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COMPUTER SUPPORTED ANALYSIS OF THE HUMAN BODY SURFACE AREA

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Abstract. *Recent scientific studies show the growing importance of the coefficients: BSA and TBSA, as an alternative to the widely used BMI. The relevant indicators are widely used in medicine, including such areas as: the treatment of burns, chemotherapy, dermatology and toxicology; as benchmarks when calculating doses of drugs and fluids. The particular problems concerning this subject are: the change of the reference parameter value which represents the patient's body weight, multiplicity and variety of applicable methods of calculating BSA and TBSA, as well as the lack of computer systems supporting the performance of all analytical processes. Therefore, this article describes: the structure of the designed and developed computer system supporting the process of research and analysis for the identified state variables, and the study of the accuracy and reliability of the methods known from the literature and a proposal of imaging of the changes in individual coefficients, both in adults and children. For simulation studies 10 most commonly used methods were selected.*
Keywords: Body surface area, Total body surface area, Body mass index, Computer aided analysis

1. Introduction.

In many fields of science, the current state of knowledge determines the potential possibility of use of the latest and most advanced technologies. The basis of any action in this case are pieces of specific information whose acquisition and interpretation often pose difficulties. This information must be collected and subsequently processed in a timely manner, and the dynamics of changes in many physical quantities can cause that they are flawed. The recognition, evaluation and correct interpretation of those errors can play a key role.

A scientific discipline in which these factors play an important role is undoubtedly biomedical engineering, which, along with scientific disciplines such as genetics, or biotechnology, decides on the progress of modern medicine. Obtaining as wide as possible set of information about the patient and his medical problems is a basis, needed for the follow-up medical procedures (diagnosis, medication, preparation for surgery, and more). The important state variables in this field, which after years of stagnation requires increased attention again – and yet to the essence of which the further contents of the article is devoted to – are: the rate of human body surface area (BSA – *Body Surface Area*) and the ratio of the total area of the human body (TBSA – *Total Body Surface Area*). These indicators provide the necessary information in numerous medical and scientific research (Figure 1).

BSA and TBSA indicators are widely used in the treatment of burns [1-6], as well as the chance of survival prognosis of the patient [7]. In this case the calculation process must be performed as fast as possible, because specific doses of fluids and drugs used in

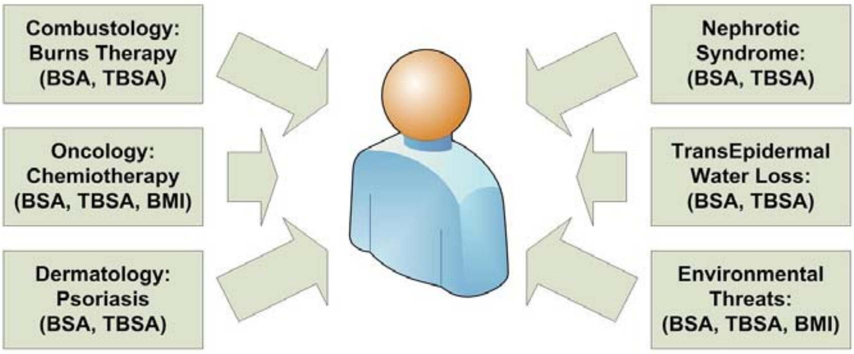

FIGURE 1. The main areas of interest for human body surface area analysis

the first phase of treatment depend on the values of BSA and TBSA coefficients. In the later stages of therapy they are used to estimate the skin area for a transplant. They are also necessary for the board certified occupational medicine physician to determine the amount of money compensation for a victim of an accident. Another field of medicine, in which the rate of BSA is increasingly being used, is oncology [8-12], where one of the methods of treatment is chemotherapy in which the patient is subjected to a mixture, by nature, dangerous chemicals. At the implementation stage of this procedure, it is very important to determine the dosage of the mixture, as a too small dose may be insufficient to destroy the cancer cells, and a too high dose may cause serious complications (toxicity, organ damage or even death). For this reason, it is especially important that the reference parameter, by which the dose is determined, is at most stable so that the determined on this basis value was reasonable and safe throughout the whole treatment period. Available in the literature study results [8] indicate that during chemotherapy the BSA index is used more often than the BMI (*Body Mass Index*), or the patient's body weight. This is due to a significantly lower ratio of the coefficient value change in relation to the change of body mass or height (for example, for a 185 cm tall person whose weighing 100 kg a loss of weight to 80 kg will result in: a change in weight by 20%: a change of the BMI from a value of 29.2 to 23.4 which equals 19.86%, and a change of the BSA rate by about 9%). Yet another department of medicine, in which the determination of the damaged surface of the human body is justified is dermatology, where on the basis of the body surface area covered by psoriasis, the decision of choosing the right kind of therapy is made [13]. In addition to the above areas of interest, the BSA coefficient is also applied in the fields of: the issue of water evaporation through the skin [14], treatment of nephrotic syndrome [15] and environmental health risk assessment [16]. In the last case, it is particularly important to calculate precisely the area of the skin surface exposed to contact with a harmful agent [16].

Taking these factors into consideration and analyzing the current state of knowledge in the field of computer systems supporting the process of assessing human body surface area [10,17,18] one can find a serious gap. The available studies show an almost total absence of complex solutions in this field. Known [19-22] and widely used BSA calculators (*Body Surface Area Calculator*), allow only the determination of values of BSA on the basis of the methods implemented in them. They do not however allow to examine only the differences resulting from the use of specific methods – thanks to which it would be possible to identify errors resulting from the use of these methods. Moreover, BSA calculators do cannot perform the simulation to study the change of the BSA as a function of variables, such as height and weight of the patient, which would undoubtedly enable a conscious choice and would improve the learning methods and processes for all those interested in teaching the relevant subjects (scientists, doctors, physicians, examiners, students, and other). The use of these BSA calculators in practice, makes it difficult to quantify the value of the surface area of each part of the body and creates unnecessary risk of committing additional calculations errors by users. This is because they have to, after using the BSA calculator, use the appropriate tables: *von Meeh* – for newborns and infants, *Lund and Browder* – in the case of older children, or so called *"The Rule of 9"* – for adults [23] and this in turn (in addition of being under time pressure) increases the computational process and can lead to very serious, in consequences, mistakes.

In the face of the situation described above, it is significant and reasonable to develop and implement a computer system supporting the research and analytical process in the area of calculating and analyzing human body surface area and carry out extensive simulation studies in this field. This article presents the results of research conducted by the authors and the characteristics of the tool that is the designed and built computer system. In addition to scientific aspects, the work has also the utilitarian meaning, as the developed system can be used in many medical centers – as a tool supporting therapeutic processes, as well as in research centers – during the implementation of numerous research and development projects.

According to the authors, by using the tools available in the developed system, one will be able to carry out a full analysis of the available methods of calculating BSA and TBSA coefficients, based on a number of available parameters and graphs representing specific functions (one or more variables). One will therefore be able to identify the differences resulting from the use of particular methods, and thus use this knowledge to select the appropriate (for a particular case) method of calculation. The conclusions drawn from this process would make a starting point for a number of medical societies that formulate recommendations on the applicability of these computational methods, to specific clinical cases.

2. **Methods of Calculating Body Surface Area.** Scientists were interested in the problem of determining the patient's body surface area since the beginning of last century [24]. The calculation of coefficient has been determined by two state variables: growth and weight of the patient. For this reason, most of the developed formulas for calculating BSA ratio, takes the form

$$BSA = a_0 * H^{a_1} * W^{a_2} \tag{1}$$

where: H – means height, W – means weight, whereas a_0, a_1 and a_2 – are certain parameters specific for different methods. It should be noted that the parameters a_0, a_1 and a_2 are the result of estimation on a set of reference data obtained on the basis of performed empirical tests. Hence, they are usually long and hard to remember strings of numbers, and as a result their use in terms of time pressure becomes even more difficult.

The large amount of currently known solutions is mainly due to the lack of a simple relation between height and weight in the entire population of humanity. The first study performed in this field included a group of 9 patients in which only one of them was a child. One of the latest research conducted and described in [24] was performed on a group of nearly 4,000 people. The results of these studies provide the estimated values of the parameters a_0, a_1 and a_2, depending on sex and age of the subjects.

