

## ORIGINAL ARTICLE

# Effectiveness of Rehabilitation for Cancer Patients with Bone Metastasis

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**Objectives:** Advances in cancer treatment have led to extended survival, and, as a result, the number of patients with bone metastases is increasing. Activities of daily living (ADL) decrease with bone metastasis and the need for rehabilitation is increasing. This study examined the effects of rehabilitation in patients with bone metastases. **Methods:** We retrospectively reviewed data of cancer patients with bone metastasis who received rehabilitation between 2016 and 2018. Efficacy of rehabilitation was evaluated in 92 patients as the change in the Functional Independence Measure (FIM) score divided by rehabilitation days (FIM change/day) and assessed by different metastatic sites. **Results:** Overall FIM scores significantly improved after rehabilitation. Moreover, FIM change/day improved in patients with pelvic metastases (n=44) more than in patients with other metastatic sites (n=48) (P=0.015). In FIM motor components, improvements in toilet, tub/shower, walk/wheelchair, and stairs were significantly greater in patients with pelvic metastasis than in those with other metastasis sites. **Conclusions:** Rehabilitation improved ADL status to a greater extent in patients with pelvic metastases than in those with other metastasis sites. Patients with pelvic metastases may fear fractures, limiting their ADL, but rehabilitation could eliminate this fear and improve FIM.

**Key Words:** Functional Independence Measure (FIM); Katagiri score; Mirels score; Pelvic metastases; Spine Instability Neoplastic Score (SINS)

## INTRODUCTION

Recent advances in cancer diagnosis, surgery, and the development of molecular targeted agents and immune checkpoint inhibitors have improved the survival of patients with advanced-stage cancers.<sup>1-3)</sup> The adoption of cancer boards to coordinate multidisciplinary therapy has extended the survival rate of cancer patients, and the number of patients with bone metastases has increased accordingly.<sup>4)</sup> To maintain and improve the activities of daily living (ADL) and quality of life (QOL) of patients, it is necessary to diagnose and treat bone metastases before the occurrence of skeletal-related events (SREs), such as fracture and paralysis. Therefore, early intervention is recommended for cancer rehabilitation. When a patient's general condition is good, ADL status

and QOL are high, and such patients are generally active, meaning that there may be a long-term mechanical load on the metastatic bones. Therefore, prognosis for survival is important for risk assessment of SREs. The Katagiri score is a prognostic prediction method,<sup>5)</sup> whereas the Functional Independence Measure (FIM) is a representative evaluation method of ADL and is used in many countries.<sup>6)</sup> Rehabilitation for patients with bone metastases increases the risk of SREs, including pathological fractures and paralysis caused by spinal cord compression. As a result, risk assessment for fractures prior to rehabilitation is necessary. The Spine Instability Neoplastic Score (SINS)<sup>7)</sup> was developed to assess spinal instability. The Mirels score<sup>8)</sup> was developed to assess the risk of pathological fracture in long bones with metastases and its scoring components include location, type, and

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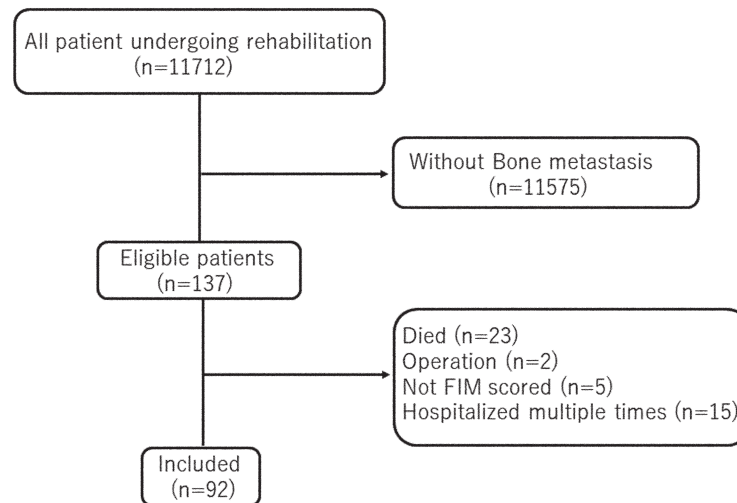
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**Fig. 1.** Study flowchart of the patient inclusion process.

size of the lesion and pain. Higher scores in both of these assessments indicate a greater risk of fracture. However, because the shape of the pelvic bone is complex, there are only a few simple methods for evaluating pelvic metastasis. This makes rehabilitation difficult for patients with pelvic metastases, and the benefits of rehabilitation for these patients have not been well evaluated.

