Original papers

Assessment of the physical fitness status of patients with hematological malignancies qualified for hematopoietic stem cell transplantation

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None declared

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Abstract

Background. Hematopoietic stem cell transplantation (HSCT) is a procedure commonly used in the treatment of various hematological disorders with the aim of curing the patient or prolonging life. The vast majority of patients must have antineoplastic therapy before HSCT, which can result in weight loss, sarcopenia or cachexia. Additionally, there is a high risk of malnutrition and physical deterioration during HSCT. By assessing physical fitness prior to HSCT, a physical therapist can individualize an exercise program, which in turn may speed up recovery after HSCT.

Objectives. The aim of the study was to assess the physical fitness of patients with hematological malignancies qualified for HSCT as an indication for prehabilitation.

Materials and methods. The study included 65 patients with hematological malignancies who were qualified for HSCT between September 1, 2022, and September 1, 2023. The reference group consisted of 219 healthy adults. The clinical study protocol involved participants performing 3 tests: the 6-minute walk test (6MWT), the timed-up and go test (TUG) and the 30-second chair-stand test (30CST).

Results. Patients with hematological malignancies were characterized by significantly lower endurance capacity (median (Me) = 420.50 (IQR 110.25) vs Me = 580.00 (IQR 133.00); $p < 0.001$) and significantly lower body strength (Me = 11.00 (IQR 6.00) vs Me = 15.00 (IQR 5.00); $p < 0.001$). There was also a statistically significant difference in the diagnosis and in the number of lines of systemic therapy. Additionally, a statistically significant difference was observed between the outcomes of the physical fitness level, particularly for TUG and 30CST, and the time from diagnosis to transplantation.

Conclusions. The presented results suggest a negative consequence of hematological disease and its treatment on the functional status of patients qualified for HSCT and indicate the need for individualized rehabilitation management depending on the type of diagnosis, the number of lines of systemic therapy, and the time between diagnosis and transplantation.

Key words: hematology, prehabilitation, physical fitness status, hematopoietic stem cell transplant

Background

Hematopoietic stem cell transplant (HSCT) refers to any procedure where hematopoietic stem cells (HSCs) of any donor type and any source are given to a recipient with the intention of repopulating and replacing the hematopoietic system in total or in part. Donor type is categorized as autologous, human leukocyte antigen (HLA)-identical sibling donor or matched unrelated donor (MUD). A haploidentical donor is defined as a family member where only 1 HLA haplotype is genetically identical to the patient. Depending on the source of HSCs, the following transplantations are distinguished: autologous-HSCT (auto-HSCT), allogeneic-HSCT-sibling (allo-HSCT-Sib), allogeneic-HSCT-matched unrelated donor (allo-HSCT-MUD), and haploidentical-HSCT (haplo-HSCT).[1]

Hematopoietic stem cell transplant is a procedure commonly used in the treatment of various hematological disorders and is associated with significantly improved survival rates. Auto-HSCT is characterized by the reinfusion of the patient's HSCs after treatment with high doses of chemotherapy, which exhibit high anticancer potential while causing irreversible damage to the hematopoietic function of the bone marrow.

According to the recommendations of the European Society for Blood and Marrow Transplantation (EBMT), high-dose chemotherapy followed by auto-HSCT is generally considered a standard treatment option in patients with plasma cell myeloma (PCM) in the consolidation of response to first-line therapy, in patients with relapsed or primary refractory lymphoma in the consolidation of response to salvage therapy, and in addition, in some subtypes of clinically aggressive lymphomas, such as mantle cell lymphoma (MCL) or T-cell lymphomas (TCLs), in the consolidation of response to first-line therapy.[1]

Allo-HSCT is a treatment with curative potential that is used in transplant-eligible patients with high-risk malignancies or other serious hematologic disorders. The most common indications for allo-HSCT include intermediate and high-risk acute myeloid leukemia (AML) and myelodysplastic syndromes (MDS), acute lymphoblastic leukemia (ALL) with adverse prognostic factors, and myeloproliferative neoplasms (MPN) with a high risk of disease progression according to international prognostic scoring systems.[1] However, one of the drawbacks of allo-HSCT is the possibility of the development of serious post-transplant complications, including acute and chronic graft-versus-host disease (GvHD), which result in significant non-relapse mortality after transplant. Therefore, the patient's eligibility for transplantation is determined individually, taking into account the patient's performance status, the presence of comorbidities, the adequate function of vital organs, and the patient's age.[2]

