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IMPACT OF NUTRITIONAL STATUS ON MUSCLE ARCHITECTURE IN ELDERLY PATIENTS HOSPITALIZED IN INTERNAL MEDICINE WARDS

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Abstract: Nutritional alterations are highly prevalent in older rather than adult hospitalized patients. In these subjects, a loss of physical performance is dependent on the impairment of muscle architecture. This study aimed to investigate the association between the nutritional status and muscle architecture in elderly patients hospitalized in internal medicine wards. 68 aged patients admitted in internal medicine wards were consecutively enrolled and stratified in three groups based on the Mini Nutritional Assessment (MNA) score: well-fed (WF), at risk of malnutrition (RM), and malnourished (M). Biochemical indices and anthropometric parameters were sampled at hospital admission. Furthermore, all patients were assessed at admission and after 7 days of hospitalization for muscle strength (hand-grip test), mass (bioimpedentiometry), and architecture (ultrasonography of vastus lateralis). At hospital admission, M patients showed lower percentage of fat free mass and muscle mass with respect to WF and RM. Furthermore, M group presented with lower muscle thickness and pennation angle, as compared to WF and RM. At admission, the MNA score was positively related to the pennation angle and muscle strength. Multivariate linear regression analysis showed that the nutritional status at admission was the only significant factor influencing pennation angle. Finally, during the first 7 days of hospitalization, a decrease of pennation angle occurred in all the groups studied. We conclude that malnutrition at admission is associated with impaired muscle architecture in elderly patients hospitalized in internal medicine wards. Moreover, muscle architecture is impacted by early hospitalization, irrespective of nutritional status.

Key words: Muscle architecture, pennation angle, malnutrition, hospitalized elderly.

Introduction

Elderly subjects undergo hospitalization more frequently than younger ones (1). For most patients, hospitalization results in functional decline independently of the cause of hospital admission. In fact, reduced mobility in hospitalized elderly patients frequently occurs and associates with negative outcomes (2).

Malnutrition, defined as a chronic condition characterized by over- or undernutrition associated with increasing disability, morbidity and mortality (3-5), is prevalent in the geriatric population (6, 7). Although malnutrition is associated with adverse clinical outcomes in hospitalized patients, screening and assessment of nutritional status are not routinely performed (8-11). The Mini-Nutritional Assessment (MNA) is an easy-to-use screening tool to check the nutritional status in the elderly (12).

Both aging and malnutrition can contribute to modifications in body composition, especially the loss of skeletal muscle mass (13). If a healthy skeletal muscle status improves both global health and physical autonomy (14), muscle strength loss is an important predictor of adverse clinical outcomes, such as hospital length stay, disability and mortality (15, 16). Age-related muscle changes may include alterations in tissue architecture, described by muscle thickness (MT), fascicle length (FL) and pennation angle (PA) (17). Muscle architecture plays a central role on muscle performance and strength (17, 18). Malnutrition and acute conditions may contribute to hypercatabolic state with consequent impairment of muscle tissue (19). A recent study reported the association of malnutrition with low muscle mass at admission in hospitalized elderly patients (13).

However, to our knowledge no data are available on the relationship between nutritional status and muscle architecture. Thus, we investigated the impact of nutritional status on muscle architecture in elderly patients at admission in internal medicine wards, taking into account any change in muscle thickness and pennation angle during early hospitalization.

Methods

Study design

The study was conducted at the Department of Medicina Interna Universitaria, "Ospedali Riuniti" in Foggia (Italy). We recruited consecutive patients aged 65 years or older admitted to our ward. The exclusion criteria were the following: dysphagia, active cancer, severe cognitive impairment (assessed with a Mini-Mental State Examination score ≤ 9 points), immobilization in bed, inability to comply with the study protocol or to provide written informed consent. Moreover, patients with a length of stay < 7 days or terminally ill were excluded. Finally, 68 patients were included in the study (Figure 1).

The study was approved by our Institutional Review Board at the Ospedali Riuniti in Foggia and performed according to the Declaration of Helsinki. All patients gave written informed consent.

