Functional Capacity and Nutritional Status in Individuals with Multiple Myeloma Eligible for Hematopoietic Stem Cell Transplantation: Observational Study

https://doi.org/10.32635/2176-9745.RBC.2025v71n4.5242EN

Capacidade Funcional e Estado Nutricional em Indivíduos com Mieloma Múltiplo Elegíveis ao Transplante de Células-Tronco Hematopoiéticas: Estudo Observacional

Capacidad Funcional y Estado Nutricional en Individuos con Mieloma Múltiple Elegibles para Trasplante de Células Madre Hematopoyéticas: Estudio Observacional

André Franco Ludwig[1]; Juliana Rauta Drum[2]; Tessa Gomes Guimarães[3]; Katiane Tremarin Morsch[4]

ABSTRACT

Introduction: Hematopoietic stem cell transplantation (HSCT) is a treatment modality for multiple myeloma (MM). This procedure requires a period of protective isolation and causes numerous adverse effects, affecting nutritional status and functional capacity. This combination tends to worsen the patient's prognosis. **Objective:** To analyze and correlate functional capacity, nutritional status and risk of falls in patients with multiple myeloma undergoing autologous HSCT. **Method:** Analytical observational study with patients of both sexes diagnosed with MM. Functional capacity was assessed by the 6-minute walk test (6MWT) and handgrip strength, nutritional status was verified by body mass index and arm circumference, and the risk of falls was assessed by the Timed Up and Go (TUG) test. Data were expressed as mean, standard deviation and confidence interval, and Pearson's coefficient was utilized to measure correlations. **Results:** The sample consisted of 54 patients, 44.4% had some degree of obesity, 85.1% did not reach the predicted distance in the 6MWT and no risk of falling was identified. Right handgrip strength showed a moderate and positive correlation with the distance covered in the 6MWT |0.49| (p=0.0001), but did not correlate with arm circumference. The TUG and the 6MWT showed a negative and moderate correlation |-0.51| (p=0.0001). **Conclusion:** The sample presented low functional capacity. Handgrip strength correlated with the 6MWT, but not with the brachial circumference, while the TUG also correlated with the 6MWT.

Key words: Multiple Myeloma; Bone Marrow Transplantation; Walk Test; Nutritional Status.

RESUMO

Introdução: O transplante de células-tronco hematopoiéticas (TCTH) é uma modalidade de tratamento para mieloma múltiplo (MM). Esse procedimento exige período de isolamento protetor e causa inúmeros efeitos adversos, afetando o estado nutricional e a capacidade funcional, essa associação tende a piorar o prognóstico do paciente. **Objetivo**: Analisar e correlacionar a capacidade funcional, o estado nutricional e o risco de queda em pacientes com mieloma múltiplo submetidos ao TCTH autólogo. **Método**: Estudo observacional analítico composto por pacientes de ambos os sexos com diagnóstico de MM. A capacidade funcional foi avaliada pelo teste de caminhada de 6 minutos (TC6) e pela força de preensão manual, o estado nutricional foi verificado pelo índice de massa corporal e pela circunferência braquial, já o risco de quedas foi avaliado pelo teste *Timed Up and Go* (TUG). Dados foram expressos pela média, desvio-padrão e intervalo de confiança, as correlações foram feitas pelo coeficiente de Pearson. **Resultados**: A amostra foi composta por 54 pacientes, 44,4% tinham algum grau de obesidade, 85,1% não alcançaram a distância predita no TC6, e não foi identificado risco de queda. A força de preensão manual direita apresentou correlação moderada e positiva com a distância percorrida no TC6 |0,49| (p=0,0001), mas não se correlacionou com a circunferência braquial. O TUG e o TC6 apresentaram correlação negativa e moderada |-0,51| (p=0,0001). **Conclusão**: A amostra apresentou baixa capacidade funcional. A força de preensão manual se correlacionou com o TC6, porém, não com a circunferência braquial, já o TUG também apresentou correlação com o TC6.

Palavras-chave: Mieloma Múltiplo; Transplante de Medula Óssea; Teste de Caminhada; Estado Nutricional.

RESUMEN

Introducción: El trasplante de células madre hematopoyéticas (TCMH) es una modalidad de tratamiento para el mieloma múltiple (MM). Este procedimiento requiere un período de aislamiento preventivo y causa numerosos efectos adversos, que afectan el estado nutricional y la capacidad funcional. Esta combinación tiende a empeorar el pronóstico del paciente. **Objetivo:** Analizar y correlacionar la capacidad funcional, el estado nutricional y el riesgo de caídas en pacientes con mieloma múltiple sometidos a TCMH autólogo. **Método:** Estudio observacional analítico compuesto por pacientes de ambos sexos con diagnóstico de MM. La capacidad funcional se evaluó mediante la prueba de caminata de seis minutos (6MWT) y la fuerza de prensión manual, el estado nutricional se verificó mediante el índice de masa corporal y la circunferencia del brazo, y el riesgo de caídas se evaluó mediante la prueba cronometrada de levantarse y caminar (TUG). Los datos se expresaron mediante media, desviación estándar e intervalo de confianza, las correlaciones se realizaron mediante el coeficiente de Pearson. **Resultados:** La muestra estuvo compuesta por 54 pacientes, el 44,4% presentó algún grado de obesidad, el 85,1% no alcanzó la distancia prevista en la prueba 6MWT y no se identificó riesgo de caída. La fuerza de agarre de la mano derecha mostró una correlación moderada y positiva con la distancia recorrida en la prueba 6MWT |0,49| (p=0,0001), pero no se correlacionó con la circunferencia braquial. El TUG y el 6MWT mostraron una correlación negativa y moderada |-0,51| (p=0,0001). **Conclusión:** La muestra mostró baja capacidad funcional. La fuerza de agarre manual se correlacionó con la prueba 6MWT, pero no con la circunferencia braquial, mientras que el TUG también se correlacionó con la prueba 6MWT.

