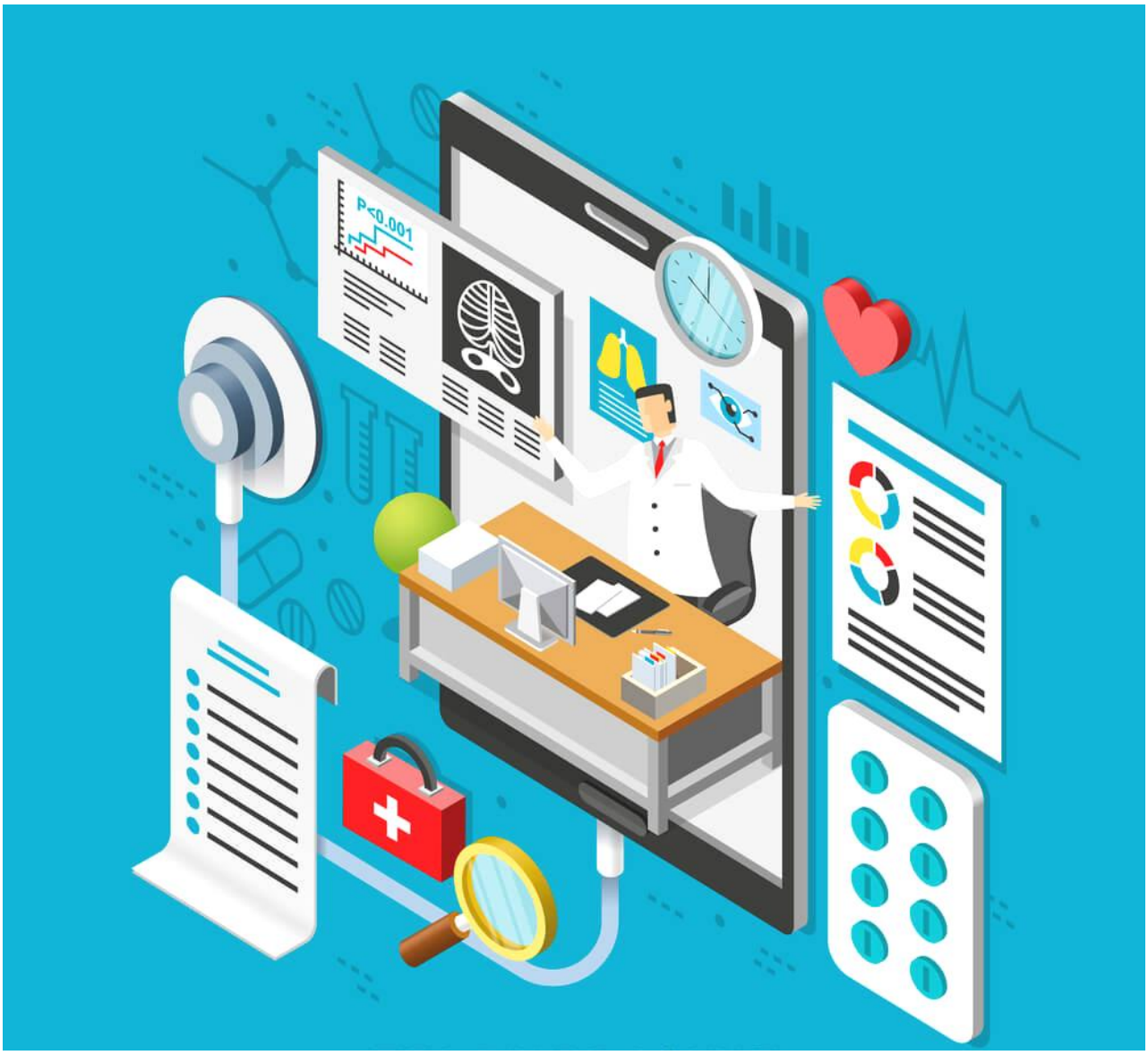
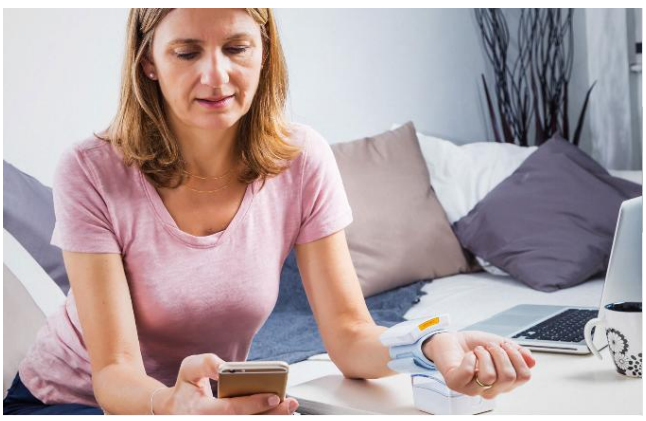
TELEMEDICINE