The latest Poltransplant data indicates that in 2022, 1,135 auto-HSCTs and 798 allo-HSCTs, including 108 haplo-HSCTs, were performed in Poland.[3]

Systemic symptoms of hematological malignancies such as fever, weight loss, weakness, or excessive night sweating are associated with various mediators derived from cancer cells and cells within the tumor microenvironment, including inflammatory and immune cells.[4] In addition to the discomforts associated with the disease, the treatment entails adverse effects. The mucosa of the gastrointestinal tract is damaged after the administration of chemotherapy. As a result, taste disorders, anorexia, nausea, vomiting, diarrhea, and weight loss are observed. Chronic leukopenia has been identified as a contributing factor in the development of bacterial, fungal and viral infections.[5] During treatment, there are side effects, including deterioration in muscle strength and lung function, deterioration in cardiovascular function, and a decrease in lean body mass, which translates into poorer function.[6]

Yoshida et al. have reported that approx. 2/3 of the study patients low muscle mass before HSCT. In any case, we should be aware that there were many patients who had already shown low skeletal muscle mass prior to highly invasive HSCT.[7] Morishita et al. have presented that up to 50% of cancer patients suffer from cachexia associated with sarcopenia before allo-HSCT.[8]

Considering the severe course of the disease and intensive treatment fraught with a wide spectrum of complications, while at the same time increasing the survival and life expectancy of patients, it becomes very important to support cancer patients. There is a high risk of malnutrition and physical deterioration during HSCT. Mohammed et al. identified pre-transplant physical assessment of the patient as an important part of the process for monitoring patient improvement and deterioration. They also pointed out that patients with hematological malignancies did not always receive the required, appropriate rehabilitation.[9]

While there is no one-size-fits-all protocol that can help physiotherapists achieve optimal benefit for patients with hematological malignancies, studies show that patients who engage in thoughtful exercise programs are able to better manage activities of daily living and require less involvement from their caregivers. By assessing physical fitness prior to treatment, a physical therapist can design an exercise program, which can speed up recovery.[9]

In addition, baseline functional assessment results can be helpful not only for guiding hospital rehabilitation but also for planning exercises to return to daily functioning and work after HSCT.[10]

Due to the subsequent stages of transplantation (chemotherapy, additional immunosuppressive treatment in allo-HSCT and early and late treatment-related complications, including GvHD), fitness assessment can be helpful in identifying high-risk patients to implement prehabilitation.[11]

Objectives

The aim of the study was to assess the physical fitness of patients with hematologic malignancies qualified for HSCT in the context of an indication for prehabilitation.

Materials and methods

A total of 65 consecutive patients qualified for HSCT in the Department of Hematology, Blood Neoplasm and Bone Marrow Transplantation of Wroclaw Medical University (Poland) between September 1, 2022, and September 1, 2023, who met the inclusion criteria (see below) and signed the patient's informed consent form (ICF), were included in the study. The reference group consisted of healthy adults matched by sex and age to the study group who met the inclusion criteria for healthy volunteers and signed the participant's ICF (see below). Patients' baseline characteristics and treatment details are presented in Table 1.

Table 1. Patients' characteristics and treatment details

Characteristic		Value
Age, Me (Q1–Q3) [years]		57.00 (45.00–64.00)
Sex [n]	male	26
	female	39
Indication for hematopoietic stem cell transplantation [n]	AL	20
	MDS	3
	MPN	8
	HL+NHL	13
	PCM	18
	SAA	3
Previous treatment [n]	chemotherapy	58
	antineoplastic treatment excluding chemotherapy	7
Number of previous therapy lines [n]	0–1	34
	2	19
	3 or more	12

Me – median; Q1–Q3 – 1st quartile–3rd quartile; AL – acute leukemia (acute myeloid leukemia and acute lymphoblastic leukemia); MDS – myelodysplastic neoplasm; MPN – myeloproliferative neoplasm; HL + NHL – Hodgkin lymphoma and non-Hodgkin lymphoma; PCM – plasma cell myeloma; SAA – severe aplastic anemia.