Palabras clave: Mieloma Múltiple; Trasplante de Médula Ósea; Prueba de Paso; Estado Nutricional.

[1,4]Grupo Hospitalar Conceição (GHC), Centro de Oncologia e Hematologia, Serviço de Reabilitação. Porto Alegre (RS), Brasil. E-mails: andrefludwig@gmail.com; ktremarin@gmail.com. Orcid iD: https://orcid.org/0000-0002-8075-4034; Orcid iD: https://orcid.org/0000-0003-1336-1430

[2,3]GHC, Centro de Oncologia e Hematologia, Serviço de Nutrição. Porto Alegre (RS), Brasil. E-mails: julianardrum@gmail.com; tessagguimaraes@gmail.com. Orcid iD: https://orcid.org/0009-0000-8496-7793; Orcid iD: https://orcid.org/0000-0001-6834-3366

Corresponding author: André Franco Ludwig. Rua Sapê, 308, Bloco/Apto. 3/203 – Cristo Redentor. Porto Alegre (RS), Brasil. CEP 91350-050. E-mail: andrefludwig@gmail.com

INTRODUCTION

Hematopoietic stem-cells transplantation (HSCT), also called bone marrow transplantation is a treatment for onco-hematologic diseases involving the administration of healthy hematopoietic stem-cells (HSCs) in patients with dysfunctional or diseased bone marrow[1-4]. This therapeutic modality is able to cure or prolong considerably the survival of patients refractory to other treatments[5-7].

The autologous method of HSCT consists in the collection of HSCs of the receptor, followed by the infusion of cells in himself, the receptor is his own donor. This modality has low risk of occurrence of the graft-versus-host-disease (GVHD) but is not utilized for every onco-hematologic disease, only in limited cases as multiple myeloma, one of the most robust indications[8-10].

Multiple myeloma is a cancer of plasma cells that builds up in the bone marrow mainly affecting men aged 65-72 years in average[8,11,12]. The main cause of morbidity of multiple myeloma is the infiltration of the monoclonal M protein in bone tissue, leading to osteolytic lesions and pathological fractures[12-14]. The lesions affect the mobility, functionality, gait and self-care, directly impacting the quality of life of these patients[14-16].

The treatment consists in high-dose chemotherapy and autologous HSCT. These factors in addition to the protective isolation, required for the transplantation, cause innumerous adverse effects[11,15,17,18]. Pre-transplantation physiotherapy, whether focused to resistance and aerobic exercise has shown to be effective in reducing the intensity of these effects[19-24].

Given that the scientific literature demonstrates the importance of physiotherapy and the nutritional status pre-HSCT for clinical outcomes during treatment of multiple myeloma, it emerges the necessity of checking possible correlations among these measures. Understanding these associations can steer nutritional therapy and physiotherapeutic follow-up aiming the accuracy and effectiveness of the management of adverse effects that the therapeutic modalities cause during hospitalization.

The objective of the present study is to analyze the functional capacity, nutritional status and risk of falls in patients diagnosed with multiple myeloma referred for autologous transplantation of HSCs and find the correlation among these variables.

METHOD

Observational, analytical study developed at the oncology and hematology center of "*Grupo Hospitalar Conceição (GHC)*" of Porto Alegre, Rio Grande do Sul (RS). Data from charts of patients evaluated between 2021 and 2024 diagnosed with multiple myeloma and referred for autologous HSCT have been collected.

Expert investigators evaluated the patients within hospital environment pre-HSCT prior to admission. For functional capacity, handgrip strength (HGS) and 6-minute walk-test (6MWT) were collected; for risk of falls, the Timed Up and Go (TUG) test and for nutritional status, the right brachial circumference (RBC) and Body Mass Index (BMI).

Inclusion criteria were: individuals of both sexes, older than 18 years of age (adult and older adults) diagnosed with multiple myeloma, autologous HSCT performed between 2021 and 2024 at GHC, and evaluated by physiotherapy and nutrition services.

Exclusion criteria were incomplete charts, comorbidities that impeded nutritional or physiotherapeutic evaluation, relapse or disease progression, which impaired the transplantation and/or rejection of HSCT post-evaluation.

An evaluation form was created to collect anthropometric data and functional tests, the following information were added: age, sex, height, weight, BMI, brachial circumference and comorbidities. Later, functional variables were included (Table 1).

RBC was verified through perimetry of the right arm at the middle point between the acromion and the olecranon. To measure this point, the individual flexes the arm at 90º degrees and after marking, perimetry is calculated with the arm extended and the hand palm turned to the thigh. RBC allows to classify the grade of depletion of the muscular and adipose reserve, being mild (23.5 to 25.9 cm), moderate (22 to 23.4 cm) and severe (< 22 cm)[25].

