Database Development for Joint Analyses of Digital Anthropometric and Medical Data

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Abstract: The Goethe Gait Lab is a laboratory for biomechanical measurements. Its main objective is to study human movement concerning normal anatomical and physiological parameters. It does this to improve our understanding of human movement and objectively measure and evaluate variations in movement development and performance that are investigated and diagnosed in health care. As part of this task, creating a human biology database that stores anthropometric data obtained from a patient capable of performing calculations based on percentile tables is necessary. No database in the literature stores medical, anthropometric and biomechanical data together, thus allowing the calculation of anthropometric parameters and disease risk analysis. We report the development of a database. It will improve the accuracy of biomechanical measurements and enable their use in a broad professional context.

Keywords: biomechanics database; gait test; balance test; training plan

1 Introduction

In the 21st Century, chronic non-communicable diseases, which are the consequence of modern lifestyles and can therefore be considered civilisation diseases, are becoming more common. Prominent examples are obesity, hypertension and musculoskeletal disorders, which impose a significant health and economic burden on the population and healthcare systems at both individual and societal levels. Prevention and early detection of these conditions are key to promoting healthy lifestyles and reducing healthcare costs. In this respect, anthropometric research and establishing a single, modern database can play a crucial role. Anthropometry is an interdisciplinary discipline concerned with the scientific study of the dimensions, proportions and changes in the human body. While visual and subjective determination of excess weight is common in everyday practice, anthropometry uses precise measurement methods to quantitatively analyse the structural and functional characteristics of the human body. Modern technologies and advanced mathematical algorithms allow anthropometric data to be used not only to detect overweight and obesity objectively but also to predict various pathological conditions, detect developmental disorders and analyse movement patterns. No comprehensive, integrated database with detailed anthropometric information and medical and personal data has been created and published. In clinical practice, only two basic anthropometric parameters are typically recorded: body weight and height, from which the body mass index (BMI) is calculated. Although BMI is widely used as an indicator for estimating nutritional status, it does not provide sufficient information on body composition and proportions or the dynamics of growth and development. In particular, for children, BMI does not reflect the individual characteristics of the developmental rate with sufficient accuracy and is, therefore, of limited use for monitoring growth and early detection of developmental abnormalities. In addition, BMI cannot identify structural and functional abnormalities that may lead to musculoskeletal problems. Consequently, BMI-based assessment alone does not provide adequate data for developing preventive health strategies or targeted medical interventions. Creating a comprehensive database, including human biological and anthropometric data, would be essential to accurately monitor health status, increase the effectiveness of preventive medicine and optimise personalised therapeutic and rehabilitation interventions. First, we briefly introduce the anthropometry methods needed to understand the challenges of building an integrative medical anthropometric database. Then, we introduce the Goethe Gait Lab (GGL), as this motion analysis system is used in our laboratory, and the biomechanical data provided by this system will form the core of the database. We aim to create an online accessible anthropometric database closely linked to anthropometry from when the data is saved. In the database, we aim to store and connect patients' characteristics and medical data with anthropometric data, allowing motion analysis. The essential requirement for the database is to execute real-time transactions (data entry, data retrieval and modification) initiated from several workstations simultaneously. Therefore, we opt for online access as it makes the database location-independent and easier to access and because web applications are one of the most rapidly developing areas of IT. In addition, we would like to use web technologies to make data capture and visualisation more efficient. This paper presents the challenges of developing a structure for an integrative, expandable anthropometric medical joint database that allows interoperability between the different data types. We specifically discuss the mathematical algorithms used in this discipline and the web application needed to use the data. Finally, we present a case study of the potential application of the database.

1.1 Anthropometry: Human Biological Methods

Within human biology, anthropometry belongs to the field of human biological methods, which is the set of techniques developed for the human biological study of the morphological (shape), physiological (physiological), measurable (metric) and heritable characteristics of humans. With the development of digitalisation and intelligent systems, anthropometric data can be used in various fields. For instance, in sports anthropology (a discipline concerned with analysing the characteristics of the human body and the physical characteristics associated with particular sports), results are used primarily in developing training plans and methods for sports pupils and elite athletes. In auxology (a discipline that studies adolescent growth laws), results are mainly used in the enrolment of children in assessing their physical development and military recruitment. Also, complex digital anthropometric measurements are increasingly used in healthcare to support diagnostics and treatments. For instance, gait analysis can be used to identify the risk of falls, make rehabilitation plans or develop exoskeleton robots [1], [2], [3]. Whatever the field of study, the main steps of anthropometric measurement are as follows. First, anthropometric data must be collected with a specific research objective or measurement purpose [4], [5]. The appropriate test methods (hand-held or automated measurements) must be selected. The anthropometric data collected should be evaluated, and the results presented. In anthropometric testing, data can be recorded on paper. There are also electronically stored anthropometric data, for example, in institutions where data on patients with musculoskeletal disorders are stored, data generated during athletes' therapeutic activities, or in rehabilitation institutions' health records. The main steps in anthropometric testing are based on the same principles in all disciplines. First, a clear definition of the purpose of the measurement is required, which may be research, diagnostic or applied health. Then, choosing appropriate measurement methods, which can be manual or automated, is essential. The present study focuses on traditional manual measurement methods, while automated anthropometric data collection methods will be analysed in detail later [6]. Evaluating the anthropometric parameters obtained during the data collection and the appropriate interpretation of the results are key to their scientific and clinical applicability. Modern anthropometric studies currently use paper-based recording methods due to the lack of a single, centralised database system to integrate and store data from different sources. However, some institutions, such as health centres specialising in treating musculoskeletal disorders, sports medicine and performance analysis laboratories, and rehabilitation institutes, already use electronic databases to record anthropometric information. However, these systems are typically limited to a specific application area and do not provide a comprehensive multidisciplinary use [7]. Creating a centralised, large-scale anthropometric database would not only allow the advancement of scientific research. Still, it could also contribute to developing clinical practice, health monitoring systems' efficiency and personalised diagnostic and therapeutic procedures. However, achieving this raises several data protection and technological and methodological challenges that require further research.

