Case report

Monitoring of nutritional status in patients with pressure injuries using the phase angle as an indicator – a study of two cases

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Summary

Introduction: Bioelectrical impedance (BIA) is one of the most widely used indirect methods for assessing human body composition. The phase angle (PhA) as its derivative is considered an indicator of cellular health and monitoring of nutritional status. Due to its safety and reproducibility, it can be used as a prognostic indicator in disease, the assessment of mortality risk, and the effectiveness of nutritional interventions, as reflected in an increasing number of scientific studies. The aim of the study was to assess nutritional status using the PhA indicator in the course of treatment in two patients with pressure injuries.

Material and methods: Two patients with pressure injuries were selected to have three consecutive BIA tests, from which the PhA indicator was calculated. In the subsequent three measurements, it was assessed, correlating this with the local wound condition on the day of the measurements taken.

Results: After the initial assessment, nutritional intervention was implemented simultaneously with medical and nursing interventions resulting from the wound care plan, observing a systematic increase in PhA parameters starting from the values: Patient I – 3.2; Patient II – 3.3 during the first examination. Subsequently, after 4 and 16 months in the final measurements, the PhA was 5.3° in Patient I and 4.5° in Patient II, which equated to full wound healing, as well as a significant improvement in the nutritional status of the patients compared to the baseline prior to implementing professional care.

Conclusions: The assessment of nutritional status should be one of the pillars of a comprehensive examination of a patient with a chronic wound, while also being a determinant of the recovery process. In the cases presented, the correlation between wound condition and the importance played by the PhA can be seen without any doubt. Its increase influences and enhances the regenerative processes within the wound as well as the patient's overall pro-health status. Further studies with a larger group of patients are needed to demonstrate and confirm the multifaceted impact of the use of the above-mentioned indicator in the treatment of chronic wounds.

Key words: pressure injuries, nutritional status, electrical bioimpedance, phase angle.

Introduction

Malnutrition and limited self-care are major risk factors for the development of pressure injuries and impaired wound healing. Several studies, including the National Pressure Ulcer Long-Term Care Study, found that weight loss and inadequate nutrition were associated with a higher risk of pressure ulcers [1–3]. Another study conducted in 22 hospitals and 29 long-term care homes in Germany involving 4,067 and 2,393 people found an association between malnutrition and pressure injury risk [4].

Dietary nutrient deficiencies are key risk factors for the development of chronic wounds and elements that impair their secondary healing. The adult body is approximately 60% water, which is distributed in intracellular, interstitial and intravascular compartments. It serves as a transport medium for the transfer of nutrients into cells and the removal of metabolic products. Water is a solvent for minerals, vitamins, amino acids and other molecules [5]. Dehydration and malnutrition can cause the skin to lose elasticity and become fragile and prone to damage [6]. Bioelectrical impedance

(BIA) is one of the most widely used indirect methods for assessing human body composition. Bioelectrical impedance is the total resistance of the body to an alternating current. It consists of resistance (R), which is the resistance to water and the electrolytes dissolved in it, and reactance (Xc), which is the capacitive resistance of the body's cells acting as capacitors [7]. Additionally, it is a non-invasive, safe and easy-to-use method with a short measurement time of up to 1 minute [8]. Bioelectrical impedance can be used in children, adults and patients who are bedridden, suffering from various chronic conditions with malnutrition, including liver cirrhosis, heart failure, cancer, diabetes, dialysed or with difficult-to-heal wounds [9–11]. A valuable prognostic indicator, but not yet fully understood, is the phase angle (PhA). It is considered an indicator of cellular health, monitoring physical health and risk of adverse events. The phase angle usually lies within the range 5–7° in healthy adults and is usually lower in women than in men, with a value below 5° indicating malnutrition [12–14]. Researchers' reports and self-reported observations indicate that the PhA can be used as a significant prognostic indicator in predicting eating disorders, disease prognosis, risk of death, and wound improvement, and as a tool to assess the effectiveness of nutritional treatment [13, 15, 16]. In contrast, other studies have assessed the correlation of PhA with markers for assessing potential malnutrition, indicating a significant correlation with the NRS-2002 scale, the SGA scale and albumin levels [17, 18].

Adequate calorie and protein intake should be periodically and closely monitored, as nutritional status may deteriorate after hospitalisation or in response to trauma and immobilisation. Identification of patients at risk of malnutrition, as well as diet fortification, should be a common and indispensable part of prevention monitoring and treatment of patients at risk.

