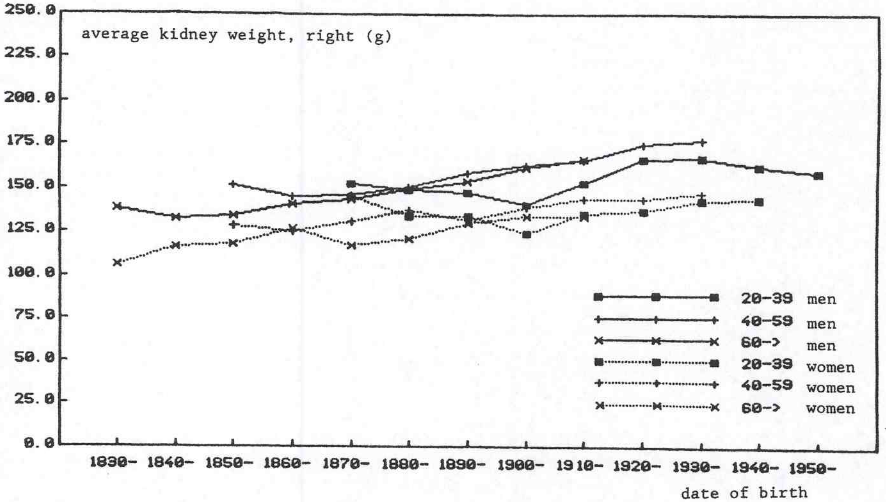


Fig. 115: Mean weight of right kidney (g) according to sex, age and date of birth

Comparison of kidney weight to height reveals similar results (figs. 116 and 117). Correlation coefficients for the right and left kidneys in both males and females was computed r = 0.34 in males, and r = 0.32 in females. Dependency of kidney weight upon body height is somewhat less than upon body weight, but quite strong. This relationship holds true for all age groups (figs. 118, 119, 120, 121).

The relationship of kidney weight as compared to body weight is given in figs. 122, 123, 124 and 125. A smooth and steady increase can be noted. Correlation coefficients were computed r = 0.42 (right) and r = 0.38 (left) in males, and r = 0.36 (right) and r = 0.34 (left) in females. An increase was found 0.91-1 g/kg in

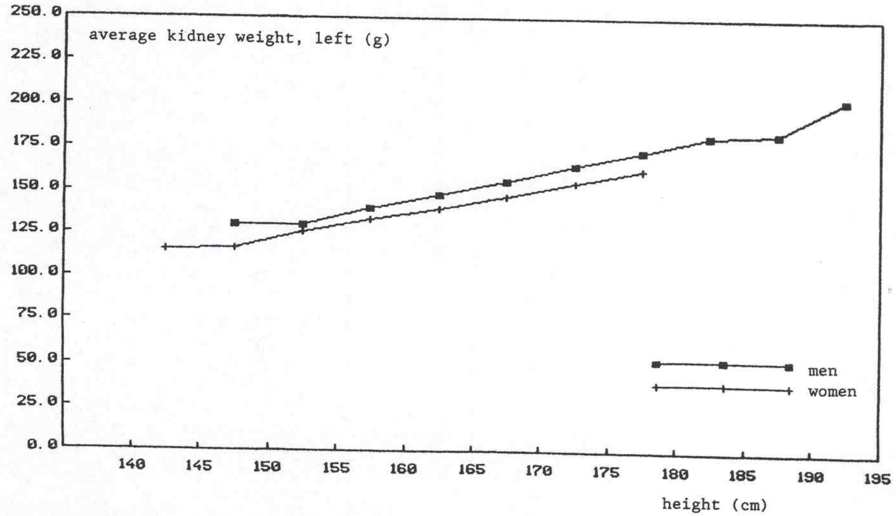


Fig. 116: Mean weight of left kidney (g) according to sex and height (cm), 1900-1981