Table 1 presents formulas for calculating the BSA index for ten most commonly used methods. These methods differ from one another (Table 2) in: the year of publication of the study, number of examined subjects and the method of specifying a standard, precise value of the BSA parameter for each person, which then allows for the estimation of the final formula. Some of the methods are based on several different formulas – depending

TABLE 1. A list of the formulas used to calculate BSA for the most commonly used methods

Method's author	**Formula**	**No.**
DuBois and DuBois [25]	$BSA = 0.007184 * W^{0.425} * H^{0.725}$	(2)
Boyd [26]	$BSA = 0.0332965 * W^{0.6157-0.0188 \ln W} * H^{0.3}$	(3)
Fujimoto [27]	$BSA = 0.008883 * W^{0.663} * H^{0.444}$	(4)
Takahira [27]	$BSA = 0.007241 * W^{0.725} * H^{0.425}$	(5)
Gehan and George [28]	$BSA = 0.0233 * W^{0.51456} * H^{0.42246}$	(6)
Haycock [29]	$BSA = 0.0024265 * W^{0.5378} * H^{0.3964}$	(7)
Mosteller [30]	$BSA = W^{0.5} * H^{0.5}/60$	(8)
Yu, Lo, Chiou (YLC) [24]	A person under 20 : $BSA = 0.015925 * (W * H)^{0.5}$	(9)
	Female 20 - 31: $BSA = 0.015984 * (W * H)^{0.5}$	(10)
	Female 32 - 51: $BSA = 0.016085 * (W * H)^{0.5}$	(11)
	Female 52 - 71: $BSA = 0.015955 * (W * H)^{0.5}$	(12)
	Female 72 - 91: $BSA = 0.015915 * (W * H)^{0.5}$	(13)
	Male 20 - 31: $BSA = 0.016091 * (W * H)^{0.5}$	(14)
	Male 32 - 51: $BSA = 0.015966 * (W * H)^{0.5}$	(15)
	Male 52 - 71: $BSA = 0.015907 * (W * H)^{0.5}$	(16)
	Male 72 - 91: $BSA = 0.015956 * (W * H)^{0.5}$	(17)
Schlich [31]	Female: $BSA = 0.000975482 * W^{0.46} * H^{1.08}$	(18)
	Male: $BSA = 0.000579479 * W^{0.38} * H^{1.24}$	(19)
Yu, Lin, Yang (YLY) [32]	Female: $BSA = 0.00844673 * W^{0.4176} * H^{0.6997}$	(20)
	Male: $BSA = 0.00798106 * W^{0.398} * H^{0.7271}$	(21)

TABLE 2. A detailed list of information concerning methods of calculating the BSA ratio

Method's author	**Year**	**Subjects**	**Method**	**Refference**
DuBois and DuBois	1916	9	Covering the body's surface	[24]
Boyd	1935	197	Covering the body's surface	[24]
Fujimoto	1968	201	No data	[10,27]
Takahira	1968	No data	No data	[27]
Gehan and George	1970	401	Covering the body's surface	[24]
Haycock	1978	81	Linear geometry	[24]
Mosteller	1987	No data	No data	[30]
Yu, Lo, Chiou	2003	3951	3D scanning	[24]
Schlich	2010	188	3D scanning	[31]
Yu, Lin, Yang	2010	270	3D scanning	[32]

on the sex of the patient, and one of them – on the membership to one of the five age groups.

3. **The Essence and Functionality of the Developed Computer System.** The developed and implemented computer system that supports the processes of human body surface analysis has a modular structure (Figure 2).

The structure of the system (Figure 2) can be divided into two work levels with diverse functionality. The first level – clinical – consists of a single module, which allows for a quick and intuitive calculation of the BSA and TBSA indicators, the use of which has specific significance for the daily tasks in a hospital or clinic. In this case, the user

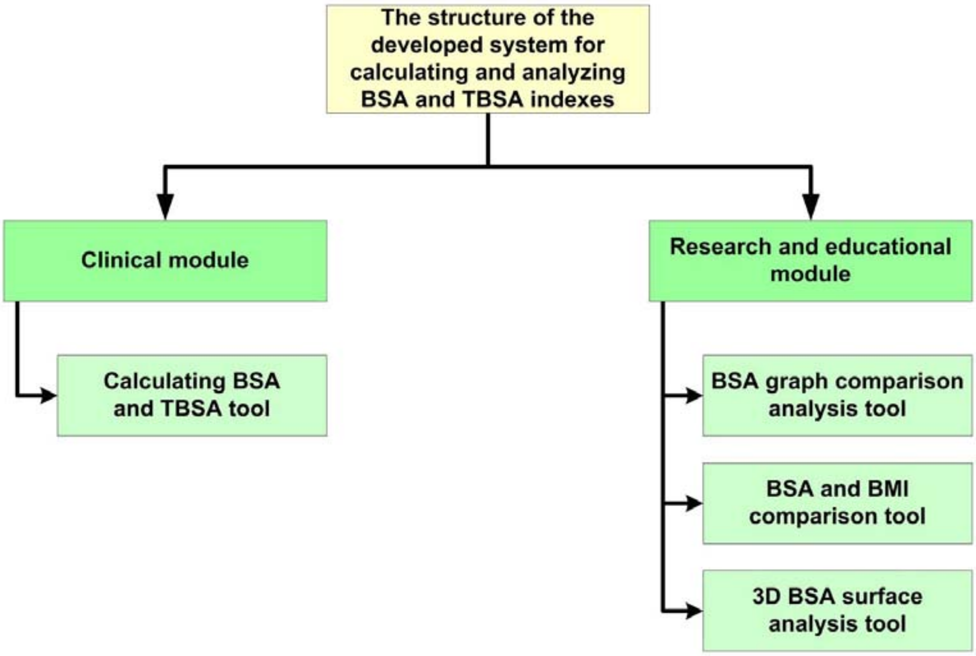

FIGURE 2. The block diagram of the developed and implemented computer system

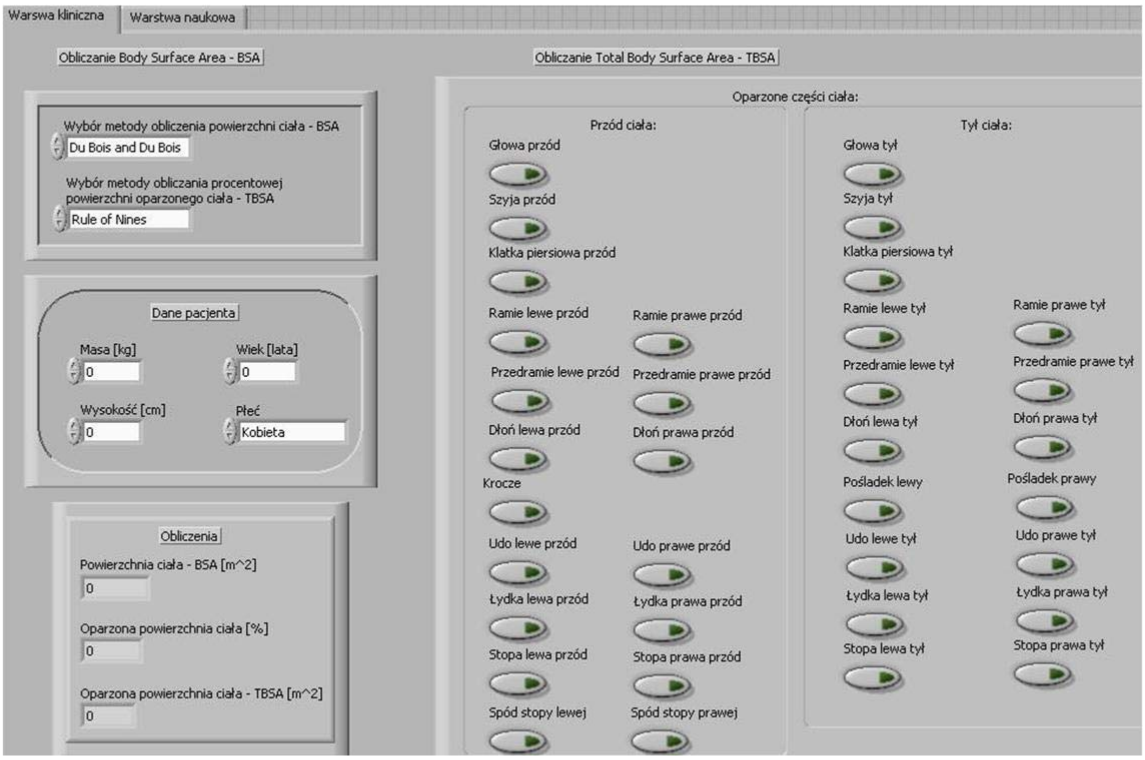

FIGURE 3. A view of the clinical level of the program used to calculate the BSA and TBSA coefficients