After analysing PubMed, Cochrane and Termedia databases, no original or review papers were found on the assessment and monitoring of nutritional status and progress of pressure injury wound treatment in patients using PhA.

Material and methods

Out of a group of 86 patients with chronic wounds enrolled in an observational/prospective study assessing nutritional status using BIA (pressure injury, diabetic foot syndrome, venous ulcers), two male patients, aged 72–62 years (mean age 67 years) with pressure injuries located at the sacrum and ischial tuberosity were purposively selected. They underwent three consecutive BIA and PhA examinations at different time intervals correlated with the local wound status on the day of the measurements. Measurement was performed using an AKERN BIA 101 Anniversary Sport Edition Analyzer (Akern SRL, Pontassieve, Florence, Italy). The system used was a tetrapolar (8-electrode) counterbalanced system (measuring current amplitude 800 µA, sinusoidal, 50 kHz). It was performed in the afternoon (7:00–12:00), in supine position, with upper (30°) and lower limbs (45°) abducted, in fasting status. After a 5-minute rest, the electrode attachment site was washed with alcohol. The phase angle indicator was developed according to the formula PhA= arc tangent Xc/R [12]. The equations used by the software to assess the specific parameters are restricted property of the company. To ensure high reliability of the results obtained, two measurement cycles were performed. Disposable electrodes (Biatrodes, Pontassieve, Fl, Italy: single electrode impedance – 25–30 Ω, compliance with Directive 93/42/ECC and ISO 10993-1:2003) were placed on the dorsal surface of the upper limb (wrist joint) and lower limb (ankle joint). All measurements were performed according to guidelines described by other authors [19–23]. Measurements were taken by a medic with experience in the method. The topical wound care regimen was performed in line with the expert consensus for clinical use – "Wound Hygiene", the "TIMERS" Strategy (Tissue, Inflammation/Infection, Moisture balance, wound Edge, Regeneration of tissue and Social factors) and the patient-centred care (PCC) model [24–26]. Dietary fortification was in the form of oral nutrient supplementation. At the time of the study, the patients scored 35–70 points on the Barthel scale; they were bedridden patients requiring third-party assistance. The study was conducted at the Wound Healing Clinic of the Fr Bronisław Markiewicz Podkarpackie Specialist Oncology Centre in Brzozów, Poland and at the patient's home from April 2021 to May 2023. The study protocol was approved by the ethics committees of the involved institution (Bioethics Commission at the University of Rzeszow: Resolution No. 4/03/2019). In addition, the guidelines of the Declaration of Helsinki were adhered to in the course of the study. Participants were informed of the purpose of the study and could withdraw at any time without giving a reason.

Case descriptions

Case I

Male, 72 years of age, history of hypertension, diagnosis of type 2 diabetes mellitus, post-COVID-19. He was alert and oriented, communicative, scored 70 points on the Barthel scale. Appetite was normal, and he had meals regularly. Body weight before hospitalisation was 97 kg; during hospitalisation weight loss was 20 kg. A pressure injury was located in the sacrum, size 4 × 4 cm; according to the red-yellow-black (RYB) classification it was "yellow" with dissolving necrosis

Fig. 1. Patient I – phase angle/wound status. **A**) Male aged 72 years with a sacral pressure injury wound measuring 4 × 4 cm, wound "yellow" according to red-yellow-black (RYB) with features of infection, profuse exudate, III/IV according to National Pressure Injury Advisory Panel. Based on the patient's history and biochemical blood tests, features of malnutrition, hypertension and after hospitalisation due to COVID-19. When the care was first implemented, the initial phase angle (PhA) result indicated 3.2° and the body mass index score was 27.3. **B**) Second follow-up measurement, 2 × 1 cm wound visibly shrunken, no signs of infection, "red" according to RYB, scanty exudate. Management according to the "TIMERS" strategy. Condition after implementation of NPWT, and subsequent switch to specialised dressing products (antiseptic gel + foam dressing). The phase angle after the implemented nutritional interventions and procedures within the pressure injury improved to 4.3°. **C**) Full healing of the wound and the third follow-up PhA measurement. At the end of treatment, the PhA indicator was within normal limits – 5.3°. Increase in blood parameters tested and reaching normal levels (haemoglobin 14.2 g/dl, albumin 4.30 g/dl). No features of malnutrition, patient mobile, capable of self-care, with recommendations for care and lubrication of the remodelled skin

