Observational study for multidimensional assessment in elderly patients hospitalized for post-fracture or elective surgery and functional rehabilitation

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Abstract

Fracture-related hospitalizations are frequent in older adults, with recovery often extended. This study evaluated the prognostic utility of the Multidimensional Prognostic Index (MPI), Handgrip Strength (HGS), Short Physical Performance Battery (SPPB), and Geriatric Depression Scale (GDS) in predicting adverse outcomes—hospitalizations, falls, or mortality—after femoral fracture or total knee arthroplasty surgery. The methods adopted were MPI assessed frailty, SPPB measured physical performance, GDS identified depression, and HGS evaluated muscle strength. Receiver Operating Characteristic (ROC) curves determined their predictive value for adverse outcomes. The study included 206 older adults (mean age 77.5, 79.6% female). At 6 months post-surgery, significant improvements were seen in SPPB (+4.35) and HGS (+1.36 kg), with notable gains among frail patients. MPI scores declined (-0.15), and Walking Test improved (+1.92). MPI showed the strongest predictive power (AUC 0.89). Higher MPI (HR 3.47) and lower HGS (HR 0.88) were significantly associated with mortality. Male sex also increased mortality risk (HR 5.99). MPI and HGS effectively predicted adverse outcomes over 6 months, supporting their use in risk stratification for older adults' post-surgery for fractures or total knee arthroplasty surgery.

Key Words: fracture-related hospitalizations, Multidimensional Prognostic Index (MPI), Handgrip Strength (HGS), Short Physical Performance Battery (SPPB), Geriatric Depression Scale (GDS).

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Among older adults, falls and instability contribute to the development of frailty, disability, and functional limitations. As the body ages, various systemic changes take place in its organs and tissues. These include a decline in activity levels, reduced flexibility, loss of nerve cells, thickening of blood vessel walls, and weakened muscle tone.[1] Such changes contribute to different geriatric conditions, such as frailty and an increased risk of falls, causing fractures and need for surgical intervention.

Muscular and neuromuscular changes that accompany aging directly affect older adults' functional capacity, including movement speed and the balance among different muscle groups. A recent study examined the association between execution speed and myoelectric activity, revealing temporal differences and imbalances between muscle groups that may compromise stability and increase fall risk.[2] These findings underscore the importance of dynamic and targeted assessments when implementing rehabilitation and prevention programs for the elderly population.

Falls are a widespread issue among older adults, often leading to serious consequences, and should be a key concern for both clinicians and policymakers. A comprehensive systematic review and meta-analysis, encompassing 104 studies with a total sample of 36,740,590 individuals, revealed that the global prevalence of falls among older adults is 26.5%.[3] One of the most dangerous consequences of falls is proximal femur fracture, very common among older adults and often result in considerable morbidity and disability.[4] Data from the National Hospital Discharge records of the Italian Ministry of Health and the Italian Institute for Statistics indicated that hospitalizations for proximal femoral fractures rose in the last twenty years. The median age of affected patients was 83 years, with a significant majority being female (76.6%).[5]

Numerous multidimensional and physical performance assessments are thought to effectively gauge the risk of negative outcomes, such as hospitalizations, falls and mortality in older people, and various research teams have explored how to combine these tests to develop comprehensive evaluation tools for predicting negative outcomes in older patients hospitalised for post-fracture or elective surgical treatment. Tools to detect frailty, sarcopenia or depression, such as MPI, HGS, SPPB, Walking Test and GDS could play an important role.

The importance of these tools was also confirmed by literature, a previous Canadian study of 1,245 participants, revealed how HGS is a simple and effective tool to identify patients at higher risk of mortality and protracted recovery after cardiac surgery;[6] a Japanese study of 331 older patients showed how participants in the low SPPB score group had a significantly higher rate of postoperative pulmonary complications;[7] an Italian study of 1259 older patients admitted for hip fracture surgical treatment demonstrated how MPI is a reliable indicator of mortality and hospital readmission at 3, 6, and 12 months.[8] The role of GDS in the prediction of negative outcomes was also confirmed by an Italian study of 240 older people, where a GDS score of 2 or higher is a significant indicator of diminished quality of life and warrants a comprehensive evaluation of the patient's mental health status.[9] However, these studies did not examine how these tools apply differently to frail and robust individuals. Additionally, to our knowledge, no study in the literature has analysed multiple tools simultaneously while comparing their differences among frail, pre-frail, and robust individuals after surgery for femoral fractures or TKA (Total Knee Arthroplasty).

Therefore, the aim of this study is to assess how these tools are applicable in a population classified as robust, pre-frail, and frail after surgical intervention of femoral fractures or TKA, and to explore their potential predictive role in adverse events such as hospitalizations, falls, or mortality.