SUMMARY:

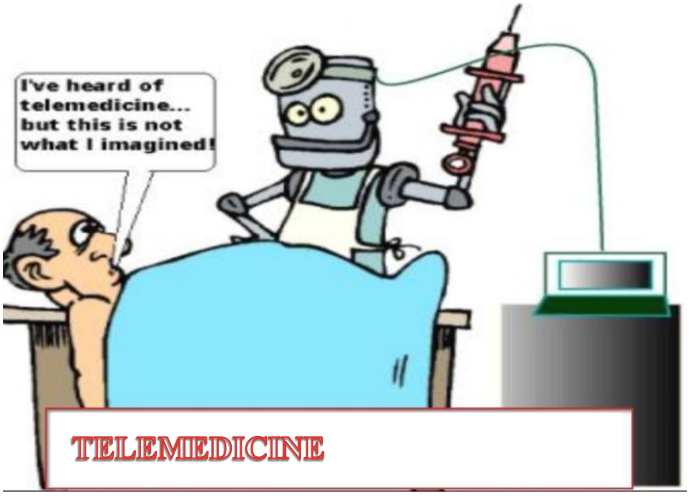
TELEMEDICINE: a field of healthcare telematics (telecommunication and information technology), used to overcome time and distance barriers during diagnostics and therapy between physicians, therapists, pharmacists and patients.

ON-LINE: state of being connected and accessible *via* a computer network (Internet).

MEDICAL DEVICE: any instrument, apparatus, appliance, material, software or other item, used either by itself or in combination with others, intended by its manufacturer to be used specifically for diagnostic and/or therapeutic purposes.

DATABASE: organized collection of data.

CLOUD: service provided by computer networks. In general, one works with programs and files that are not physically stored or installed on the local computer but are shared across a pool of resources, somewhere in the „cloud". This solution changes the use of the Web entirely, as the cloud is accessible from any place *via* appropriate Internet access.



"I've heard of telemedicine… but this is not what I imagined!

The aim of this practice is to learn about the principles and different categories of telemedicine, a novel type of healthcare method. The remote patient-monitoring system is discussed and performed in detail. Remote monitoring involves acquiring medical data (blood pressure, pulse rate, body weight), building and use of an online database (sorting and processing the acquired data), suggesting a medical diagnosis and finally, monitoring the patient.

Further readings:
Medical biophysics practice:
17. Measurement techniques,
Levente Herényi: Statistics and Informatics

telemedicina
telemedicine
(U.S.:telehealth, EU: eHealth)
Telemedizin

THEORETICAL OVERVIEW

High-end technical tools, information technology and a well trained professional staff able to use every element of the system are required in daily medical practice nowadays. Telemedicine improves the health care system by enabling and instant and efficient connection between patients, physicians and pharmacists.