according to National Pressure Injury Advisory Panel (NPIAP) stage III/IV. The wound showed features of infection (wound at risk score greater than 3) with large exudate, requiring acute and mechanical debridement. No pain on palpation (Fig. 1 A). Sharp debridement was performed initially to evacuate necrosis and assess the depth of the wound (loci at 8 and 5 cm). Blood tests were ordered at each follow-up (Table 1). Oral nutritional supplements (ONS) were implemented, according to the recommendations of producers, starting with ready-to-use protein preparations, through immunomodulating preparations, up to supplementation of preparations containing arginine, zinc and antioxidants. The patient was considered eligible for negative pressure wound therapy (NPWT) (Activac, Aspirionix) at a negative pressure of – 125 mm Hg (Fig. 1 B). The therapeutic process from the patient receiving professional care to complete healing lasted approximately four months. During this time, in addition to therapeutic measures, simple/basic activation exercises were suggested and implemented by the family, intensive diet fortification was carried out based on the results of bioimpedance parameters – PhA and biochemical blood tests (Table 1) – and the patient was motivated and encouraged to take pro-health measures (Fig. 1 C).

Case II

Male, 62 years of age, history of multiple sclerosis, sensory disturbance of the lower half of the body. He was conscious, lying periodically verticalized with the help of a rehabilitation specialist and transferred to a wheelchair. He was alert and oriented, communicative, with a large self-care deficit according to the Barthel scale score of 35 points. He took his meals regularly. A pressure injury wound without visual signs of infection was located within the right ischial tuberosity measuring 4 × 4 cm with features of hollowing along the muscles to a depth of approximately 9 cm, according to RYB "red", according to NPIAP III/IV, profuse exudate, requiring debridement especially within the lodges and hollows (Fig. 2 A). Cyclic biochemical blood tests were performed (Table 2), based on which dietary supplementation with ONS preparations was implemented and modified starting with dietary fortification through increased protein supply and immunomodulatory supplements to reduce oxidative stress. Subsequently, the patient was found eligible for NPWT (Activac, Aspirionix), which was carried out for a period of 20 days in a sequence of dressing changes (4–6 days), negative pressure – 125 mm Hg with a satisfactory effect of a decrease in the inflammatory marker C-reactive protein, as well as visual improvement of the wound itself, and

Table 1. Values of selected morphotic and biochemical parameters of the patient's blood

Parameters	Result	Measurement
Haemoglobin [13–18 g/dl]	10.5	1A
Albumin [3.5–5.2 g/dl]	3.60	
CRP [0–6 mg/l]	3.2	
Haemoglobin [g/dl]	12.6	1B
Albumin [g/dl]	4.20	
CRP [mg/l]	7.9	
Haemoglobin [g/dl]	14.2	1C
Albumin [g/dl]	4.30	
CRP [mg/l]	5.7	

CRP – C-reactive protein

Fig. 2. Patient II – phase angle/wound status. **A**) Male, 62 years of age, lying, dependent with a pressure injury wound within the right ischial tuberosity measuring 4 × 4 cm with a coexisting channel approximately 9 cm deep. Wound "red" according to red-yellow-black (RYB) without signs of infection, profuse exudate, III/IV according to National Pressure Injury Advisory Panel. History, multiple sclerosis, decreased appetite, vital parameters within normal limits. At the time of care (haemoglobin 12.4 g/dl, albumin 3.65 g/dl, C-reactive protein (CRP) 51.8 mg/dl). The initial phase angle (PhA) result indicated a level of 3.3° and the body mass index result was at 23.4. **B**) Second follow-up measurement, wound shrunken, with visible entrance to the canal 4 cm deep. Wound without signs of infection, "red" according to RYB, scarce exudate with slight bleeding on examination and during debridement. Condition after several cycles of negative pressure wound therapy, and subsequent switch to specialised dressing products (hydrofibre + superabsorbent). Follow-up blood tests showed an increase in haemoglobin (15.2 g/dl), while the inflammatory parameter CRP decreased (3.7 mg/dl). A rehabilitation therapist was additionally included as a part of the cooperation to improve the patient's condition. The phase angle indicator improved to 4.2° after dietary fortification interventions and pressure ulcer procedures were implemented. **C**) Complete healing of the resulting wound and a third follow-up PhA measurement 16 months after professional care. After completion of treatment, the PhA indicator improved significantly to 4.5°, but was still below normal, which was nevertheless already sufficient to allow healing of the resulting wound. The last measurement and blood test results varied within normal limits with a noticeable increase in the albumin level (4.56 g/dl). With further recommendations for improvement, nutritional supervision, pressure relief and care of the remodelled skin, the patient was instructed to continue care by his family