action is limited to the introduction of basic patient information, such as (Figure 3): height, weight, age and sex of the patient and the possible methods for determining of the BSA and TBSA indicators (other than the default). As a result the system will calculate the values of the BSA coefficient and both the percentage and the exact values of TBSA coefficient. The second level of the program – education and research, consists

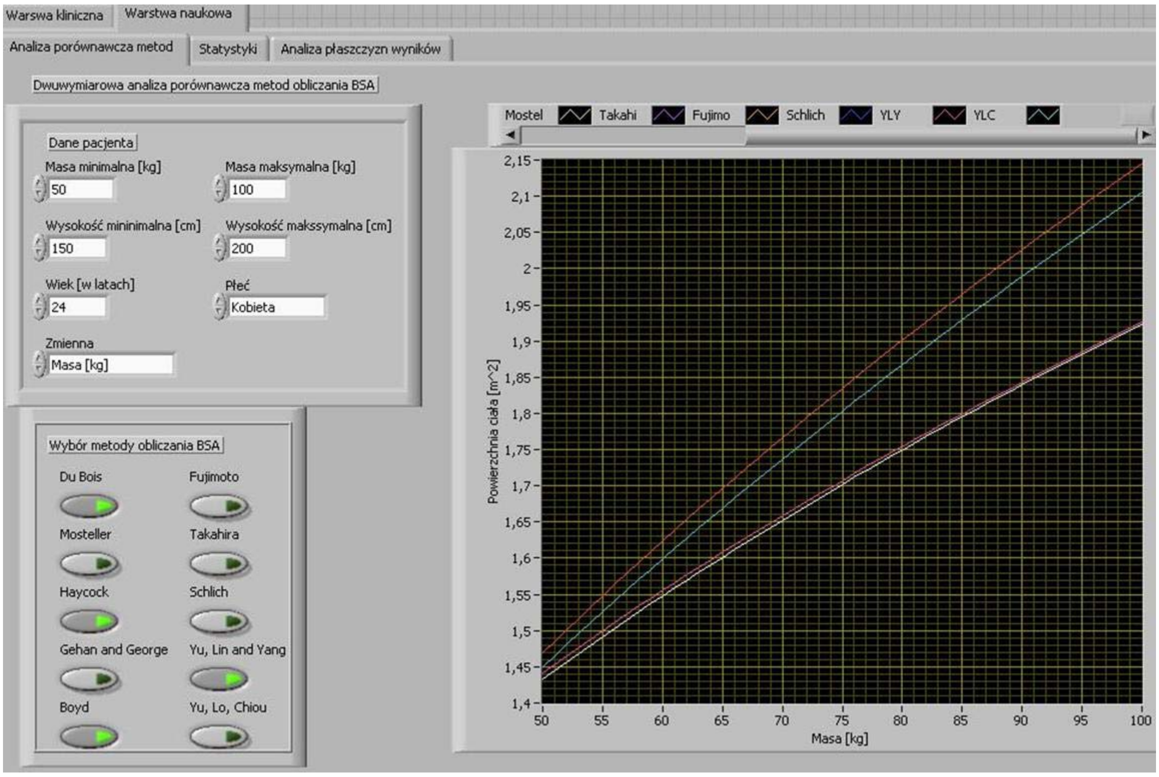

FIGURE 4. A view of the first module of the educational and research level of the program used to plot and image BSA graphs

of three modules that allow to perform a complete research procedure, based on graphs obtained for the user-selected methods (among all implemented in the system). The first module allows plotting up to 10 graphs, thus allowing a comparison of the similarities and differences between them (Figure 4). The second module allows a comparison of the graph representing the BMI index and the BSA chart – Figure 5 (and to determine the basic statistical parameters in this field). And the last of the available modules (Figure 6) allows to perform a complete comparative analysis (defined by the authors as the surface analysis) between the two planes representing the selected sets of solutions in the range of the calculated BSA coefficients.

Comparing the three-dimensional surfaces, obtained from selecting by the user two defined methods (Figure 6), allows to observe of divergence in the whole range of variation of the analyzed values of weight and height. Hence, it can be observed, for which the of state variables the BSA value is greatest and for which it is minimal. One can also estimate the angle between the planes, which indicates the gradient of changes of the BSA coefficients. When using the described method one can also recognize a place where the planes intersect to form a curve of intersection. This curve provides that a common space of solutions for both analyzed methods (for the same weight and height) exists.

4. The Characteristic of the Performed Simulation Research.

4.1. **The range of the research.** One of the most important issues in the discussed field is to determine which of the following formulae (Table 1), and in which cases, offers the best results. It is also important to indicate the measurable benefits from using the BSA index rather than BMI or only the patient's body weight. Therefore, the essence of the study consists of the results of a comparative analysis of the mentioned methods. As a result, the curves representing the specified range of state variables (weight and height)

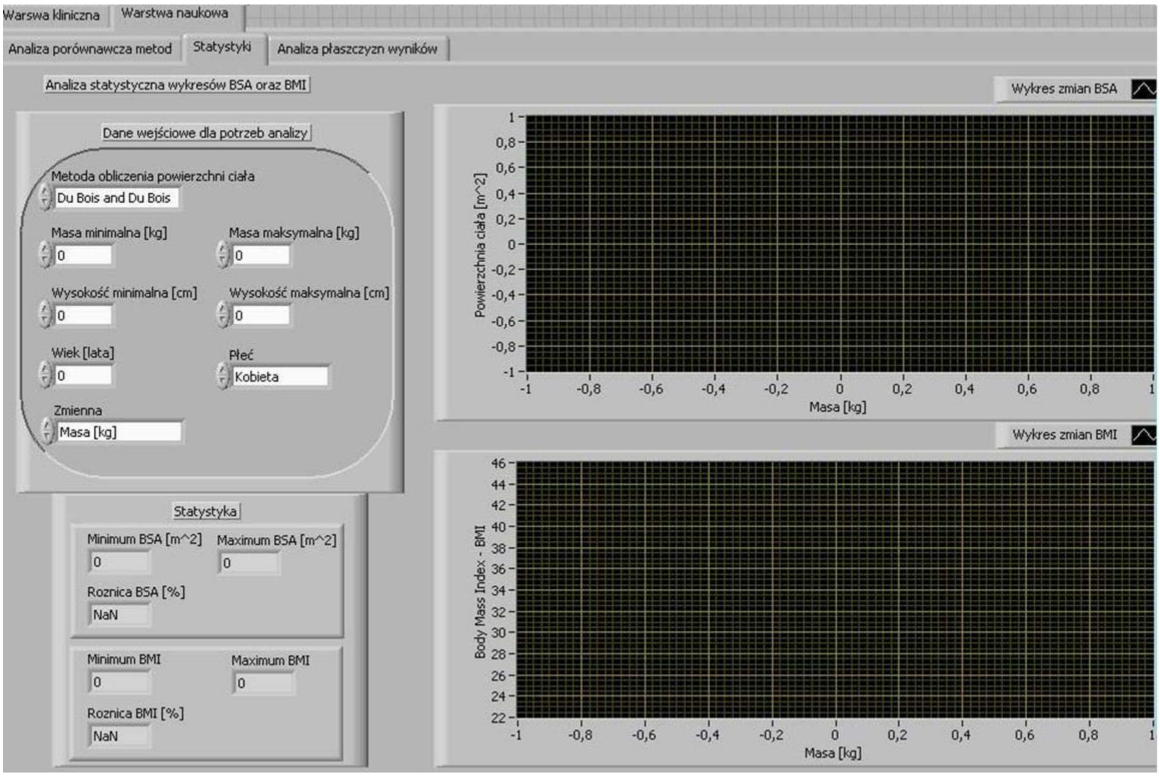

FIGURE 5. A view of the second module of the educational and research level of the program used to perform statistical analysis concerning BSA and BMI indicators