Inclusion and exclusion criteria

The study was assessed based on specific inclusion and exclusion criteria. Inclusion criteria for the study group were as follows: 1) age between 18 and 75 years at the time of signing the ICF; 2) understanding and voluntarily signing an ICF prior to any study-related assessments or procedures being conducted; 3) confirmed diagnosis of hematological malignancy; 4) being qualified for HSCT. Inclusion criteria for a reference group were as follows: 1) age between 18 and 75 years at the time of signing the ICF; 2) understanding and voluntarily signing an ICF prior to any study-related assessments or procedures being conducted; 3) never treated for cancer; 4) no concomitant diseases; 5) no concomitant therapies or medications. Exclusion criteria for both groups were as follows: 1) significant medical condition or psychiatric condition that would prevent participation in the study; 2) condition, including the presence of laboratory abnormalities, that would place the study participant at unacceptable risk if they were to participate in the study; 3) condition that would interfere with the ability to interpret the data from the study.

Research methods

The detailed clinical study protocol involved participants performing 3 tests: the 6-minute walk test (6MWT), the timed-up and go test (TUG) and the 30-second chair-stand test (30CST).

The 6MWT was used to determine endurance capacity; the TUG was used to assess agility and dynamic balance, which is important in activities that require quick maneuvers or quick movement decisions; and the 30CST was used to assess lower body strength.

All 3 tests in the study group were performed on patients after signing the ICF within 3 days prior to the transplant conditioning regimen.

The 6MWT was performed in an enclosed space on a flat surface 30 m long. Participants had to walk as far as possible in 6 min. They were instructed to move at a walking pace, were not allowed to run or trot, and had to turn around at the beginning and end of the corridor, maintaining continuity and a walking pace. Before and immediately after the test, all participants had their blood pressure and heart rate checked. If necessary, the participants were allowed to slow down or rest during the test by sitting down in a chair, but the time was not stopped. We measured the distance (in meters) the study participant walked during the test.

The TUG required the study participants to perform a sequence of tasks relevant to independent mobility. These included getting up from a chair, walking a distance of 3 m, turning around, taking the same route back to the chair, and sitting down. The result of the TUG was the total time (in seconds) required to complete this sequence. No loss of balance was allowed during the test. The study participant started the TUG in a seated position on the chair. At the command "start", they would get up from the chair and walked the designated distance of 3 m at the fastest possible pace, then turned around and returned to the chair and sat down in the starting position. Then they heard the command "stop".

The 30CST began in an active sitting position on a chair (without support). The study participant had their arms crossed. On the “start” command they hey alternated between standing up to a full standing position and sitting down in the chair within 30 s. The tester counted the number of full repetitions performed. Prior to the test, the study participants performed 2–3 test repetitions.

The above tests show high predictive value. They can be used to plan, conduct and control the effects of exercises and physical activity.[12,13]

Statistical analyses

Continuous variables were described as mean with standard deviation (SD) or median with minimum and maximum values. Categorical variables were provided as numbers with frequencies. Normal distribution was tested using the Shapiro–Wilk test. The Mann–Whitney U test was used to compare outcomes between 2 groups (study vs reference). The Kruskal–Wallis test was performed with post hoc Dunn–Bonferroni depending on the type of diagnosis and the number of lines of systemic therapy. The monotonicity of the relationship between time from diagnosis to transplantation and fitness test scores was checked using 2W scatter plots. The variable of time from diagnosis to transplantation was divided into ranges and the new variable was used as the grouping variable, and Kruskal–Wallis test was performed with post hoc Dunn–Bonferroni. The characteristics of the groups and the results were presented using descriptive statistics. All the statistical analyses were performed using STATISTICA v. 13.3 (StatSoft Poland, Cracow, Poland) and PQ Stat v. 1.8.2 (PQStat Software, Poznan/Plewiska, Poland). The results were considered statistically significant at $p < 0.05$.

Ethics

This study complies with the Declaration of Helsinki and was approved by the Wroclaw Medical University Ethics Committee (approval No. KB-843/2021, date of approval: October 28, 2021).

Results

The study group consisted of 65 patients (26 men and 39 women) with a mean age of 53.14 ±14.01) (range: 22–74 years). The reference group consisted of 219 individuals (112 men and 107 women) with a mean age of 53.29 ±15.13 (range: 20–75 years). Prior to the physical fitness assessment, the height and weight of each participant (study and reference group) were measured and used to calculate body mass index (BMI). The results were compared between groups and no differences were found (all $p > 0.05$). The results are summarized in Table 2.