Table 2. Values of selected morphotic and biochemical parameters of the patient's blood

Parameters	Result	Measurement
Haemoglobin [13–18 g/dl]	12.4	2A
albumin [3.5–5.2 g/dl]	3.65	
CRP [0–6 mg/l]	51.8	
Haemoglobin [g/dl]	15.2	2B
Albumin [g/dl]	4.36	
CRP [mg/l]	3.7	
Haemoglobin [g/dl]	14.9	2C
Albumin [g/dl]	4.56	
CRP [mg/l]	7.5	

CRP – C-reactive protein

shrinkage of the resulting wound bed. Wound exudate decreased significantly, which allowed the continuation of treatment with specialised antimicrobial dressings and absorbent dressings, including superabsorbent, with normalisation of the frequency of changes every 2nd day (Fig. 2 B). The duration of treatment of the pressure ulcer was 16 months, which resulted from factors dependent and independent of the patient. The management was based on the expert consensus "Wound Hygiene" and "TIMERS", where special attention was paid to systematic wound debridement, the concept of dressing changes (performed by the local primary care centre), education of the wife and patient on the role of pressure relief and the importance of additional nutritional supplementation. In addition, a physiotherapist was included in the care to supervise the patient's motor improvement (Fig. 2 C). The main constraints that undoubtedly influenced the duration of therapy were the family's financial deficits, the co-morbid disease (multiple sclerosis) and the long distances from the supervising treatment centre. The above-mentioned factors were not a contraindication to providing professional care for the patient, which was adapted to the family's financial and caring capacity along the lines of the PCC model.

Discussion

Electrical bioimpedance is a broad term that refers to the conduction of electrical current to assess physiological characteristics of the body in health and disease. The history of the development and application of this method is extensive and spans many scientific disciplines [27]. Since the 1980s, the assessment of body composition using bioimpedance has taken a quantum leap from being an innovative method to becoming a completely new clinical tool, as evidenced by the growing number of papers produced and current scientific inquiries [28–30]. Piccoli *et al.* [31] demonstrated the value of baseline BIA measurements for classifying hydration, nutritional status and for monitoring changes in response to applied treatments, in specific disease entities. Barnett *et al*. [32] first reported the increase in the popularity of the method and significance of the PhA in the 1940s as an exceptional prognostic factor in the assessment and care provided to patients.

The prevalence of abnormal nutritional status tends to be underestimated, while assessment is omitted from the routine examination of patients (the answer to the above problem appears to be intricate and multifaceted, and may also require a separate discussion). This is despite the fact that for years, expert groups have recommended assessment of nutritional status and estimation of the risk of malnutrition as a fundamental and routine part of the patient examination [5, 33].

Our study focused on showing the impact of screening, improving the nutritional status of patients based on an examination of two purposively selected cases with a pressure injury wound, where the correlation of nutritional status was presented simultaneously with the local measures carried out for the treatment of the ulcer itself, using PhA.