HGS was calculated by the mean of three measures at each upper limb by hydraulic dynamometer (Jamar®) and the patient seated with legs, hips and elbows at 90º degrees. The cutoff to verify the reduction of HGS was based on sex, laterality and age-range, being 61.18KF for men and 25.28KF for women, both with mean age of 59 years[26].

BMI was calculated by the division of the body weight (kg) by the height squared: weight/(height *x* height). Adults were classified according to criteria of the World Health Organization (WHO) and older adults, according to Pan American Health Organization (PAHO)[27].

6MWT was calculated on a flat 30-meter corridor marked by cones in both ends, the patient rested for 10-15 minutes before the test. At rest, blood pressure (BP), oxygen peripheral saturation (SpO2), BORG dyspnea scale (0 – 10), and heart rate (HR) were measured.

The patient was instructed to walk as fast as possible along the 30-meter distance for six minutes with the

digital oximeter attached to a hand finger. A health professional followed up the test, collecting SpO2, HR and dyspnea intensity at every minute. The extension of each lap around the cone at the end is 30 meters, the number of laps is added, multiplied by 30 meters and added to the remaining meters walked to obtain the value of the distance walked[28]:

Walked = *Number of laps x* 30 + *remaining meters*

Sex, age, height and value of delta of HR were considered for the calculation of the distance predicted[28]:

Predicted = 356,658 - (2.303 *x age*) + (36.648 *x sex*) + (1.704 *x height*) + (1.365 *x ΔHR)*

Zero (0) stands for females and one (1), males. ΔHR is obtained by HR collected at the 6th minute, subtracted by HR collected at the 1st minute of the test[28].

TUG test was analyzed by time in seconds of walking along a flat 3-meter distance. At first, the patient was seated at a chair with back and was instructed to "go" when stopwatch was initiated. Walked for three meters, rotated 180 degrees and returned to the chair, stopwatch was stopped when the patient sat and the mean time of two timed trials was recorded, the cutoff to indicate risk of fall was ≥ 12.47 seconds[29].

The Ethics Committee of GHC approved the study, report number 7,008,779 (CAAE (submission for ethical review): 81444324.9.0000.5530) in compliance with Directives 466/2012[30] and 510/2016[31] of the National Health Council (CNS). Information were obtained for scientific purposes only and use and confidentiality of the data statements were submitted to the Ethics Committee. Data extracted from charts were encrypted in zip file, password protected and monitored with history of access. Only assigned investigators were granted access to the data and signed the Data Usage Commitment Agreement.

Software Ene version 3.0[32] was utilized to estimate the sample size based on the study of Penna et al.[33]. An error α of 5% (0.05) and an error β of 20% were determined assuming an expected R of 0.40, being necessary a minimum N of 44 individuals.

The data were represented by descriptive statistics and Pearson's coefficient[34] was adopted for correlations among functional and nutritional variables. The Shapiro-Wilk was applied for normality, discrepant values were identified and removed utilizing the method Rout (Q defined in 1%), and level of significance of $p<0.05$. The software GraphPad Prism[35] 8.4.2 was utilized for statistical analyzes.

RESULTS

The sample consisted of 54 patients, 44.5% women (n=24) and 55.5% men (n=30), descriptive statistics is presented in Table 1. The main comorbidities associated were systemic arterial hypertension, diabetes *mellitus*, depression, pathological fracture of spine or limbs, asthma, chronic pulmonary obstructive disease, other cardiopathies and obesity.

Adults presented mean BMI of 30.53 ± 5.67kg/cm², older adults, mean of 29.30 ± 4.16kg/cm². Mean RBC was 30.47 cm, and 24.07% of the patients presented mild depletion (n=13), 9.25%, moderate depletion (n=5) and 66.66% presented satisfactory results (n=36).

Table 1 also presents the values of functional variables and absolute and relative frequencies of the patients estimated below cutoff. The mean right HGS for men was 51.48 |43.77 – 59.18| KF and left, 50.39 |41.72 – 59.05| KF. For women, the mean right HGS was 28.90 |24.25 – 33.54| KF and left, 28.26 |24.03 – 32.49| KF. A significant percent of the sample presented values of HGS below the cutoff according to sex.

The 6MWT distances walked and predicted were analyzed. Little more than 100 meters separate the means of these distances, since 85.1% of the patients walked less than predicted and 14.82%, equal or greater than predicted. The TUG results showed low risk of falls for the majority of the participants and only 18.5% were above the cutoff, revealing risk of fall.

Figure 1 (A and B) portrays moderate and positive correlation between HGS (right/left) and 6MWT. A statistically significant difference was observed for the correlation between right HGS and 6MWT (p=0.0001), Pearson's R of |0.49| CI 0.26 – 0.67. Pearson's R for left HGS and 6MWT was |0.44| CI 0.20 – 0.63 with statistically significant difference (p=0.0007). Therefore, the participants with high scores of HGS walked more than six meters (high functional capacity).

The correlation between risk of fall (TUG) and 6MWT and between RBC and right HGS can be observed in Figure 2 (A and B). There was moderate and negative correlation between TUG and 6MWT with statistically significant difference (p=0.0001) and Pearson's R |-0.51| CI -0.68 – -0.28. Patients walking greater distances in 6MWT (better functional capacity) performed TUG in less time (lower risk of fall).