TELEMEDICINE

Telemedicine is the use of telecommunication and information technology to provide medical diagnosis or therapy from a distance. It has been used to overcome distance barriers and to use on-line access to medical services that would often not be consistently available in rural communities.
Telemedicine can be divided into following main categories:

- **Teleconsultation** is when diagnosis and therapeutic decisions are made involving a remote physician or other health professional via telecommunication devices (e.g., consultation between the physician and the pharmacist by telephone).
- **Telemanipulation** is a remote manipulation in which the doctor is able to perform the examination (e.g., endoscopy) or surgery on a patient from a distance using elements of robotics, cutting edge communication technology and fast feedback systems (e.g.: Da Vinci surgery, a video-controlled robotic-assisted telesurgery, QR code 1.).
- **Telediagnostics** is remote diagnostics in which the act of diagnosing a given symptom, issue or problem is made from a distance. Although the patient and the diagnostician are separated by a large distance, they are in an interactive connection (e.g., transtelephonic ECG, QR code 2.).
- **Remote control or telemonitoring** is employed when bedside medical professionals are replaced by various technical devices which detect, process and communicate the vital signals towards and interactive receiver (e.g.: WIWE remote ECG-analysis tool, QR code 3.).

The scheme of the telemonitoring is shown in Fig 1.

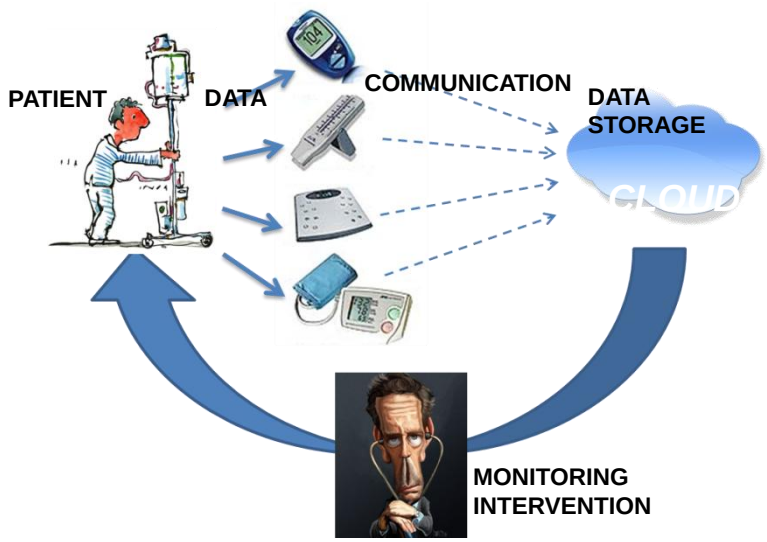


Fig. 1. *Scheme of remote monitoring.*

It's been said that the very first phone call, in Boston on March 10, 1876, ("Mr. Watson, come here! I want to see you") was actually a request for medical assistance, and the first application of telemedicine. Alexander Graham Bell, the inventor of the telephone spilled battery acid on himself on that fateful day, and was simply calling his colleague Thomas A. Watson next door for help.

The following links can be reached fast with the QR codes (quick response code) using a proper smart phone application.

QR code 1. *Da Vinci robot www.youtube.com/watch?v=VJ_3GJNz4fg*

QR code 2. *Transtelephonic ECG - https://www.youtube.com/watch?v=01054L53HNA*

QR code 3. *WIWE, a tool to record and analyze ECG signals https://www.youtube.com/watch?v=s0Js-kcSCXE*

A new, **e-Prescription** system is going to be launched in Hungary in November, 2017. Authorized health professionals will electronically prescribe medication through an electronic health-service cloud, and pharmacists will see the medical records of the patient and read e-Prescriptions from this database. The physician will know if and when the prescription order has been dispensed. Patients not picking up their medication will be recorded to improve patient management.

Measurement is an operation of comparison, during which the measured **physical quantity** is compared with (divided by) a chosen standard value of the same physical quantity called the **unit**. The result of the operation is the **numerical value**.

PHYSICAL QUANTITY=
NUMERICAL VALUE · UNIT

E.g.:
– the height of Mount Kékes above the mean sea level = 1014 m
– a systolic blood pressure= 145 mmHg
– the average mass of the human brain = 1500 g.

About precision and accuracy there is further information in Chapter 17. MEASUREMENT TECHNIQUES of the Medical Biophysics Practices manual.