Materials and Methods

Study population

This study is based on data reached in Casa di Cura Clinica Latteri Valsalva, Palermo, Italy from July 2023 to September 2024, data were collected in collaboration with medical doctors from the Geriatric Unit of Department of Internal Medicine and Geriatrics of University of Palermo. The study was approved by the Ethics Committee "Comitato Etico Locale Palermo 1" of Azienda Ospedaliera Universitaria Policlinico (07/2023). Informed consent was obtained from all participants. For the aims of this research, we included only older people, *i.e.*, men and women older than 60 years, who underwent surgery for femur fracture or placement of prosthetic knee, femur, or hip within the previous 5 days, hospitalized in the department of rehabilitation medicine. Data were gathered at baseline (0 months), as well as at 3 and 6 months. Patients were excluded from the study if they were younger than 60 years old, if they were unable to understand or provide informed consent, or if more than five days had passed since their surgical procedure at the time of recruitment.

Exposure

Patients who underwent the multidimensional assessment and physical/instrumental testing had undergone surgical procedures up to 5 days prior, including hip arthroplasty (right/left), femur surgery (right/left), knee arthroplasty (right/left), intramedullary nailing of the femur (right/left), hip and femur endoprosthesis (right/left), and revision of hip (right/left) and knee (right/left) prostheses.

Outcomes

Multidimensional prognostic index

At hospital admission, to all older patients, the MPI derived from information obtained through a standard Comprehensive Geriatric Assessment was administered. Briefly, the MPI includes (10): i) Activities of Daily Living (ADL) index, which defines the level of dependence/independence in six daily personal care activities (bathing, toileting, feeding, dressing, urine and bowel continence and transferring (in and out of bed or chair); ii) Instrumental Activities of Daily Living (IADL) considering eight activities that are more cognitively and physically demanding than ADL, *i.e.* managing finances, using the telephone, taking medications, shopping, using transportation, preparing meals, doing housework and washing; iii) Short Portable Mental Status Questionnaire (SPMSQ), a ten-item questionnaire investigating orientation, memory, attention, calculation, and language; iv) CIRS Comorbidity-Index , derived from Cumulative Illness Rating Scale (CIRS) that uses a 5-point ordinal scale (score 1-5) to estimate the severity of pathology in each of 13 systems, including cardiac, vascular, respiratory, eye-ear-nose-throat, upper and lower gastrointestinal, hepatic, renal, genitourinary, musculoskeletal, skin disorder, nervous system, endocrine-metabolic and psychiatric behavioral disorders. CIRS Comorbidity-Index (CI) represents the number of categories with a score of 3 or more (referring only to the first 13 categories), maximum score obtainable is 13; v) Mini Nutritional Assessment (MNA)-short form (SF), a brief questionnaire comprising anthropometric measurements combined with a questionnaire regarding loss of appetite, recent weight loss, mobility, acute distress, and neuropsychological problems; vi) Exton Smith Scale (ESS), a five items questionnaire determining physical and mental condition, activity, mobility and incontinence, indicating the risk of pressure sores; vii) number of medications taken at the hospital discharge; viii) cohabitation status divided as living alone, in an institution, or with family members.

For each domain, a tripartite hierarchy was used, *i.e.* 0 = no problems, 0.5 = minor problems, and 1 = major problems, based on conventional cut-off points derived from the literature for each item.[10] The sum of the calculated

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scores from the eight domains was divided by eight to obtain a final MPI risk score ranging from 0 = no risk to 1 = higher risk of mortality.[11] Traditionally, the division of MPI is made using three categories, *i.e.*, MPI-1 (low risk of mortality, robustness) <0.33; MPI-2 (intermediate risk, pre-frailty) between 0.33 and 0.66; and MPI-3 (high risk, frailty) with an MPI value >0.66. The execution of MPI requires, in mean, 15 minutes.[12] It is possible to download for free the software at the following address https://multiplat-age.it/index.php/ en/tools. In

The Delta MPI was also calculated as the difference between baseline and 3 months, and between baseline and 6 months, considering a Minimal Clinically Important Difference (MCID) of 0.03, as indicated in the literature.[13]

Physical performance

The Short Physical Performance Test (SPPB) was conducted at baseline, 3 and 6 months to evaluate the functional ability of the lower limbs.[14] Each participant completed a 4-meter walk at their usual pace, a five-time sit-to-stand test, and three balance assessments (side-by-side stance, semi-tandem stance, and tandem stance). Before each test, the experimenter provided a demonstration. A stopwatch was used to record the time for each task, and scores (ranging from 0 to 4 points) were assigned based on established criteria.[14] The final score, ranging from 0 to 12, was obtained by summing the individual test scores. In this case as well, the difference in SPPB between baseline and 3 months, and between baseline and 6 months was calculated, considering a MCID of 1 point in the SPPB score, as indicated in the literature.[15] The Walking Test was extracted from the SPPB and used as a tool by analysing the difference between baseline and 3 months, and between baseline and 6 months. An improvement of 1 point corresponds to an increase of 0.1 m/s, which is considered the minimal detectable change according to the most recent literature.[16]