Electronically stored anthropometric data are used as supplementary information to support medical diagnosis and treatment. However, there are advanced motion analysis systems that capture and analyse these parameters in a targeted way. These systems are typically designed for specialised applications: they are mainly used to optimise the biomechanical performance of elite athletes or to map anthropometric characteristics of specific diseases. Therefore, their design and operating principle are often so exact that they cannot be adapted for other populations, such as the elderly or patients with a broader healthcare population. This limitation is a particular problem in the health sector, where the integration of anthropometric data could contribute to improving the efficiency of diagnostic and therapeutic processes. Healthcare professionals need an easy-to-use, user-friendly database system that allows quick and easy access to anthropometric information without requiring engineering or IT expertise. The implementation of such a system could greatly facilitate patient monitoring, the development of preventive health strategies and the optimisation of rehabilitation processes. However, creating a widely applicable anthropometric database poses several technological and data protection challenges. The lack of adequate data storage and processing infrastructure and the need to protect sensitive personal data are complex issues that require a multidisciplinary approach and further research in health informatics, medicine, and data protection. Today, anthropometric data are still mainly measured using hand-held anthropometric measuring devices, which are anthropometers, rod callipers, callipers, condyle thickness gauges, leather shredder gauges, tape measure, Georg measuring tape, goniometer, finger thickness gauges and grip metre.

Figure 1
Anthropometric measuring instruments

1.2 Static and Dynamic Anthropometric Measurements

Anthropometric measurements can be static or dynamic. Static anthropometry is a body size measurement taken from a person in a stationary, standing or sitting position. The measurement is performed with the head in a horizontal position in

'Frankfort horizontal', with the upper limb hanging next to the body. (The 'Frankfort horizontal' is an anatomic reference line used in anthropometry: it is a horizontal plane passing through the lowest point of the lower margin of the two bony orbits and the uppermost point of the tragus cartilage of the ear.) [8]. Static measurement is an absolute anthropometric, direct or indirect measurement. Direct mode means the determination of the dimensions between the measuring points; for example, the direct dimension of the upper limb length is the distance between the acromion (shoulder) and dactylic III (middle finger). In contrast, indirect mode means the distance between the two directly determined distances. An example is the indirect measure of upper limb length, where the finger height is subtracted from the shoulder height. In dynamic anthropometric measurement, the focus is on human movement and the associated axis of motion. The joints allow different directions of movement in various planes according to their axes of motion. Movement is characterised by the angle of deflection and the plane of deflection. We distinguish between uniaxial, biaxial and triaxial motions. In uniaxial motion, for example, there is a bending and steering in the wrist joint in a transverse direction, where the plane of motion is in the direction of the arrow. In biaxial motion, for example, there are two types of motion in the egg joint. One motion is about the oblique axis, while the other is about the arrow axis. Finally, both previously mentioned motions can occur in triaxial motion.

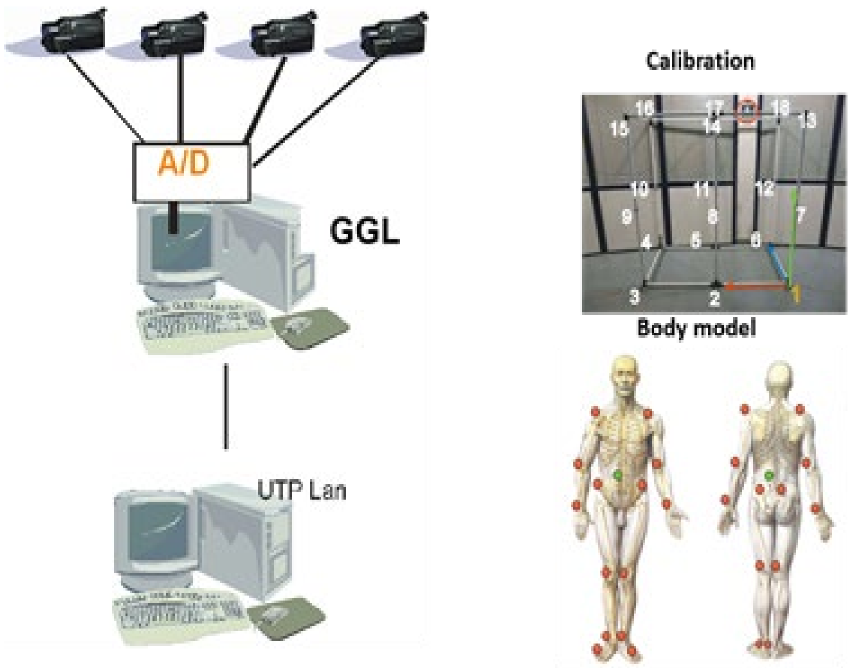

Figure 2
Goethe Gait Lab

1.3 The Goethe Gait Lab (GGL) Motion Analysis System

The GGL is a video-based 3D motion analysis system that provides objective biomechanical data for various professional needs. This system can be used:

1) in biomechanics

2) for motion analysis

3) for motion analysis in various sports

4) for gait analysis

5) for traditional medical diagnostic measurements in orthopaedics, traumatology and movement rehabilitation.