There are functional remote patient monitoring systems already present in some „micro-environments" in Hungary. These typically involve remote telemonitoring services provided by a health practitioner or a group of physicians to a small patient community. Telemonitoring system helps limit visits to a family doctor to manageable levels and provides professional healthcare from a distance in the convenience of the patient's home. The costs of healthcare can be reduced substantially this way.

By providing a close monitoring of health parameters, telemonitoring could become the most efficient method of disease prevention (primary prophylaxis) and early diagnosis (secondary prophylaxis). Because telemonitoring is the most widely used telemedicine application in Hungary, we discuss in detail its steps of medical data collection, data storage (on-line database) and patient follow-up.

MEDICAL DATA COLLECTION

Data are always collected with a purpose. In case of medical data, we collect data about the health condition of the examined person, the patient. The method of data collection is **"medical examination"**. The physician or a healthcare professional performs a measurement (Definition can be found in the textbox). The most common "health indicators", which are typically measured by general practitioners and characterize the overall health condition are:

- blood pressure
- pulse rate
- blood sugar level
- body weight
- body temperature
- respiratory parameters

There is an available **measurement range** for every instrument, which is delimited by the lowest and highest measurable values. Measurement ranges of medical measuring devices are set to the possible range of the physiological parameters (e.g., for the Microlife BP W100 wrist blood pressure monitor used in our practice the ranges of blood pressure and pulse rate are 20-280 mmHg and 40-200 beats per minute, respectively). If the measured value is out of range, then the device displays an error message (e.g., „LO" and „HI" refer to too low and too high values, respectively).

Reliable medical data can be collected only by certified medical devices. Medical devices are legally defined in order to ensure patient safety. Medical device is any instrument, apparatus, software, material or other article that is intended by its manufacturer to be used specifically for diagnostic and/or therapeutic purposes in human beings.

Accuracy is a very important property of every measuring device. Accuracy indicates **how much the average of the results of repeated measurements deviates from the true value**. Precision of medical devices needs to be certified according to strict protocols by a competent authority. The certification information must always be included in the device documentation (e.g., the Microlife BP W100 wrist blood pressure monitor was approved by the BHS, British Hypertension Society.)

DATA STORAGE, ONLINE DATABASES

Following data collection the results of the measurement are transmitted into a central database through a communication channel. There are numerous methods to achieve this. Probably the simplest transmission is to manually enter the data into a computer, just as it will be done during our practice. Due to advances in information technology (IT), wireless personal detectors (e.g., blood pressure monitor, blood sugar monitor, body analysis scales, etc.) can be connected to smartphones which collect and forward data using special applications into a central database (Fig. 2.). The communication channels between the device and the database involve local Buetooth or WiFi and the internet.

Fig. 2. *Blood pressure monitor with bluetooth smart technology.*

A database is an organized collection of data. Numerical values loaded into a data storage device represent a dataset. A dataset becomes a database only if it systematic organization allows for a dedicated handling and interpretation. An important feature of a database is that not only data, but relationship between different data are accessible as well. The physical realization of a database may take the form of a classical library (Fig. 3.) or a computer network with a large-capacity server (Fig. 4.).

Fig. 3. *Library of the 3rd Department of Internal Medicine in 1922.*

In telemedicine, online **databases accessible through cloud technology have** become common. A cloud is a service provided by computer networks in which one works with programs and files that are not physically stored or installed on the local computer but are shared across a pool of resources, somewhere "in the cloud". The greatest advantage of cloud-based health databases is that both the patient (i.e., the automatic device performing the measurement) and the monitoring healthcare provider can mutually access them through the Internet.

The key concerns of telemedical information sytems are **data protection** and **data security**. Data protection refers to the regulation of the collection, storage and use of personal medical data according to the legal and technical principles of personal information protection. Telemedicine providers realize data protection at different levels. Records (databases) are usually stored at physically restricted area. Access to the database or to individual records is restricted to authorized users only (registered users with user name, password, and an adjusted level of access). Communication of health information (patient-cloud-health care provider) must be realized by authenticated channels.