Results of physical fitness level

In the 2 tests used, the 6MWT and the 30CST, the mean score in the reference group was statistically higher than the mean score in the study group. Patients with hematological malignancies had significantly lower endurance capacity and significantly lower body strength Assessment of dynamic agility and balance, important for activities requiring rapid maneuvering, showed no statistically significant differences. (Table 3).

For all tests used, a statistically significant difference was shown depending on the diagnosis (Fig. 1, Table 4).

A statistically significant difference was observed between the outcomes of the 6MWT and 30CST tests and the number of lines of systemic treatment (Fig. 2, Table 5).

In addition, the monotonicity of the relationship between the time from diagnosis to transplantation and the results of the physical fitness status was checked (Fig. 3). As an alternative approach, due to the non-monotonic relationship, the variable time from diagnosis to transplantation was divided into ranges and the new variable was used as a grouping variable. A statistically significant difference was observed between the outcomes of the physical fitness level, particularly for TUG and 30CST and the time from diagnosis to transplantation (Fig. 4, Table 6).

Table 2. Demographic and clinical results (Mann–Whitney U test; study group vs reference group)

Group	n	Age [years] Me (Q1–Q3)	Body height [m] Me (Q1–Q3)	Body weight [kg] Me (Q1–Q3)	BMI Me (Q1–Q3)
All (both groups)	284	56.00 (48.00–63.00)	1.70 (1.64–1.76)	76.00 (66.00–86.50)	26.03 (23.36–29.38)
Study group	65	57.00 (45.00–64.00)	1.70 (1.63–1.76)	79.00 (63.00–90.00)	27.14 (23.35–29.76)
Reference group	219	56.00 (49.00–63.00)	1.70 (1.64–1.76)	76.00 (66.00–85.00)	26.02 (23.37–29.29)
Z (study group vs reference group)		0.14	0.77	−0.35	−0.97
p-value		0.881	0.438	0.723	0.328

Me – median; Q1–Q3 – 1st quartile–3rd quartile 3; BMI – body mass index; *p < 0.05.

Table 3. Results of physical fitness level (study vs reference group). Mann–Whitney U test

Group	n	6MWT [m] Me (Q1–Q3)	TUG [s] Me (Q1–Q3)	30CST [n] Me (Q1–Q3)
All (both groups)	284	535.00 (437.00–620.00)	6.04 (5.00–7.17)	15.00 (12.00–18.00)
Study group	65	420.50 (379.00–490.00)	6.39 (5.50–7.24)	11.00 (9.00–15.00)
Reference group	219	580.00 (499.00–632.00)	6.00 (5.00–7.07)	15.00 (13.00–18.00)
Z (study group vs reference group)		7.68	−1.53	6.68
p-value		<0.001*	0.124	<0.001*

Me – median; Q1–Q3 – 1st quartile–3rd quartile; 6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test; n – number of repetitions; *p < 0.05.