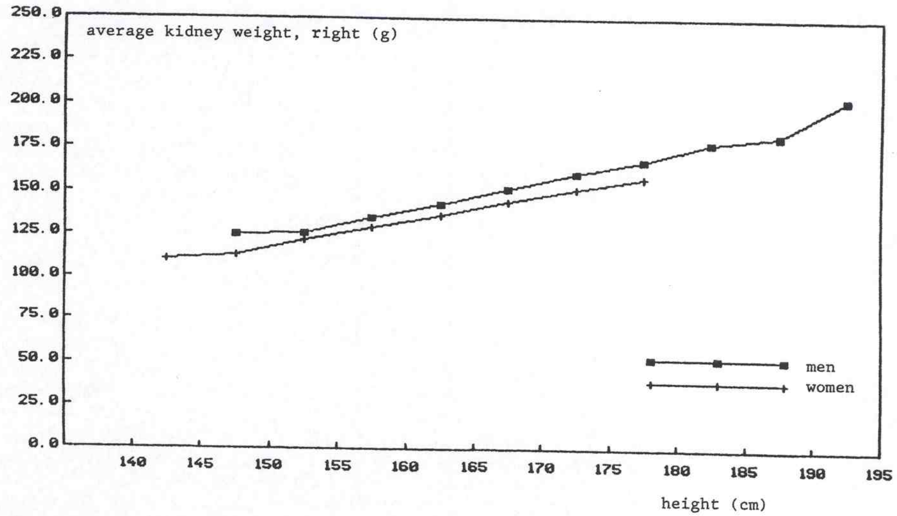


Fig. 117: Mean weight of right kidney (g) according to sex and height (cm), 1900-1981

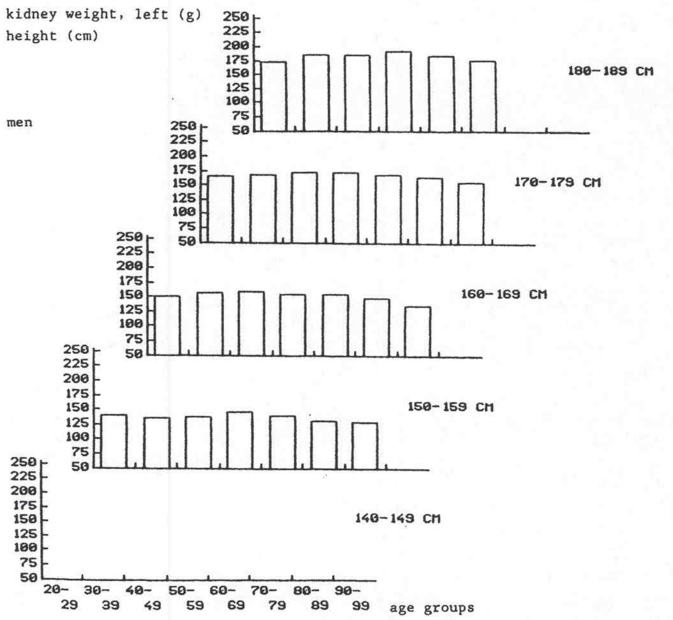


Fig. 118: Mean weight of left kidney (g) in males, according to age and height (cm), 1900-1981