Handgrip strength

A digital dynamometer (KERN and Sohn GmbH) was used to measure handgrip strength, with all assessments carried out by the same examiner. Before the test, participants watched a demonstration and completed two practice attempts. After a five-minute familiarization period, they stood upright with their arm, forearm, and wrist in a neutral position.[17] They were then instructed to exert maximum grip force for 5 seconds. The test was conducted three times using the dominant hand, with a one-minute rest between trials. Three values of HGS were recorded for statistical analysis, using the highest of these three results. Similarly, a change in HGS of at least 2.9 kg between baseline and 3 months, and between baseline and 6 months, was considered clinically significant, as supported by the literature.[18]

Geriatric depression scale

GDS was administered to participants to assess depressive symptoms and overall mental health. A score of ≥2 was used as a threshold to identify individuals at risk of poor quality of life. Data collection involved structured interviews conducted by trained professionals.[19]

Participants characteristics

The following variables were considered as potentially important covariates: sex, fractures as reason of hospitalization and use of any antipsychotics/antidepressants considered as categorical variable; age and length of stay, were considered as continuous variable (Table 1).

Follow up

MPI, GDS, SPPB, Walking Test, HGS and any negative events, such as death, falls or hospitalization, were gathered at baseline, as well as at 3 and 6 months. For 3- and 6-month follow-ups, patients were summoned by telephone and then went to the Clinica Latteri for repeat physical and instrumental testing.

Statistical analyses

Means and Standard Deviations (SD) were used to describe quantitative measures, whilst percentages and counts were used for categorical variables. Characteristics of the study participants at baseline were compared according to frailty status (robust, pre-frail, frail) using Chi-square tests for categorical variables, or Fisher's exact test when the expected cell counts were <5. For continuous variables, one-way ANOVA was used, followed by Bonferroni post-hoc tests for multiple comparisons.

Delta MPI, Delta HGS, and Delta walking speed were calculated as the difference between the mean values of each measure at baseline and at 3 or 6 months across the three groups. An ANOVA test was then performed to determine whether these differences were statistically significant, by frailty status at baseline. ROC curve of MPI, SPPB and HGS were performed to define the predictive value of negative outcomes (mortality, falls, hospitalizations) and De Long test[20] for statistically compare the Area Under the Curve (AUC) of two ROC curves to determine whether one variable is significantly better than another in distinguishing between conditions (Table 2).

The association between fractures, SPPB, any antipsychotics/antidepressant, sex (male), GDS, MPI, age, handgrip strength, length of stay at baseline and all-cause mortality during the follow-up was explored by Cox proportional hazard models, estimating Hazard Ratios (HR) and 95 % Confidence Intervals (95 % CI). A preliminary univariate analysis was conducted for each variable, followed by a multivariate model including all predictors and relevant adjustment variables (e.g., age, sex, handgrip strength, MPI). We applied a p-value cutoff of 0.10 in the univariate analysis to select variables for inclusion in the multivariate model. Collinearity was assessed using the Variance Inflation Factor (VIF), and variables with VIF > 2 were excluded from the final model, except for adjustment variables, which were retained regardless of VIF.

All statistical tests were two-tailed, and a p-value < 0.05 was statistically significant. All analyses were performed using RStudio.

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Table 1. *Characteristics of patients included.*