We use a particular sphere grid developed by the Goethe Gait Lab, which gives high accuracy, practically less than 1 per cent, which means we can test deviations in the millimetre range. Similarly, using 18 calibration points, the position of the chambers can be measured.

It is important to note that the fixed point is the absolute zero of the system. A salient point on the calibration body defines the zero point of the Descartes coordinate system concerning which the directions are given. The x coordinate is taken as the (sagittal) direction of progress, i.e. the direction of motion. The coordinate is the vertical direction, i.e. the direction in which the foot is lifted, and the z-direction is the lateral direction (horizontal). It was necessary to create this type of coordinate axis with a left-hand twist to be paired with the designations used in medical examinations. It could be presented and interpreted by both trainers and the medical profession. The basic test is the so-called Dempster's body model, which applies to the whole body and follows the body's movement. Naturally, the anthropometric characteristics of the subjects are measured beforehand, and the model has adapted accordingly. During the measurement, the images from the four cameras form the basis for the motion analysis test. Therefore, the cameras must be set in predetermined positions before making recordings. Calibration is also necessary to make the markers on the subject visible and traceable. The calibration tools are the calibration cube and the illuminated reference point. The size of the calibration cube is 170 cm in height and is adapted to an average human weight of 70 kg. Therefore, the height of the cube is 170 cm (y-axis), the length is 160 cm (x-axis), and the width is 80 cm (z-axis). The calibration cube used in our laboratory at the university consists of 18 points. For a successful calibration, the cube must be positioned in front of the lens of the four cameras so that all eighteen points of the reference point and the cube are visible in the images. Furthermore, the cube's orientation will provide the sagittal plane where the subject must move. As the anthropometric data in the database is closely linked to the Dempster and Jensen data model, the placement of markers should be based on aspects of these data models. The markers should be placed on the anatomical points defined in the Dempster and Jensen data model. Following the acquisition of the images, the points (markers) to be measured should be selected frame by frame, representing the anthropometric measurement points we used in addition to the motion analysis study. A feature of APAS allows the x, y, and z coordinate data of the markers to be saved to an Excel file. An algorithm is needed to determine the anthropometric data from these coordinate values if we obtain the anthropometric data. Since we discuss a three-dimensional data structure, the algorithm has high processor and memory requirements. Therefore, anthropometric data from the GGL markers can only be determined on the workstation and separated from the database. It is necessary to write the algorithm in a different programming language (e.g., C) and run it separately from the GGL program. The next subtask is to determine whether the anthropometric data should be transmitted directly from the program. Via a port, or whether the program should generate an output target format file that it imports into the web application.

Figure 3
GGL recording

The database design is based on a relational data model since Windows and UNIX operating systems are based on this logical model. In this model, data are defined in two-dimensional tables. Examples are the Dempster and Jensen data model tables in the previous chapter. You need a browser, a Web server and a database server to use the database. When anthropometric data is collected, it is good, so it is entered into the database via a browser. The pages displayed in the browser are written in the programming language of the Web server server-side program (in our case, this programming language is PHP) and are loaded from the Web server into the client-side browser.

1.4 Database Structure Development

The primary objective of the system analysis is to define the scope of the data to be stored, the initial step of which is a literature search. It should include assessing which anthropometric data parameters are relevant to the research and application objectives. For example, body measurement data are particularly appropriate for studying body composition and locomotor dynamics. They can also be used in diagnostic and preventive health procedures by associating with certain disease groups. However, visual characteristics such as eye or hair colour are not considered relevant for these analyses. In addition to selecting anthropometric data, it is also essential to determine what other patient-related information is needed for the database to function effectively. The needs of the potential database users, the data structure required for the computational and analytical processes, and the evaluation criteria should be considered. Systematic identification of these factors will ensure that the database provides valuable information for anthropometric research and health applications and remains sustainable and expandable in the long term.

Anthropometric measurement data: The data linked to anthropometric measurements may derive from hand-hold (manual) measurements and data defined by image processing algorithms. The image processing algorithm can identify the anatomical points from the images from which the data measured by manual anthropometric measurement can be derived. We used the standard hand-hold instruments and their associated methods to determine the human body's qualitative and quantitative characteristics. The web application had to consider the anthropometric data acquisition process as the whole database was closely linked to the measurement.

User data: The database user data will contain the username, password, and privilege level.