During the first examination (Figs. 1 A, 2 A), in addition to the previously discussed PhA, the body mass index (BMI) could also be determined from the given height and weight parameters. Body mass index, a simple parameter commonly used to classify body weight in adults, allows a quick diagnosis of underweight and obesity, but has a high risk of error in the elderly population [34], as shown by the BMI results obtained (Patient I – 27.3; Patient II – 23.4, respectively). These results indicate that the patient's condition does not require intervention or more extensive diagnostics, which in a way addresses the underestimated problem of malnutrition encountered either in the home or hospital setting [35]. A parameter that requires further analysis is the PhA; the subjects during the baseline examination obtained the following results: Patient I – 3.2; Patient II – 3.3. In the study by Kubo *et al*. [36], the aim was to clarify the efficacy of the assessment of malnutrition using PhA and the geriatric nutritional risk index (NRI) and to calculate the malnutrition cut-off points for PhA in elderly hospitalised patients, according to sex. Participants in the study were patients hospitalised in 2017–2019. The study included 160 patients aged 65 years or older who were admitted to the rehabilitation unit (which approximates the average age presented in our study as well). The study found that PhA was an important factor associated with malnutrition in both male and female patients. Furthermore, they presented cut-off points for predicting malnutrition of 4.03° in male patients and 3.65° in female patients. They additionally found a significant correlation between PhA and malnutrition in both male and female patients. Kyle *et al*. [37] reported that the cut-off value for malnutrition using PhA was 5.0° for males and 4.6° for females, and Varan *et al*.[38] indicated a value of 4.7° as the cut-off point. Also, our study published in *Nutrients*, where a comparison of PhA with other scales of nutritional status and albumin concentration was undertaken, is consistent and showed a strong correlation between PhA and the Mini Nutritional Assessment (MNA), NRI scales and albumin score ($p < 0.001$, $R > 0.5$). It means that those with a higher PhA value also had a better nutritional status. Those with a lower PhA had a higher risk of malnutrition (MNA), as well as lower NRI scale scores or albumin concentration levels [13]. Undoubtedly, certain differences in the results obtained in the studies presented result from the different ages of the subjects, mobility, ethnic group or assessment scales. However, they already provide a reliable point of reference, which, based on the above results, unquestionably points to features of malnutrition in the subjects presented during the first tests.

Severe infections, viruses, fungi and injuries including the presence of chronic wounds induces and stimulates a cascade of catabolic reactions. The body continually strives for constant homeostasis through which energy requirements increase during illness. Undoubtedly, SARS-CoV-2 coronavirus infection (which one patient underwent), with its inflammatory and vascular factors, is clearly linked to the aetiology of the formation of decubitus lesions.

In particular, metabolic acidosis and signs of microthrombosis contribute to skin damage by exacerbating or accelerating these processes at different stages of their evolution. Simultaneous general pain may mask the ongoing infection as well as the progression of pressure ulcer formation, while in the long term there are a number of other health implications leading to the so-called long COVID syndrome, as proven by numerous scientific studies [39, 40].

Protein is responsible for the synthesis of enzymes involved in healing, cell proliferation and collagen and connective tissue synthesis. Based on recommendations, protein intake is in the range 1.25–1.5 g/kg body weight per day. For patients with grade III/IV pressure injuries, the suggested level is 1.5–2.0 g/kg, depending on the size of the decubitus ulcer and total protein loss from draining wounds [2, 41]. Cox *et al*. published recommendations for protein supplementation in ulcers, with scales by category of damaged structures, namely: grades I and II 1–1.4 g/kg, and in grades III and IV 1.5–2.0 g/kg, and the maximum requirement may be 2.2 g/kg body weight, but these interventions should be introduced with caution in an older group of patients, monitoring liver and renal functional parameters [42].

Confirmation of the thesis that the greater the degree of injury on the NPIAP scale, the greater the risk of malnutrition is provided by a study by Allen *et al*. [43], which showed that individualised assessment and nutrition planning, in elderly patients with NPIAP score II or III pressure ulcers with other energy inputs, is associated with improved wound healing compared with standard nutrition plans (37% vs. 23.4%, $p < 0.05$) [5]. With regard to these relevant data, in our study, patients and the family providing care received recommendations for dietary fortification enriched with protein products and support with immunomodulatory preparations. Figures 1 B and 2 B present the second follow-up measurement of the bioimpedance/PhA and local wound status. The measurements indicate that the measures implemented were reflected in an improvement in the local wound condition, wound healing (shrunken wounds of smaller diameter and depth, wound bed red, slight bleeding, scarce exudate, surrounding skin in better condition), and an increase in the PhA parameter to 4.3 for Patient I and 4.2 in Patient II. Victoria-Montesinos *et al*. reviewed randomised clinical trials, where a total of eight studies with a total of 606 participants were included in the analysis [44]. The main objective of this systematic review and meta-analysis was to assess the association between different dietary strategies, PhA and hand grip strength in patients diagnosed with cancer. Various forms of intervention, support (oral nutritional supplement) and nutritional counselling were provided in all studies included in this meta-analysis. Significant increases in PhA were observed after different nutritional strategies, detecting the same increase in strength. The results suggest that these indices can be successfully used, as screening methods, and to assess the nutritional status as well as the functional status of patients receiving professional care.