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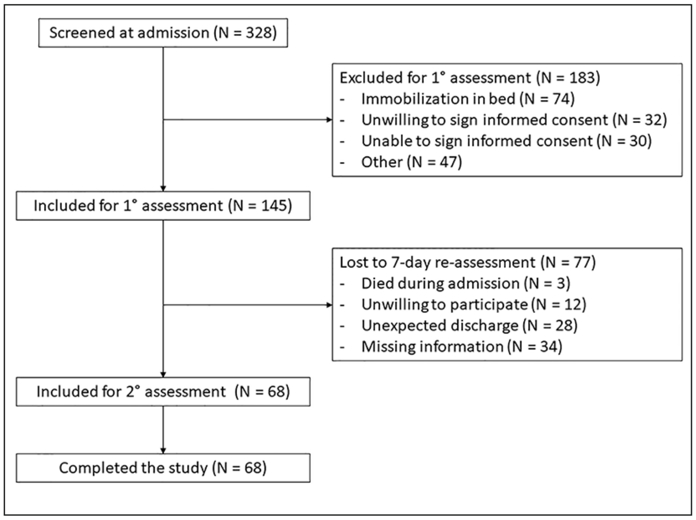
Figure 1
Flowchart of study participants



MNA was performed by the same investigator, and patients were divided in three groups according to the nutritional status: WELL-FED (WF, score > 23.5 points), RISK OF MALNUTRITION (RM, score 23.5 – 17 points); MALNOURISHED (M, score < 17 points) (20).

Outcome measures

At the hospital admission time, physical activity was estimated through the Physical Activity Scale for the Elderly (PASE) questionnaire (21). Cognitive status was assessed through the Mini-Mental State Examination (MMSE) while function autonomy was measured using the activities of daily living (ADL) (22, 23). Laboratory tests such as haemoglobin, white blood cell (WBC) count, lymphocytes, serum creatinine, total cholesterol, HDL and LDL cholesterol, triglycerides, albumin, C-reactive protein (CRP) and ferritin were assessed. Body weight and height were also measured according to standardized procedures. Body mass index (BMI) was calculated as the ratio between weight in kilograms and the square of height in meters.

Intra-hospital mobility levels were evaluated using the "de Morton Mobility Index" (DEMMI) (24).

Body composition, muscle strength and architecture were assessed at two occasions during their admission, i.e. within 48 h after admission and at day 7 after the first assessment.

Body composition was assessed by bioelectrical impedance using a BIA 101-F device (Akern/RJL, Florence, Italy), as previously reported (25).

Muscle strength was evaluated by performing the handgrip strength test, using the Hand Grip Dynamometer Kern MAP 80K1S (Kern, Balingen, Germany). The patients were instructed to apply as much handgrip pressure as possible by using the hand. The measurements were repeated 3 times, and the highest score was recorded in kilograms. Three trials for each hand were carry out and the best value of the strongest hand was considered in the analyses (26).

To evaluate muscle architecture, we performed right vastus lateralis muscle ultrasound according to a previously published standardized protocol (27). The ultrasonographic images of right vastus lateralis muscle were obtained using a Philips iU22 xMATRIX Ultrasound system with a 12.5 MHz linear array L12-5 transducer (Philips S.p.A., Milano, Italy) and analyzed with ImageJ Software.

Statistical analysis

Data were expressed as count and percentages/interquartile range (IR) for qualitative values, and as mean ± standard deviation of the mean (SDM) for quantitative variables. Gaussian distribution of the samples was evaluated by the Kolmogorov-Smirnov test. Comparison among groups for continuous variables was performed using one-way analysis-of-variance (ANOVA) or Kruskall-Wallis tests for parametric or non-parametric distribution respectively. The Tukey test was used for the post hoc analysis. Nominal and categorical variables were analysed by the Pearson's Chi-Squared test.

The correlation analysis between variables was performed by using the Pearson correlation test followed by linear regression. A two-way ANOVA was used to test the main effects of time and nutritional status as between-subject factor; the interaction time × nutritional status was studied, and a Tukey test was applied as post hoc test for multiple comparisons.

The odds ratio (OR) and the 95% confidence interval (CI) were calculated. Here, ORs >1 implies a higher chance for malnutrition relative to the reference category. Multivariate logistic regression analysis was used to analyse the association between indices of muscle architecture (muscle thickness, pennation angle) and nutritional status. The selection of covariates in the multivariate analysis was performed by backward selection, using $p < 0.1$ as cut-off, with age and genre forced into the model.