There was no correlation between right HGS and RBC (Pearson's R |0.23| CI -0.03 – 0.47), indicating that patients with similar brachial circumferences present different scores of HGS (p=0.08).

Table 1. Characterization of the sample and quantitative variables

Variable	N	Mean	Standard deviation	CI 95%	N (%)
Age (years)	54	59.0	9.31	56.46 – 61.54	-
Height (m)	54	163.1	11.25	160.0 – 166.1	-
Body weight (kg)	54	78.86	20.61	73.24 – 84.49	-
RBC (cm)	54	30.47	4.22	29.32 – 31.62	-
BMI (kg/m²)	54	29.23	5.20	27.81 – 30.65	
- Adults	29	30.53	5.67	28.61 – 32.45	-
- Older adults	25	29.30	4.16	27.72 – 30.89	-
HGS (KF)					
- Men - **R**	30	51.48	20.63	43.77 – 59.18	24 (80)
- Men - **L**	30	50.39	23.21	41.72 – 59.05	24 (80)
- Women - **R**	24	28.90	11.00	24.25 – 33.54	13 (54.1)
- Women - **L**	24	28.26	10.02	24.03 – 32.49	14 (58.3)
6MWT walked (m)	54	421.4	101.9	393.6 – 449.2	46 (85.1)
6MWT predicted (m)	54	513.4	63.92	495.9 – 530.8	-
TUG (s)	54	11.41	6.36	9.671 – 13.15	10 (18.5)

Captions: BMI: body mass index; RBC: right brachial circumference; CI: confidence interval; HGS: handgrip strength; R: right; L: left; CI: confidence interval; KF: kilogram force; S: seconds; 6MWT: 6-minute walk test; N (%): absolute and relative frequencies of patients below the estimated cutoff; TUG: Timed Up and Go.

DISCUSSION

In all, 54 patients in autologous hematopoietic stem-cells (HSC) pre-transplantation period diagnosed with multiple myeloma were investigated. The mean age of the sample was 59.0 ± 9.31 years, relatively high, however, when compared to the global mean age of diagnosis of multiple myeloma (65 to 72 years), it was low.

The functional capacity was evaluated by 6MWT and HGS. It is expected that individuals with multiple myeloma had functional capacity below the predicted values[14-16]. The mean distance walked by the individuals of the sample was 421.4 ± 101.9 meters, similar to the study of Shah et al.[36]. The evaluation of the functional compromise pre and after HSCT in patients with multiple myeloma showed that the mean distance walked in the 6MWT pre-transplantation was 452 ± 185 meters.

These data reinforce that, even before the transplantation, these patients had their functionality

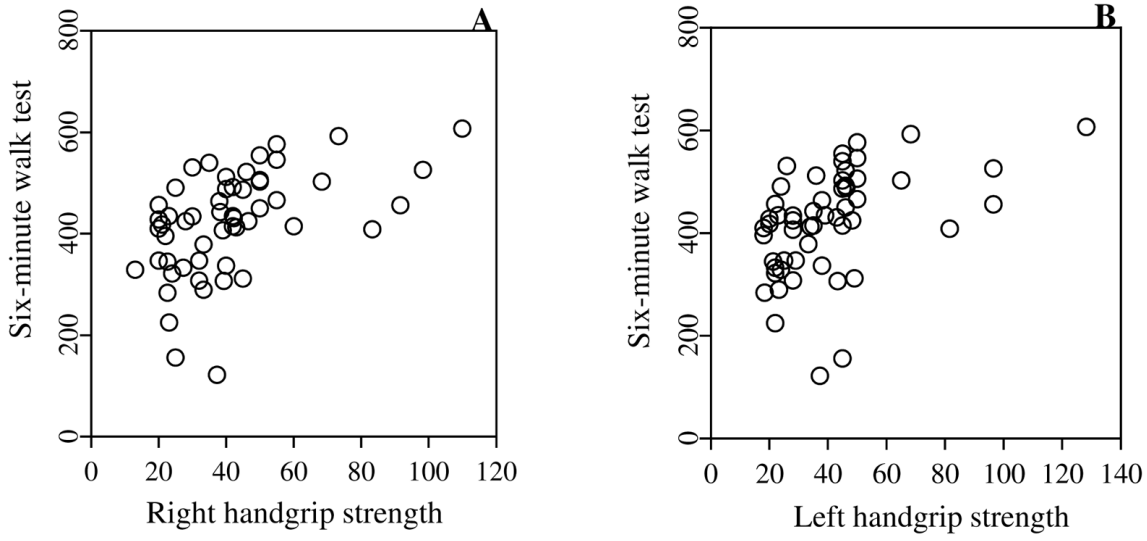

Figure 1. A: Pearson's correlation coefficient between right HGS and 6MWT. Pearson's *R* of |0.49|, showing moderate and positive correlation with statistically significant difference (p=0.0001). B: Pearson's coefficient correlation between left HGS and 6MWT. Pearson's *R* of |0.44| showing positive and moderate correlation with statistically significant difference (p=0.0007)