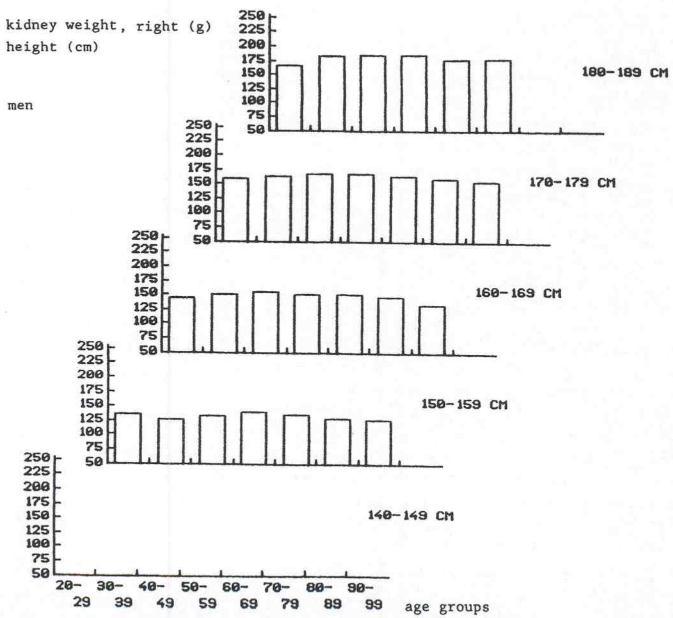


Fig. 119: Mean weight of right kidney (g) in males, according to age and height (cm), 1900-1981

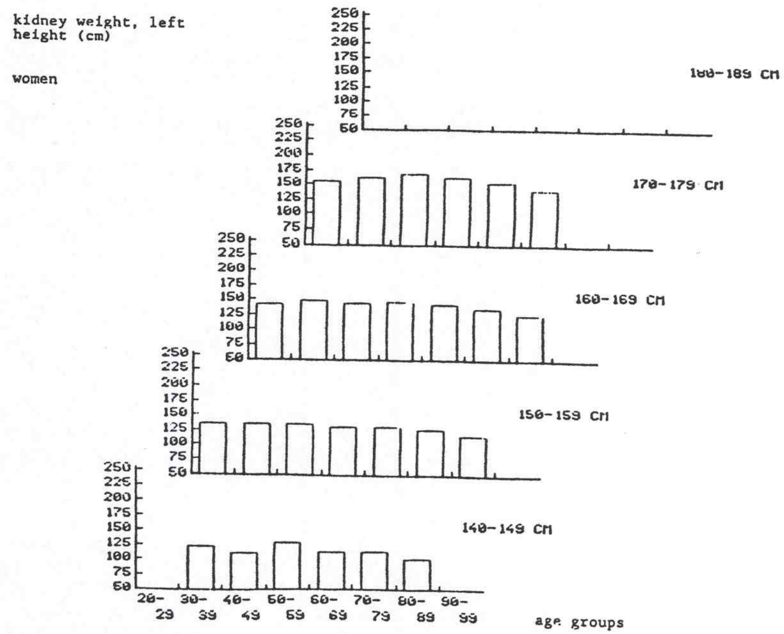


Fig. 120: Mean weight of left kidney (g) in females according to age and height (cm)

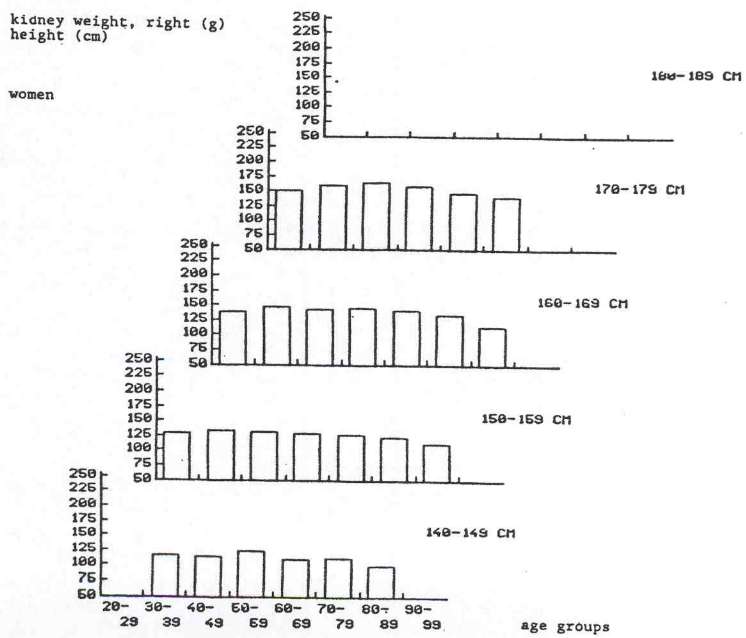


Fig. 121: Mean weight of right kidney (g) in females according to age and height (cm)

