ISSN 2355-0082

The Potential of "GENIUS": Deep Learning Integrated Application to Fight Obesity

Putu Nindya Krisnadewi Rahadi[1], Ananda Eka Raharja[1], Andi Ahmad Haidir[2]
[1] Faculty of Medicine, Udayana University, Denpasar, Bali, Indonesia
[2] Faculty of Economy and Business, Udayana University, Denpasar, Bali, Indonesia

Accepted 20 March 2024
Approved 31 May 2024

***Abstract*— Lifestyle changes regarding food consumption and sedentary lifestyle has led to increase prevalence of obesity worldwide, including in Indonesia. Obesity as a risk factor for various diseases has become an urgent issue considering that currently available therapies have not shown optimal results in overcoming this problem. The "GENIUS" application is present as a body types analysis system and program recommendations for obesity therapy. The purpose of writing this paper is to find out the potential, construction mechanism, and operating mechanism of the application. The methodology of writing this paper is literature review, based on secondary data from databases such as Google Scholar, PubMed, and ScienceDirect. The construction mechanism of the application includes process of collecting dataset, creating the application and deep learning system, and launching the application. The technology utilized in the application involves image processing deep learning and recurrent neural networks, enabling it to generate outputs suit to each individual's needs and provide appropriate program recommendations. Through the "GENIUS" application, users can also consult with medical professionals, receive recommendations, and record clinical data progress in a single digital application accessible via smartphones. The application also provides an interesting sub-feature in the form of reward points given to users for using the application's features. The implementation of the application involves the quadruple helix model. The benefits of the application encompass the fields of health and knowledge, aiming to prevent obesity in order to foster an intelligent generation and achieve a healthy Indonesia.**

***Keywords*— deep learning; diet; exercise; obesity; personal digital assistant**

I. INTRODUCTION

In recent years, obesity has become a global health issue associated with changes in people's lifestyles, such as changes in eating habits and lack of physical activity [1]. Obesity is a condition in which excess fat accumulates in the body as a result of an imbalance between energy intake and energy expenditure. If left untreated, obesity can lead to various serious health problems, such as diabetes mellitus, hypertension, coronary heart disease, respiratory disorders, musculoskeletal disorders, and others [2].

According to data from the World Health Organization (WHO) in 2016, about 650 million adults worldwide are classified as obese. The global prevalence of obesity reached 13%, with more cases occurring in women (15%) than in men (11%). In addition to adults, WHO data also recorded that about 340 million children and adolescents aged 5-19 years are classified as overweight (overweight) to obese [3].

In Indonesia, the prevalence of obesity is 28.7% in adults aged 18 years and over. Meanwhile, for children aged 5-12 years, about 10.8% of them are obese. Recent data on the obesity problem in Indonesia shows that this problem is not yet well controlled. Based on the results of the 2016 National Health Indicators Survey (SIRKESNAS), the number of obese people with a Body Mass Index (BMI) of 27 or higher was recorded at 20.7%, which is an increase from the results of the 2013 Basic Health Research (RISKESDAS) which showed a percentage of 15.4% [4].

The association between obesity and the risk of life-threatening chronic diseases also increases the urgency of this problem. Data from the 2018 RISKESDAS showed that the prevalence of non-communicable diseases related to metabolic syndrome such as diabetes mellitus and hypertension has continued to increase [5]. A study by Pammer et al. (2021) also proved that individuals with metabolic syndrome have a 1.26 times higher risk of death than those who do not [6].

Therapeutic options available today to address obesity include lifestyle modification, medication, endoscopic procedures, and surgery [7]. However, the available therapies have not shown optimal results in addressing obesity globally. Only less than 5% of individuals have been able to lose weight significantly through a combination of diet and exercise. Studies also show that 90% of individuals who participate in diet modification programs regain weight within two years,

or what is known as "yo-yo dieting" [8]. If repeated, "yo-yo dieting" can pose more serious health risks because it disrupts the body's normal metabolism, makes it more difficult to lose weight in the future, and increases the risk of heart disease [9]. Meanwhile, pharmacological and surgical therapies also have side effects, a higher risk of mortality, and a higher cost.