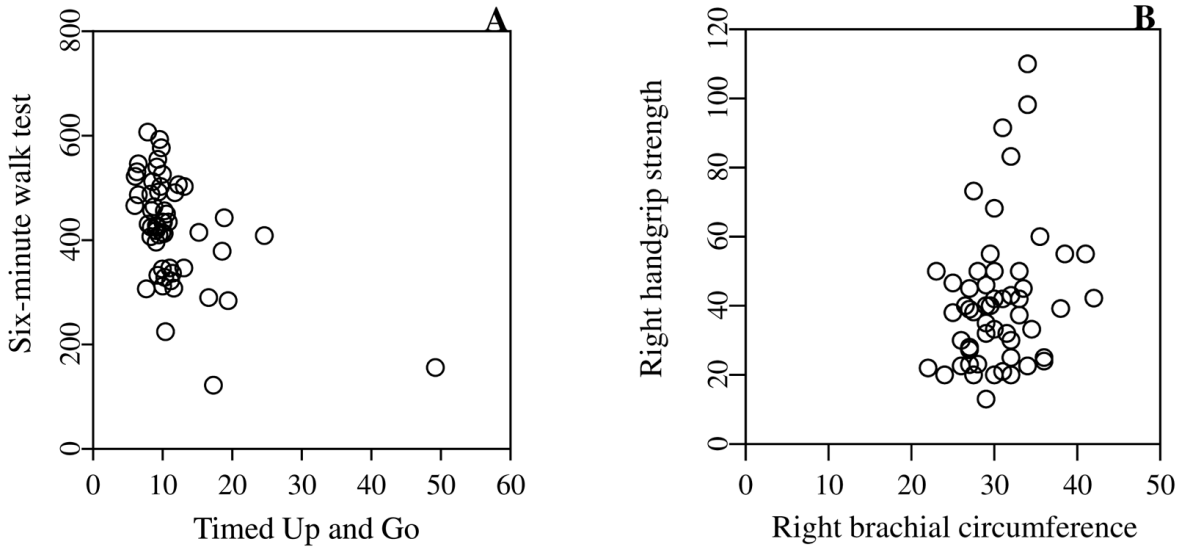

Figure 2. A: Pearson's coefficient correlation between TUG and 6MWT. Pearson's *R* of |-0.51| demonstrating negative and moderate correlation with statistically significant difference (p=0.0001). B: Pearson's coefficient correlation between right HGS and RBC. Pearson's *R* of |0.23| demonstrating inexistence of correlation and without statistically significant difference (p=0.08)

already compromised because of the disease and the treatment, suggesting that early interventions with rehabilitation can be necessary to mitigate the effects of declined functional capacity and improve the prognosis.

The mean right and left HGS for men was 51.48 ± 20.63 KF and 50.39 ± 23.21 KF, respectively. Larsen et al.[26] analyzed the functional capacity of recently diagnosed patients with multiple myeloma in age ranges from 35 to 90 years old and found that the mean HGS for 59-years old men was 61.18 ± 39.35 KF.

80% of the study sample presented values below the cutoff, suggesting a significant reduction of the muscular strength. HGS is recognized as a prognostic marker in many clinical conditions and its compromise prior to HSCT can lead to high risk of complications and worse functional recovery. These findings show the importance of resistance muscle strength training for this population.

In women, the mean right HGS was 28.90 ± 11.00 KF and 28.26 ± 10.02 KF for the left, a slight difference compared to the findings of Larsen et al.[26] (25.28 ± 7.33 KF); however, multiple myeloma affects men more than women[11-13], and HGS reference normal values for women diagnosed with multiple myeloma need further studies and analyzes.

Usually, TUG is applied to evaluate the risk of falls in older adults, a variable included in the study due to the mean age of diagnosis of multiple myeloma (65-72 years globally)[11-13], a neoplasm which develops in advanced aged individuals. However, two factors found in the results need to be addressed: first, the mean age of the sample was 59.0 ± 9.31 years and second, no risk of falls was found in the sample, since the mean TUG was 11.41 ± 6.36 seconds and the cutoff was based on the study of Alexandre et al.[29] with a cutoff for the Brazilian population above 12.47 seconds.

Wildes et al.[37] evaluated the risk of falls in two groups of patients with multiple myeloma, eligible and non-eligible for HSCT. The eligible presented a mean age of 69.6 ± 3.8 years and mean TUG of 11.9 ± 3.4 seconds, both below the values of the non-eligible (74.0 ± 6.0 years and 15.8 ± 6.1 seconds, respectively). The authors concluded that age (younger patients) influences the performance of TUG and both interfere in the eligibility to transplantation. However, the mean age of the study sample can explain the low risk of falls.

The BMI (29.23 ± 5.20 kg/m²) was elevated when compared to the randomized clinical trial of Larsen et al.[38] (25.6 ± 4.6 kg/m²) in patients with multiple myeloma. In counterpart, a prospective study found a mean BMI of 30.1 ± 5.2 kg/m² in patients with the same pathology, indicating literature variability[39]. These differences can be attributed to factors as demographic profile, age-range, nutritional status prior to diagnosis, socioeconomic characteristics of the populations studied and presence of comorbidities.

The elevated BMI reveals an additional challenge during follow-up of the patient with multiple myeloma, especially within the context of the transplantation, such as metabolic and inflammatory complications in obese or overweight individuals[40], potentially leading to worst functional outcome, therefore, nutritional evaluation before and during HSCT is paramount.

BMI not always reflects the nutritional status since it is a population-based tool targeted to measure health risks in epidemiologic studies or screening, but not utilized as an individual health measure[40].