However, a 'traditional' increase in dietary intake is not a sufficient step on the way to achieving the success of full recovery of the patient, or the injury under treatment. In this situation, other types of supplements or strategies are needed to help and counteract stagnation. Therefore, the last elements worth considering (supplementation) are vitamins and minerals that are to improve both the functioning of individual organs and the body as a whole. Vitamins A, C and E, zinc, selenium, magnesium, arginine and glutamine play a key role in preventing and alleviating peroxidative damage and wound remodelling, while also being able to accelerate the healing process [41, 45]. Such multidimensional measures were also taken in the patients described here, so that after a period of less than 4 and 16 months, the last bioimpedance measurements could be taken due to the completion of therapeutic measures and full healing of the resulting ulcers. During the last examinations (Figs. 1 C, 2 C), the patients achieved the following results (PhA); Patient I – 5.3° and Patient II – 4.5°, resulting in a final increase in the PhA parameter of 2.1° and 1.2° respectively (Initial condition Patient I – 3.2°, Patient II – 3.3°). Based on Kyle *et al*., the patients' final results classify their nutritional status as good and not at risk of malnutrition and, in the case of Patient II, requiring further nutritional support and care. The rationale for this appears to be multifactorial, with co-morbidities (MS, reduced mobility, low Barthel score), as well as the amount of exudate or the location and depth of the ulcer, also in line with our observations on a larger study group [16].

The use of effective and non-invasive methods of assessing nutritional status is crucial in order to understand a patient's deficits and provide the patient with the correct care during therapy. The cases presented here show clearly that the presence of difficult-to-heal wounds (even more so, pressure injuries) can and do induce an abnormal nutritional state indicating the presence of malnutrition. The research topic undertaken is extremely inspiring, as it contributes to the growing popularisation of nutrition, methods of measuring and assessing this state (BIA), as well as drawing attention to the roles and wide range of opportunities facing medical personnel wishing to combine theoretical knowledge with practical clinical management (evidence-based medicine). Numerous studies support the fact that the PhA, measured non-invasively by means of electrical bioimpedance analysis, may represent a potentially new, objective and clinically useful indicator of normal nutritional status, while at the same time being, thanks to its simplicity, a useful screening tool in monitoring and evaluating the effectiveness of the nutritional interventions undertaken [7, 30, 46, 47].

All this information prompts us to promote knowledge in the community and to follow the recommendations of expert groups and scientific societies. Failure or misdiagnosis of the nutritional status of patients hospitalised and/or at home can lead to dangerous complications, imposing a burden on the treatment process and, in extreme situations, lead to the death of the patient due to cachexia [48].

Conclusions

Due to its versatility, the PhA is increasingly being used as an indicator in the assessment of nutritional status. Its screening potential, as presented in this paper, illustrates a cyclical upward trend per unit time, in response to appropriate treatment algorithms. In the absence of its non-invasiveness, reliability and sensitivity, it is becoming an important parameter that can complement other methods of assessing nutritional status. Individuals with difficult-to-heal wounds of significant size and depth of damaged structures (especially those with pressure injuries) may show signs of malnutrition. Assessment of nutritional status in this group should be one of the pillars of a comprehensive examination, while also being a determinant of the recovery process. Standardising the method in clinical practice will increase the possibilities for a detailed assessment of nutritional status and allow individualised planning and implementation of nutritional interventions. Nutritional support for patients with wounds that are difficult to heal, especially those with pressure injuries, brings tangible benefits and speeds up the healing process.

In summary, PhA was consistently associated with biochemical blood results, where lower PhA results were reflected in levels of albumin and haemoglobin. It was observed that an increase in the above-mentioned parameters resulted in a better local wound condition, systematic reduction and final healing of the wound.