All tests were 2-sided, and P values < 0.05 were considered to be statistically significant. Statistical analysis was performed with the Statistical Package for Social Sciences version 20.0 (SPSS, Inc., Chicago, IL) and the package Graph-Pad Prism 6.0 for Windows (GraphPad Software, Inc., San Diego, CA).

Results

Table 1 shows the clinical and biochemical characteristics of the study population. The mean age was 77.3 (± 7.6), and 58.8% of the patients were women. According to the MNA score at admission, 36.8% of the patients were WF, 33.8% were RM, and 29.4% were M. There were no significant differences among groups as regards gender, polypharmacotherapy, comorbidities, the mini-mental state examination (MMSE), the (PASE), DEMMI, serum creatinine, C-reactive protein and ferritin level. Differences were found concerning age, activities of daily living (ADL), blood haemoglobin and lymphocytes, and serum total cholesterol, HDL-cholesterol,

Table 1
Clinical and biochemical characteristics of patients at baseline, according to study groups

	Well-fed (WF) N = 25 (36.8%)	Risk of Malnutrition (RM) N = 23 (33.8%)	Malnourished (M) N = 20 (29,4%)	P value
Age (years)	71.6 ± 3.9	75.7 ± 6.7	81.2 ± 4.1	< 0.001
Gender (M/F)	11/14	10/13	7/13	0.799
Living independently (N, %)	18 (72)	14 (61)	15 (75)	0.561
Polypharmacotherapy (N, %)	23 (92)	22 (96)	20 (100)	0.430
Co-morbidities > 3 (N, %)	19 (76)	19 (83)	18 (90)	0.472
ADL (score)	5.9 ± 0.8	5.8 ± 1.1	5.8 ± 1.9	0.955
MMSE (score)	24.3 ± 6.3	21.4 ± 5.8	21.1 ± 7.2	0.176
PASE (score)	114 ± 32.4	119.3 ± 46.7	109.8 ± 42.7	0.372
DEMMI	58.2 ± 11	57.3 ± 14	56.7 ± 19	0.942
Haemoglobin (g/dL)	13.1 ± 1.7	10.4 ± 2.8	10.0 ± 1.9	< 0.001
WBC (N/µL)	5438 ± 2151	6596 ± 3135	6440 ± 2615	0.268
Lymphocytes (N/µL)	1267 ± 286	1147 ± 186	934 ± 122	0.038
Creatinine (mg/dL)	0.97 ± 0.36	1.27 ± 0.53	1.17 ± 0.91	0.240
Total Cholesterol (mg/dL)	176.5 ± 52.0	138.9 ± 33.4	126.4 ± 18.3	< 0.001
LDL-Cholesterol (mg/dL)	103.9 ± 47.8	81.3 ± 33.8	92.6 ± 27.1	0.148
HDL-Cholesterol (mg/dL)	56.2 ± 21.6	42.6 ± 25.6	33.0 ± 5.9	0.002
Triglycerides (mg/dL)	120.9 ± 47.5	115.3 ± 54.7	72.6 ± 36.8	0.003
Albumin (g/dL)	3.5 ± 0.6	3.2 ± 0.7	2.5 ± 1.8	< 0.001
C-reactive protein (mg/L)	13.5 ± 14.8	15.3 ± 18.2	21.3 ± 19.8	0.317
Ferritin (ng/mL)	145.1 ± 29.3	139.9 ± 47.5	255.6 ± 77.9	0.250

Statistical differences were assessed by one-way analysis of variance or Pearson's Chi-squared test. ADL, activities of daily living; MMSE, mini-mental state examination; PASE, physical activity scale for the elderly; WBC, white blood cells; LDL, low-density lipoproteins; HDL, high-density lipoproteins.