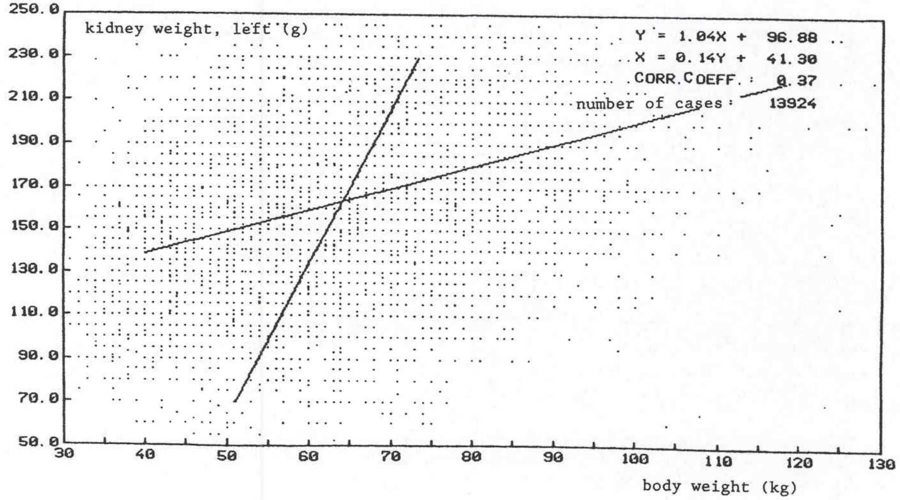


Fig. 122: Weight of left kidney (g) in males (≥ 20 years) and body weight (kg) linear regression, 1900-1981

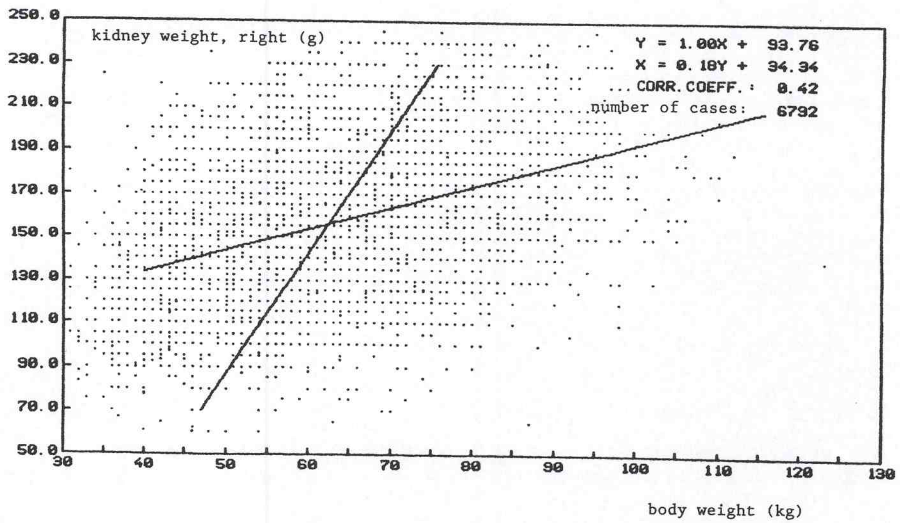


Fig. 123: Weight of left kidney (g) in females (≥ 20 years) and body weight (kg), linear regression, 1900-1981