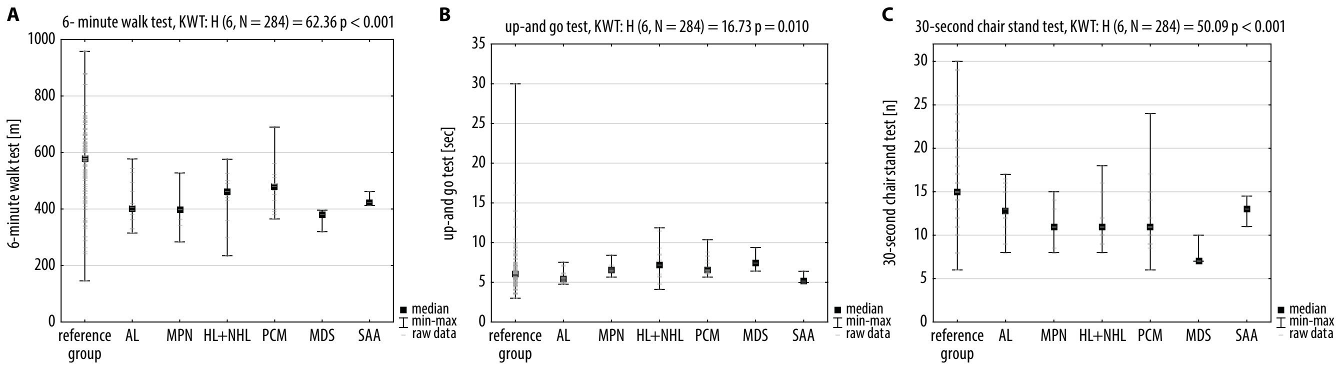

Fig. 1. Results of 6MWT (A), TUG (B) and 30CST (C) in groups divided by diagnosis (study group) vs reference group

KWT – Kruskal–Wallis test; 6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test.

Table 4. The statistical significance of the effect of diagnosis type on physical fitness level in the overall Kruskal–Wallis test with post hoc Dunn–Bonferroni test

Physical fitness level test	Overall test	Post hoc test						
		group	Ref	AL	HL + NHL	MDS	MPN	PCM
6MWT	<0.001	AL	<0.001*	–	–	–	–	–
		HL+NHL	0.007*	1.000	–	–	–	–
		MDS	0.130	1.000	1.000	–	–	–
		MPN	0.005*	1.000	1.000	1.000	–	–
		PCM	0.024*	1.000	1.000	1.000	1.000	–
		SAA	0.936	1.000	1.000	1.000	1.000	1.000
TUG	0.010*	AL	1.000	–	–	–	–	–
		HL+NHL	1.000	0.507	–	–	–	–
		MDS	1.000	0.602	1.000	–	–	–
		MPN	1.000	0.700	1.000	1.000	–	–
		PCM	0.267	0.043*	1.000	1.000	1.000	–
		SAA	1.000	1.000	1.000	1.000	1.000	1.000
30CST	<0.001*	AL	0.176	–	–	–	–	–
		HL+NHL	0.005*	1.000	–	–	–	–
		MDS	0.043*	1.000	1.000	–	–	–
		MPN	0.025*	1.000	1.000	1.000	–	–
		PCM	0.001*	1.000	1.000	1.000	1.000	–
		SAA	1.000	1.000	1.000	1.000	1.000	1.000

6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test; AL – acute leukemia (acute myeloid leukemia and acute lymphoblastic leukemia); HL + NHL – Hodgkin lymphoma and non-Hodgkin lymphoma; MDS – myelodysplastic neoplasm; MPN – myeloproliferative neoplasm; PCM – plasma cell myeloma; SAA – severe aplastic anemia; Ref – reference group; * p < 0.05.

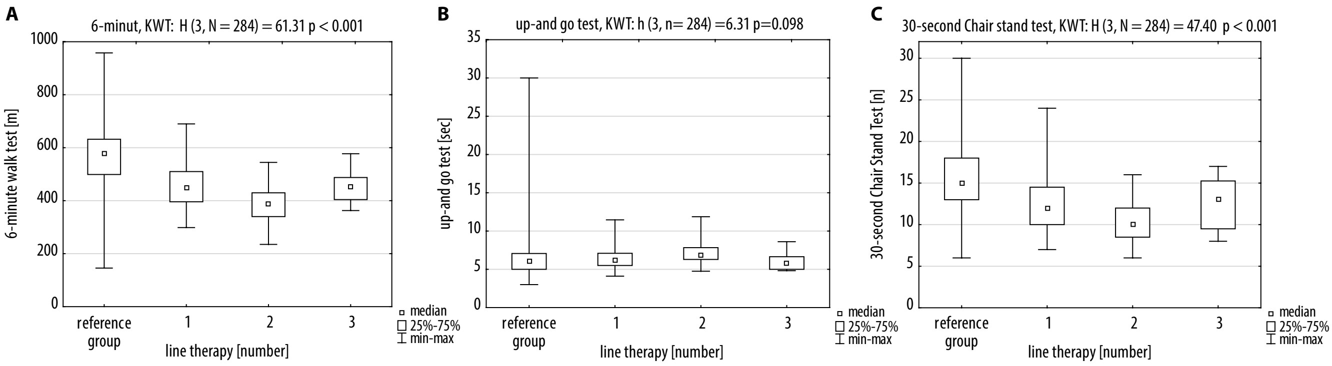

Fig. 2. Results of 6MWT (A), TUG (B) and 30CST (C) in groups divided by the number of lines of treatment (study group) vs reference group

KWT – Kruskal–Wallis test; 6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test.