In this study, we collected and analyzed data on cancer patients who received rehabilitation at our hospital, with a special focus on cancer patients with bone metastasis. The aim of the study was to analyze the relationship between rehabilitation effects and patient characteristics based on bone metastasis sites and bone fracture risk scores.

## METHODS

### Study Design and Subjects

This was a retrospective, descriptive study using a review of clinical records. Ethics approval was obtained from the Research Ethics Board of Kindai University to conduct this study (approval number: 2019–089). The requirement for informed consent was waived by the ethics board. The clinical records of all patients with bone metastases who were admitted to our hospital and received rehabilitation at the rehabilitation department between 2016 and 2018 were reviewed from computerized databases. We reviewed consultation notes, progress notes, operative reports, magnetic resonance imaging (MRI) or computed tomography (CT) scans of the spine for vertebral metastases, whole-body bone scans and X-rays for extraspinal metastases, and abdominal

and chest imaging for organ metastases.

Our hospital provides rehabilitation for locomotor, respiratory, cardiovascular, cerebrovascular, and cancer disorders. Physical therapy is performed for almost all diseases, while occupational, speech, and hearing therapy are performed as needed. A rehabilitation plan is prepared according to the characteristics of the disease and is changed according to the condition of the patient. FIM assessment is performed on the first and last day of rehabilitation.

A total of 11,712 patients who received rehabilitation were assessed for study eligibility. Of these, 137 were identified to have bone metastases. Of the remaining 137, patients were excluded from data analyses if their FIM scores were incomplete, if they received surgical therapy, or if they died during the hospital stay. Patients admitted to the hospital multiple times were evaluated only for the first admission after confirmation of bone metastasis. Ninety-two patients were included for evaluation (**Fig. 1**).

### Data Correction and Measurement

Data were acquired on patient characteristics, including age, gender, length of rehabilitation, bone metastasis, type of primary tumor, and treatment for bone metastases. We obtained FIM scores before and after rehabilitation.<sup>6,9)</sup> We calculated the SINS and the Mirels score for predicting pathological fracture of the spine and long bones, respectively, as described previously.<sup>7,8,10,11)</sup> We also calculated the Katagiri score<sup>5)</sup> as a survival prognosis score.

## Evaluation of Instability: SINS, Mirels Score, and Pelvic Metastases in the Acetabulum or Elsewhere

The SINS<sup>7)</sup> system is based on one clinical factor (pain) and five radiographic parameters (location, bone lesion quality, spinal alignment, vertebral body collapse, and involvement of posterolateral spinal elements). Each component is assigned a score that reflects its contribution to overall instability of the spinal segment. The six individual scores of each component are added for a cumulative score ranging from 0 to 18. A high total score indicates severe instability.<sup>10)</sup>

The Mirels scoring system<sup>8)</sup> is based on four characteristics: site of lesion, nature of lesion, size of lesion, and pain. All features were assigned progressive scores ranging from 1 to 3. The three categories for site of the lesion were upper extremity (1), lower extremity (2), and the peritrochanteric area of the femur (3). According to Mirels' recommendation, prophylactic fixation is highly indicated for a lesion with an overall score of 9 or more. A lesion with an overall score of 7 or less can be managed using radiotherapy and drugs. An overall score of 8 presents a clinical dilemma.<sup>11)</sup>

For pelvic metastasis, depending on whether acetabular bone metastases were present, we used positron emission tomography/computed tomography (PET/CT), a bone scan, MRI, and CT to investigate the patient.

## A Prognosis Prediction Method: Katagiri Score

The Katagiri scoring system<sup>5)</sup> is based on the six prognostic factors of primary characteristics, visceral metastases, laboratory data, ECOG-PS (Eastern Cooperative Oncology Group Performance Status), previous chemotherapy, and multiple bone metastases. For the primary characteristic category, patients with lung cancer were categorized into two subgroups based on treatment with or without molecular targeted agents, and patients with prostate and breast cancers were categorized according to sensitivity to hormonal therapy. The Katagiri score represents the sum of the scores for each factor and ranges from 0 to 10. The Katagiri scores were categorized into the following three groups: 0–3, high survival rate; 4–6, intermediate survival rate; and 7–10, low survival rate.<sup>12)</sup>