In the current era of digitalization, technology is advancing rapidly in various aspects of human life. One algorithm that has experienced rapid development is deep learning, which is an algorithm that can learn on its own. This technology can automate various complex problems, including analyzing human body types and providing program recommendations. In this case, the technology that can be applied is image processing, which is a part of deep learning that uses multiple computational layers to generate a specific architecture through the concept of object detection [10]. The concept of object detection is an advanced algorithm of the classification procedure, which works by determining the location of an object in an image, then classifying the selected image location according to the predefined category [11]. Meanwhile, the recurrent neural network (RNN) concept is also used to determine the prediction and recommendation of diet and exercise programs that are suitable for a person. This concept is able to read hidden patterns in data by adding computation between nodes in each hidden layer.

Based on the urgency of the problems that have been outlined, there is a need for innovative preventive efforts to prevent obesity and the diseases that can be triggered by obesity. These efforts can be made by empowering all aspects of society, especially the younger generation, while also utilizing the industrial revolution with digitalization through an application called "GENIUS: Gen Z Innovation to Fight Upon Obesity" which is integrated with deep learning. In an effort to create a smart young generation and achieve a healthy Indonesia, in line with the Sustainable Development Goals (SDGs) 2030, point three, namely healthy and prosperous life, and utilizing the industrial revolution 4.0, the author presents a breakthrough in the idea of a paper entitled “The Potential of “GENIUS”: Deep Learning Integrated Application to Fight Obesity”.

II. METHOD

The method of writing this paper uses literature review method from appropriate sources with key words based on the topics raised. Key words used include "obesity", "deep learning", "personal digital assistant", "exercise", and "diet". The data source used in the preparation of this paper is in the form of secondary data derived from literary sources related to the topic raised. The library sources used come from scientific journals such as Google Scholar, PubMed, and ScienceDirect. Other sources used are articles from health associations and government institutions that accountable for the truth. Data collection is based on the results of research and previous assessments that are valid and relevant to the topics discussed.

The data that has been collected is then analyzed systematically with argumentative descriptive analysis techniques. The author presents a descriptive analysis based on valid and relevant data from the results of research and previous studies that are able to strengthen the arguments presented. Arguments are arranged systematically according to the writing component. Drawing the conclusions of this paper is based on the problem formulations and the purpose of writing, and using synthesis analysis studies. The process of synthesis analysis is carried out to combine the formulation of the problem, the purpose of writing, and the discussion, so that conclusions can be drawn which can summarize the essence of writing this scientific paper. The conclusions drawn represent points of ideas, accompanied by recommendations or suggestions for the development of the author's ideas.

III. RESULT AND DISCUSSION

A. Overview of Obesity

Obesity is defined as a condition where there is an excessive accumulation of fat within the body that can adversely affect health [12]. An individual is considered obese when their body mass index (BMI) is equal to or greater than 30 kg/m^2 [3]. Based on the distribution of fat in the body, obesity can be categorized into two types:

1. Apple-type obesity

Individuals with apple-type obesity resemble the shape of an apple, characterized by excessive fat accumulation in the upper body, around the chest, shoulders, neck, as well as the wall and cavity of the abdomen [13]. This type of obesity is more common in males and is sometimes referred to as android obesity. In individuals with apple-type obesity, the waist circumference increases, leading to a larger weight-to-height ratio (WHR) [14].

2. Pear-type obesity

Individuals with pear-type obesity resemble the shape of a pear, characterized by excessive fat accumulation in the lower body, around the hips and thighs [13]. This type of obesity leads to a wider body shape, hence it's also referred to as peripheral obesity. Pear-type obesity is more common in females and is sometimes referred to as gynoid obesity [14].

Obesity is caused by an imbalance between the amount of energy intake and the amount of energy expenditure [12]. When the amount of energy consumed from food and drink exceeds the energy used for physical activity, excess energy is stored in the form of fat. Obesity can also be caused by genetic

abnormalities, such as Prader-Willi Syndrome, MC4R Syndrome, and Wilson Turner congenital leptin deficiency [2]. The accumulation of fat in adipose tissue plays a role in secreting adipokines and free fatty acids, leading to systemic inflammation that ultimately results in insulin resistance and elevated triglyceride levels. Furthermore, obesity increases the deposition of fatty acids in the cardiac myocardium, leading to left ventricular dysfunction, which contributes to the development of coronary heart disease. Fatty acids can also disrupt the renin-angiotensin system, causing salt retention and increased blood pressure, resulting in hypertension [2].