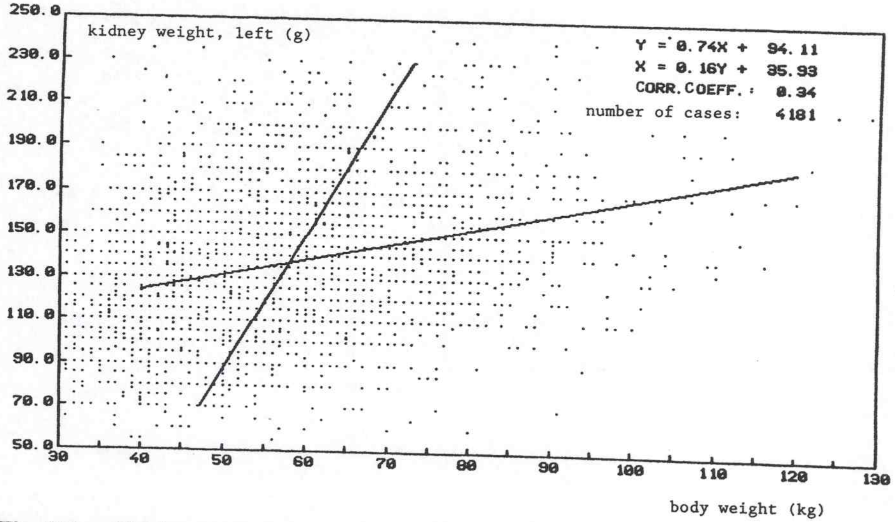


Fig. 124: Weight of right kidney (g) in males (≥ 20 years) and body weight (kg), linear regression, 1900-1981

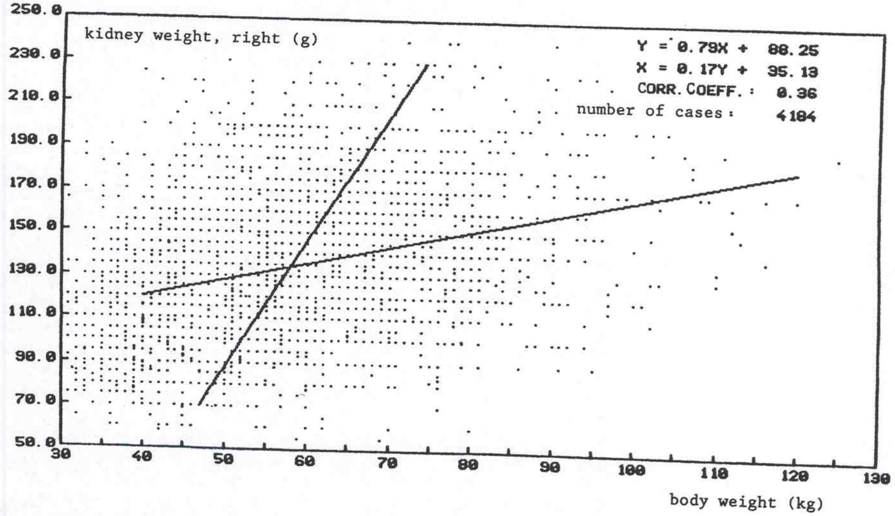


Fig. 125: Weight of right kidney (g) in females (≥ 20 years) and body weight (kg), linear regression, 1900-1981

26. Discussion

Kidney weight was measured including hilear fat in accordance with most other authors (GREENWOOD, 1904; GREENWOOD and BROWN, 1913; ROESSLE and ROULET, 1932). A synopsis of kidney weight published by various authors is given in table 33.

The left kidney was found to be heavier than the right kidney, but differences are small. Although development of morphology and function of the kidney is terminated at 2 years of age (FRIEDERSZIK, 1954), kidney weight increases until 20-30 years. Acceleration peaks were observed by several authors BEAN (1920); KRESS (1902); UOTILA (1940); and VIERORDT (1906).

A strong relation between kidney weight and body weight or height was found by several authors (GREENWOOD, 1904; GREENWOOD and BROWN, 1913; MÜHLMANN, 1927; ZSCHOCH and KLEMM, 1972). ZSCHOCH and KLEMM (1972) reported correlation coefficients between kidney weight and body weight as $r = 0.57$ in males, and $r = 0.41$ in females, and between kidney weight and height $r = 0.39$ in males, and $r = 0.35$ in females.

A decrease of kidney weight with increasing age was found by several authors (BEAN and BAKER, 1919; ROESSLE and ROULET, 1932; UOTILA, 1940; VIERORDT, 1906). Out data are very close to that reported by these authors.