	Robust N=13 (%)	Pre frail N=135 (%)	Frail N=58 (%)	Overall N=206 (%)	p values
Age					
Mean (SD)	71.4 (4.19)	76.3 (6.16)	81.9 (6.94)	77.5 (6.94)	p<0.001
Sex					
F	9 (69.2)	106 (78.5)	49 (84.5)	164 (79.6)	p=0.36
Fracture					
No	11 (84.6)	101 (74.8)	16 (27.6)	128 (62.1)	p<0.001
Yes	2 (15.4)	34 (25.2)	42 (72.4)	78 (37.9)	
SPMSQ					
Mean (SD) Time 0	0.923 (0.760)	1.50 (1.12)	3.12 (2.21)	1.92 (1.67)	p<0.001
EXSTON SMITH					
Mean (SD) Time 0	16.5 (1.20)	14.1 (2.26)	10.2 (2.08)	13.1 (2.90)	p<0.001
ADL					
Mean (SD) Time 0	5.62 (0.768)	3.58 (1.51)	1.19 (1.02)	3.03 (1.84)	p<0.001
IADL					
Mean (SD) Time 0	1.00 (0)	1.00 (0)	0.776 (0.421)	0.937 (0.244)	p<0.001
CIRS					
Mean (SD) Time 0	3.69 (1.11)	4.48 (1.33)	4.86 (1.13)	4.54 (1.29)	p<0.007
MEDICATIONS					
Mean (SD) Time 0	4.15 (1.41)	6.17 (2.66)	7.36 (2.27)	6.38 (2.60)	p<0.001
MNA					
Mean (SD) Time 0	11.7 (0.630)	9.81 (1.98)	7.41 (2.04)	9.25 (2.30)	p<0.001
Housing					
Family	13 (100)	89 (65.9)	16 (27.6)	118 (57.3)	p<0.001
Community-dwelling	0 (0)	1 (0.7)	1 (1.7)	2 (1.0)	
Alone	0 (0)	45 (33.3)	41 (70.7)	86 (41.7)	
GDSmini					
Time 0					
Absent	4 (30.8)	22 (16.3)	5 (8.6)	31 (15.0)	P=0.002
Mild-moderate	8 (61.5)	81 (60.0)	26 (44.8)	115 (55.8)	
Severe	1 (7.7)	32 (23.7)	27 (46.6)	60 (29.1)	
Falls					
Yes	0 (0)	0 (0)	2 (3.4)	2 (1.0)	p=0.13
No	13 (100)	135 (100)	56 (96.6)	204 (99.0)	
Chair stand					
Mean (SD)	0 (0)	0.052 (0.283)	0 (0)	0.034 (0.230)	p=0.30
Walking Test					
Mean (SD)	1.46 (0.660)	0.888 (0.923)	0.224 (0.531)	0.737 (0.885)	p<0.001
Balance					
Mean (SD) Time 0	1.46 (0.877)	1.04 (0.883)	0.224 (0.497)	0.839 (0.885)	p<0.001
SPPB					
Mean (SD) Time 0	2.92 (1.32)	1.97 (1.80)	0.448 (0.958)	1.60 (1.74)	p<0.001
Any antipsychotics/antidepressants					
No	12 (92.3)	110 (81.5)	39 (67.2)	161 (78.2)	p=0.04
Yes	1 (7.7)	25 (18.5)	19 (32.8)	45 (21.8)	
Mean handgrip					
Mean (SD)	24.5 (7.10)	18.3 (6.06)	13.1 (7.28)	17.2 (7.11)	p<0.001
Lenght of stay					
Mean (SD)	14.2 (3.63)	17.4 (3.99)	20.4 (5.49)	18.0 (4.74)	p<0.001

Table 2. De Long test for ROC curves comparison.

Variables		Lower 95% CI	Upper 95% CI	p values
MPI 0.8914141	SPPB 0.79	0.02	0.17	0.009
MPI 0.8914141	Strenght 0.78	0.10	0.20	0.02
MPI 0.8914141	GDS 0.76	0.02	0.21	0.01
SPPB 0.7910534	Strenght 0.78	-0,1	0.11	0.86
SPPB 0.7910534	GDS 0.76	-0,06	0.11	0.63
Strenght 0.7815296	GDS 0.76	-0,08	0.11	0.80

Results

Out of 235 initially screened patients, 206 older adults (mean age 77.5 years, 79.6% female) were included. The 29 excluded participants either had severe dementia or were unable to provide informed consent, with no caregiver available to assist. At baseline, the average MPI score was 0.57 (0.15). Only 6.4% of patients were classified as robust (MPI <0.33), while 65.3% were pre-frail (MPI 0.33–0.66) and 28.3% frail (MPI >0.66). Frail patients were significantly older, had higher fracture incidence, longer hospital stays, and lower scores in HGS and SPPB, especially in balance and Walking Test (all p<0.001) (Table 1).

We assessed changes in HGS, MPI, SPPB, and Walking Test from baseline to 3 and 6 months (*Supplementary Table 1*). SPPB scores significantly improved by 2.94 points at 3 months and 4.35 points at 6 months (p<0.001 for all). All groups showed at least a 1-point improvement, considered clinically meaningful (Figure 1).[14] HGS improved significantly: +1.16 kg at 3 months (p=0.008) and +1.36 kg at 6 months (p<0.001). Notably, only the frail group showed an average gain of ≥2.9 kg, a threshold recognized as clinically relevant in the literature (Figure 2).[17] Delta-MPI scores significantly decreased over time: by 0.14 at 3 months and 0.15 at 6 months (p<0.001 for all). All patient groups (robust, pre-frail, frail) had a reduction