In general, the management of obesity includes lifestyle modifications, pharmacological therapy, and surgery, as described below:

1. Lifestyle modifications, involve adjustments to dietary habits and physical activity. In Indonesia, the recommended dietary pattern is the "T-plate" model and reducing daily calorie intake by around 500 kcal to achieve a weight loss of approximately 0.5 kg per week [15]. Additionally, physical activity is recommended through moderate-intensity exercise 3-5 times per week. Low-impact aerobic exercises like swimming, brisk walking, or aerobic workouts are advised, with a total duration of 150 minutes per week, then gradually increased according to capabilities [16].
2. Pharmacological therapy, which is indicated for patients with a BMI $\geq$ 30 kg/m^2 or BMI $\geq$ 27 kg/m^2 with associated conditions like hypertension, diabetes mellitus, and others. Some drugs approved by the Food and Drug Administration (FDA) for long-term use to manage obesity include orlistat, liraglutide 3 mg, gelesis100, and setmelanotide [17].
3. Surgery, which is an effective therapeutic option for obesity in patients with a BMI $\geq$ 30 kg/m^2 with comorbidities. Bariatric surgery includes procedures such as BPD (Bilio-pancreatic diversion), SG (sleeve gastrectomy), RYGB (Roux-en-Y gastric bypass), and AGB (adjustable gastric banding) [18].

B. Potency of Body Image Analysis, Program Suggestion System, and Deep Learning Algorithm Technology

The body shape analysis system is a process that can detect human body shape types. This system is inspired by the individuals who follow diet programs, but do not achieve their desired targets due to the lack of precision in the techniques and strategies that they used. A study was done by Muslihah et al (2013) showed that the quality of the diet is related to individual knowledge about nutrition ($p<0.01$) [19]. A good perception and knowledge about body shape are essential so that each individual can adjust programs and methods to lose or maintain a body shape that fits with their respective goals. This is also supported by research from Ismayanti (2020), which indicates that a lack of nutritional knowledge in an individual results in 11-fold higher risk of having poor nutritional status compared to those with good nutritional knowledge [20].

Individuals who experience obesity have higher urgency to acquire a suitable design and monitoring for their diet program. The arrangement of diet programs and exercise patterns needed among individuals can differ based on the clinical parameters that need to be corrected [21]. Therefore, the implementation of a personal digital assistant (PDA) is necessary to overcome this issue. PDA is a digital media in the application form that can organize users' needs. The diet analysis system with PDA has the potential to be well-implemented for individuals with obesity, as it can provide information adjusted to each individual's needs. The use of PDA is also relatively easy and practical since it can be used anytime and anywhere through the user's smartphone [22].

Deep learning as a system that analyses datasets without human assistance allows the system learn and have precise and intelligent decisions autonomously. Through pattern identification in complex datasets, deep learning methods can provide information for disease diagnosis and prediction, which ultimately can be used for the management and prevention of health disorders such as obesity. A study conducted by Forte *et al.* (2023) showed that deep learning neural networks presents a good accuracy (75%) and validity (ROC AUC 66%) in people at risk of obesity [23]. Another study by Bhaskar and Manikandan (2019) successfully classified their samples with an accuracy of 98% [24]. Therefore, application development through deep learning has great potential to provide benefits to individuals with obesity.

In the present scenario, community welfare is paramount, necessitating solutions to health-related challenges through technological advancements in medical research. Previous research utilizing a new personal area sensor network that revolutionizes activity recognition, called RNN, had promising results. This network employs multiple sensor nodes dispersed throughout the body, utilizing recurrent neural networks (RNNs) to analyze local sensor data and classify activities. Aggregating results through a weighted voting process at a central node enhances accuracy and conserves energy, as sensor nodes transmit local results exclusively for recognized activities [25]. Using RNN research conducted by Musa (2022), a respectable accuracy of 95.74% was found. Experimentation involving sensor nodes on various body parts demonstrated superior recognition accuracy across eight activities compared to existing methods. Consequently, optimizing sensor node configuration

enhances activity recognition accuracy while minimizing transmissions from supporting nodes [26].

Visualization of deep learning computation is described in **Figure 1** and **Figure 2**.