Evaluation of data: The evaluation of anthropometric data consists of several interdependent steps that ensure the reliability and scientific validity of the data. Firstly, the data from anthropometric measurements are calculated, during which individual body measurements and proportions are determined. It is followed by processing the results of other medical questionnaires, which allow the patient's health status and lifestyle factors to be considered. Finally, the results of the statistical analyses are evaluated, allowing the identification of relationships, trends and predictive patterns between the different variables. The integrated application of these steps will ensure an in-depth interpretation of anthropometric data, help to identify the links between body composition, health status and potential risk factors. The complex analytical process can contribute to developing prevention strategies, refining diagnostic methods, and designing personalised health interventions. The system design examined the relationships between the relations, resulting in the system specification. The relationship between ties [9] involves using keys to create relationships between tables. This key can be identified in one relation, determined in another, or described. These keys are also called unique keys. The relationship between relations can be 1:1, 1:N and N: M.

1:1 relations (one-to-one relations): In the case of a whole relation, one of the two relations (tables) involved in the relation is selected, and the defining (key) attributes of the other relation and the attributes assigned to the relation are added to its schema (column). In the case of a mixed (full-partial) relation, the key of the relation in the partial relation is associated with the entire page. This way, there will be no fields with null values. You can associate the relation key with either side for a partial relation.

1:N relationship (one-to-many relationship): For a 1:N relation, the attributes of the other related key and the characteristics of the relation are added as new attributes to the relation schema on the "N" side.

N: M relationship (more-many relationships): In the case of N: M relations, a new schema (relation) is added, whose attributes are the key attributes of the related relations and the relation's attributes.

Structuring new data entry: At this design stage, we need to consider whether to save new data by increasing the number of fields in a given table or by creating a separate table to store the new data. This question is essential, for example, when creating a new segment parameter table. The structure of the new segment parameter table to be created may differ from the structure of the previously used segment parameter table. The number of columns and rows in the table may vary. It refers to the difference in the number of fields in the segment parameter table in the database. Real-time multi-user database usage is the ultimate goal, so if adding a new field to an existing table is required. It will necessitate additional resources, which should be considered when saving the data of the new table. You have to create the new field in the existing table with a further statement, and only then can you save the data into the new field. The solution is to create a separate table for the table structure, where the fields represent the number of rows and columns of the new table to be created. This step enables you to create new tables dynamically, without altering the structure of existing tables. Consideration should also be given to defining the relationships between tables. It is then necessary to decide whether there should be a direct relationship between two tables or whether the relationship should be implemented by linking fields in separate tables. After the system analysis, system design and implementation of the physical layer, the data set of the anthropometric database has to be defined. An important aspect is the connectivity between the datasets, which is closely related to evaluating the measurement results. Clear interconnectivity between the datasets will allow us to monitor the data input and output from the database.

The datasets in the database are as follows:

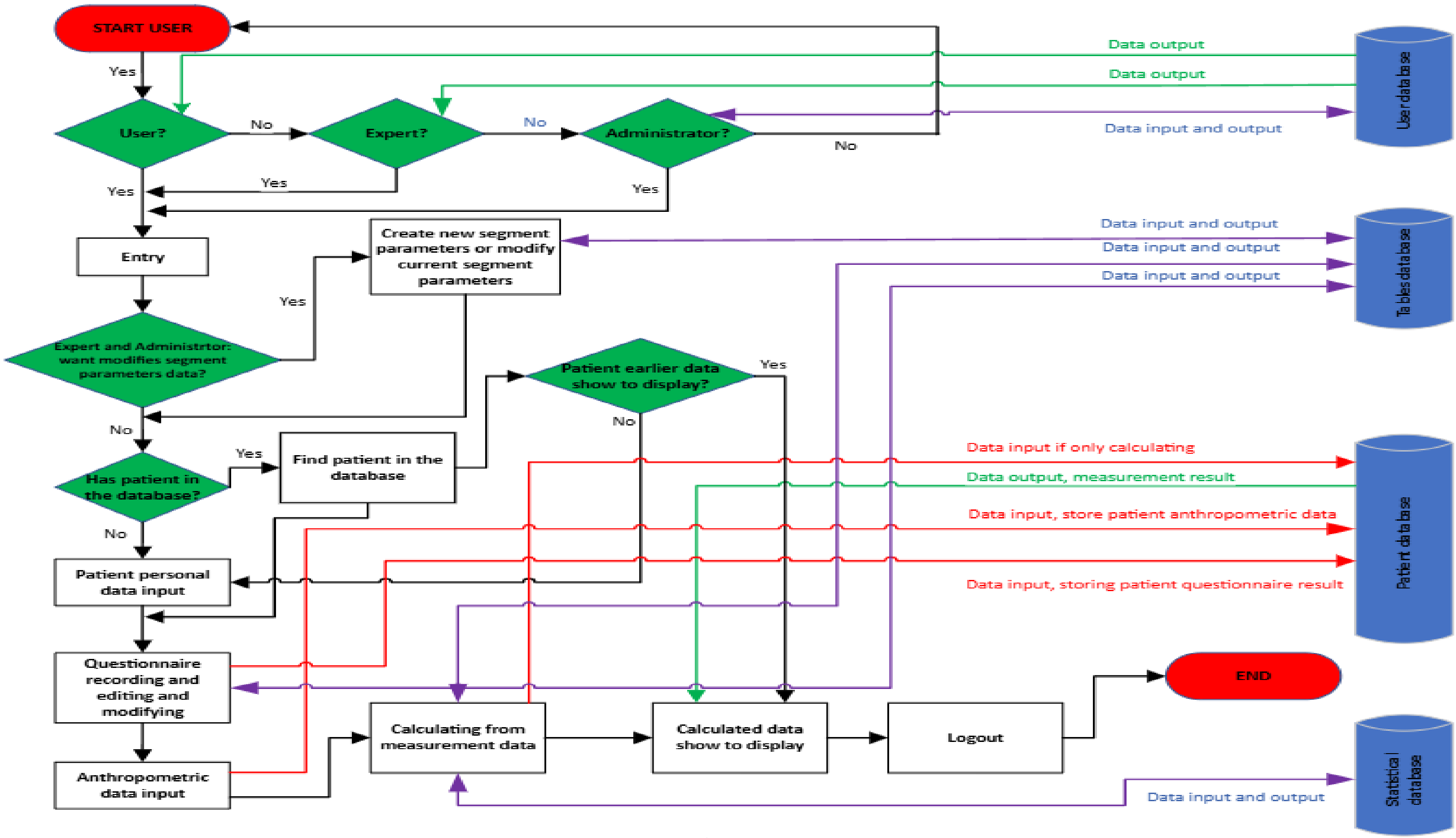

Figure 4

Flowchart of the use of an anthropometric database

Patient dataset: In addition to personal data, the patient's data file records the results of anthropometric measurements and previous tests. This data file contains primary information from the medical history questionnaires and relevant patient-related assessment data, which play a crucial role in clinical decision making and long-term health follow-up. The database is organised around this patient-specific data set, as the anthropometric data and the derived computational results are unique and directly related to the individual patient's health status. The database structure allows for systematic storage and efficient access to data, supporting diagnostic and therapeutic processes and the development of preventive health strategies.

Tables data file: The spreadsheet contains anthropometric coefficients and derived body models essential for determining the actual body segment centre of gravity for motion studies. It is necessary because the human body cannot be biomechanically considered a simple mechanical support structure consisting of rods and ball joints. Human motion modelling is not reducible to the mechanical properties and parameters of inanimate rods since the geometry of the limbs shows significant differences compared to rods of uniform thickness. The limbs are often thinner at one end and have a non-circular cross-section, which means that the centre of mass of the limb is not located at the segment centre line. Anthropometric parameters are supplemented with constants that vary with age, sex and body size. These constants allow body models to be tailored to each patient, thus ensuring high precision in biomechanical analysis, musculoskeletal diagnosis and rehabilitation planning.

Statistical dataset: A related dataset to the patient dataset is the statistical dataset because data derived from patient data are also stored there. In this case, however, the data stored here are used so that they cannot be used to identify the individual in the population under study. Evaluation algorithms are statistical calculations, and anthropometric calculations belong to this group. The calculations are carried out using the body models described in the previous chapters, which are contained in the data set of tables. This data file contains the data for the body models described and used in the literature and any new body models formulated by experts. In addition, this dataset contains data from additional tables that may be used for anthropometric calculations, such as those needed to estimate morphological age. These data will grow if we use new tables for anthropometric calculations, although not to the same extent as the patient data.

User dataset: The definition of the user dataset was essential for online use. It is the data set in which the primary data of the users and the privilege levels associated with the users are stored. *Data flow in the database* In the flowchart of the anthropometric database usage, it is possible to trace the direction of data flows for each process. (Figure 4) According to this approach, there can be one-way (input or output) input- or output-only data flows and two-way data flows. The fundamental difference between the two data flows is that simple data-input-only data flows typically represent only data input after calculations. In this case, there was no need to extract data from the data set, as the results of the calculations are displayed by another process, which takes care of the data extraction. Suppose a user with expert or administrator privileges wants to modify an existing segment parameter table. In that case, retrieving data from the table to be altered and storing the new values will result in a two-way data flow since the same process will perform both the data retrieval and the data entry. We have marked these data flows in different colours in the flowchart. Purple indicates bidirectional data flow, green only indicates data flow for outputs, and red only indicates data flow for inputs. A bidirectional data flow exists between the administrator privilege scan and the user data file for identification. Only the administrator can add new users, and only the administrator can change the privilege levels of existing users. When logging in, the user and expert users retrieve the privilege level data from the user dataset, so only a one-way data flow is defined.

2 Case Study: Automated Anthropometric Measurement

One of the most important tasks of today's parents is to educate their child (ren) to lead a healthy lifestyle and to protect their development and health. Anthropometry can monitor a child's development and, as a preventive method, detect various developmental disorders at an early stage. Furthermore, specific movement therapies linked to the detected disorder can be better targeted, and we can monitor the effectiveness of treatments. One example is the anthropometric morphological age assessment, which can be used to determine the age of a child between 9 and 14 years of age with a skeletal age accuracy, or in other words, the child's developmental age.