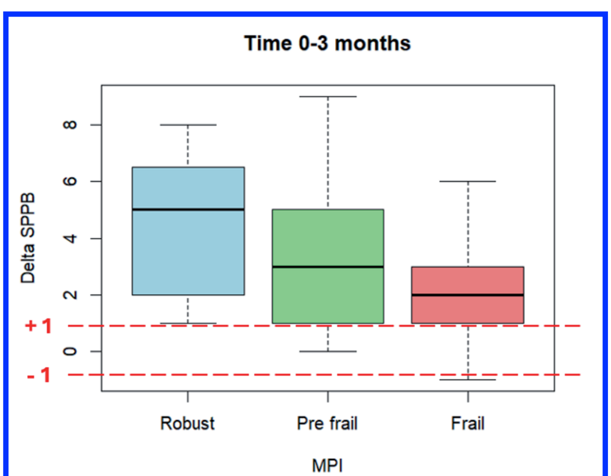

Figure 1. Comparison of delta SPPB between MPI groups time 0-3-6 months.

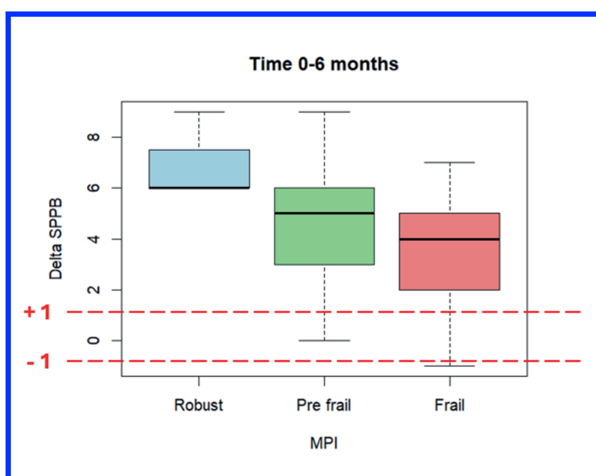

Figure 2. Comparison of delt handgrip strenght between MPI groups time 0-3-6 months.

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of at least 0.03, which is considered meaningful (Figure 3).[12] Delta- Walking Test speed also improved significantly: +1.43 points at 3 months and +1.92 at 6 months ($p<0.001$ for all). All robust patients improved by ≥1 point at both follow-ups (equivalent to a 0.1 m/s increase), while not all pre-frail and frail patients reached this threshold (Figure 4). *Supplementary Table 1* reported all the Delta for SPPB, MPI, Handgrip strength, Walking Test between baseline and 3 or 6 months.

The study aimed to evaluate the usefulness of these tools in predicting adverse outcomes (hospitalizations, falls, mortality) in patients categorized as robust, pre-frail, or frail after surgery. ROC curve analysis showed the MPI had the strongest predictive value (AUC 0.89), followed by SPPB (0.79), HGS (0.79), and GDS (0.77) (Figure 5). MPI showed significantly higher prognostic power than SPPB ($p=0.009$), HGS ($p=0.02$), and GDS ($p=0.01$). No significant differences were found among SPPB, HGS, and GDS.

A multivariate model including all significant predictors and relevant adjustment variables revealed that male patients had a significantly higher mortality risk compared to females (HR 5.99, 95% CI 1.23–31.94, $p=0.03$). Higher MPI scores were strongly associated with increased mortality risk (HR 3.47, 95% CI 1.76–6.79, $p<0.001$), while lower HGS scores were predictive of higher mortality (HR 0.88, 95% CI 0.79–0.98, $p=0.02$). No significant associations were found with fractures, SPPB scores, use of antidepressants/antipsychotics, GDS, age, or hospital stay duration (*Supplementary Table 2*, Figure 6).

Discussion

To the best of our knowledge this is one the first study analysing the role of multidimensional assessment and physical/instrumental tests in older patients hospitalised for post-fracture or elective surgical treatment and subsequent functional rehabilitation. The aim of this study was to assess how these tools are applicable in a population classified as robust, pre-frail, and frail after surgical intervention of femoral fractures or TKA, and to explore their potential predictive role in adverse events such as hospitalizations, falls, or mortality.