Fig. 4. *Server room today.*

FOLLOW-UP, REMOTE MONITORING

Data loaded into the database are checked and evaluated regularly, and the professional staff intervenes if necessary (e.g., referral into hospital). In Hungary the general practitioner takes care of healthcare monitoring and controls the medical status of chronic or elderly patients regularly. Telemedicine could minimize the number of doctor visits, which would reduce costs. The currently used telemedicine applications have powerful algorithms to identify emergency situations or conditions that require immediate medical action (e.g., calling ambulance due to high blood sugar level).

felhő alapú számítástechnika
cloud computing
Rechnerwolke

Fig. 5. *Microlife BP W100 wrist blood pressure monitor.*

Fig. 6. *Ensure the correct position during the measurement.*

Two values are measured as the blood pressure E.g..: 135/75 mmHg. First number shows the pressure value in the main artery during the heart compression (*systolic value*), the second number shows the pressure between the heart beats (diastolic value).

Fig. 7. *iHealth body analysis scale.*

THE MEASUREMENT

Students will play both the role of the remotely monitored patient and the monitoring doctor. Results of the measurements, collected by the patients will be loaded into the database "in the cloud" manually. This database will be available during the "Biostatistics and informatics" practices, establishing a strong interactive connection between the two subjects. The database can be reached from anywhere through the Internet, which enables diagnosis making and patient monitoring. Furthermore, data evaluation by the students can be accomplished as well.

MEDICAL DATA COLLECTION

Blood pressure and pulse rate measurement

Blood pressure and pulse rate will be measured by the Microlife BP W100 wrist blood pressure monitor (Fig. 5.). Avoid physical activity, eating or smoking immediately prior to the measurement. Sit down for at least 5 minutes before the measurement and relax. Always take the measurement on the left arm while sitting. Remove any items of clothing and your watch, so that your wrist is free. Ensure that the cuff is positioned correctly. Support your arm in a relaxed position and ensure that the device is level with your heart (Fig. 6.).

Press the ON/OFF ⏻ button to start the measurement. The cuff will be inflated automatically. Stay relaxed, do not move and do not flex your arm muscles until the measurement result is displayed. Breathe normally and do not talk. When a certain high set-point cuff pressure is reached, pumping stops and cuff pressure begins to fall gradually. If the set-point pressure was not high enough, then the cuff will automatically be inflated further. During the measurement, the heart symbol flashes in the display and a beep sounds every time a heartbeat is detected. The result, comprising the systolic (129 mmHg in Fig.5.) and the diastolic (78 mmHg in Fig. 5.) pressures and the pulse rate (63 beats per second in Fig. 5.) are displayed, and a long beep is played. Repeat the measurement at least two times. Wait 15 s between the measurements.

Positioning of the arm may change the result. Make further three measurements with the left hand raised above the head and 3 three measurements with the left hand completely lowered. At the end of each measurement the device automatically stores the result including date and time. Repeatedly pressing the M-button displays the previously recorded measurements.

Measuring body weight

A digital body analysis scale, iHealth Core is used to measure the body weight during this practice. Stand on the scale without footwear. Step on the lower left corner of the scale to turn it on and wait until "0.0" appears on the display (Fig. 7. red circle). Stand still, do not move until your weight appears on the display (in kg units). The scale can store up to 200 weight results for each user. When each user's memory is full, new measurements will overwrite the oldest ones.

TELEMEDICINE DATABASE

Database of the student measurements can be reached *via* the telemedicine website, which was established for the purpose of this practice at the following link: http://195.111.72.188/telemed . The following starting screen is displayed (Fig. 8.).

Fig. 8. *Main screen of the telemedicine site.*

First, choose the language on the right side of the page (change language). Only registered users can use the site, therefore please register by clicking "Sign up here". During the registration process (Fig. 9.) you will have to type in your user name, password which cannot be changed later.