Table 5. The statistical significance of the effect of the number of treatment lines on physical fitness level in the overall Kruskal–Wallis test with post hoc Dunn–Bonferroni test

Physical fitness level test	Overall test	Post hoc test			
		treatment lines	1	2	3
6MWT	<0.001*	2	0.884	–	1.000
		3	1.000	1.000	–
		Ref	<0.001*	<0.001*	0.006*
TUG	0.097	2	0.791	–	–
		3	1.000	0.366	–
		Ref	1.000	0.103	1.000
30CST	<0.001*	2	1.000	–	–
		3	1.000	1.000	–
		Ref	<0.001*	<0.001*	0.062

6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test; 1–3 – the number of lines of treatment; Ref – reference group; * p < 0.05.

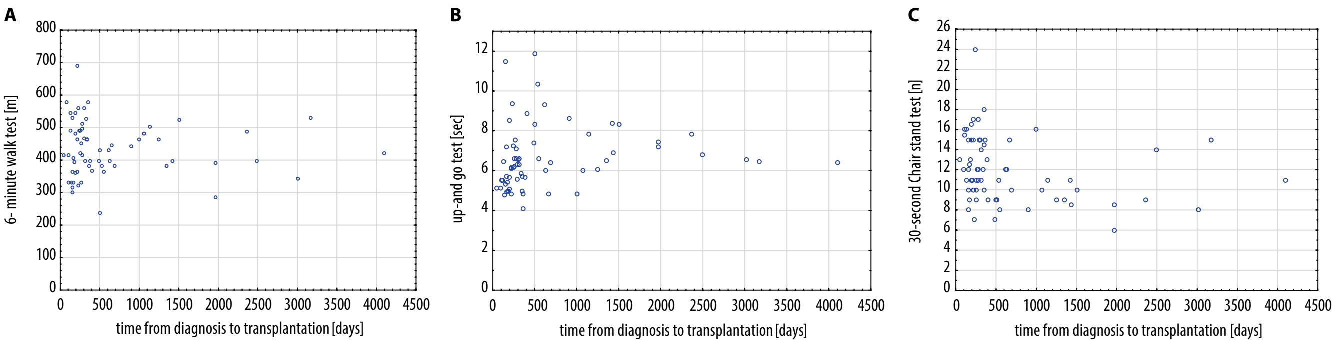

Fig. 3. Relationship between time from diagnosis to transplantation and 6MWT (A), TUG (B) and 30CST (C)

KWT – Kruskal–Wallis test; 6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test.

Discussion

Prehabilitation is the multidirectional preparation of the patient for treatment. All activities undertaken are intended to prevent the emergence of functional limitations that may occur in the patient during and after treatment. Its implementation has been shown to reduce the incidence of complications, shorten the duration of hospitalization, and have a positive impact on patients' quality of life. However, there are few prehabilitation pathways for cancer patients, especially those who are not qualified for surgical treatment.[14] The lack of prehabilitation standards also applies to patients with hematological malignancies. At the same time, many publications contain information on the negative effects of cancer and anticancer treatment on the body, primarily on the deterioration of functional parameters, a decrease in muscle strength or cardiovascular fitness or general fatigue.[6,15–17]