Table 33: Kidney weight in males according to various authors

Authors	number of cases	weight (g) right	weight (g) left	total	age
Reid 1843	17	156	167		30-40
Boyd 1861	305			319.7	20-50
	239			254.0	50-70
Blosfeld 1864	36	150	162		25-50
Engel 1869		146.7	153.8		20-29
		115.6	136.4		30-50
		107.0	115.3		51-70
Thoma 1882	13			316	25-50
Bean and Baker 1919	911			339.9	22-75
Bean 1926	307			353.5	20-59
	70			305.2	60-89
Roessle and	458			277.8	21-60
Roulet 1932	50			261.1	61-80
Wald 1947	254			311.5	20-59
	53			273.0	60-79
Uotila 1940	65			283.7	25-50
	51			231.5	51-80
Urban et al. 1977		147.3	143.3		20-79
Own data	1501	157.15	162.45	319.6	20-39
	2979	162.35	166.30	328.8	40-59
	2993	144.95	145.80	290.8	60.89

Table 33: Kidney weight in females according to various authors

Authors	number of cases	weight (g) right	weight (g) left	total	age
Reid 1843 (96)	11	148	156		30-40
Boyd 1861 (19)	259			276.7	20-50
	256			238.5	50-70
Blosfeld 1864 (16)	8	133	138		25-50
Engel 1869 (30-33)		102.1	103.1		51-70
Thoma 1882 (131)	11			292	25-50
Bean and Baker 1919 (10)	304			310.4	22-75
Bean 1926 (12)	132			303.8	20-59
	14			274.3	60-89
Roessler and	105			243.3	21-60
Roulet 1932 (101)	34			224.2	61-80
Wald 1947 (137)	64			254.7	20-59
	22			227.0	60-79
Uotila 1940 (134)	71			242.6	25-50
	50			233.4	51-80
Urban et al. 1977	141	123.4	125.2		20-79
Own data	905	137.35	141.15	178.5	20-39
	1708	138.5	141.10	279.6	40-59
	1877	118.95	122.27	241.2	60-89

27. Synopsis of organ weight/body weight in autopsied children

The relative weight of measured organs (organ weight (g)/body weight (kg)) is shown in Fig. 126 for boys and in Fig. 127 for girls. The measurements show good agreement between the results obtained for boys and girls. A continous decline in relative brain weight can be noted whereas the relative brain weight of the other organs remained nearly constant. The data of the different organs are discussed in the corresponding chapters. Kidney and spleen show the lowest relative weight (organ weight (g)/body weight (kg)) measuring 4 g/kg of the body weight. Relative weight of liver and of brain was computed 35-55 g/kg at an average. Relative heart weight (g/kg) is slightly higher in boys than in girls and in good agreement with data reported by other groups (Tab. 20, page ...).