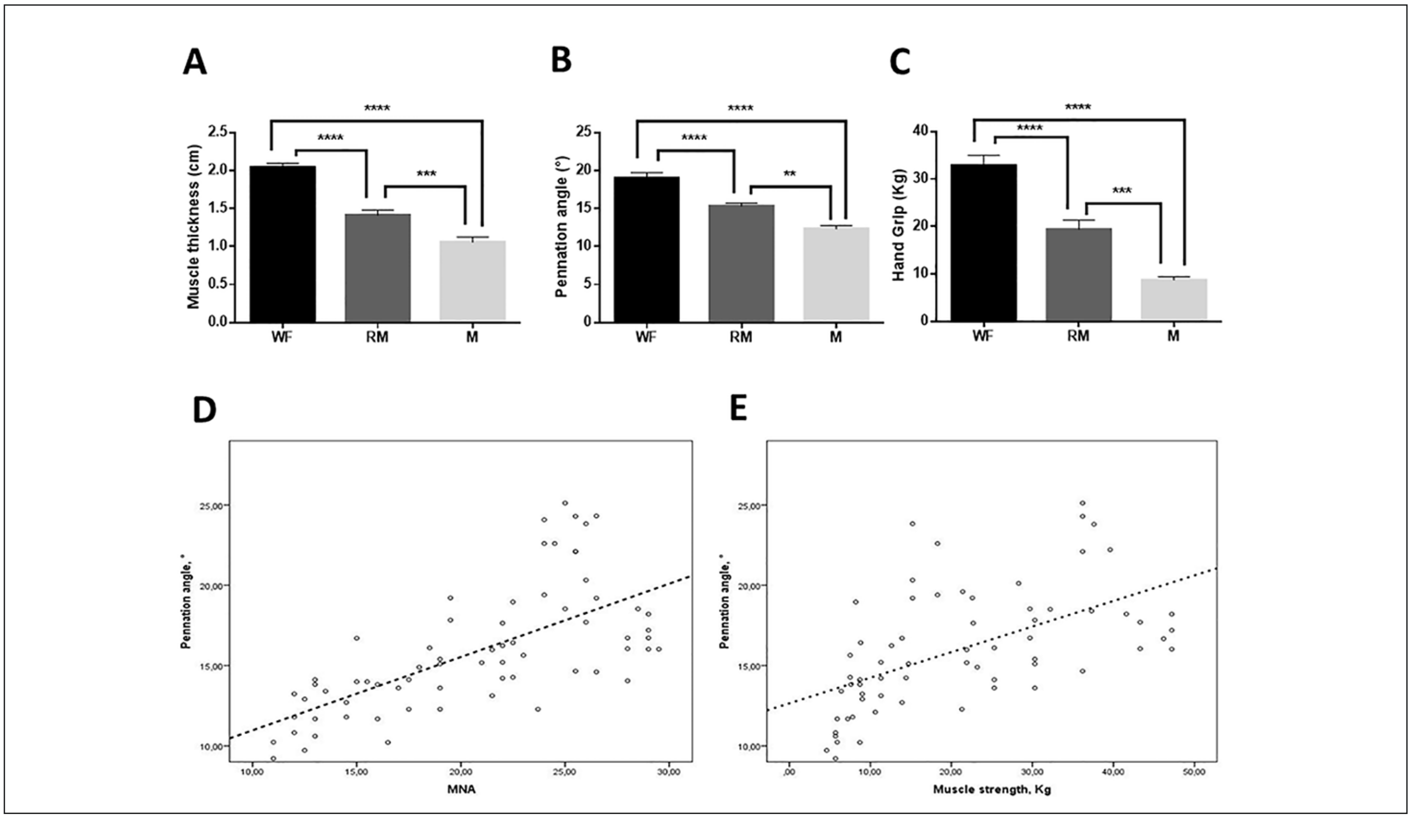
Table 2
Anthropometric measures and bioimpedentiometric parameters in patients at baseline, according to study groups

	Well-fed (WF) N = 25 (36.8%)	Risk of Malnutrition (RM) N = 23 (33.8%)	Malnourished (M) N = 20 (29,4%)	P value
BMI (Kg/m^2)	25.7 ± 2.2	25.5 ± 2.6	22.4 ± 2.8	< 0.001
Arm circumference (cm)	26.1 ± 1.8	27.8 ± 6.3	20.0 ± 3.1	< 0.001
Thigh circumference (cm)	45.2 ± 4.7	40.2 ± 2.2	36.1 ± 4.9	< 0.001
Waist circumference (cm)	96.2 ± 4.5	107.3 ± 10.9	83.0 ± 4.7	< 0.001
Calf circumference (cm)	32.1 ± 2.6	32.4 ± 2.6	24.5 ±2.5	< 0.001
FM (%)	26.6 ± 5.4	37.6 ± 5.8	42.1 ± 3.9	< 0.001
FFM (%)	73.4 ± 5.4	62.4 ± 5.8	57.9 ± 3.9	< 0.001
MM (%)	34.5 ± 3.6	28.0 ± 5.1	25.1 ± 3.2	< 0.001