1.5 Automation of Morphological Age Determination

To determine the morphological age, we need to know the different body dimensions of the subject. These are shoulder width, forearm circumference and hand circumference. All three body measurements are given in centimetres. These three body dimensions can be used to determine the plasticity index. In addition to the plasticity index, we need the height, expressed in centimetres, the body weight (kg) and the subject's calendar age in decimal terms. Body mass, height, shoulder width, forearm, and arm circumference should be determined using anthropometric measurements. At the same time, the decimal age of the subject should be calculated by a simple mathematical operation. The subject's birthday is then calculated as the day of the year and divided by the number of days in the year, 365. The resulting decimal value between 0 and 1 is added to the subject's birth year to three decimal places. The leap year is ignored in this case, and if the subject was born on 29 February, the value of 28 February is used. Taking advantage of the possibility offered by the database, decimal age decimal values can be saved in the database. The working group of János Mészáros, Zsófia Mészáros, Miklós Zsidegh, András

Prókai, Ildikó Vajda, Andreas Photiou and János Mohácsi examined the effects of socio-economic changes over the last 20 years on the age group 7-18 years for boys in a study entitled "Generational growth differences and post-generational education" [10], [11], [12], [13]. This study illustrates that time and person hours invest a lot of energy. We highlight that anthropometric data were collected between 1980 and 1982 for boys aged 7-18 as part of the first exercise. At that time, anthropometric data were recorded on paper, while the related calculations were done by computer. The penetration of personal computers was low then, so it can be assumed that the calculations were done on paper or with calculators, and the results were recorded on paper. In the other half of the study, anthropometric data were collected between 2003 and 2005. By then, the IT tools were available to store the data and results from them electronically. Data recorded in the 1980s also had to be saved for research purposes. Tables were used to visualise the anthropometric data, while the associated statistical calculations and the graphs of the results of the calculations were carried out using computer software. Excellent attention and skill were required to organise the data and perform the calculations because inaccuracies could distort the study results. The automation solution formulated in this chapter will make the sorting and calculation tasks following anthropometric data entry more accurate and faster. The lengthy labour, time and energy-consuming process can be significantly reduced by using pre-defined input fields, automatic generation of tables and machine-coded formulation of the morphological age calculation steps. This solution approaches the automation task mainly on a theoretical level and is, therefore, not exclusively written in PHP. In this case, the PHP environment is instead formulated as a medium or sample for implementing the programming task. So, we would like to emphasise that the task can be implemented in other programming languages; we just chose the web application for one of the most popular visualisation formats. The web interface should not only provide a data access function but should be able to return the data in a validated form after the morphological computation. To save the data, we have chosen to save it in SQL database, one of today's most common storage formats. For this purpose, we have chosen the WAMP server as one of the program families, and we plan to implement the web application in the PHP programming language. We will implement the related algorithms in PHP so that the algorithm instructions will be in this programming language. This solution will ensure the user can determine morphological age after simple web access on any workstation. Since the morphological age estimation of a child's deformation can be described on several combination sheets due to the different growth rates of the other body dimensions, it was necessary to define population tables of body dimensions by age group. This population table by age group includes the previously mentioned body height, body mass and plasticity index. In our thesis, we implemented tables to automatically determine morphological estimation based on the Human Biology Practice Manual [8]. In addition to the child's primary data, one table saved in the database contains the decimal values of months and days. In contrast, the other table contains the parameters (body weight, height and plastic index) needed for the morphological age estimation.

1.6 Mathematical Algorithm for the Calculation of Morphological Age

As an example of illustrating the mathematical algorithm, we will present the calculation of the morphological age. The morphological age can determine whether the child has reached the average development corresponding to its calendar age or, if not, the calendar age value. The determination is made by comparing the calculated value with a table of averages of body measurements by age group. An important point to note is that the table should be representative of the population to which the person under study belongs. Therefore, values from other countries cannot be used for this purpose. It is advisable to re-establish these reference data every ten years because, for example, data recorded in the last century are no longer suitable for establishing morphological ages [14].

1.7 Data Needed to Determine the Morphological Age

Chronological age expressed in decimal [year] (DCK): simply by writing the decimal value of the calculated month and day of birth to the third decimal place after the year of birth. In determining the decimal value of the month and day of birth, the day of birth age is calculated as the day of the year divided by the number of days in the year, i.e. 365 (excluding leap years). For example, if the subject was born on 22 May 2000, then 22 May is the 142nd day of the year, divided by 365, which gives a value of 0.389, so the subject's age in decimal terms would be 2000.389. From this, the decimal value of the person's calendar age is obtained by rewriting the test date to decimal and then subtracting the decimal value of the date of birth. If the date of the examination is 23 November 2012, then the decimal value of the examination is 327/365=0.8958, so the decimal value of the examination date is 2012.896. Height [cm] (TTM): This value for our sample subject is 154.5 cm. Body weight [kg] (TTS): this value for our sample subject is 41.60 kg. Plastic index [cm] (PLX): the plastic index is the sum of the shoulder width, forearm circumference and hand circumference measured in cm - this value for our sample subject is 74.4 cm, obtained by adding the values of shoulder width 36.4 cm, forearm circumference 24.0 cm and hand circumference 14.0 cm [7], [14].

1.8 The Procedure for Determining Morphological Age

Determine, to the nearest 0.25, the height (154.5 cm), weight (41.60 kg) and plastic index (74.4 cm) of the subject, separately, corresponding to how old he is. The chronological and three ages selected based on the above body measurements are averaged. The age corresponding to height is 12.8 years, according to the table.