At baseline, after surgical treatment, the mean MPI score was 0.57 and more than 90% of participants included were classified as pre-frail or frail. Patients identified as frail tended to be older, experienced more frequent fractures, stayed in the hospital for longer periods, and showed reduced performance in HGS and the SPPB, particularly in balance and Walking Test. An American study of 652 older participants showed how HGS is directly associated with frailty: a 10-kg increase in baseline HGS was linked to a

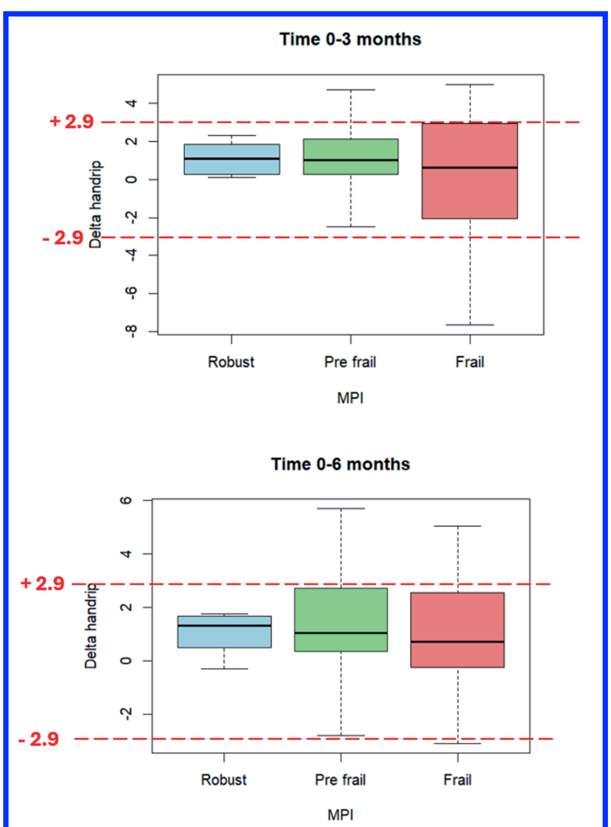

Figure 3. *Comparison of delta MPI between MPI groups time 0-3-6 months.*

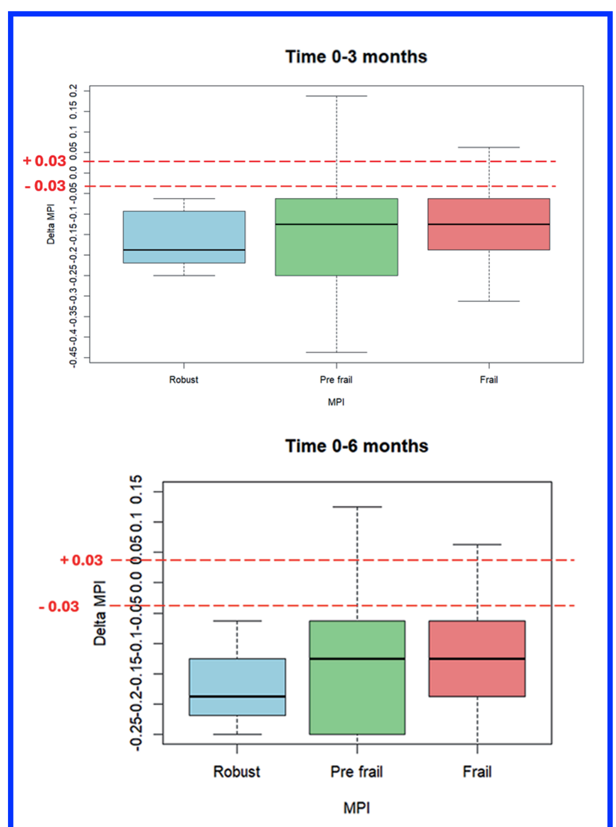

Figure 4. *Comparison of delta Walking Speed Test between MPI groups time 0-3-6 months.*

5% lower likelihood of losing IADL, an 8% lower chance of decreasing ADL, a 12% reduced risk of worsening disability, compared to individuals with lower HGS (21). Also a Brazilian study of 786 community-dwelling older adults demonstrated how total SPPB score has good diagnostic accuracy to discriminate between non-frail and frail older adults, revealing the power of this tool for detecting frailty.[22]

