

Morphometric and clinical analysis and nutritional and dietary management of malnourished adult patients in the Marrakech Tensift Al Haouz region, Morocco

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ABSTRACT

This study examined the morphometric and clinical aspects as well as the nutritional and dietary management of undernourished adult patients in the Marrakech Tensift Al Haouz region, Morocco. It highlighted the specific challenges faced by these patients, in particular the significant differences in nutritional requirements and management strategies. Our results showed a significant increase in caloric intake from 19.97 ± 0.64 kcal/kg/d to 27.23 ± 0.12 kcal/kg/d for all patients. Muscle mass increased from 16.71 ± 4.76 kg to 18.75 ± 3.58 kg. The mean albumin increased to 35.9 g/L, indicating an improved protein reserve. Similarly, pre-albumin increased to 186.3 mg/dL, suggesting a rapid response to nutritional intake. At the same time, C-reactive protein levels fell, indicating a reduction in systemic inflammation. In addition, it is important to note that body mass index differed between the sexes, with women tending to gain muscle mass more slowly than men. The results highlight the urgent need to adopt a personalized approach to improving the health and well-being of undernourished patients by adjusting nutritional and dietary interventions to the specific needs of each individual.

Introduction

Undernutrition is a major health problem in the Marrakech Tensift Al Haouz region of Morocco, particularly among adults.^{1,2} This challenge is compounded by difficult socio-economic conditions, limited access to healthcare, and gaps in nutritional management.

Undernutrition in adults is often underestimated, despite its significant impact on overall health and the management of chronic diseases. Worldwide, around 1.5 billion adults are undernourished or overweight, with serious implications for public health. In developing countries, undernutrition is a particularly severe problem, affecting around 10% of the adult population. In Morocco, the situation is also worrying, with around 18% of adults showing signs of undernutrition, according to the latest statistics.³

This study aimed to analyze the morphometric and clinical aspects of malnourished adult patients while evaluating nutritional and dietary management strategies adapted to this population. This approach seeks to improve clinical outcomes by optimizing nutritional interventions and reducing the complications associated with undernutrition, such as worsening of underlying pathologies and increased morbidity.

ity. It also aimed to improve patients' quality of life and limit prolonged hospitalizations and avoidable complications. By implementing nutritional interventions from diagnosis and throughout treatment, this study aimed to raise awareness among healthcare professionals of the importance of nutrition in the management of undernourished patients. It proposed solutions tailored to the specific needs of this population, thereby contributing to better management of undernutrition in the Marrakech Tensift Al Haouz region and improving local health outcomes.

Materials and Methods

Study background and sample

This case study is part of a larger study of 2021 patients, conducted over 15 months from January 2022 to March 2023. The overall study population included individuals seen and interviewed at various study sites. Of these participants, 1111 were identified as showing signs of undernutrition using our specific assessment methodology, including diagnosed adults aged between 18 and 65.

Participants

The participants selected for this study comprised 1111 adults aged 18-65 years, randomly selected from consultations in clinics and private practices. Of these individuals, 672 were identified as having signs of undernutrition (235 women, 437 men).

Inclusion criteria required that participants be aged 18 years or older and that their state of undernutrition be confirmed by clinical and anthropometric assessments. In addition, patients had to be under regular medical care and have given informed consent to participate in the study.

Anthropometric measurements and body composition

Anthropometric measurements, such as weight, height, and body mass index (BMI), were performed using an accurate mechanical column scale (SECA 756) for weight, with fine graduation for increased accuracy. Height was measured using a measuring tape accurate to 0.1 cm. In addition, body analyses were carried out using an impedance meter (Inbody 570), enabling a detailed assessment of the participants' body composition, including fat mass, lean mass, visceral fat, extracellular and intracellular water, as well as other parameters relevant to detecting undernutrition or its degree of severity.

These measurements were taken while the participants were dressed only in their underwear, without shoes or socks, and without any metal or jewelry, to avoid any interference with the electrodes of the measuring equipment.

Biochemical and biological analyses

For undernourished adults in the Marrakech Tensift Al Haouz region, biochemical and biological analyses played a fundamental role in understanding their nutritional status and effectively managing their undernutrition.

These tests provided a detailed picture of nutritional deficiencies and signs of inflammation so that interventions

can be guided appropriately. One of the key tests is albumin, a crucial marker with normal levels of between 35 and 50 g/L. A drop in albumin may indicate chronic undernutrition, often exacerbated by underlying health conditions or medical treatments. Prealbumin (or transthyretin), with normal values of 20-40 mg/dL, is particularly sensitive to recent fluctuations in nutritional status, providing an early indication of protein deficiency.