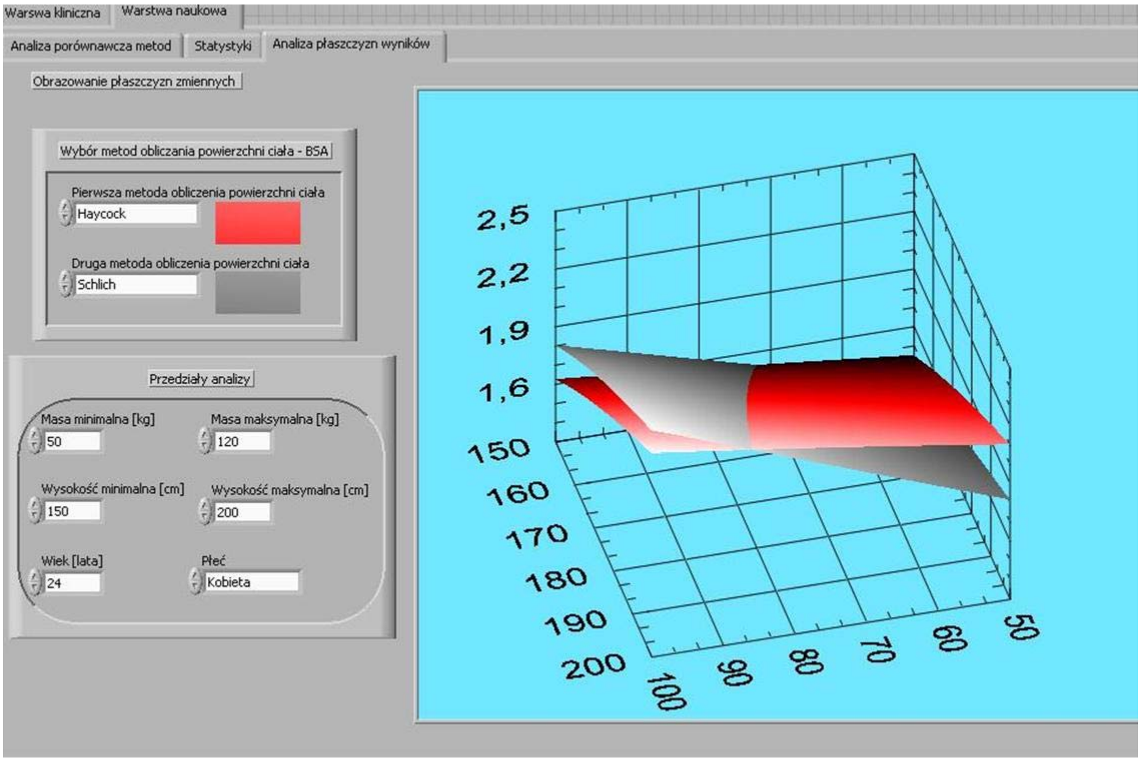

FIGURE 6. A view of the third module of the educational and research level of the program used for 3D analysis of the BSA indicators

are adequately imaged and compared with each other. This, in turn, allows to estimate the accuracy of each method in relation to weight, height and gender.

The scope of research concerns four people: a 20 year old adult women with variable body weight from 50 kg to 120 kg and height from 150 cm to 200 cm, a 20 year old adult male with an identical range of variables, and children – a girl and a boy weighing from 10 kg to 60 kg and height change from 40 cm to 120 cm. The assumptions are dictated by the most frequent cases of BSA calculations for medical purposes [4,8]: the treatment of burns and chemotherapy. Including the age parameters which allow a comparison of the effectiveness of specific methods for children and young people who – in the process of developing the estimated formula for BSA calculation – are not examined with as much detail as adults. It should also be noted that only one of the described methods (Table 1), was developed for carrying out the calculation of the BSA for children (children ratios between the different parts of the body are different than in adults [25]).

It should be also added that the adoption of such broad ranges of variability of individual physical quantities in the study is dictated by the desire to carry out a review covering the widest possible population of individuals. The adoption of a too narrow range of variability allows a visualization of changes of the BSA coefficient only on a small interval, as a result of which the results adopt a form similar to a linear graph.

4.2. **Results of the study for a female.** In order to simplify the interpretation of the results, Figure 7 shows the curves of change of the BSA indicator for an adult woman with a fixed height of 150 cm and a variable weight: 50 to 120 kg. The results show a high correlation in seven out of ten cases, in the surrounding of the value of 1,47 m^2, when the mass of equals 50 kg. The three other cases of analysis lower the arithmetic mean at this point – which is particularly visible in the *Schlich* graph (the difference between the results is about 0,15 m^2). With the weight increase the increase in discrepancy between the results is also observed. In the case of extremely high weight (120 kg) the difference between the BSA values is 0.39 m^2 (which means an increase of 260% when compared to the value obtained for the weight 50 kg). It is also noteworthy that two of the methods compared with each other: *DuBois* and *YLY* retain a high similarity of the results (because for mass value off 120 kg the difference is close to 0%).

For comparative purposes, Figure 8 shows the results of a study, for a 200 cm tall woman with variable weight – between 50 kg and 120 kg. In this case the discrepancy between the curves can be regarded as similar to the whole range of variation of the body mass. However, one should pay attention to the distinctive *Schlich* graph, which values are significantly higher than in other cases (in particular, from the weight of 70 kg). The change of the *Schlich* graph in comparison to other graphs should also be noted (including the chart from Figure 7), which indicates the high rate of increase of the function's values, compared with the functions representing the remaining curves.

Figure 9 shows, on the other hand, different results (to the mentioned above) of the BSA values analysis for a woman weighing 50 kg and a variable height in the range from 150 cm to 200 cm. In this case, clear differences between the curves were observed, differing in an additional way by the degree of inclination. In addition, a group of curves showing some convergence was observed (for example, *DuBois, YLY* and *Takahira* graphs resemble differences in the BSA values of 0.05 m^2). It is also noteworthy that despite the observed discrepancies, differences in extreme values of BSA – for a fixed body weight – do not exceed 0.204 m^2.

Figure 10 shows the differences between the graphs (for an identical case as illustrated in Figure 9) in a case when a woman's body mass is 120 kg. The obtained results allow to conclude that the effect of weight gain for a person is a change of the area of the greatest

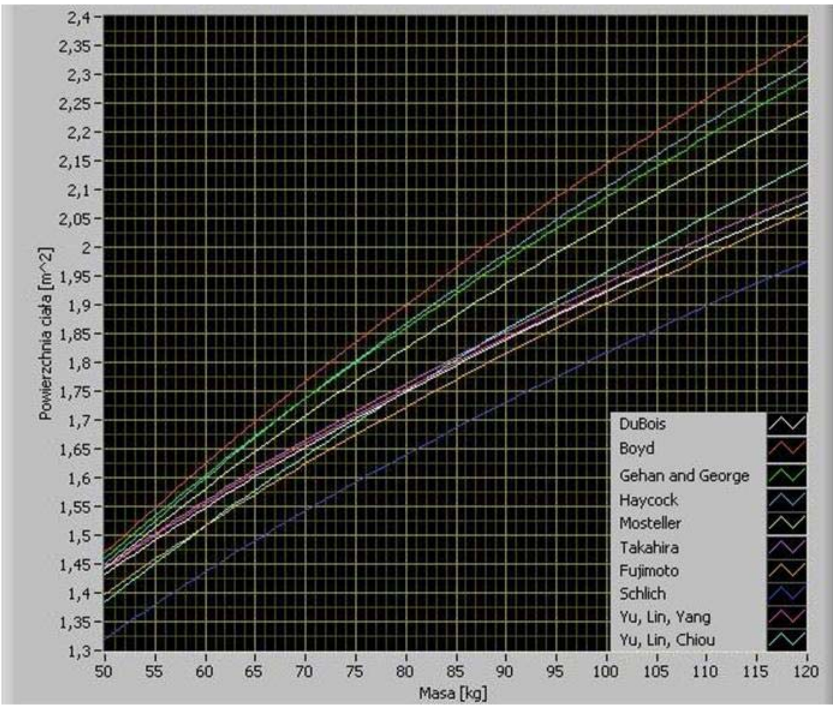

FIGURE 7. The results of a comparative analysis of variation curves of BSA for an adult, short female with a variable body mass