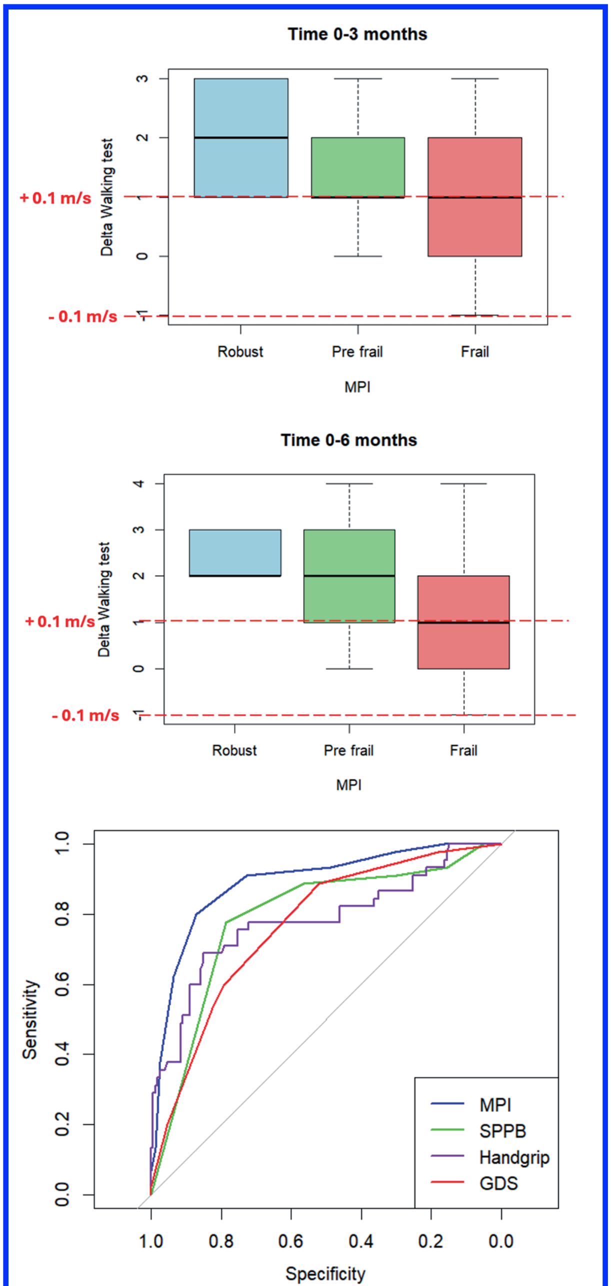

Figure 5. ROC curve of MPI, SPPB and handgrip predictive value of negative outcomes (deaths, falls, hospitalizations), (AUC MPI:0.8936335, AUC SPPB: 0.7932665, AUC Handgrip: 0.7860672, AUC GDS: 0.76904760).

Delta-MPI scores showed a notable decline over time, dropping by 0.14 at 3 months and 0.15 at 6 months, both statistically significant changes, overall showing a clinical improvement after rehabilitation. Each patient group (robust, pre-frail, and frail) experienced a decrease of at least 0.03, a threshold regarded in the literature as clinically meaningful.[12] The importance of delta-MPI was already analysed by a previous Italian study, between admission and discharge in 960 older patients, they showed how patients identified as frail or pre-frail at admission showed a reduction in MPI score at discharge, with decreases of 0.03 and 0.07 respectively, while robust patients experienced a significant increase in MPI score of 0.04.[12] Also differences in HGS have a crucial role, this is supported by findings from a Spanish study involving 110 older adults, which demonstrated that HGS, measured upon admission to an Orthogeriatric Unit following a hip fracture, was strongly associated with the patients' subsequent functional recovery.[23]

During the 6-month follow-up, the most significant improvements consistently occurred between baseline and 3 months, with only modest gains between 3 and 6 months. Patients classified as robust showed the greatest improvements in SPPB, HGS, MPI, and Walking Test, followed by pre-frail and frail patients, respectively. Regaining preoperative functional status is crucial for restoring independence after surgery.[24] Importantly, this aspect of recovery can be enhanced, a Singaporean study of 117 patients showed that frail patients undergoing colorectal surgery experienced better functional outcomes when they participated in prerehabilitation programs focused on physical conditioning, compared to those who received standard surgical care.[25]

The study sought to assess how effectively these tools could predict adverse outcomes, such as hospitalizations, falls, and mortality, in patients classified as robust, pre-frail, or frail after surgery. ROC curve analysis revealed that the MPI had the highest predictive accuracy, followed by the SPPB and HGS, and then the GDS. Last part of our

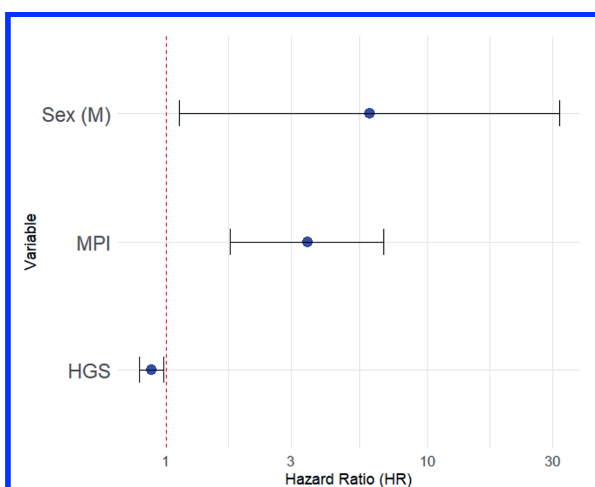

Figure 6. Graphical representation of Multivariate analysis.