More than half of the patients investigated herein was classified as overweight or obese according to BMI. Obesity is associated with worst prognosis of the patient with cancer, but it is indispensable to investigate sarcopenic obesity characterized by the reduction of muscle mass and elevated BMI. Sarcopenic obesity is associated with increased chemotherapy toxicity, physical worsening during treatment and mortality[41].

Viana et al.[42] evaluated patients pre-HSCT: 51.4% of the sample was diagnosed with multiple myeloma, 55.6% of these patients were overweight according to BMI, but 48.6% of those classified as well-nourished according to the patient-generated subjective global assessment (PG-SGA) presented sarcopenia. This finding shows the limitation of BMI as unique parameter for evaluation and nutritional diagnosis.

If only BMI is considered, sarcopenic obesity can go unnoticed. In this sense, it is essential to use complementary instruments as PG-SGA, exams of body composition and functional measures for effective and accurate approach of the nutritional status.

There was no correlation between right HGS and RBC, suggesting that patients with similar brachial circumferences presented distinct grades of HGS. RBC is the perimeter occupied by the bones, muscles and adipose tissue of the arm, therefore, patients with large RBC do not necessarily present good scores of HGS, especially those with elevated BMI associated, indicating that the preponderant factor for high RBC can be the amount of adipose and not muscular tissue.

Magnetic resonance imaging and computed tomography are the gold standard for better definition of muscle mass. However, these are costly, barely portable tools requiring skilled professionals to manage the equipment, in addition to poorly defined cutoff values for low muscle mass[43]. RBC alone to evaluate the nutritional status and functional condition of the patient may not be satisfactory, requiring other tools for better monitoring of the nutritional risk.

Correlational results indicate a positive and moderate correlation between right/left HGS and 6MWT. Souza et al.[44] correlated these variables in the pre-transplantation period of liver for patients with mean age similar to the study sample (54.34 ± 8.18). The authors found a positive and moderate correlation for right HGS and 6MWT (Pearson's R |0.5| and p=0.0004) and for left HGS and 6MWT (Pearson's R of |0.5| and p=0.0001).

The correlation of the variables of functional capacity indicates that patients with high HGS are the same that walked longer distances in 6MWT. In the same line, patients who walk shorter distances in the 6MWT present low values of HGS. These two functional variables are important for the performance of the patient with multiple myeloma that will be transplanted, since functional capacity, especially, physical function, can significantly contribute for the prognosis and quality of life post-transplantation[45-47].

Cross-tabulation of 6MWT and TUG have also shown moderate, but negative |-0.51| correlation, that is, inversely proportional. The patients who walked greater distances in 6MWT completed TUG in less time, presenting low risk of falls and high functional capacity, while patients who took longer to complete TUG walked less in 6MWT. Ozdemir et al.[48] correlated the distance walked in 6MWT with the time taken to complete TUG in patients with heart failure and found negative, but strong correlation between these two variables (Spearman' R of |-0.71| and p=0.001).

Usually, the multidisciplinary evaluation of the oncologic patient does not include scales to quantify the risk of fall; in most of the cases, falls are sub-notified by the patients[49]. The sample investigated did not present important risk of fall; however, the mean age of this population was 59.0 ± 9.31 years. In that sense, it is important to understand that globally, the numbers indicate that at diagnosis, 45% of the patients are aged 75 years or older and it is known that ageing is one of the main risk factors for falls in multiple myeloma[37,47].

To the best existing knowledge, and based on the study development, it was noticed how the decline of the functional capacity and nutritional status are relevant for this population and can impact the prognosis. The knowledge about the correlations among the variables investigated can improve the physiotherapeutic and nutritional follow-up of the transplanted patient focused to the evolution of the aspects that correlate with functional capacity.

The small sample size at the institution where the study was conducted and the impossibility of determining cause and effect relations are some of the study limitations because observational studies are unable to explain the details of the findings. Future studies with larger samples in randomized and blinded clinical trials are suggested to best understand the relations of these variables for this population.

CONCLUSION

Patients with multiple myeloma evaluated in the study presented low functional capacity but without important risk of falls, elevated BMI and variations of RBC. Values of HGS and TUG were correlated with the distance walked in 6MWT, but values of RBC were not correlated with HGS. Notwithstanding the findings, the mean age of the

sample is low, given the pathology, which can explain the absence of risk of falls. In counterpart, prior comorbidities can interfere in poor rates of functional capacity. These factors pre-HSCT can draw attention and focus in rehabilitation to improve the prognosis during and after transplantation in multiple myeloma.

CONTRIBUTIONS

All the authors contributed substantially to the conception and design of the study, acquisition, analysis and interpretation of the data, wording and critical review. They approved the final version for publication.

DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

DATA AVAILABILITY STATEMENT

All the content underlying the text is contained in the manuscript.

FUNDING SOURCES

None.