Statistical differences were assessed by one-way analysis of variance. BMI, body mass index; FM, fat mass; FFM, free-fat mass; MM, muscle mass.

Figure 2

Panels A-C: muscle architecture (thickness – panel A – and pennation angle – panel B) and strength (hand-grip – panel C) in patients at baseline, according to study groups. Statistical differences were assessed by one-way analysis of variance. Panels D-E: correlation between the mini-nutritional analysis (MNA) score and pennation angle (panel D) or muscle strength (panel E) in all the patients considered in this study at baseline



triglycerides and albumin. In particular, post hoc analysis showed that malnourished patients were older than WF and RM, while the ADL score was lower in M with respect to RM and WF, and in RM as compared to WF. Anthropometric and bioimpedentiometric parameters are shown in Table 2 and were all different among the groups studied. Particularly, post hoc analysis showed that M group had significant lower mean values of BMI, arm, thigh, waist and calf circumferences, as well as FFM and MM percentage, compared to RM and WF groups. On the contrary, FM was higher in M subjects rather than RM and WF.

Muscle architecture and strength parameters at admission, stratified according to the nutritional status, are represented in figure 2A-C. Compared to WF patients, muscle thickness and pennation angle were significantly lower in RM and M patients, and further in M rather than RM. A similar trend was observed for muscle strength.

The analysis of the relationship between the nutritional status and muscle architecture/strength parameters revealed a significant positive correlation between the MNA score and pennation angle ($\varrho = 0.716$, $p < 0.001$; Figure 2D) and hand-grip strength ($\varrho = 0.769$, $p < 0.001$; Figure 2E).

A multivariate analysis was performed to verify the most important factors associated with pennation angle and showed that the presence of malnutrition was the only independent predictor (OR: 1.42, $p < 0.001$).