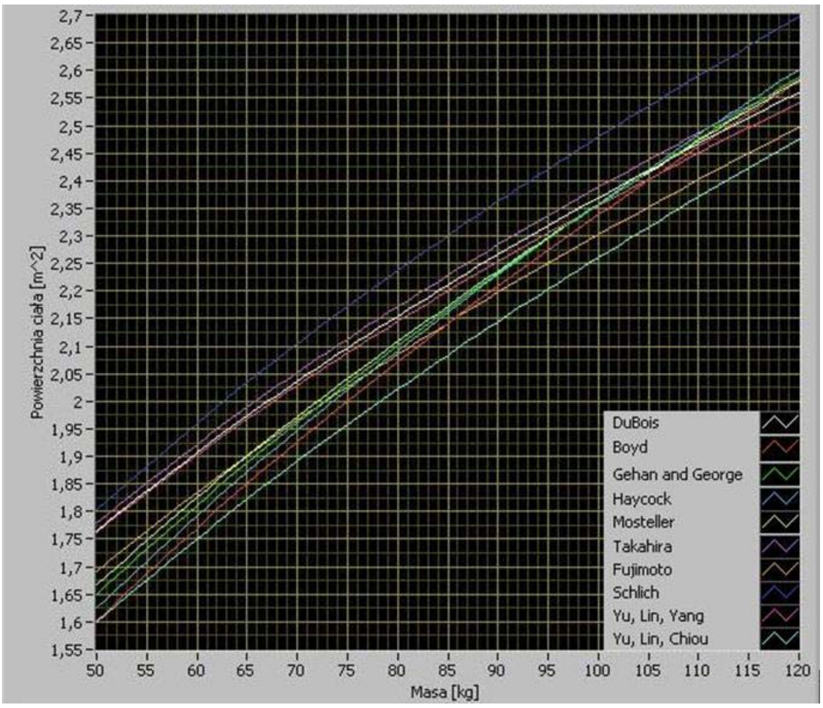

FIGURE 8. The results of a comparative analysis of variation curves of BSA for an adult, tall female with a variable body mass

number of intersections of curves in the left half-plane plot, in relation to the right half-plane. However, one can still note the different levels of inclination of the curves and different gradients of their growth. In addition, graphs shown in Figure 9 and Figure 10, in contrast to the graphs shown in Figure 7 and Figure 8, are similar in shape to linear functions. It should be also added that the values of the extreme subtractions between

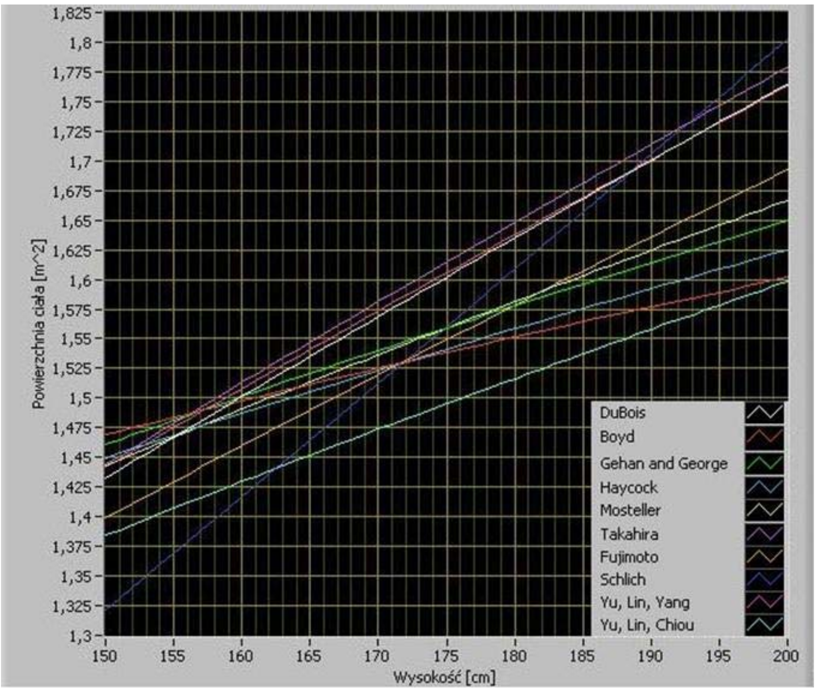

FIGURE 9. The results of a comparative analysis of variation curves of BSA for an adult, slim female with a variable height

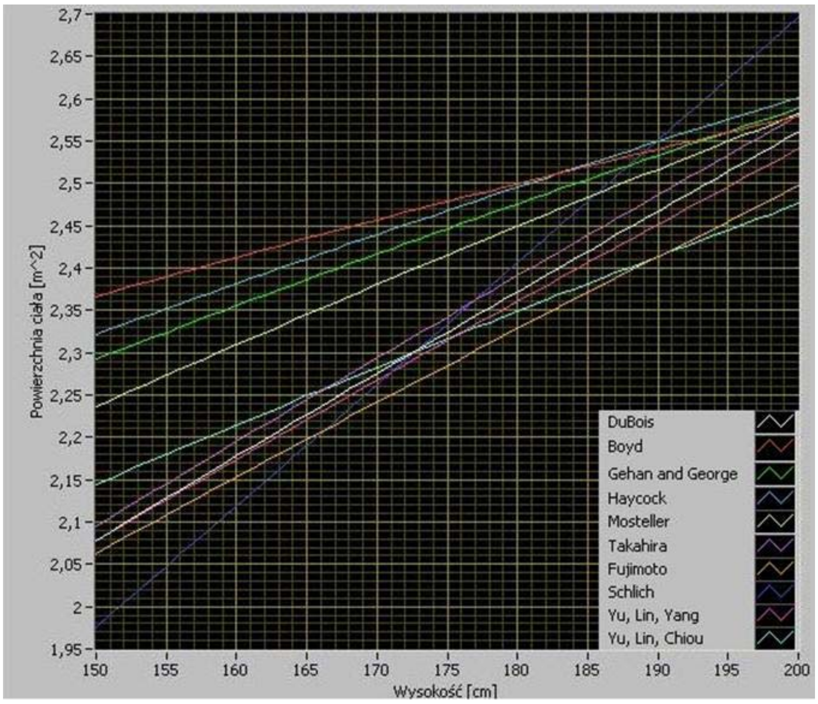

FIGURE 10. The results of a comparative analysis of variation curves of BSA for an adult, obese female with a variable height

the BSA indicators increase, particularly in the area of the origin (from about $0,148\text{m}^2$ to about $0,39\text{m}^2$, which means a change of more than 260%).