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study confirmed the value of ROC analysis: higher MPI scores were strongly associated with increased mortality risk, while lower HGS scores were predictive of higher mortality.

Adoption of exercise programs in water or on land represents a fundamental component of rehabilitation for older adults after surgery or for fall prevention. Comparative studies have shown that while water exercise provides a low-impact environment ideal for individuals with reduced mobility, land-based training promotes improvements in strength and proprioception in more functional conditions.[26] Therefore, a personalized choice between these modalities may optimize functional recovery and quality of life.

Prognostic indices can be valuable tools for clinicians, helping guide more informed decision-making in the care of older adults. It is well recognized that overlooking a patient's prognosis during clinical decisions can result in suboptimal or inappropriate care. All the previous studies analysed a single tool, without having a real comparison between different tools, as we did in our work. An Italian study of 1,140 participants revealed how MPI values are associated with higher mortality and other negative outcomes, such as institutionalization, rehospitalization, and access to home care services,[27] or another Italian study of 87 patients, where participants with poor SPPB scores at hospital discharge had a greater risk of rehospitalization or death and a steeper increase in activity of daily living difficulty.[28]

MPI showed the highest predictive accuracy in our study, among the tools commonly used to evaluate frailty among older people. MPI predicts future health outcomes because it reflects a comprehensive deterioration in an older patient's overall health status. Many reasons could explain this result: MPI brings together various aspects of health, it is derived from a comprehensive geriatric assessment that takes into account elements such as physical functioning, mental status, nutritional condition, existing medical conditions, medication burden, and the level of social support available to the patient.[29]

The present study should be interpreted within its strengths and limitations. As previously said to the best of our knowledge, this is one of the first studies comparing the strength of different tools after surgical intervention of femoral fractures or TKA. Secondly, our study categorized participants as robust, pre-frail, or frail, and examined how each group responded differently to various assessment tools during follow-up. Thirdly, we had a six-month follow-up, which allowed us to observe changes over time and assess the progression or improvement in patients' health status. This study also has several limitations. First, our comprehensive assessment—combining physical and instrumental methods—was conducted postoperatively, following surgeries for femoral fractures or TKA. A preoperative evaluation would have offered a stronger baseline for comparing postoperative outcomes. Secondly, the study was conducted at a single centre, which limits the generalizability of the findings and may introduce bias due to local clinical practices. Lastly, the sample size was smaller than what is typically achievable in multicentred studies. Another limitation is the lack of standardization in postoperative rehabilitation, which may have influenced recovery trajectories.

Conclusions

MPI demonstrated the highest predictive accuracy among frailty assessment tools in this study. Its comprehensive nature allows early detection of hidden health issues and better prediction of adverse outcomes such as hospitalizations, falls, and mortality over six months. Clinically, MPI offers a valuable tool for stratifying risk in older adults' post-surgery, enabling more targeted interventions. Its use could also reduce preventable complications and associated healthcare costs.

In addition, HGS scores were independently associated with higher mortality risk, further supporting the importance of including functional measures in frailty assessments. Future studies should explore the routine implementation of both MPI and HGS in clinical settings and evaluate their combined utility in improving long-term outcomes across diverse patient populations.

List of abbreviations

MPI, Multidimensional Prognostic Index
HGS, Handgrip Strength
SPPB, Short Physical Performance Battery
GDS, Geriatric Depression Scale
ROC, Receiver Operating Characteristic
TKA, Total Knee Arthroplasty
ADL, Activities of Daily Living
IADL, Instrumental Activities of Daily Living
SPMSQ, Short Portable Mental Status Questionnaire
CIRS, Cumulative Illness Rating Scale
CI, CIRS Comorbidity-Index
MNA, Mini Nutritional Assessment
ESS, Exton Smith Scale
MCID, Minimal Clinically Important Difference
SPPB, Short Physical Performance Test
AUC, Area Under the Curve
VIF, Variance Inflation Factor

Conflict of interest

The authors declare no potential conflict of interest, and all authors confirm accuracy.

Ethics approval

The Ethics Committee "Comitato Etico Locale Palermo 1" of the Azienda Ospedaliera Universitaria Policlinico approved this study (07/2023). The study is conformed with the Helsinki Declaration of 1964, as revised in 2013, concerning human and animal rights.

Informed consent

All patients participating in this study signed a written informed consent form for participating in this study.

Patient consent for publication

Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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Online supplementary material:

Supplementary Table 1. Delta for SPPB, MPI, Handgrip strength, Walking speed test between baseline and 3 or 6 months.

Supplementary Table 2. Hazard Ratios for most important variables: Results from Multivariate analysis.