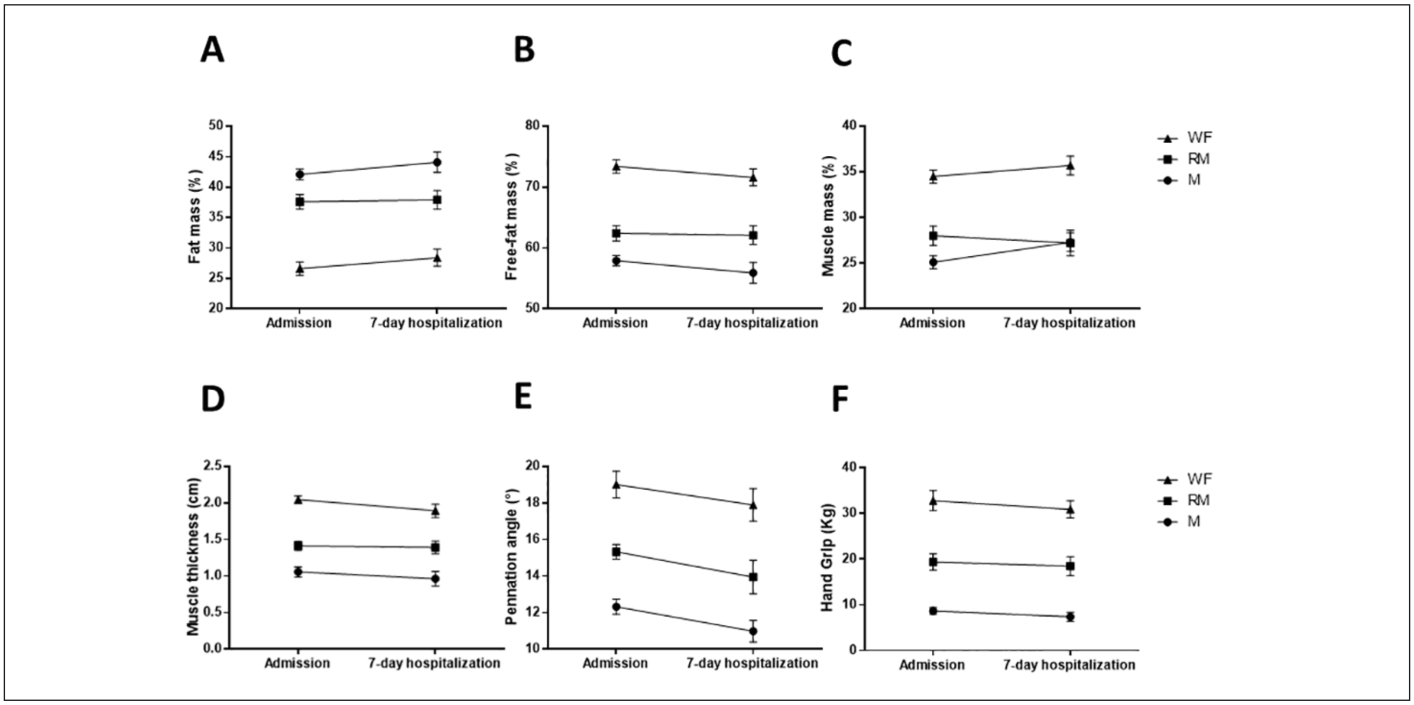
Figure 3 represents the changes of body composition (fat mass, free-fat mass, muscle mass), muscle architecture (muscle thickness and pennation angle), and muscle strength (hand-grip) parameters during the first 7 days of hospitalization, stratified by the nutritional status. Of note, a significant impact of early hospitalization was observed for the pennation angle ($F(1, 130) = 4.693$, $p = 0.0321$), irrespective of the nutritional status. No other changes dependent on the hospitalization, the nutritional status, or the interaction of these factors were observed for the remaining parameters.

Discussion

The present study demonstrates that elderly patients who present with malnutrition at admission in internal medicine wards are characterized by compromised muscle architecture. Furthermore, nutritional status is the main determinant of muscle architecture at hospital admission. However, the impairment in muscle architecture observed during the first 7 days of hospitalization was not dependent on nutritional status.

Figure 3

Variations of bioimpedentiometry (panels A-C), muscle architecture (muscle thickness – panel D – and pennation angle – panel E), and muscle strength (hand-grip, panel F) in patients stratified according to the nutritional status, between in-hospital admission and 7-day hospitalization. Statistical differences were assessed by two-way ANOVA



Skeletal muscle undergoes several changes during aging, such as a loss of muscle mass and a reduction in performance. Several studies described the association of a high risk of malnutrition and lower muscle mass at admission (13, 28).

To the best of our knowledge, this is the first study to investigate the impact of nutritional status on muscle architecture in elderly patients hospitalized in internal medicine wards.

Muscle architecture is an important parameter affecting the muscle function. In fact, previous studies demonstrated a lower PA in elderly subjects as compared to younger individual, which was associated with reduced hand-grip strength (17, 29). In our study, malnourished patients showed lower muscle mass, architecture and strength with respect to well-fed ones.

In line with a previous study, we did not find a decrease of muscle mass during hospitalization due to the high prevalence of inactivity and malnutrition in older patients (13). Interestingly, our data evidenced that early hospitalization is associated with a drop in pennation angle, the most important parameter of muscle architecture. However, this reduction was not related to nutritional status. Indeed, we could not find any changes in muscle mass, thickness and strength in the well-fed, risk of malnutrition or malnutrition group.

Physical activity and nutrition are the main anabolic stimuli for muscle protein synthesis (Koopman and van Loon 2009). A previous study described a significant decrease of lean body mass after seven days of hospitalization in aged patients undergoing colorectal surgery (30). However, this may be dependent on causes related to abdominal surgery, such as reduced appetite, vomiting and impaired gastrointestinal function. A randomized-controlled study in elderly patients admitted in acute medicine wards could not demonstrate the efficacy of feeding support on mid-arm circumference, triceps skinfold thickness and hand grip strength (31). A dietary supplementation in hospitalized elderly patients with malnutrition demonstrated a positive impact on free-fat mass, but not on hand-grip strength (32). Taking into account data from previous studies and ours, even though malnutrition can lead to a negative skeletal muscle protein balance, followed by muscle loss, it is conceivable that physical inactivity would be the most influent factor on muscle homeostasis (33).