4.3. **Results of the study for a male.** By analogy to the described in Paragraph 4.2 manner studies concerning the BSA coefficient were conducted for a 150 cm tall male with a variable weight in a range from 50 kg to 120 kg. Results of the studies are presented

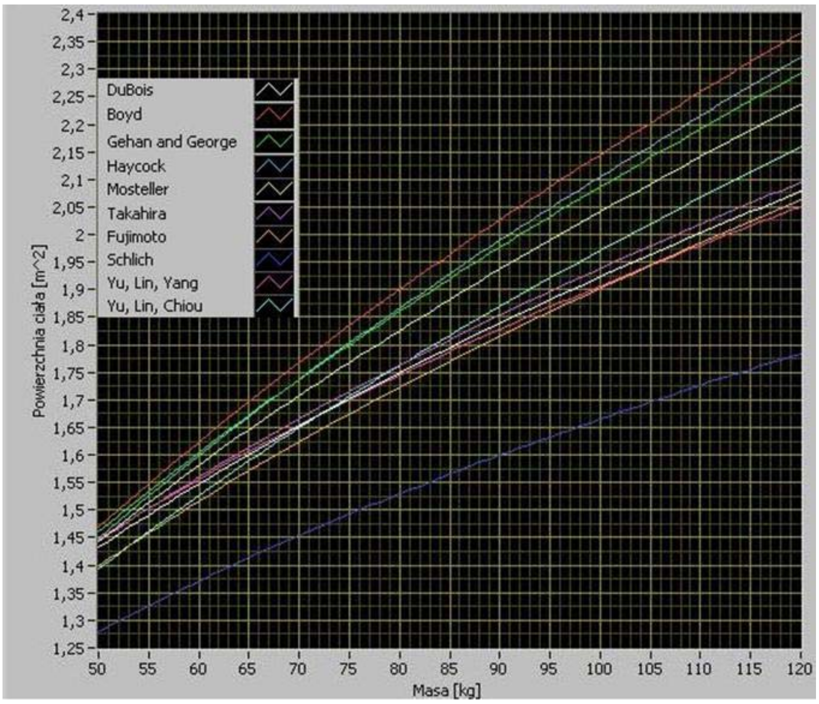

FIGURE 11. The results of a comparative analysis of variation curves of BSA for an adult, short male with a variable body mass

in Figure 11. The character of the obtained results is usually similar with the results for the opposite sex. However, quite different results are obtained when using the *Schlich* method, which in turn causes significant differences at the edges of the considered intervals (0,19 m^2 for 50 kg – but in case one does not take into consideration the *Schlich* chart this value is approximately 0,075 m^2 and 0,582 m^2, for 120 kg – in case you omit the *Schlich* chart, this value is approximately 0,316 m^2). Moreover, the presented graphs show the convergence of solutions for most of the methods in the vicinity of small values of the mass, whereas when the value of this variable increases, an divergence of the results also increases – even by about 0,5 m^2, which for the average BSA value of 2.14 m^2 is nearly 23 % of this value.

Figure 12 illustrates the results of further research on BSA coefficient in the case of a 200 cm tall man weighing from 50 kg to 120 kg. In this case, it should be noted that the extreme difference in BSA values, recorded for the body weight of 50 kg is higher as the same difference recorded for the mass of 120 kg. Thus, the observed relation shows an exactly opposite direction than the direction illustrated in Figure 11. Also interesting is the relatively small difference between the BSA rates resulting from the *Schlich* formula – compared with other graphs.

In Figure 13, for comparative purposes, the set of BSA function values is illustrated concerning a man with a body weight of 50 kg and a variable range of height from 150 cm to 200 cm. As a result of this study a satisfactory resemblance to three methods: *Du Bois, Takahira* and *YLY* was noticed, alongside with significant differences in all other cases. Also – as in the case of a female – the highest change of BSA values (which can be observed in Figure 13 – in the form of an angle of the graph to the axis) was noted in the case of the *Schlich* method.

Figure 14 illustrates on the other hand the BSA graphs in the case of a man weighing 120 kg and a variable range of height from 150 cm to 200 cm. By analyzing the obtained results it was observed that the largest difference of BSA values occurs in the case of

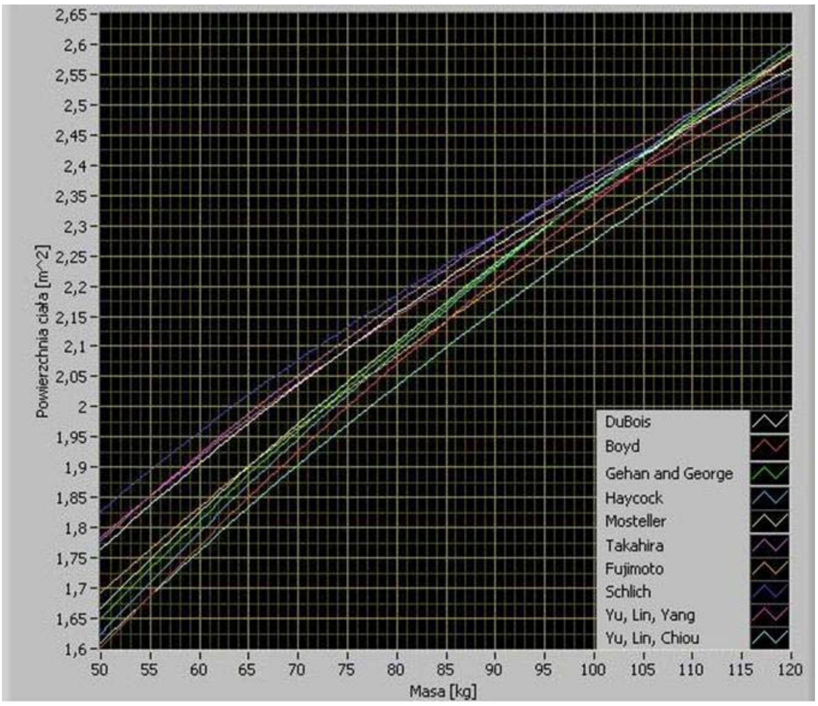

FIGURE 12. The results of a comparative analysis of variation curves of BSA for an adult, tall male with a variable body mass

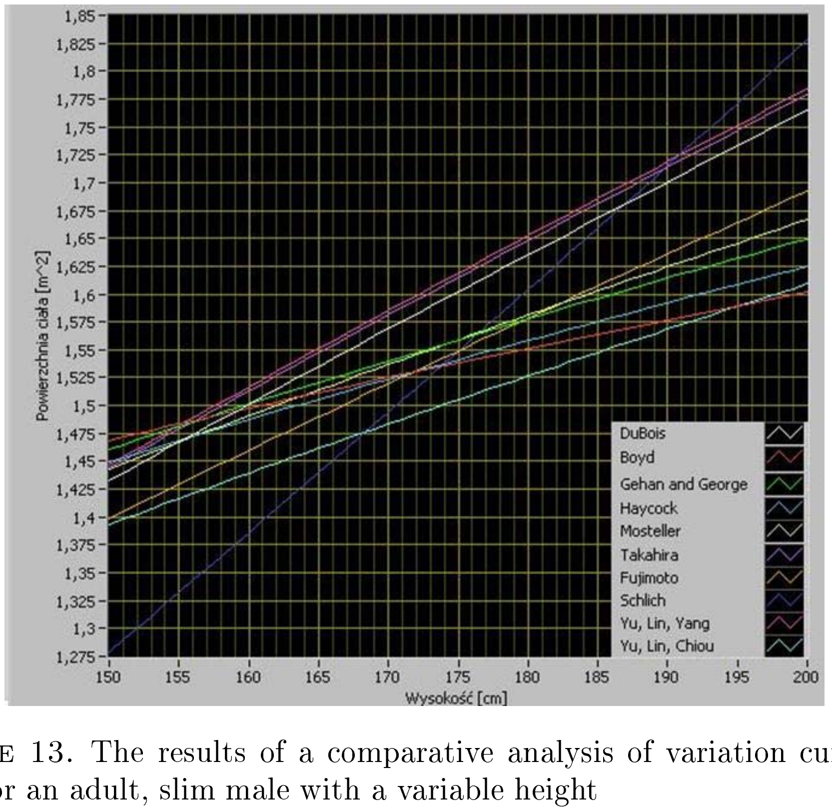

FIGURE 13. The results of a comparative analysis of variation curves of BSA for an adult, slim male with a variable height

the extreme height value of 150 cm (two out of all analyzed methods ways: *YLY* and *Fujimoto* show a relatively high convergence for the range of variation from 150 cm to about 180 cm). It was also observed that the graph representing the *Schlich* method reaches a minimum value for the initial value of the height, while in the case of the final value of the height, it is similar to the mean BSA value, determined on the basis of the