Assessment of iron stores was also essential. Ferritin, normally between 30 and 400 ng/mL, is used to assess the body's iron reserves, while serum iron levels, which vary from 60 to 170 µg/dL, help to detect any deficiencies that may lead to anemia. Vitamins also played a key role: vitamin B12, with normal levels of 200 to 900 pg/mL, is essential for red blood cell formation and neurological function, while vitamin B9 (folic acid), with a range of 3 to 17 ng/mL, supports DNA synthesis and blood cell production.

Calcium (2.2 to 2.6 mmol/L) and zinc (70 to 120 µg/dL) are monitored for their importance in bone health and metabolism, as deficiencies in these minerals may result from malabsorption or increased needs due to illness. Finally, C-reactive protein (CRP) is measured to assess inflammatory status, although high levels can sometimes mask signs of undernutrition, requiring careful analysis to differentiate inflammation from true nutritional deficiency.

By integrating these various analyses, we obtained an overall picture of patients' nutritional status, enabling us to personalize interventions and improve their quality of life in a targeted and effective way.

Ethical considerations

All precautions according to the Declaration of Helsinki were taken to protect the privacy and confidentiality of the personal information of those involved in the research. Informed consent was obtained from the participants, who were properly informed of the objectives and methods.

Results

Undernutrition represents a significant public health issue, often overlooked in clinical care. This study focused on undernourished adult patients who benefited from targeted nutritional intervention.

Prevalence of associated pathologies in adult malnourished patients

The distribution of associated diseases in malnourished patients is presented in Figure 1. According to our results, the average age of the malnourished patients (n=672) was 37.7 years. For coeliac disease, 7 women and 19 men were identified, indicating a higher prevalence in men. For chronic pancreatitis, 13 of the 21 patients were women, suggesting a higher incidence in this group. Crohn's disease and hemorrhagic rectocolitis affected 2 women and 11 men, also indicating a significant prevalence in men. Irritable bowel syndrome was relatively evenly distributed, with 105 women and 129 men. In contrast, all the cases of tuberculosis involved men. Renal failure affected 24 women and 21 men, showing a slight female predominance. Depressive syndrome was seen predominantly in women, with 30 cases

out of 32, while hyperthyroidism also affected a large number of women (61 out of 67). For cancer, 34 patients were women and 40 men, while diabetes showed a higher incidence among women (87 cases).

Impact of nutritional intervention on calorie intake and muscle mass as a function of sex

The evolution of muscle mass and ingesta is presented in Figure 2. For women, caloric intake increased from 19.5 kcal/kg/d to 27.1 kcal/kg/d ($p=0.0007$), indicating a statistically significant difference, as did muscle mass, which rose from 13.4 kg to 16.2 kg ($p=0.0075$). In men, on the other hand, ingesta also increased, from 20.4 kcal/kg/d to 27.3 kcal/kg/d ($p=0.0170$), but muscle mass showed only a slight increase from 20.1 kg to 21.3 kg, without significance ($p=0.3446$). For all participants, ingesta increased from 20.0 kcal/kg/d to 27.2 kcal/kg/d ($p=0.0089$), while muscle mass increased from 16.7 kg to 18.8 kg ($p=0.1761$), indicating a lack of statistical significance.

Relationship between biomarkers and improvement in the nutritional status of malnourished adult patients

The results showed significant improvements in biomarkers between T0 and T6, indicating a marked recovery in the nutritional status of malnourished patients (Table 1). Mean albumin increased from 26.4 g/L to 35.9 g/L, reflecting improved protein reserve. Similarly, pre-albumin increased from 125.8 mg/dL to 186.3 mg/dL, suggesting a rapid response to nutritional intake. At the same time, CRP levels decreased from 5.1 mg/L to 2.8 mg/L, indicating a reduction in systemic inflammation.

Analysis of perceived appetite and protein levels at the time of undernutrition assessment (T0)

The results of our study showed a correlation between patients' perception of appetite (Liker Scale) and their protein levels at T0. Among the 368 patients with a very low perception of appetite, we observed an average protein level of 6.215 kg, with a distribution of 126 women (5.73 kg) and 242 men (6.7 kg) (Table 2). For those with a low perception of appetite, the protein level increased slightly, reaching an average of 7.02 kg, with 86 women (6.94 kg) and 176 men (7.1 kg). This phenomenon continues with the perception of average appetite, where protein levels rise to 7.6 kg, although the number of patients is reduced. However, it is notable that no patient reported a high or very high perception of appetite.