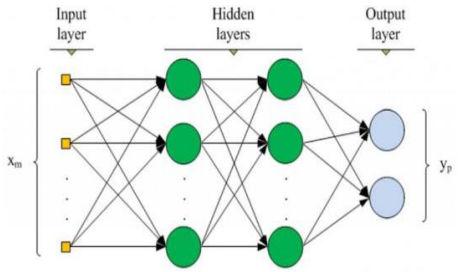

Fig 1. Visualization of Deep Learning Computational Architecture

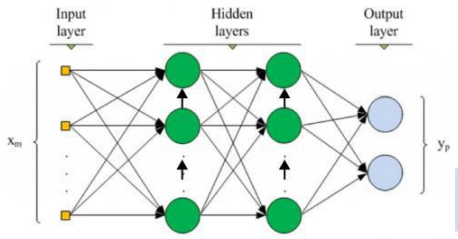

Fig 2. Visualization of Deep Learning Computational Architecture of RNN Type

C. *Mechanism of Construction of "GENIUS" Application*

The construction of the "GENIUS" application consists of three stages, including the process of collecting data sets, creating a PDA application and deep learning system, and the installation of deep learning and launch of the application.

The deep learning applied in the "GENIUS" application is a supervised learning model. This means that the parameters used in this application are input parameters and output parameters in the form of labels. The data collection process consists of two stages, namely data sets related to body image analysis and program suggestion. The data set related to body image analysis is collected by inputting human body sketch images and their interpretations. The data set of body sketch shapes contains data such as the positions of the head, body, and upper and lower extremities as labels for detecting objects and interpreting their body types. Meanwhile, the data set related to program suggestion contains a collection of data and parameters such as food consumed on previous days and the day, exercise performed on previous days and the day, and the user's clinical data history.

The use of two types of data sets in this application requires two deep learning training processes. For the body image analysis data set, the concept used is the pre-trained network EfficientDet, which is then trained in such a way that it can detect the body parts shown in the sketch image and interpret their shapes. As for the program suggestion data set, the concept used is Recurrent Neural Network (RNN), which is then trained in such a way that it can provide diet and exercise program recommendations for users according to their individual needs and conditions. The architecture model is described in **Figure 3** [27].

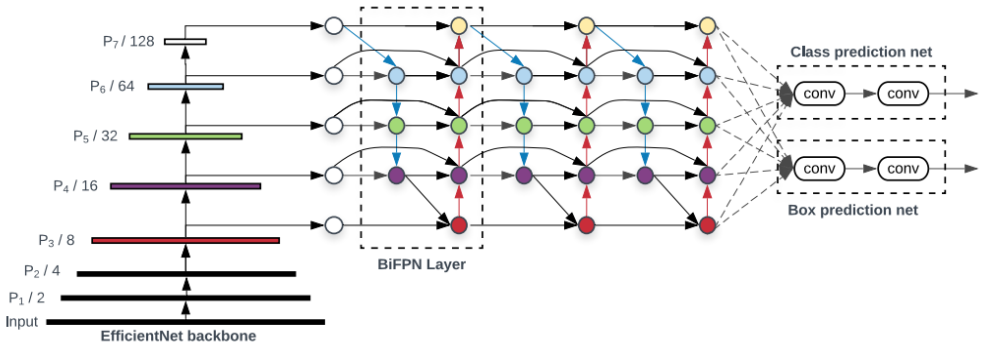

Fig 3. Architecture of the Pre-trained EfficientDet Network

After that, the validation and testing stages will be carried out using a subset of the dataset. If the accuracy score does not reach 80%, the training process will be repeated with changes to the architecture. If the accuracy score reaches 80% or higher, the application will be created and the two deep learning models will be installed on the PDA. The application and its features will also be tested for functionality to ensure that the PDA is able to operate properly.

The final stage in the application construction is launching the application to the general public. At this stage, the application can be accessed by the public and the interaction between the database and the user will be configured. In addition, the application requires regular maintenance and evaluation for the convenience of users and to gather user feedback for the advancement of the application.

D. *Mechanism of Operation of "GENIUS" Application*

The features in the "GENIUS" application are a comprehensive implementation of the concept for treating obesity, as described in **Figure 4**.

1. Feature “Me and My Body”

This feature is a body shape analysis feature and program adjustments that the user will go through. The data that needs to be input by the user is a full body photo with minimal clothing, body weight and height. Body image analysis technology will produce output in the form of an interpretation of body shape and body mass index. Through program suggestion technology, this feature will also provide recommendations for exercise and diet programs that suit the user's comfort preferences and the goals the user wants to achieve. This feature will be very useful because it makes the implementation of programs run by users more focused and targeted according to each individual's conditions.

2. Feature “Hello Doctor”

This feature is a feature that can be used by users to get in touch with medical personnel who are members of the "GENIUS" application partners. With this feature, users can discuss and consult with medical personnel regarding the program they are undergoing, complaints or difficulties that arise during the program, as well as updates regarding their body condition.