We are aware of the limitations of our study. First, the fact that this study was performed on a small sample and in a single centre may have presented some bias and could not draw solid conclusion. Second, muscle architecture and strength were not measured simultaneously in the same anatomical site, since pennation angle is assessed on the vastus lateralis muscle, while muscle strength is evaluated by hand-grip dynamometer. Furthermore, the observational design did not allow us to suggest suitable interventions. Finally, this study presents limited generalizability because of a selected initially hospitalized population.

Conclusion

In elderly patients hospitalized in internal medicine wards, a compromised nutritional status at admission was significantly associated with an impairment of muscle architecture. However, the nutritional status did not impact changes of these parameters during early hospitalization.

Conflict of interest: The Authors declare that they have no conflict of interest.

Ethicals Standards: The study complies with the current Italian laws, it was approved by our Institutional Review Board and performed according to the declaration of Helsinki.

References

1. US Centers for Disease Control and Prevention. Number, percent distribution, rate, days of care with average length of stay, and standard error of discharges from short-stay hospitals, by sex and age. 2010
2. Brown CJ, Friedkin RJ, Inouye SK. Prevalence and outcomes of low mobility in hospitalized older patients. J Am Geriatr Soc 2004;52:1263-1270
3. Harris D, Haboubi N. Malnutrition screening in the elderly population. J R Soc Med 2005;98:411-414
4. Dorner TE, Luger E, Tschinderle J, Stein KV, Haider S, Kapan A, Lackinger C, Schindler KE. Association between nutritional status (MNA(R)-SF) and frailty (SHARE-FI) in acute hospitalised elderly patients. J Nutr Health Aging 2014;18:264-269
5. Artaza-Artabe I, Saez-Lopez P, Sanchez-Hernandez N, Fernandez-Gutierrez N, Malafarina V. The relationship between nutrition and frailty: Effects of protein intake, nutritional supplementation, vitamin D and exercise on muscle metabolism in the elderly. A systematic review. Maturitas 2016;93:89-99
6. Rasmussen HH, Holst M, Kondrup J. Measuring nutritional risk in hospitals. Clin Epidemiol 2010;2:209-216
7. Laur CV, McNicholl T, Valaitis R, Keller HH. Malnutrition or frailty? Overlap and evidence gaps in the diagnosis and treatment of frailty and malnutrition. Appl Physiol Nutr Metab 2017;42:449-458
8. Vestbo J, Prescott E, Almdal T, Dahl M, Nordestgaard BG, Andersen T, Sorensen TI, Lange P. Body mass, fat-free body mass, and prognosis in patients with chronic obstructive pulmonary disease from a random population sample: findings from the Copenhagen City Heart Study. Am J Respir Crit Care Med 2006;173:79-83
9. Vanderwee K, Clays E, Bocquaert I, Gobert M, Folens B, Defloor T. Malnutrition and associated factors in elderly hospital patients: a Belgian cross-sectional, multi-centre study. Clin Nutr 2010;29:469-476
10. Heli V, Ihab H, Kun H, Brad M, Jessica W, Vera N. Effects of exercise program on physiological functions in postmenopausal women with metabolic syndrome. Int J Gerontol 2013;7:231-235
11. Malara A, Sgro G, Caruso C, Ceravolo F, Curinga G, Renda GF, Spadea F, Garo M, Rispoli V. Relationship between cognitive impairment and nutritional assessment on functional status in Calabrian long-term-care. Clin Interv Aging 2014;9:105-110
12. Vellas B, Guigoz Y, Garry PJ, Nourhashemi F, Bennahum D, Lauque S, Albarede JL. The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. Nutrition 1999;15:116-122
13. Pierik VD, Meskers CGM, Van Ancum JM, Numans ST, Verlaan S, Scheerman K, Kruizinga RC, Maier AB. High risk of malnutrition is associated with low muscle mass in older hospitalized patients - a prospective cohort study. BMC Geriatr 2017;17:118-