REFERENCES

1. Rocchi S, Zannetti BA, Marconi G, et al. Multiple myeloma: the role of autologous stem cell transplantation in the era of immunotherapy. Cells [Internet]. 2024;13(10):853-3. doi: https://doi.org/10.3390/cells13100853
2. Dac DT, Koshihara H, Cho M, et al. Sarcopenia and clinical outcomes in lymphoma and multiple myeloma patients receiving hematopoietic cell transplantation: a systematic review and meta-analysis. Inter J Hematol. 2025;122(1):25-34.
3. Mohammed J, Alghamdi A, Hashmi SK. Full-body physical therapy evaluation for pre-and post-hematopoietic cell transplant patients and the need for a modified rehabilitation musculoskeletal specific grading system for chronic graft-versus-host disease. Bone Marrow Transplant. 2018;53(5):625-7.
4. Yu MS, Lee H, Kim HK, et al. Exercise barriers and facilitators during hematopoietic stem cell transplantation: a qualitative study. BMJ Open. 2020;10(9):e037460.
5. Pianko MJ, Golob JL. Host-microbe interactions and outcomes in multiple myeloma and hematopoietic stem cell transplantation. Cancer Metastasis Rev. 2022;41(2):367-82.
6. Chen JJ, Wu PT, Liao Y, et al. Aerobic exercise in anthracycline-induced cardiotoxicity: a systematic review of current evidence and future directions. Am J Physiol Heart Circ Physiol. 2017;312(2):H213-22.
7. Rodríguez EM, García-García J, Ríos-Hernández A, et al. Effects of exercise programs on psychoemotional and quality-of-life factors in adult patients with cancer and hematopoietic stem cell transplantation or bone marrow transplantation: a systematic review. Int J Environ Res Public Health. 2022;19(23):15896.
8. Kanate AS, Majhail NS, Savani BN, et al. Indications for hematopoietic cell transplantation and immune effector cell therapy: guidelines from the American Society for Transplantation and Cellular Therapy. Biol Blood Marrow Transplant. 2020;26(7):1247-56.
9. Zhang XH, Wang Y, Yan CH, et al. The consensus from The Chinese Society of Hematology on indications, conditioning regimens and donor selection for allogeneic hematopoietic stem cell transplantation: 2021 update. J Hematol Oncol. 2021;14(1):1-20.
10. Snowden JA, Sharrack B, Akil M, et al. Indications for haematopoietic cell transplantation for haematological diseases, solid tumours and immune disorders: current practice in Europe, 2022. Bone Marrow Transplant. 2022;57(8):1217-39.
11. Florent Malard, Neri P, Bahlis NJ, et al. Multiple myeloma. Nat Rev Dis Primers. 2024;10(1). doi: https://doi.org/10.1038/s41572-024-00529-7
12. Kumar SK, Callander NS, Alsina M, et al. Multiple myeloma, version 3.2017, NCCN clinical practice guidelines in oncology. J Natl Compr Canc Netw. 2017;15(2):230-69.
13. Charliński G, Jurczyszyn A. Non-secretory multiple myeloma: Diagnosis and management. Adv Clin Exp Med. 2022;31(1):95-100.
14. Bertamini L, D'Agostino M, Gay F. MRD assessment in multiple myeloma: progress and challenges. Curr Hematol Malig Rep. 2021;16(2):162-71.
15. Cowan AJ, Green DJ, Kwok M, et al. Diagnosis and management of multiple myeloma: a review. JAMA. 2022;327(5):464-77.
16. Dao A, Mahoney DF, Miller MJ,et al. Preventing osteolytic lesions and osteomyelitis in multiple myeloma. J Bone Oncol. 2022;37:100460.
17. Hanamura I. Multiple myeloma with high-risk cytogenetics and its treatment approach. Int J Hematol. 2022;115(6):762-77.
18. Callander NS, Jacobus S, Fonseca R, et al. Daratumumab-based quadruplet therapy for transplant-eligible newly diagnosed multiple myeloma with high cytogenetic risk. Blood Cancer J. 2024;14(1):69.
19. Dimeo F, Schwartz S, Wesel N, et al. Effects of aerobic exercise on the physical performance and incidence

of treatment-related complications after high-dose chemotherapy. Blood. 1997;90(9):3390-4.