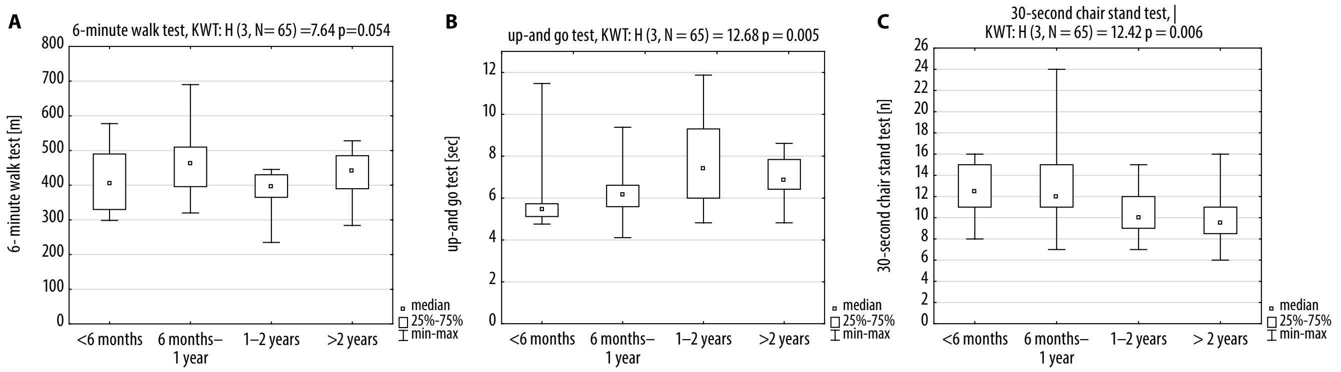

Fig. 4. Results of the 6WMT, TUG and 30CST in groups divided by the time of diagnosis to transplantation in the study group

KWT – Kruskal–Wallis test ; 6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test.

Table 6. The statistical significance of the effect of the time from diagnosis to transplantation on physical fitness level in the overall Kruskal–Wallis test with post hoc Dunn–Bonferroni test

Physical fitness level test	Overall test	Post hoc test			
		time to transplantation	<6 months	6 months–1 year	1–2 years
6MWT	0.054	6 months–1 year	0.421	–	–
		1–2 years	1.000	0.066	–
		> 2 years	1.000	1.000	0.656
TUG	0.005*	6 months–1 year	1.000	–	–
		1–2 years	0.024*	0.223	–
		> 2 years	0.024*	0.252	1.000
30CST	0.006*	6 months–1 year	1.000	–	–
		1–2 years	0.414	0.121	–
		> 2 years	0.121	0.016*	1.000

6MWT – the 6-minute walk test; TUG – the timed-up and go test; 30CST – the 30-second chair-stand test; * $p < 0.05$.

The TUG test used in the study is one of the tools for assessing frailty, the identification of which is important because it is considered a very strong predictor of morbidity, disability and death, especially in elderly patients.[18] Frailty is characterized by decreased physiological function due to reduced muscle strength and endurance, and the prognosis of frailty syndrome can inform the evaluation of several invasive therapies, including chemotherapy.[19] In addition, according to a study by Nascimento et. al., the occurrence of complications due to frailty can be prevented by implementing physical exercise that is properly adapted to the patient's general condition.[18] Hedge and Murthy showed that traditionally used risk stratification parameters such as chronological age, comorbidity and performance status may not fully capture physical function and physiological fitness, highlighting the need for improvement in pre-transplant assessment (PTA).[20]

Patients in the study group compared to healthy subjects in the reference group performed statistically significantly worse in the 30CST, which assessed lower limb muscle strength. Similar results in post-transplant patients were presented by Morishita et al.,[8] who found that the decrease in knee joint extensor strength was independent of gender. In contrast, a study by Ishikawa et al. showed that lower limb extensor strength at the knee joint before transplantation was a significant factor in reduced extensor strength after transplantation.[21] At the same time, the function of the quadriceps muscle of the thigh is considered to be representative and predictive of other skeletal muscles. As a result, it can be used to assess the patient's functional status.[22] The fact that the strength of the quadriceps femoris muscle is reduced in patients with hematological malignancies prior to treatment was also highlighted by Granger, who suggested possible reasons for this condition. This situation may be explained by cancer-related factors such as decreased protein synthesis with increased protein catabolism and increased tumor necrosis factor, leading to muscle atrophy and contractile dysfunction.[23] A 2015 study by Fiuza-Luces et al highlighted that the loss of muscle mass and strength caused by therapy is a challenge to recovery, even up to 5 years after HSCT.[24] Consequently, prehabilitation targeting muscular strength and mass growth seems to be significant. Early exercise may help reduce the decline in strength and muscle mass, according to research by Liang et al.[25]