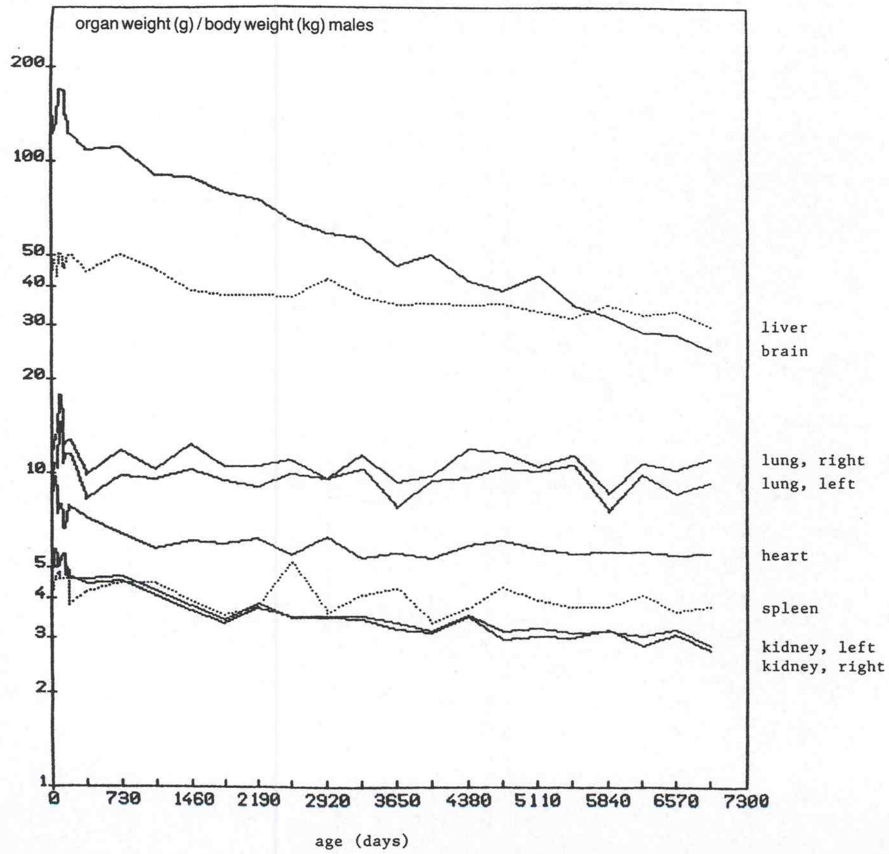


Fig. 126: Relative weight of different organs (g/kg) in boys according to age, 1900-1981

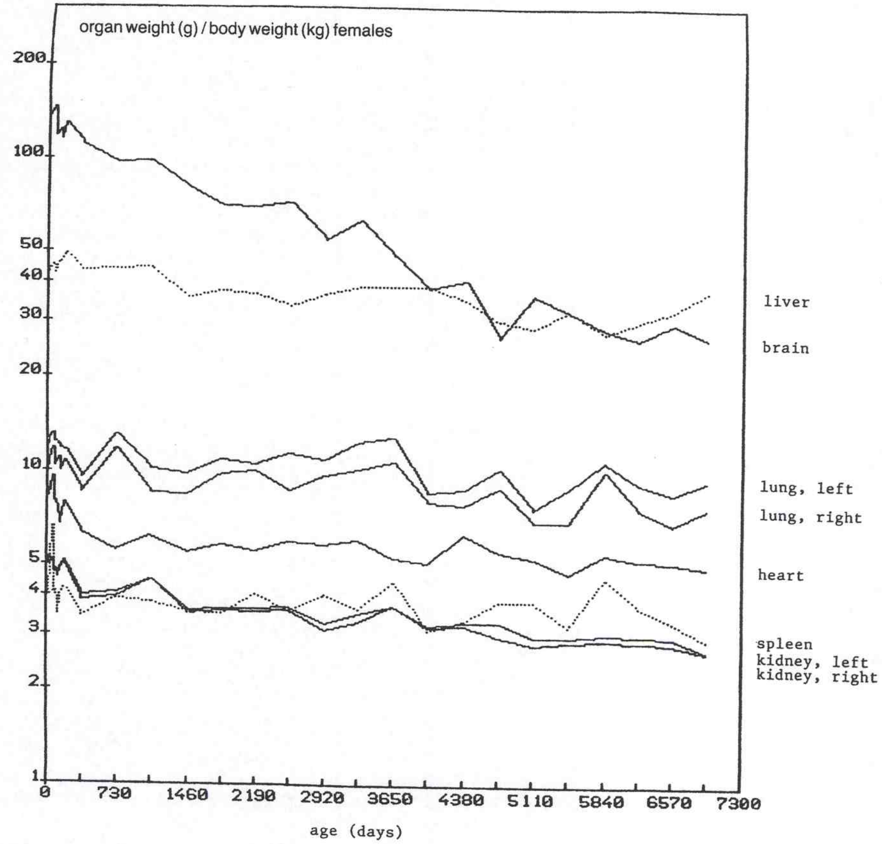


Fig. 127: Relative weight of different organs (g/kg) in girls according to age, 1900-1981

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