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References

1. Horn SD, Bender SA, Ferguson ML, et al. The national pressure ulcer long-term care study: pressure ulcer development in long-term care residents. J Am Geriatr Soc 2004; 52: 359-367.
2. Saghaleini SH, Dehghan K, Shadvar K, et al. Pressure ulcer and nutrition. Indian J Crit Care Med 2018; 22: 283-289.
3. Serpa LF, Oliveira AS, Nogueira PC, et al. Risk for undernutrition and development of pressure injury in hospitalised patients in Brazil: multicentre prospective cohort study. Int Wound J 2020; 17: 916-924.
4. Bavelaar JW, Otter CD, Bodegraven AA, et al. Diagnosis and treatment of (disease-related) inhospital malnutrition: the performance of medical and nursing staff. Clin Nutr 2008; 27: 431-438.
5. Munoz N, Posthauer ME, Cereda E, et al. The role of nutrition for pressure injury prevention and healing: the 2019 International Clinical Practice Guideline Recommendations. Adv Skin Wound Care 2020; 33: 123-136.
6. Ghaly P, Iliopoulos J, Ahmad M. The role of nutrition in wound healing: an overview. Br J Nurs 2021; 30: S38-S42.
7. Małecka-Massalska T, Popiołek J, Teter M, et al. Use of phase angle to assess the nutritional status of patients with mental anorexia nervosa. Psychiatr Pol 2017; 51: 1121-1131.
8. Szczygieł B. Malnutrition. In: Szczygieł B (ed.). Malnutrition associated with disease. Wydawnictwo Lekarskie PZWL, Warsaw 2011, 39-50.
9. Więch P. Application of bioelectrical impedance, phase angle, and bioelectrical impedance vector analysis in the assessment of the nutritional status of a population of healthy adults and children, University of Rzeszów Publishing House, Rzeszów 2019.
10. Więch P, Bińkowska-Bury M, Korczykowski B. Body composition as an indicator of the nutritional status in children with newly diagnosed ulcerative colitis and Cronh's disease – a prospective study. Prz Gastroenterol 2017; 12: 55-59.
11. Franco-Oliva A, Ávila-Nava A, Rodríguez-Aguilar EA, et al. Association between phase angle and the nutritional status in pediatric populations: a systematic review. Front Nutr 2023; 10: 1142545.
12. Norman K, Stobäus N, Pirlich M, et al. Bioelectrical phase angle and impedance vector analysis-clinical relevance and applicability of impedance parameters. Clin Nutr 2012; 31: 854-861.
13. Uemura K, Doi T, Tsutsumimoto K, et al. Predictivity of bioimpedance phase angle for incident disability in older adults. J Cachexia Sarcopenia Muscle 2020; 11: 46-54.
14. De Marchis M, Ciarnella M, Federici A, et al. Evaluation of nutritional status through bioimpedance analysis in a group of Cystic Fibrosis patients. Clin Ter 2022; 173: 471-474.
15. Norman K, Wirth R, Neubauer M, et al. The bioimpedance phase angle predicts low muscle strength, impaired quality of life, and increased mortality in old patients with cancer. J Am Med Dir Assoc 2015; 16: 173.e17-173.e1.73E22.
16. Skórka M, Więch P, Przybek-Mita J, et al. Nutritional status of people with a coexisting chronic wound and extended assessment using bioelectrical impedance. Nutrients 2023; 15: 2869.
17. Zhou S, Yu Z, Shi X, et al. The Relationship between phase angle, nutrition status, and complications in patients with pancreatic head cancer. Int J Env Res Public Health 2022; 19: 6426.
18. Do Amaral Paes TC, de Oliveira KCC, de Carvalho Padilha P, et al. Phase angle assessment in critically ill cancer patients: Relationship with the nutritional status, prognostic factors and death. J Crit Care 2018; 44: 430-435.
19. Kyle UG, Bosaeus I, de Lorenzo AD, et al. Bioelectrical impedance analysis – Part II: Utilization in clinical practice. Clin. Nutr 2004; 23: 1430-1453.
20. Yanovski SZ, Hubbard VS, Heymsfield SB, et al. Bioelectrical impedance analysis in body composition measurement: National institutes of health technology assessment conference statement. Am J Clin Nutr 1996; 64: 524-532.
21. Kushner RF. Bioelectrical impedance analysis: a review of principles and applications. J Am Coll Nutr 1992; 11: 199-209.
22. Lukaski HC, Bolonchuk WW, Hall CB, et al. Validation of tetrapolar bioelectrical impedance method to assess human body composition. J Appl Physiol 1986; 60: 1327-1332.
23. Więch P, Woloszyn F, Trojnar P, et al. Does body position influence bioelectrical impedance? An observational pilot study. Int J Environ Res Public Health 2022; 16: 9908.
24. Murphy C, Atkin L, Swanson T, et al. International consensus document. Defying hard-to-heal wounds with an early antibiofilm intervention strategy: wound hygiene. J Wound Care 2020; 29: 1-28.
25. Atkin L, Bućko Z, Conde Montero E, et al. Implementing TIMERS: the race against hard-to-heal wounds. J Wound Care 2019; 23: 1-50.
26. Lusk JM, Fater K. A concept analysis of patient-centered care. Nurs Forum 2013; 48: 89-98.
27. Lukaski HC. Evol bioimpedance: circuitous journey estimation physiological function Assess body composition return Clin Res Eur J Clin Nutr 2013; 67: 2-9.
28. Ward LC. Electrical bioimpedance: past future J Electr Bioimpedance 2021; 12: 1-2.
29. Lukaski HC, Garcia-Almeida JM. Phase angle in applications of bioimpedance in health and disease. Rev Endocr Metab Disord 2023; 24: 367-370.
30. Bellido D, García-García C, Talluri A, et al. Future lines of research on phase angle: strengths and limitations. Rev Endocr Metab Disord 2023; 24: 563-583.
31. Piccoli A, Codognotto M, Piasentin P, et al. Combined evaluation of nutrition and hydration in dialysis patients with bioelectrical impedance vector analysis (BIVA). Clin Nutr 2014; 33: 673-637.
32. Barnett A, Swamp S. The physiological mechanisms involved in the clinical measure of phase angle. Am J Physiol 1936; 114: 366-382.
33. Kottner J, Cuddigan, J, Carville, K et al. Prevention and treatment of pressure ulcers/injuries: the protocol for the second update of the international Clinical Practice Guideline 2019. J Tissue Viability 2019; 28: 51-58.
34. Eknoyan E. Adolphe Quetelet (1796-1874): the average man and indices of obesity. Nephrol Dial Transplant 2008; 23: 47-51.
35. Mziray M, Żuralska R, Książek J, et al. Malnutrition in the elderly, methods of assessment, prevention and treatment. Ann Acad Med Gedan 2016; 46: 95-105.
36. Kubo Y, Noritake K, Nakashima D, et al. Relationship between nutritional status and phase angle as a noninvasive method to predict malnutrition by sex in older inpatients. Nagoya J Med Sci 2021; 83: 31-40.
37. Kyle UG, Soundar EP, Genton L, et al. Can phase angle determined by bioelectrical impedance analysis assess nutritional risk?