The age corresponding to weight is 12.2 years, according to the table, and the age corresponding to the plastic index is 13 years, according to the table. Thus, the first approximate estimate of the morphological age of the subject is (12.507 + 12.8 + 12.2 + 13)/4 = 12.63 years.

The calculated value must be corrected if the subject's height differs significantly from the corresponding chronological age. The estimated age should be reduced by 5% if the subject's height is greater than the height of subjects one year older than the subject, but not greater than those two years older. If the subject's height is less than the height of those one year younger than the subject, but more remarkable than those two years younger, the morphological age determined under point 2 shall be increased by 5%. If the subject's height matches the height of those more than two years older or younger, the correction is +/- 8%. Since the difference between the calculated morphological age value and the chronological age value is less than 0.25, it can be concluded that the subject is of age-appropriate development. Two additional tables in the database are needed for the morphological age displays using the web application. In these two tables, we save the decimal value of the chronological age to three decimal places and the parameters necessary to estimate the morphological age. Since we both want to save data in the database with decimal precision, the type of these data in the database must be FLOAT. From a programming point of view, simple mathematical operators (multiplication, division and addition) can be used to calculate the morphological age in PHP. Then, of course, the final result can also be stored in a database. In practice, this means that the values retrieved from the database are first put into variables, then mathematical operations are performed on these variables. Of course, for more complex motion analysis studies, the more complicated mathematical operations must be broken down into elementary steps. However, the variables used for the mathematical formulae (anthropometric data stored in the database) are trained in the same way as for determining morphological age, i.e., they are also stored in variables after being extracted from the database. The image processing algorithm should be hosted on a client-side workstation. The anthropometric data provided by the image processing algorithm and the measurement results calculated from them shall be saved directly or indirectly to the database. Indirect saving will allow the application running on the workstation to generate a file with a unique extension, which must be imported into the database via the web application. The file generated by the image processing algorithm. The test was performed, including anthropometric data related to the segments, the date of measurement, subject baseline data, and the evaluation results of the motion analysis measurement. As this is a website and, through it, a database that is continuously accessible from the web, it is still essential to further develop existing security features. Given the public nature of the website, it will also be necessary to provide a language option in the future so that the site can be accessed and used not only in Hungarian. In addition to the Hungarian language, the English version should be developed first. Since the database contains the anthropometric data set associated with the motion capture system, it would be helpful to build on the knowledge and experience of this system and use some of the functions on the site. One such feature is the use of percentile tables linked to statistics. When examining the motion analysis, the graphical representation of the data obtained from the system will also be displayed on the website, supported by animations. The anthropometric measurements used in the database can be used for public health projects. Criteria should be established in collaboration with appropriate health, education and government professionals to make the database suitable for a wide range of studies on larger populations.

3 Discussion

We have developed a database structure in which anthropometric and medical data can be stored together and connected for a medical database and biomechanical analysis system. The following information helps create the database and, therefore, is valid for many professional groups.

This database is suitable for the following: At first, according to our best knowledge, this is the first database that has never been created where a patient's medical data and anthropometric parameters are stored together in separate biomechanical tests, which are not carried out by recording anthropometric parameters but by calculating the location of markers. Therefore, the resulting body models and measurements do not or only, to a limited extent, consider the actual proportions of the human body in the modelling. The mechanical model then consists only of nodes and the "rods" connecting them, which, in terms of their mechanical parameters, are half the parameters of a bridge structure or various supports. However, the human body's segments cannot be considered simple supports, not only because of their thickness and shape. For example, in the case of an arm or a leg, the position of the centre of mass of a part cannot be calculated as simply as for a rod made of a homogeneous material. Second, the segments of the human body are not made of homogeneous material but of different tissues. The segments of the human body, e.g. the hand or the foot, cannot be replaced by a simple rod as a shape because the end nearer the trunk is usually thicker. Thus, it cannot be regarded as a cylinder. It is why, as early as 1955, Dempster developed a weighting system based on a pseudo-definite series of measurements, which allowed for a more accurate determination of the proportions and mechanical model of the human body. However, this model can only be derived for measurements and modelling if, for example, Dempster's weight factors are to be used in conjunction with anthropometric measurements. Third, data on individual-specific physical development could, of course, also be extracted from this database. In today's fast-paced world, the evaluation time of a test result is crucial. We try to minimise this time while considering the result's accuracy and validity. The database we have created meets this need. In the past, the data acquisition time for a study in the anthropometric discipline could take several months or even 1-2 years, and measurement results were at best recorded on a local server and at worst on paper. After data collection, only the calculations and evaluations defined by the research were carried out, which could also take several months. With an online database, data collection can be significantly shortened, as there is already a working server in the background at the moment of data collection, which can be accessed from anywhere, regardless of location; all that is needed is an internet connection.