14. McLeod M, Breen L, Hamilton DL, Philp A. Live strong and prosper: the importance of skeletal muscle strength for healthy ageing. Biogerontology 2016;17:497-510
15. Leong DP, Teo KK, Rangarajan S, Lopez-Jaramillo P, Avezum A, Jr., Orlandini A, Seron P, Ahmed SH, Rosengren A, Kelishadi R, Rahman O, Swaminathan S, Iqbal R, Gupta R, Lear SA, Oguz A, Yusoff K, Zatonska K, Chifamba J, Igumbor E, Mohan V, Anjana RM, Gu H, Li W, Yusuf S. Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. Lancet 2015;386:266-273
16. Bohannon RW. Muscle strength: clinical and prognostic value of hand-grip dynamometry. Curr Opin Clin Nutr Metab Care 2015;18:465-470
17. Narici MV, Maganaris CN, Reeves ND, Capodaglio P. Effect of aging on human muscle architecture. J Appl Physiol (1985) 2003;95:2229-2234
18. Kawakami Y, Abe T, Kanehisa H, Fukunaga T. Human skeletal muscle size and architecture: variability and interdependence. Am J Hum Biol 2006;18:845-848
19. Vandewoude MF, Alish CJ, Sauer AC, Hegazi RA. Malnutrition-sarcopenia syndrome: is this the future of nutrition screening and assessment for older adults? J Aging Res 2012;2012:651570-
20. Guigoz Y, Vellas B. The Mini Nutritional Assessment (MNA) for grading the nutritional state of elderly patients: presentation of the MNA, history and validation. Nestle Nutr Workshop Ser Clin Perform Programme 1999;1:3-11
21. Washburn RA, Ficker JL. Physical Activity Scale for the Elderly (PASE): the relationship with activity measured by a portable accelerometer. J Sports Med Phys Fitness 1999;39:336-340
22. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-198
23. Katz S, Akpom CA. A measure of primary sociobiological functions. Int J Health Serv 1976;6:493-508
24. de Morton NA, Davidson M, Keating JL. The de Morton Mobility Index (DEMMI): an essential health index for an ageing world. Health Qual Life Outcomes 2008;6:63-
25. Heitmann BL. Prediction of body water and fat in adult Danes from measurement of electrical impedance. A validation study. Int J Obes 1990;14:789-802
26. Martone AM, Marzetti E, Calvani R, Picca A, Tosato M, Santoro L, Di GA, Nesci A, Sisto A, Santoliquido A, Landi F. Exercise and Protein Intake: A Synergistic Approach against Sarcopenia. Biomed Res Int 2017;2017:2672435-
27. Ticinesi A, Narici MV, Lauretani F, Nouvenne A, Colizzi E, Mantovani M, Corsonello A, Landi F, Meschi T, Maggio M. Assessing sarcopenia with vastus lateralis muscle ultrasound: an operative protocol. Aging Clin Exp Res 2018;30:1437-1443
28. Sousa AS, Guerra RS, Fonseca I, Pichel F, Amaral TF. Sarcopenia among hospitalized patients - A cross-sectional study. Clin Nutr 2015;34:1239-1244
29. Thom JM, Morse CI, Birch KM, Narici MV. Influence of muscle architecture on the torque and power-velocity characteristics of young and elderly men. Eur J Appl Physiol 2007;100:613-619
30. Henriksen MG, Hansen HV, Hessov I. Early oral nutrition after elective colorectal surgery: influence of balanced analgesia and enforced mobilization. Nutrition 2002;18:263-267
31. Hickson M, Bulpitt C, Nunes M, Peters R, Cooke J, Nicholl C, Frost G. Does additional feeding support provided by health care assistants improve nutritional status and outcome in acutely ill older in-patients?--a randomised control trial. Clin Nutr 2004;23:69-77
32. Bos C, Benamouzig R, Bruhat A, Roux C, Valensi P, Ferriere F, Tome D. Nutritional status after short-term dietary supplementation in hospitalized malnourished geriatric patients. Clin Nutr 2001;20:225-233
33. Wall BT, Dirks ML, van Loon LJ. Skeletal muscle atrophy during short-term disuse: implications for age-related sarcopenia. Ageing Res Rev 2013;12:898-906