Analysis of weight and calorie intake by sex

The results presented in Figure 3 showed a significant change in patients' weight and calorie intake over the course of the study. For women, the average weight rose from 39.5 kg to 43.7 kg, with calorie intake increasing from 770.25 kcal to 1185.36 kcal. This increase indicated a marked improvement in their nutritional status. For men, the average weight also increased from 45.4 kg to 49.9 kg, with calorie intake rising from 926.16 kcal to 1362.27 kcal. This indi-

cated that the men also benefited from better nutritional management, contributing to their weight gain. Overall, the average weight of the total group increased from 42.45 kg to 46.8 kg, with calorie intake rising from 847.73 kcal to 1274.36 kcal.

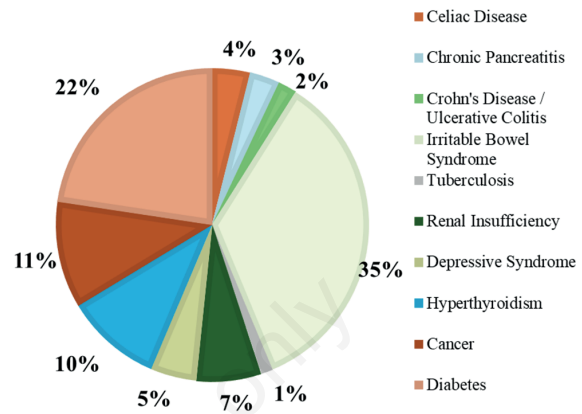


Figure 1. Distribution of associated pathologies.

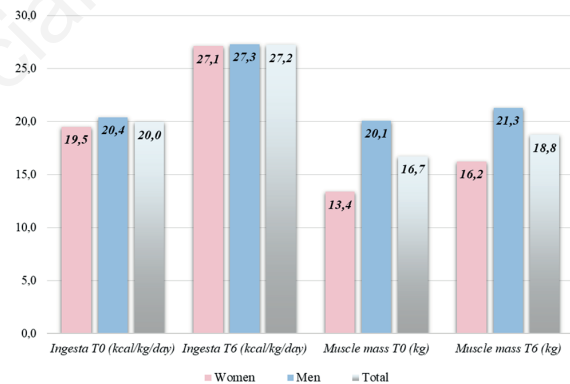


Figure 2. Evolution of muscle mass and ingesta.

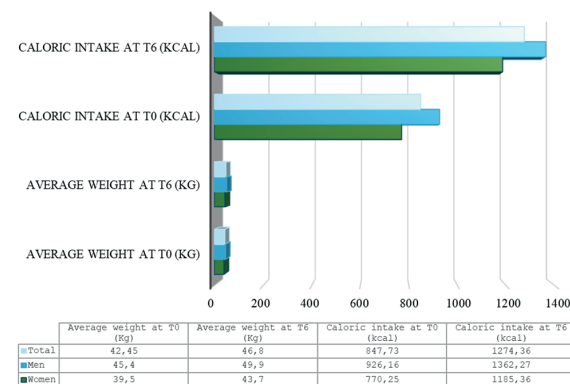


Figure 3. Evolution of weight and caloric intake.

Impact of nutritional management on food quality, number of meals and nutritional status

The results shown in Table 3 showed an increase in the average number of meals per day from T0 to T6, rising from 2.87 to 3.07 for women and from 2.95 to 3.72 for men. The food quality score [measured by the external quality assessment (EQA) score] also improved significantly: for women, it rose from -33 to 46, while for men, it rose from -26 to 61. These scores suggested a shift from consumption of low-quality foods to better-quality food choices. At the same time, the average BMI increased from 15.5 to 17.6 for women and from 16.3 to 18 for men, reflecting an improvement in nutritional status.

Discussion

Our study targeted several objectives, principally adequate and complete diagnosis to determine a case of undernutrition (n=2021) including adult patients (n=1111); we were able to detect 672 adult cases of undernutrition (235 women, 437 men).

This study examined the impact of nutritional management on caloric intake and muscle mass in malnourished patients. In our sample (672 participants), the results showed a significant increase in caloric intake, from 19.97 ± 0.64 kcal/kg/d to 27.23 ± 0.12 kcal/kg/d for all patients. Although muscle mass increased from 16.71 ± 4.76 kg to 18.75 ± 3.58 kg, it is important to note that the in-

creases observed were not always statistically significant. A proper diagnosis is crucial in determining the right protocol to implement, as indicated by a study carried out in China in 2011.⁴ Overall caloric intake showed a significant improvement, suggesting that increased caloric intake, particularly of protein, is associated with an improvement in muscle mass. These results indicate that higher caloric intake promotes muscle synthesis, leading to a significant increase in muscle mass.⁵