3. Feature “Let’s Move”

This feature is a feature that serves as a guide for users to do sports and physical activities according to the program that has been analyzed through the “Me and My Body” feature. Users can record physical activity carried out every day, then this feature will provide information regarding the estimated number of calories expended from recorded physical activity.

4. Feature “Happy Diet”

This feature is a feature that serves as a guide for users to make adjustments to diet patterns according to the program that has been analyzed through the “Me and My Body” feature. Users can record food and drinks consumed each day, then this feature will provide information regarding the estimated number of calories included from recorded consumption.

5. Feature “My Healthy Diary”

This feature is a useful service for users to record a combination of all the information recorded in the four features above. Some of the information that can be input in this feature includes age, anthropometric data such as body weight, height, waist circumference, abdominal circumference, and waist-to-hip ratio, as well as clinical data such as blood pressure, fasting blood sugar, triglyceride levels, and blood sugar levels. HDL-C, LDL-C, and cholesterol. All input data will be synchronized via a cloud-based system with the health service center to facilitate comprehensive user health monitoring.

6. Sub-Features

The features of this application are equipped with the "Share My Journey" sub-feature as a forum for users who want to share their daily lives in carrying out diet and exercise programs. This sub-feature also becomes a platform for building a community between users to motivate each other to live healthy and avoid obesity. Apart from that, this application also has a sub-feature in the form of reward points which will be obtained every time a user opens the application and uses the features in it. These points can later be exchanged for various attractive prizes.

Fig 4. Interface of “GENIUS” Application

After the application is well constructed, relationships and collaboration with related parties must be carried out so that the application target can use this application optimally. Related to this, the model used is quadruple-helix (QH) which involves four parties, namely academics, government, industry and society. Academics play a role is in designing and developing application concepts, preparing resources for implementing applications, as well as executing manufacturing and manufacturing processes according to standard procedures that are designed to be ready for use. The government plays a role as a party that has important authority in providing guarantees for the protection of copyrighted works of applications, as well as regulates and strives for applications and services in it to be accessible to the whole community. The health industry and institutions, play role to facilitate consulting services and carry out quality control of the content and services in the application, so that the information contained in it can be ascertained the truth and validity. The community, especially the younger generation and people with obesity, as users of the application, play a role as a party that can provide feedback and input for the development of applications in a better direction, and can reach people's aspirations and market needs.

IV. CONCLUSION

The "GENIUS" application is potential to be developed as a personal digital assistant that can be used as a preventive tool against obesity through a combination of holistic management. The construction mechanism of this application includes the stages of collecting datasets, creating applications and deep learning systems, as well as installing deep learning and launching applications. The operating mechanism of this application can fulfill individual needs that vary between users through the use of body image analysis technology and recommendation programs with deep learning systems. The implementation of this application involves academics, government, health institutions, and the community. This application is useful in the field of health and knowledge in order to realize a smart generation and a healthy Indonesia. The suggestions that can be given are the need for active participation from various parties to realize this application and the need to test this application to evaluate the features in it so that it can meet user needs.

ACKNOWLEDGMENT

We thank Dauhwaru Team for providing us financial and psychological support for the writing of this literature review.

REFERENCES

[1] Suhaema S, Masthalina H. Pola Konsumsi dengan Terjadinya Sindrom Metabolik. *Kesmas Natl Public Heal J* 2015; 9: 340.

[2] Panuganti KK, Nguyen M, Kshirsagar RK. Obesity. *StatPearls*, https://www.ncbi.nlm.nih.gov/books/NBK459357/ (2022, accessed 26 July 2023).

[3] WHO. Obesity and overweight, https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (2021, accessed 26 July 2023).

[4] Kemenkes RI. FactSheet_Obesitas_Kit_Informasi_Obesitas.pdf. *Epidemi Obesitas* 2021; 1–8.

[5] Listyandini R, Pertiwi F, Riana D. Asupan Makan, Stress, dan Aktivitas Fisik dengan Sindrom Metabolik pada Pekerja Di Jakarta. *J Kaji dan Pengemb Kesehat Masy* 2020; 01: 19–32.

[6] Pammer LM, Lamina C, Schultheiss UT, et al. Association of the metabolic syndrome with mortality and major adverse cardiac events: A large chronic kidney disease cohort. *J Intern Med* 2021; 290: 1219–1232.