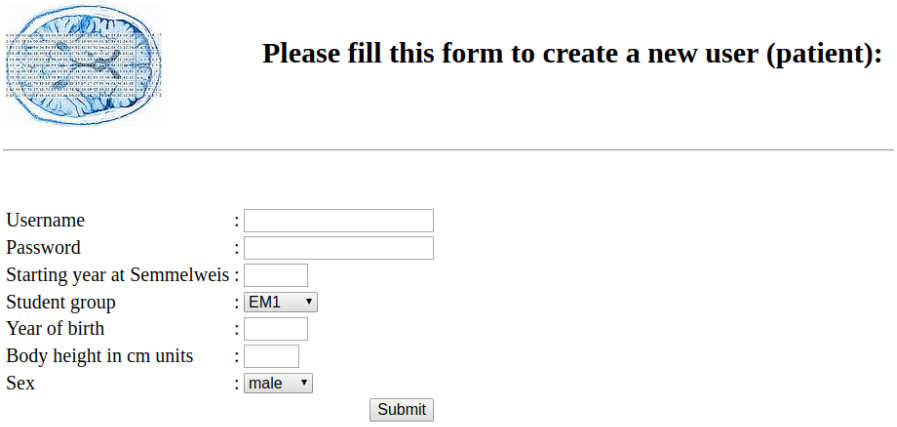


Fig.9. *Registration to the telemedicine database.*

Everybody is responsible for the confidentiality and remembering the user name and password. Forgotten passwords cannot be replaced. Fill in the other required fields as the year at Semmelweis, student group, year of birth, body height in cm, sex and submit. These data are handled confidentially. **Attention!** By registration you agree, that all the data, that are loaded into the database can be used by the students on the Medical biophysics and Biostatistics and informatics practices anonymously.

Registration can be done during the practices only. Loading the measured data into the database and export from the database can be done from home *via* the Internet as well. After successful registration, the „Data upload and retrieval" page is displayed (Fig. 10.).

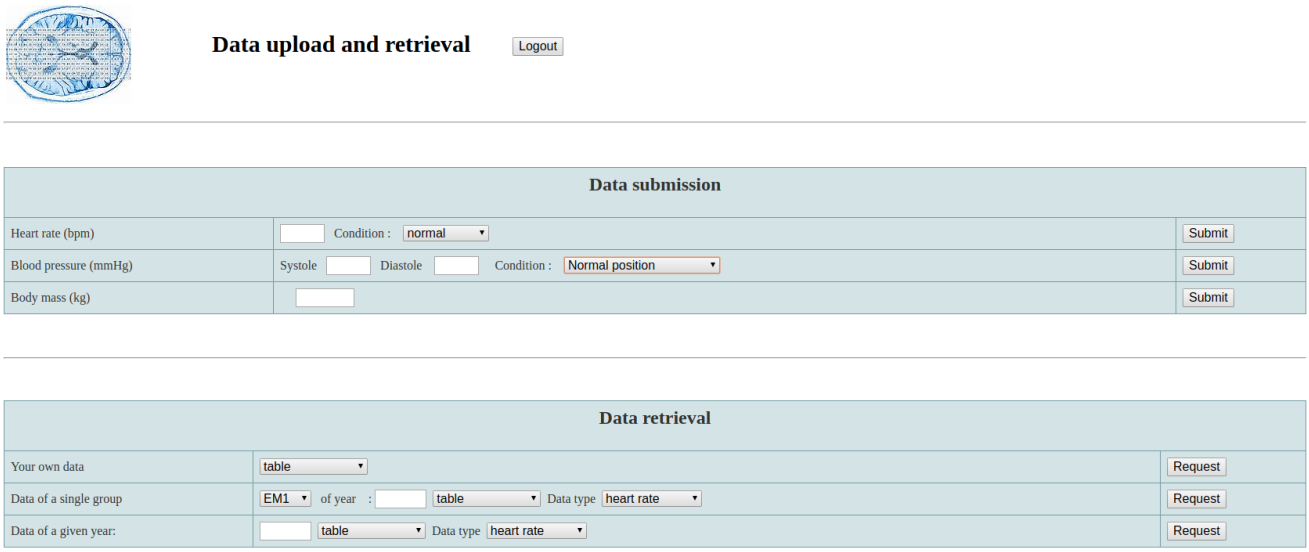


Fig.10. *Data upload to the database and retrieval from the database.*

The "Data upload and retrieval" window can be reached by registered users directly from the starting page of the site after signing in with the user name and password.