20. Hydock DS, Lien CY, Schneider CM,et al. Exercise preconditioning provides long-term protection against early chronic doxorubicin cardiotoxicity. Integr Cancer Ther. 2011;10(1):47-57.
21. Almstedt HC, Kazakia GJ, Evans KD, et al. Combined aerobic and resistance training improves bone health of female cancer survivors. Bone Rep. 2016;5:274-9.
22. Güçlü MB, Barğı G, Sucak GT. Impairments in dyspnea, exercise capacity, physical activity and quality of life of allogeneic hematopoietic stem cell transplantation survivors compared with healthy individuals: a cross sectional study. Physiother Theory Pract. 2019;37(1):52-63.
23. Morishita S, Kaida K, Tanaka T, et al. The benefit of exercise in patients who undergo allogeneic hematopoietic stem cell transplantation. J Int Soc Phys Rehabil Med. 2019;2(1):54-61.
24. Ferro Y, Vignali L, Baldari G, et al. Therapeutic fasting in reducing chemotherapy side effects in cancer patients: a systematic review and meta-analysis. Nutrients. 2023;15(12):2666.
25. Sampaio LR. Técnicas de medidas antropométricas. In: Sampaio LR, organizador. Avaliação nutricional. Salvador: EDUFBA; 2012. p. 89-101.
26. Larsen RF, Möller AB, Nielsen DL, et al. Physical function in patients newly diagnosed with multiple myeloma: a danish cohort study. BMC Cancer. 2020;20:1-11.
27. Barao K, Forones NM. Body mass index: different nutritional status according to WHO, OPAS and Lipschitz classifications in gastrointestinal cancer patients. Arq Gastroenterol. 2012;49(2):169-71.
28. Britto RR, Probst VS, Andrade AFD, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. Braz J Phys Ther. 2013;17(6):556-63.doi: http://dx.doi.org/10.1590/S1413-35552012005000122
29. Alexandre TS, Meira DM, Rico NC, et al. Accuracy of timed up and go test for screening risk of falls among community-dwelling elderly. Rev Bras Fisioter. 2012;16(5):381-8.
30. Conselho Nacional de Saúde (BR). Resolução n° 466, de 12 de dezembro de 2012. Aprova as diretrizes e normas regulamentadoras de pesquisas envolvendo seres humanos. Diário Oficial da União, Brasília, DF. 2013 jun 13; Seção I:59.
31. Conselho Nacional de Saúde (BR). Resolução nº 510, de 7 de abril de 2016. Dispõe sobre as normas aplicáveis a pesquisas em Ciências Humanas e Sociais cujos procedimentos metodológicos envolvam a utilização de dados diretamente obtidos com os participantes ou de informações identificáveis ou que possam acarretar riscos maiores do que os existentes na vida cotidiana, na forma definida nesta Resolução. Diário Oficial da União, Brasília, DF. 2016 maio 24; Seção 1:44.
32. Ene version [Internet]. Versão 3.0. Reino Unido: BRE Group; [Sem data]. [Acesso 2025 jan 10]. Disponível em: https://kb.breeam.com/knowledgebase/internationally-approved-ene-01-calculation-software/
33. Penna GB, Silva TC, Aparecida Paz A, et al. Functional capacity, pulmonary function, and quality of life in hematopoietic stem cell transplantation survivors. Support Care Cancer. 2021;29(7):4015-21. doi: https://doi.org/10.1007/s00520-020-05947-3
34. Tuchman SA, Lane A, Hornsby WE, et al. quantitative measures of physical functioning after autologous hematopoietic stem cell transplantation in multiple myeloma: a feasibility study. Clin Lymphoma Myeloma Leuk. 2015;15(2):103-9
35. Graph Pad: Prism [Internet]. Versão 8.4.2. Boston: GraphPad; 2020. [acesso 2023 dez 19]. Disponível em: https://www.graphpad.com/updates/prism-900-release-notes
36. Shah N, Giralt S, Stadtmauer E,. Patient-reported outcomes and patient-performed testing in measuring functional impairment after stem cell transplant in patients with multiple myeloma. Blood. 2016;128(22):538.
37. Wildes TM, Rosko A, Tuchman SA. Geriatric assessment in older adults with multiple myeloma. J Am Geriatr Soc. 2019;67(5):987-91.
38. Larsen RF, Jarden M, Minet LR, et al. Exercise in newly diagnosed patients with multiple myeloma: A randomized controlled trial of effects on physical function, physical activity, lean body mass, bone mineral density, pain, and quality of life. Europ J Haematol. 2024;113(3):298-309.
39. Schwartz FR, Riederer I, Dillinger S, et al. Prospective multireader evaluation of photon-counting CT for multiple myeloma screening. Radiol Imaging Cancer. 2022;4(6):e220073.
40. Rubino F, Cummings DE, Eckel RH, et al. Definition and diagnostic criteria of clinical obesity. Lancet Diabetes Endocrinol [Internet]. 2025;13(3):221-62. Disponível em: https://www.thelancet.com/journals/landia/article/PIIS2213-8587(24)00316-4/abstract
41. Sociedade Brasileira de Nutrição Parenteral e Enteral, Associação Brasileira de Nutrição, Sociedade Brasileira de Oncologia Clínica. Diretriz BRASPEN de terapia nutricional no paciente com câncer. BRASPEN J. 2019;34(Supl 1):2-32.
42. Viana ACC, Maciel MHS, Vieira LJB, et al. Evaluation of nutritional risk factors in hematopoietic stem cell transplantation-eligible patients. Einstein (São Paulo). 2020;18:eAO5075.

43. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):1631.

44. Souza TAC, Morais IM, Neves FB, et al. Correlação entre capacidade funcional, força muscular respiratória e força de preensão palmar em candidatos a transplante de fígado. Clin Biomed Res. 2022;42(4).

45. Turesson I, Velez R, Kristinsson SY,et al. Prognostic evaluation in multiple myeloma: an analysis of the impact of new prognostic factors. Br J Haematol. 1999;106(4):1005-12.

46. Gulbrandsen N, Wisloff F, Grov EK. Health-related quality of life in multiple myeloma patients receiving high-dose chemotherapy with autologous blood stem-cell support. Med Oncol. 2001;18:65-77.

47. Cook G, Ashcroft AJ, Cairns DA, Williams CD, Rule S, Brown JM, et al. A clinical prediction model for outcome and therapy delivery in transplant-ineligible patients with myeloma (UK Myeloma Research Alliance Risk Profile): a development and validation study. Lancet Haematol. 2019;6(3):e154-66.

48. Ozdemir HY, Karahan AY, Gür H. The 6-minute walk test and fall risk in patients with heart failure: a cross-sectional study. Heart Lung. 2024;64:80-5.

49. Wildes TM, Fiala MA. Falls in older adults with multiple myeloma. Eur J Haematol. 2018;100(3):273-8.

Recebido em 24/4/2025
Aprovado em 8/8/2025

Scientific-editor: Anke Bergmann. Orcid iD: https://orcid.org/0000-0002-1972-8777