[7] Tucker S, Bramante C, Conroy M, et al. The Most Undertreated Chronic Disease: Addressing Obesity in Primary Care Settings. *Curr Obes Rep* 2021; 10: 396–408.

[8] UCSF. Obesity Treatment | UCSF Health, https://www.ucsfhealth.org/conditions/obesity/treatment (2023, accessed 26 July 2023).

[9] Contreras RE, Schriever SC, Pfluger PT. Physiological and Epigenetic Features of Yoyo Dieting and Weight Control. *Front Genet* 2019; 10: 1–12.

[10] Shah HA, Liu J, Yang Z, et al. DeepRF: A deep learning method for predicting metabolic pathways in organisms based on annotated genomes. *Comput Biol Med* 2022; 147: 105756.

[11] Song S, Baek S. Body shape matters: Evidence from machine learning on body shape-income relationship. *PLoS One* 2021; 16: 1–17.

[12] Kemenkes RI. Apa itu Obesitas ? - Direktorat P2PTM, https://p2ptm.kemkes.go.id/infographic-p2ptm/obesitas/apa-itu-obesitas (2018, accessed 26 July 2023).

[13] Pranata I gusti ngurah agung cahya. Menghindari Resiko Obesitas Dengan Mengukur Indeks Masa Tubuh. *J Pendidik Kesehat Rekreasi* 2016; 1: 1–23.

[14] Fu J, Hofker M, Wijmenga C. Apple or pear: Size and shape matter. *Cell Metab* 2015; 21: 507–508.

[15] Kemenkes. Pedoman_Umum_Gentas_Gerakan_berantas_obesitas.pdf. 2017; 1–41.

[16] Oppert JM, Bellicha A, van Baak MA, et al. Exercise training in the management of overweight and obesity in adults: Synthesis of the evidence and recommendations from the European Association for the Study of Obesity Physical Activity Working Group. *Obes Rev* 2021; 22: 1–12.

[17] Tchang BG, Aras M, Kumar RB, et al. Pharmacologic Treatment of Overweight and Obesity in Adults. *Endotext*, https://www.ncbi.nlm.nih.gov/books/NBK279038/ (2021, accessed 27 July 2023).

[18] Lin X, Li H. Obesity: Epidemiology, Pathophysiology, and Therapeutics. *Front Endocrinol (Lausanne)* 2021; 12: 1–9.

[19] Muslihah N, Winarsih S, Soemardini S, et al. Kualitas Diet Dan Hubungannya Dengan Pengetahuan Gizi, Status Sosial Ekonomi, Dan Status Gizi. *J Gizi dan Pangan* 2013; 8: 71.

[20] Ismayanti D. The relationship of body shape perception, eating disorders, nutritional knowledge and food intake with nutritional status adolescent girls in Ayodya Pala. *ARGIPA (Arsip Gizi dan Pangan)* 2020; 4: 74–84.

[21] Cornish LS, Moraes C. The Impact of Consumer Confusion on Nutrition Literacy and Subsequent Dietary Behavior. *Psychol Mark* 2015; 32: 558–574.

[22] Aguilar E, Remeseiro B, Bolaños M, et al. Grab, Pay, and Eat: Semantic Food Detection for Smart Restaurants. *IEEE Trans Multimed* 2018; 20: 3266–3275.

[23] Forte P, Encarnação S, Monteiro AM, et al. A Deep Learning Neural Network to Classify Obesity Risk in Portuguese Adolescents Based on Physical Fitness Levels and Body Mass Index Percentiles: Insights for National Health Policies. *Behav Sci (Basel)*; 13. Epub ahead of print 2023. DOI: 10.3390/bs13070522.

[24] Bhaskar N, Manikandan S. A Deep-Learning-Based System for Automated Sensing of Chronic Kidney Disease. *IEEE Sensors Lett*; 3. Epub ahead of print 1 October 2019. DOI: 10.1109/LSENS.2019.2942145.

[25] Berna M, Płaczek B. Smartphone and Supporting Nodes.

[26] Musa F, Basaky F, E.O O. Obesity prediction using machine learning techniques. *J Appl Artif Intell* 2022; 3: 24–33.

[27] Tan M, Pang R, Le Q V. EfficientDet: Scalable and efficient object detection. *Proc IEEE Comput Soc Conf Comput Vis Pattern Recognit* 2020; 10778–10787.