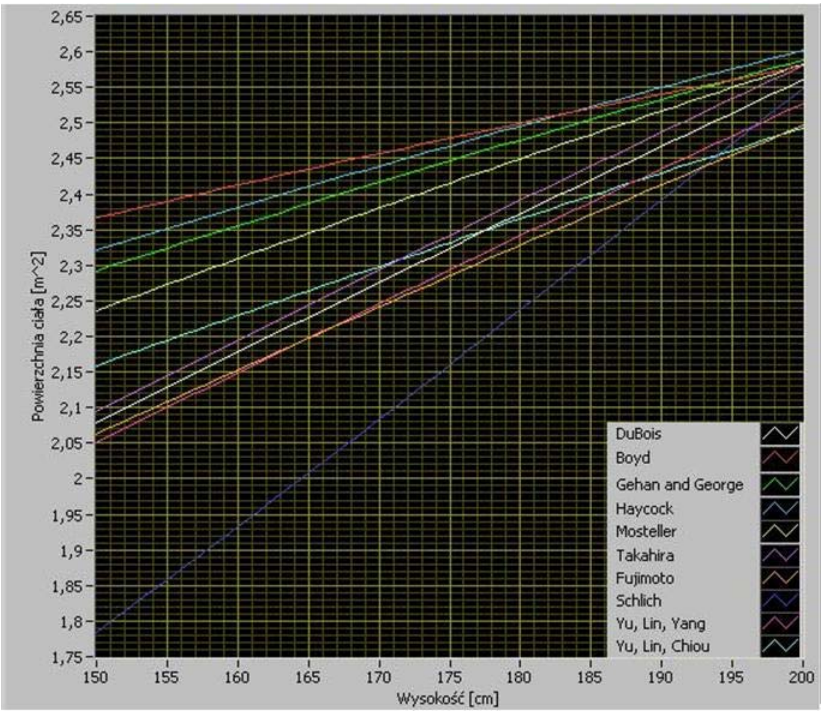

FIGURE 14. The results of a comparative analysis of variation curves of BSA for an adult, obese male with a variable height

results of all the methods (and so, the observed occurrence confirms the highest growth index in the examined interval of state variables).

4.4. **Results of the study for children.** Due to the fact that the body proportions of adults and children (including newborns and infants) are different, the formulas used in calculating the values of BSA and TBSA should be chosen in such a way as to allow the most accurate approximation to the actual values. In practice, the most commonly used procedure for calculating the values of BSA for children is the *Haycock* formula [24], hence Figure 15 shows the results of calculation of this index, for the case of a 40 cm tall child and a variable weight from 10 kg to 60 kg. The range of variation of the mass was extended above the commonly occurring limit for a 40 cm tall child in order to allow the most efficient observation of the nature of the graph representing the relevant case.

The lowest observed values of BSA (Figure 15) are associated with the *Schlich* graph. However, significant differences between the BSA values cause large discrepancies between the extreme values of the mass at the beginning of the coordinate system (for example, for the BSA values at the level of 0.306 m^2, the difference is 0.247 m^2, which is more than 80%). Therefore, if one does not take into account the *Schlich* graph, the average value of the BSA would amount to 0.323 m^2, and the difference in extreme values to 0.121 m^2 (which is 50% less). However, the difference in the result of not taking the *Schlich* graph into account reached 0.121 m^2, and it still represents about 37% of the mean value. Furthermore, the in the relevant graph one can clearly notice the convergence of the four methods (*DuBois, Fujimoto, Takahira* and *YLY*) around a narrow range of solutions. While the BSA values for the *Haycock* method, dedicated for calculation of the BSA ratio for children differ from the BSA values for the four previously mentioned methods, and are very close to the values calculated by the *Gehan and George* formula.

In interpreting the results of further research in the relevant field, Figure 16 shows the calculated values of BSA in the case of a 120 cm tall girl with a variable weight in the range

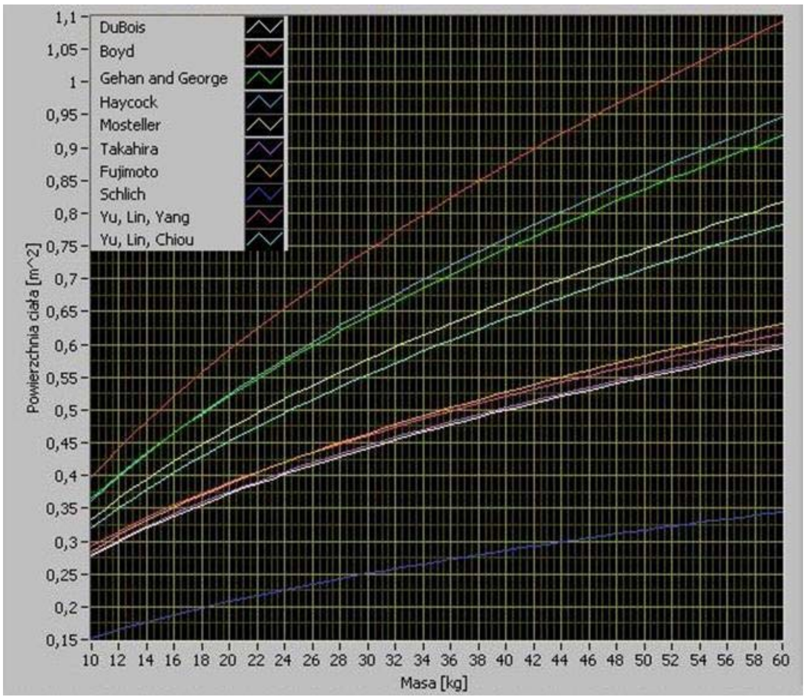

Figure 15. The results of a comparative analysis of variation curves of BSA for a child with a constant height and a variable body mass value

from 10 kg to 60 kg. The mass range of variation was extended to cover the less common values in order to accurately determine the nature of the plotted curves. Based on the obtained results it can be observed that nine out of ten graphs reach converge results in range of body weight from 10 kg to 32 kg. However, for the weight of 32 kg one can distinguish a group of four charts that were calculated by the following methods: *DuBois, Fujimoto, Takahira* and *YLY*, which retain discrepancies reaching only 0.05 m^2 (results of the BSA calculation in the case of boys, for the corresponding values of weight and height are practically the same as shown in Figure 15 and Figure 16). This observation indicates that at such an early stage of human development the differences in body composition between the sexes does not significantly influence the changes in the BSA coefficient.

4.5. **Sensitivity analysis of the BSA and BMI coefficients due to a change of the patients body mass.** A group of coefficients that are often used to determine the dose of a mixture of drugs during chemotherapy indicators are: BSA and BMI. Therefore, in the developed system the designers also implemented a tool that allows one to conduct a comparative analysis of relevant values, based on calculations of the relevant statistical parameters. Figure 17 shows sample results concerning the flexibility of the BSA and BMI parameters in the case of a 160 cm tall, 24 year old woman with a variation of body weight from 50 kg to 110 kg. In this case, the BSA parameter was obtained from the *DuBois and DuBois* method (the obtained BSA coefficients for the extreme values of mass are: 1.501 m^2 for the mass of 50 kg, and 2.099 m^2 for the mass of 110 kg). In the present case, the percentage change in the values of BSA, relative to the maximum weight was 28.47%, while the percentage difference in BMI for the same case, amounted up to 54.55%. On this basis it was observed that the percentage change of the BSA coefficient (calculated using the *DuBois and DuBois* formula) is almost twice smaller than the corresponding percentage change in the BMI parameter. Thus, the use of the BSA coefficient in medical practice – instead of BMI ratio, allows to achieve a smaller sensitivity of this parameter