It has also been emphasized that nutritional management can have a direct and positive impact on muscle recovery, particularly in patients with moderate to severe levels of undernutrition.⁶⁻⁸ The significant improvements in biomarkers between T0 and T6 indicate a marked recovery in patients' nutritional status. Mean albumin increased to 35.9 g/L, reflecting improved protein reserve. Similarly, pre-albumin increased to 186.3 mg/dL, suggesting a rapid response to nutritional intake. At the same time, CRP levels fell, indicating a reduction in systemic inflammation. These results are similar to those reported in a study conducted in Sweden in 2024,⁹ and another conducted in Croatia in 2014.¹⁰

The relationship between perceived appetite, protein levels, and muscle mass is based on the idea that higher levels of appetite lead to increased protein consumption, thereby promoting an increase in muscle mass. Our results confirm this hypothesis. In the table analyzed, patients with a low perception of appetite (score of 1) had significantly low protein levels, with 5.73 kg for women and 6.7 kg for men. In contrast, those who rated their appetite as average

Table 1. Variation of Biomarkers between T0 and T6.

Parameter	T0	T6	Variation
Albumin (g/L)	26.4	35.9	9.5
Prealbumine (mg/dL)	125.8	186.3	60.5
CRP (mg/L)	5.1	2.8	-2.3

CRP, C-reactive protein.

Table 2. Appetite Perception and protein levels by sex.

Appetite perception	Number of patients (women)	Protein level (women) (kg) at T0	Number of patients (men)	Protein levels (men) (kg) at T0	Number of patients (total)	Protein levels (total) (kg) at T0
Very low	126	5.73	242	6.7	368	6.215
Low	86	6.94	176	7.1	262	7.02
Medium	23	7.3	19	7.9	42	7.6
High	0	N/A	0	N/A	0	N/A
Very high	0	N/A	0	N/A	0	N/A

N/A, not available.

Table 3. Number of meals and food quality score.

Group	Number of meals per day at T0	Number of meals per day at T6	Food quality score at T0 (EQA)	Food quality score at T6 (EQA)	Average BMI at T0 (kg/m ²)	Average BMI at T6 (kg/m ²)
Women	2.87	3.07	-33	46	15.5	17.6
Men	2.95	3.72	-26	61	16.3	18
Total	2.91	3.40	-30	54	15.9	17.8

EQA, external quality assessment; BMI, body mass index.

(score of 3) had higher protein levels, reaching 7.3 kg for women and 7.9 kg for men. This trend suggests that an improved perception of appetite is linked to an increase in protein intake.

In addition, previous studies have shown that increased protein intake correlates with improved muscle mass, particularly in malnourished patients. Thus, our data indicate not only that protein levels increase with appetite perception but also that an increase in these levels could have a direct impact on muscle mass, in line with what was reported in a study carried out in Ohio in 2021.¹¹

According to our study, the number of meals per day is almost identical between the sexes, with an average of around 2.91 at T0 and 3.40 at T6. However, the quality of food consumed, measured by the EQA score, showed a clear improvement. At T0, the food quality score was low, with values of -30 for all participants, whereas at T6, this score rose to 54, indicating significant progress towards a better-quality diet. Despite a modest increase in the number of meals, it is clear that food quality played a crucial role in improving the nutritional status of malnourished patients. For our sample of 672 undernourished adults, although the number of meals was almost equivalent between men and women, the quality of the food varied considerably. This observation highlights the fact that the number of meals was not the determining factor; on the contrary, it was the quality of the food that contributed to the improvement in nutritional status.¹²⁻¹⁴

In addition, it is important to note that BMI differs between the sexes, with women tending to gain muscle mass more slowly than men. At T0, the mean BMI for women was 15.52 ± 1.17 , while at T6 it rose to 17.62 ± 5.26 . In comparison, the mean BMI for men was 16.33 ± 1.75 at T0 and rose to 18 ± 3.20 at T6. This difference may be explained by hormonal and metabolic factors that influence the distribution and synthesis of muscle mass, underlining the importance of nutritional management adapted to the specific needs of each sex.¹⁵

Conclusions

Our study of undernutrition in adults in the Marrakech Tensift Al Haouz region revealed an alarming prevalence of undernutrition, confirming observations from previous research. Among 1111 participants, 672 cases of undernutrition were identified, highlighting the fact that this condition often goes unnoticed. These results highlight the importance of early detection and appropriate nutritional management, which are essential for preventing short- and long-term complications. Despite the existing protocols, our results show significant improvements, in line with other similar studies. This underlines the need for proactive, preventive management of undernutrition. By integrating rigorous monitoring tools and raising awareness of the issues among healthcare professionals, we can better meet patients' nutritional needs and reduce the risks associated with undernutrition.

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