A comparison between healthy and hospitalised subjects. Clin Nutr 2012; 31: 875-881.
38. Varan HD, Bolayir B, Kara O, et al. Phase angle assessment by bioelectrical impedance analysis and its predictive value for malnutrition risk in hospitalized geriatric patients. Aging Clin Exp Res 2016; 28: 1121- 1126.
39. Li D, Cao W, Zhou Q, et al. COVID-19 and primary wound healing: a new insights and advance. Int Wound J. 2023; 20: 4422-4428.
40. Davis HE, McCorkell L, Vogel JM, et al. Long COVID: major findings, mechanisms and recommendations. Nat Rev Microbiol 2023; 21: 133-146.
41. Acton C. The importance of nutrition in wound healing. Wounds UK 2013; 9: 61-64.
42. Cox J, Rasmussen L. Enteral nutrition in the prevention and treatment of pressure ulcers in adult critical care patients. Crit Care Nurse 2014; 34: 15-27.
43. Allen B. Effect of sofa comprehensive nutritional program on pressure ulcer healing ,length of hospital stay, and charges to patients. Clin Nurs Res 2013; 22: 186-205.
44. Victoria-Montesinos D, García-Muñoz AM, Navarro-Marroco J, et al. Phase angle, handgrip strength, and other indicators of nutritional status in cancer patients under going different nutritional strategies: a systematic review and meta-analysis. Nutrients 2023; 15: 1790.
45. Molnar J, Underdown MJ, Clark WA. Nutrition and chronic wounds, nutrition and chronic wounds. Adv Wound Care 2014; 3: 663-681.
46. Lee Y, Kwon O, Shin CS, et al. Use of bioelectrical impedance analysis for the assessment of nutritional status in critically ill patients. Clin Nutr Res 2015; 4: 32-40.
47. Kyle UG, Genton L, Pichard C. Low phase angle determined by bioelectrical impedance analysis is associated with malnutrition and nutritional risk at hospital admission. Clin Nutr 2013; 32: 294-299.
48. Buscemi S, Batsis JA, Parrinello G, et al. Nutritional predictors of mortality after discharge in elderly patients on a medical ward. Eur J Clin Invest 2016; 46: 609-618.