The heart rate, blood pressure and body weight values measured in different conditions can be submitted line by line in the "Data submission" part. After typing in the value, do not forget to click the „Submit" button at the end of the corresponding row. *Please, pay attention, and do not click the Submit button of a different row instead!* Once the value was submitted, it is not possible to make corrections. When the values are submitted, they are forwarded to the database and new values can be typed in the empty spaces. Be aware that next to the pulse rate and blood pressure data the condition of the measurement can be selected from a drop-down menu. In case of pulse rate the possibilities are: *normal* or *after activity*. At the blood pressure measurement the possible choices are: *arm up*, *arm down*, *normal position* and *normal position after activity*.

There are a number of possibilities for data retrieval. In the first row, data that were recorded by the actual user, or „Your own data" can be listed in a format of your choice. You may choose a „table" in which all the submitted values are listed in a separate page on the screen. The „csv file for Excel" makes it possible to export a comma-delimited „.csv" file which can be imported into Excel for further processing. Similarly, by choosing the proper group number in the next row entitled „Data of a single group" the data of the entire study group can be listed in the previously introduced formats. In this case both the group number and the year should be marked. The student has to specify which group of data should be listed out of the four choices.
If one needs a larger sample for making statistics, then „Data of a given year" can be exported in the next row after specifying the year, format and type of the measurement.
From the three data retrieval choices listed in separate rows, only one can be realized at a time by clicking the "Request" button at the end of the row.
Please click the „Logout" button at the end of your work to leave the telemedicine database.

TASKS

1. Measure the blood pressure and heart rate in three different positions, first: holding your left arm in normal position in level with your heart, second: after completely lowering left arm, and third: after raising the left arm above the head. Measure three times in every position.

2. Measure your body weight!

3. Register to the *telemedicine database* by filling in the registration form. **Registration can be made only during the practice!**

4. After registration, log in to the online database and load the measured data. This step can be done following the practice through the Internet from home as well.

5. Calculate and compare the mean values of the measured heart rate and blood pressure data for the different situations. Is there a difference? Explain why!

6. Compare the mean of your blood pressure data in the normal position with the values in Table 1. Determine the category of your blood pressure. *This is not a final diagnosis yet!*

7. Download from the online database the blood pressure data of the year 2016 and compare it with your measurement made in the normal position. Discuss the result!

Hypertension, also known as high blood pressure disease, is a long-term medical condition in which the blood pressure in the arteries is persistently elevated. The diagnosis is valid if: the mean of the resting blood pressure values measured 3 times in at least 1 week intervals is higher than 139 mmHg systolic and higher than 89 mmHg diastolic value.

Classification of blood pressure levels		
Category	**Systolic (mmHg)**	**Diastolic (mmHg)**
Optimal	< 120	< 80
Normal	120-129	80-84
High-normal	130-139	85-89
Hypertension	> 140	> 90
Grade 1.	140-159	90-99
Grade 2.	160-179	100-109
Grade 3.	≥ 180	≥ 110
Isolated diastolic hypertension	< 140	> 89
Isolated systolic hypertension	≥ 140	< 90

Table 1. *Classification of blood pressure values according to the European Society of Hypertension (2008)*

measurement	**blood pressure (mmHg)**				**pulse rate (1/min)**	**body weight (kg)**
			systole	**diastole**		
1.	**normal position**	**1.**				-
2.		**2.**				-
3.		**3.**				-
4.	**arm up**	**1.**			-	-
5.		**2.**			-	-
6.		**3.**			-	-
7.	**arm down**	**1.**			-	-
8.		**2.**			-	-
9.		**3.**			-	-
10.	-	-	-	-	-	

Table 1. *The measurement table.*