Significant differences were also observed in the 6MWT results. Patients with hematological malignancies were able to walk a shorter distance compared to healthy participants, indicating poorer endurance performance. Similar findings were reported by Potiaumpai et al., who compared the results of the 6MWT in transplant-eligible patients with those of healthy subjects of a similar age. The results for healthy adults ranged from 417.76 m to 582.22 m for women and from 416.69 m to 713.94 m for men. In comparison, patients achieved significantly lower results, with women ranging from 91.44 m to 487.68 m and men ranging from 243.84 m to 655.32 m.[26] Some patients with hematological malignancies have also been shown to have poorer endurance and lower limb strength at the time of diagnosis, several months before treatment.[23] A meta-analysis by Liang et al. showed that exercise had a beneficial effect on patients' lower muscle strength, fatigue and quality of life. It is recommended that patients begin exercise as soon as possible after diagnosis.[25]

The type of diagnosis also appears to be important. Compared with the reference group, significantly lower scores were observed for MPN, lymphoma and PCM on the 6MWT and 30CST, for AL on the 6MWT and for MDS on the 30CST. Hematological malignancies are a group of diseases with different symptom profiles. With this in mind, prehabilitation planning would need to take into account the expected condition of the patient, depending on the diagnosis and the time between diagnosis and transplantation.

In the 1990s, some patients were still advised to adopt a sedentary lifestyle.[27] For patients with hematological disorders, rest and avoidance of strenuous exercise are often recommended because of the frequent occurrence of cytopenias.[28] But is this the right approach? This study clearly showed that in 2 of 3 tests, patients with hematological neoplasms performed statistically significantly worse than the healthy group. This means that patients are already impaired before starting treatment. As many authors have pointed out, the introduction of heavy treatment, with its many complications, has led to a further deterioration in patients' fitness.[8,29,30] Therefore, it is reasonable that patients should be advised at the time of diagnosis to exercise according to their capabilities to maintain physical fitness and minimize treatment side effects. Wiskemann et al. showed that exercise is beneficial at all stages of treatment.[31] It seems most appropriate to use exercise and proper nutrition in patients after diagnosis to prepare them for treatment.[32] Hegde and Murthy also emphasized early involvement in physical training to avoid a lack of physical mobility.[20]

Only in certain cases should exercise be avoided. Absolute contraindications to physical training include: acute phase of infection; fever; severe pain and increased pain due to movement; platelet count below 10,000/μL; acute bleeding; and hemoglobin level below 8 g/dL with oxygen deficiency. At the same time, the contraindications listed do not preclude participation in activities of daily living.[27]

Limitations

The study has the advantage of presenting fitness results between a group of healthy volunteers and patients with hematological malignancies. Thanks to this comparison, we know the importance of both prehabilitation and rehabilitation in patients with hematological disorders prior to treatment. One of the biggest limitations of this study is the size of the study group. Ultimately, we plan to expand the number of people studied so that we can determine functional status with greater accuracy, depending at least on the diagnosis and/or age and sex.

Conclusions

The significant discrepancy in functional performance between the groups confirms the impact of hematological disorders on the deterioration of patients' fitness and indicates the need for individualized rehabilitation management depending on the type of diagnosis and time between diagnosis and transplantation. At the same time, poorer pre-treatment physical fitness may affect functional status post-treatment. This highlights the need for rehabilitation support for patients with hematological malignancies both before and during treatment.

Future research directions

It seems important to create a protocol for the prehabilitation and rehabilitation management of patients with hematological malignancies in order to help specialists select appropriate parameters for patients to exercise. To achieve this objective, it is necessary to study the impact of different types of training on the functional status of patients in the pre- and peri-transplant periods. With reference to information from the available literature, it is also necessary to study the impact of prehabilitation on the treatment process, taking into account changes in patients' functional status.

Supplementary data

The Supplementary materials are available at https://doi.org/10.5281/zenodo.13989751. The package includes the following files:

Supplementary Fig. 1. Assessment of age (years) normality using the Shapiro–Wilk test.

Supplementary Fig. 2. Assessment of body height (m) normality using the Shapiro–Wilk test.

Supplementary Fig. 3. Assessment of body weight (kg) normality using the Shapiro–Wilk test.

Supplementary Fig. 4. Assessment of BMI normality using the Shapiro–Wilk test.

Supplementary Fig. 5. Assessment of 6MWT results normality using the Shapiro–Wilk test.

Supplementary Fig. 6. Assessment of TUG results normality using the Shapiro–Wilk test.

Supplementary Fig. 7. Assessment of 30CST results normality using the Shapiro–Wilk test.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

Use of AI and AI-assisted technologies

Not applicable.

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