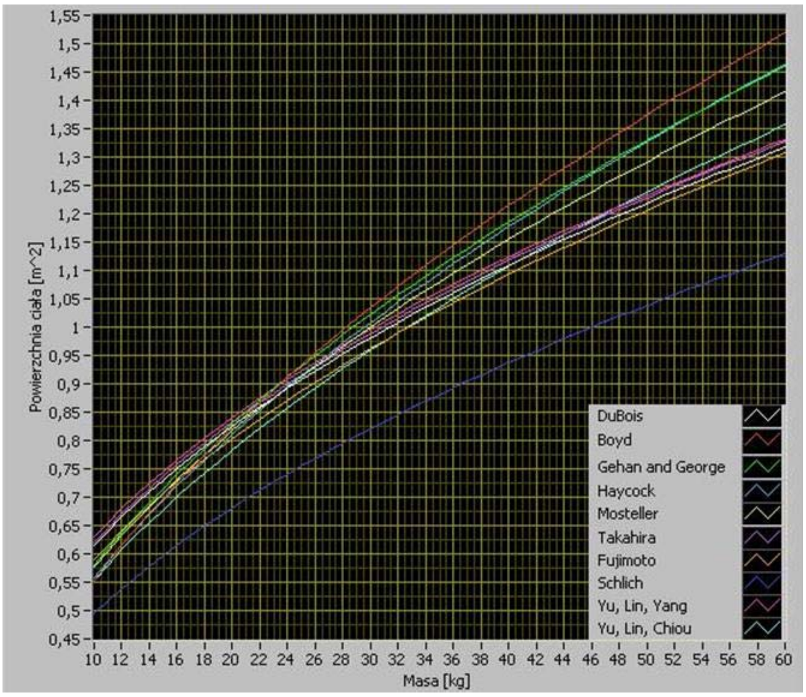

Figure 16. The results of a comparative analysis of variation curves of BSA for a girl with a constant height and a variable body mass value

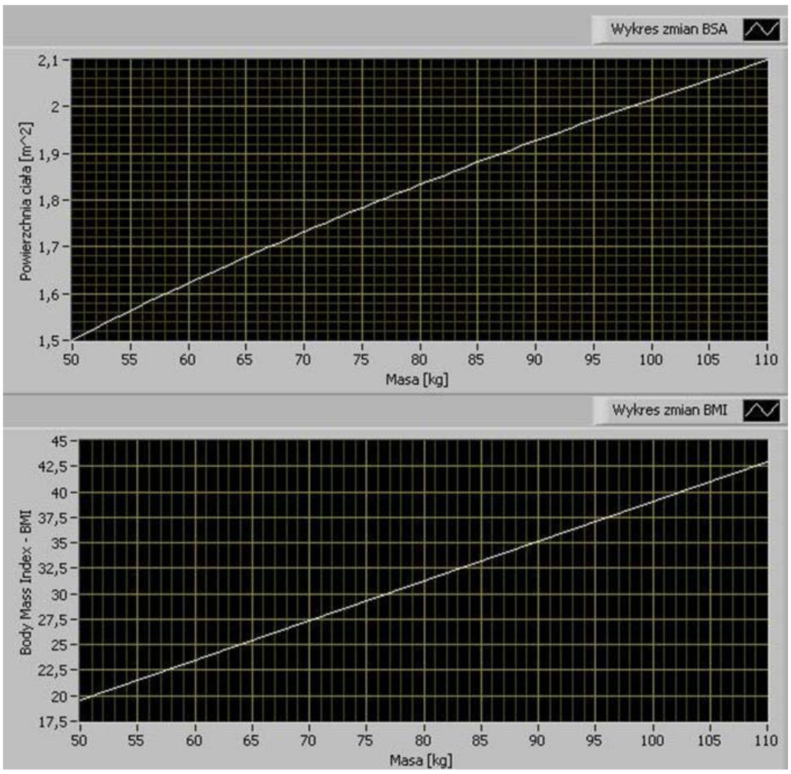

Figure 17. A view of one of the modules implemented in the computer system, dedicated for conducting comparison analysis of the BSA and BMI parameters in relation to the changes of the patient's body weight

in relation to the changes of mass, which in the case of chemotherapy [8] and the related with the procedure changes in the body weight is particularly important [10].

5. **Summary and Conclusions.** The developed and implemented computer system is a valuable tool that can be practically used in several different cases, occasions and levels of medical and scientific routine. It is possible that the system can be commonly used by physicians and clinicians, in all cases requiring decisive and prompt action, when it is necessary to determine the BSA and TBSA values. It is also possible to use it for teaching purposes. In this way it is possible to even more effectively raise the awareness of students and doctors by showing significant differences between the various methods and to indicate the cases where a specific method can be applied, and when it actually should not be used. The latest available methods of measuring the body surface area can be compared with the often used, older formulas to determine which ones are better suited for use in a given case. The developed system can also be successfully used by researchers at the stage of developing new methods for determining the BSA and TBSA indicators, or in the development of new computer tools that can assist in all analytical processes in the relevant field. As a result, when using the system, in contrast to the described in the literature available solutions, it will be possible to transition to a whole new spectrum of research, including in its scope two-and three-dimensional state space.

The conducted and presented in this paper deliberations indicate that there are significant differences between the available methods that undoubtedly arise from different values of the coefficients of the approximating function adopted by the authors of these methods, which in turn affects the nature of the resulting curve: the degree of inclination and the gradient. Observations made during the tests, which show that, depending on the method used, differences between the BSA and the TBSA values for adults can greatly exceed the value of 10%, suggests – that not taking them into account at the stage of the selection of doses of drugs may have important implications for the health of patients. It may indeed prove (for example during chemotherapy) that, despite the much greater stability of the BSA ratio, the additional error resulting from the improper choice of the calculation method, exceeds the consequences resulting from the originally used BMI. Hence, the authors developed a tool which creates a new opportunity for a discussion on the topic of the legitimacy of the current procedures, and enables the scientists and doctors at the centers of research and teaching to make an attempt to verify them in a relatively easy way.

During the performed research, particular attention was paid to the *Schlich* graphs which values, in most cases, were much lower in relation to the values obtained from the application of the other nine methods. Further doubts are raised in this case for the fact that the *Schlich* method, which was published in 2010, was based on the results obtained using the 3D scanner on a sample of over 180 patients. Furthermore, attention is drawn to the *DuBois and DuBoi* and *Yu, Lo, Yang* graphs analysis results. The *DuBois and DuBois* method was published 94 years ago, and its formula was estimated on the basis of the results obtained on a group of nine people, with only one person being a child. While the *Yu, Lo and Yang* formula was based on the results obtained using the 3D scanner on a group of 270 people. Considering the discrepancies observed during the research, it is striking how the BSA values obtained by both methods are similar, for both adults and children. The obtained results for the methods of *Yu, Lo, Chiou* and *Yu, Lo Yang* also proved to be interesting. The first mentioned method was established seven years earlier than the other, and was developed on the basis of the 3D scanning method on 3951 subjects. Despite such a large group of subjects and the use of very precise methods of measurement, the BSA values obtained and compared with both those methods are slightly different. What is surprising is the convergence of the mentioned methods with the *DuBois* method, which was developed in the early twentieth century and based on the group of only 9 people. An observation that is worth mentioning is that the greatest discrepancies between the results of BSA calculations are obtained for neonates, infants and children. By definition, the value of the BSA coefficient of an infant or child (compared with an adult) is small and results of a much lower value of their body weight and height. Thus, the observed and the largest discrepancies between the extreme values of the BSA coefficients concerning children, indicate the need to pursue further research in the relevant field. The presented results demonstrate that the issue of selecting the proper method of calculating the BSA index is not easy, and the resulting differences and the consequences can be very serious.

Summarizing the results of the study it should be noted that the issue of calculating the rate of human BSA is still a current problem and it is not quite properly resolved. The discrepancies between the results of recently conducted experiments (based on a 3D scanner measurements) suggest that the correct choice of the approximating function parameters values is a difficult issue – even when advanced tools are available to use. The study suggests that discrepancies resulting from the use of improper BSA calculating methods can cause much more serious consequences than the changes resulting from the instability of the BMI index. This finding can also provide a basis to improve some procedures related to specific nosology cases. It is also worth mentioning that it is highly likely that only the adoption of an appropriate calculating procedure guaranties the high quality of medical treatment, when concerning the patient's weight loss caused by, for example, an implemented therapeutic procedure.

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