Fourth, this database has a lot of application areas. Biomechanical movement testing has a wide range of applications beyond the scope of sport and rehabilitation. They provide the scientific and medical community with beneficial information for detecting, treating and preventing musculoskeletal, neurological and cardiovascular problems. Below are some examples of how biomechanical testing can help patients and professionals in different areas. *Assessment and Diagnostics* Biomechanical movement tests are essential in medical diagnosis and assessment of physical condition. Analysing movement parameters (e.g. walking or running) can provide crucial information on the risks and signs of various diseases. Example: *scoliosis*: Biomechanical testing allows for measuring curvatures and assessing muscle balance. Accurate measurements help determine the disease stage and the most appropriate treatment. Choosing the right therapeutic exercises (such as physiotherapy) can help slow down the progression of the disease and prevent more serious consequences such as pain or limited mobility. *Choosing the proper sport/exercise* By considering the individual physical condition and level of development, biomechanical testing can help you choose the most appropriate sport or form of exercise, minimising the risk of injury and maximising performance. Correct movement patterns and posture analysis for training are essential to avoid injuries. *Example: Sport wearing* Biomechanical and anthropometric measurements and databases play a significant role in the production of sports shoes for the following reasons: a. Comfort: anthropometric data (such as foot length, width and arch height) help ensure that shoes fit users' foot shape properly, thereby maximising comfort. b. Performance: biomechanical measurements such as stride dynamics, load distribution, and movement mechanics help design sports shoes to support optimal performance. c. Proper cushioning and stability can improve athlete performance [15], [16]. Injury prevention: biomechanical analysis allows shoes to be designed to reduce the risk of injury. For example, proper sole design and flexibility can help reduce stress on the foot and joints. d. Customizability: anthropometric data allow shoes to be tailored to different user needs, considering different foot shapes and sports specificities. e. Market needs: sports shoe manufacturers also adapt to market needs, and biomechanical and anthropometric research helps them better understand consumer preferences and needs. f. Innovation: Research and measurements constantly reveal new ways to improve footwear, for example, using new materials and technologies to improve performance and comfort. Biomechanical and anthropometric measurements and databases play a key role in optimising products, improving the user experience and maintaining competitiveness in sports footwear manufacturing. *Example: running and knee injuries.* For runners, biomechanical movement analysis can be fundamental in preventing knee injuries. Motion analysis can help identify inappropriate running techniques that may place excessive stress on the knee. Through correct posture, stride, and foot positioning, runners can avoid common knee injuries, such as patellofemoral syndrome, associated with pain in the front of the knee. *Example: rehabilitation of an athlete.* Biomechanical movement testing also plays a key role in athletes' rehabilitation programmes. For example, during rehabilitation after an ankle injury, movement analysis can be used to monitor how the athlete returns to standard movement patterns. With the help of this database, coaches and therapists can recommend personalised rehabilitation exercises that will help them recover faster and safer. *Disease Risk Definition and Prevention* Biomechanical testing allows one to accurately model patients' pre-defined health risks and develop preventive measures to prevent future health problems. *Example: Cardiovascular diseases.* Biomechanical movement testing can measure the efficiency of subjects' movements and muscle activity. Low intensity of movement, inadequate use of the body or excessively unilateral movement patterns (e.g. prolonged sedentary work) can lead to cardiovascular problems in the long-term. Based on the results of these studies, doctors can suggest lifestyle changes, such as introducing regular exercise, to reduce the risk of heart attack or stroke. *Example: osteoporosis.* Biomechanical movement tests can also help in the early detection of osteoporosis. Doctors can predict bone fragility by measuring the load-bearing capacity of bones and analysing the forces generated by exercise. In prevention, adjusting the correct form of exercise (e.g. strength training) and good nutrition (e.g. calcium and vitamin D intake) is recommended to prevent osteoporosis. *Rehabilitation and Therapy* In the rehabilitation process, biomechanical movement tests can be instrumental in measuring the rate of recovery and the effectiveness of treatment. For clinicians and therapists, movement data provide the opportunity to monitor how the body responds to specific treatment methods accurately. *Example: post-stroke rehabilitation* In post-stroke rehabilitation, biomechanical movement tests help determine the recovery rate of motor function. Activating different muscle groups in the body and improving balance and coordination are all essential in post-stroke recovery. By coordinating movement tests with rehabilitation programmes, we can achieve the desired results more quickly and effectively.

Conclusions

In this study, we developed a theoretical anthropometric database structure for the integrated storage of patient-specific anthropometric data, medical history and other relevant health information to support motion testing, biomechanical analysis and clinical decision making. The database structure is designed to adapt to individual differences, allowing for the personalised generation of body models.

Strengths of the study:One of the main advantages of the anthropometric database is that it can store more detailed morphological and biomechanical information in addition to the traditional body mass index (BMI) and basic body measurements (height, weight). It allows more accurate diagnostic and preventive conclusions to be drawn. Other studies and systems usually record a limited number of anthropometric parameters. At the same time, the current structure also considers data such as body segment midpoints and body proportions, which play an essential role in movement analysis. Most existing methods are based on static anthropometric analysis or only deal with partial datasets. At the same time, the model we develop can interpret the data dynamically in context with each other. Discussing the limitations of the study it is important to note that the database exists as a theoretical model in its current state, and its practical applicability has not yet been tested. Although the structure is flexible and well-established based on the literature, additional challenges may arise during the implementation. Validation studies with patient data are unavailable, so the practical operation's effectiveness and reliability have yet to be empirically tested. In addition, privacy and ethical aspects need to be elaborated in detail to ensure that the database meets the standards used in clinical and research settings. Overall, the database we have designed is a promising initiative in anthropometric and biomechanical research, which could contribute to developing diagnostic and therapeutic procedures in the long-term.

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