## ADL Evaluation Method: FIM

The FIM score<sup>6,9)</sup> considers six areas of self-care (eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting), two of sphincter control (bladder and bowel), three of transfer ability (in a bed, chair, and/or wheelchair; on and off a toilet; and in and out of a tub and/

or shower), two of locomotion (walk/wheelchair and stairs), two of communication (comprehension and expression), and three of social cognition (social interaction, problem solving, and memory). The 18 categories are each scored from 1 to 7 for a possible maximum score of 126. Within a category, a score of 1 or 2 indicates complete dependence because the person contributes less than half the energy and requires maximal or complete assistance. A score of 3 to 5 indicates modified dependence, with the person exerting more than half the energy but still needing some assistance. A score of 6 or 7 indicates independence, either with or without use of an assistive device to perform the task, and no helper is needed.<sup>13)</sup>

## Determination of Weight-bearing

Patients with bone metastases first consulted an orthopedic surgeon to determine the level of bed rest required. If necessary, a medical corset was constructed. If the pain was severe, we administered analgesics 30 min before the start of rehabilitation. When there was a metastasis to the acetabulum and pain was experienced during weight-bearing, we stopped further weight-bearing. In cases where a wheelchair was required, the affected limb was allowed to touch the ground during transfer. The patients were switched to bed rehabilitation if the pain persisted after the administration of analgesics.

## Data Analysis

Data were analyzed using JMP Version 14.0 (SAS Institute Japan). Descriptive statistics were used for the demographic and clinical data. Continuous variables were described as means (standard deviation, [SD]) for parametric data and medians (interquartile range [IQR]) for nonparametric data. The Shapiro–Wilk test was used to determine if the distribution was normal. The Mann–Whitney U test and Wilcoxon matched-pairs signed-rank test were used for comparisons of nonparametric data. We investigated factors related to changes in each item of the FIM score by performing a univariate analysis along with a Wilcoxon signed-rank test. Spearman's rank correlation coefficients were used to assess the relationship between length of rehabilitation and FIM score changes. The chi-square test was used for comparisons of the proportions.  $P < 0.05$  was considered statistically significant. Because rehabilitation efficacy is related strongly to the duration of rehabilitation,<sup>13)</sup> FIM efficiency was calculated as the change in FIM score divided by the duration of rehabilitation in days (FIM change/day).

## RESULTS

The characteristics of the final study cohort are shown in **Table 1**. The majority of patients had a bone metastasis lesion at the spine, followed by pelvis and limb metastases. Although most patients received chemotherapy and radiation therapy for treatment of their cancer and bone metastasis, some received only palliative care. As shown in **Table 2**, the primary tumors were predominantly lung or esophageal cancers, followed by breast cancer, hepatocellular carcinoma, and gastric cancer, with two patients having unknown primary tumors. No fractures occurred during rehabilitation.

For the SINS, most patients (66.1%) scored 7–12 points, followed by 0–6 points (23.5%) and 13–18 points (10.2%) (**Table 1**). For the Mirels score, most patients (64.2%) had a score of 9 or above, whereas 28.5% had a score of 7 or below, and 7.1% had a score of 8 (**Table 1**). Of the pelvic metastases, 54.5% were metastases to the acetabulum and 45.5% were elsewhere.

The distribution of the Katagiri scores is shown in **Table 1**. There was no significant difference in the distribution between patients with or without pelvic metastasis ( $P=0.14$ ). Similar results were obtained for spine metastases ( $P=0.17$ ) and limb metastases ( $P=0.11$ ) (Chi-squared test).

The total FIM score and the motor component of the FIM score improved significantly after rehabilitation, whereas the cognitive component score did not change (**Table 3**). The duration of rehabilitation (day) correlated significantly with the changes in FIM (**Fig. 2**). In addition, grooming ( $r=0.24$ ,  $P=0.018$ ), dressing-upper body ( $r=0.41$ ,  $P<0.0001$ ), dressing-lower body ( $r=0.23$ ,  $P=0.028$ ), toileting ( $r=0.24$ ,  $P=0.02$ ), and bed/chair/wheelchair transfer ( $r=0.22$ ,  $P=0.03$ ) correlated significantly with the duration of rehabilitation (day). The total FIM scores before rehabilitation (baseline value) were not significantly different between patients with or without pelvic metastases (**Appendix 1**).

Because the duration of rehabilitation was significantly associated with FIM changes, FIM changes were divided by the number of rehabilitation days (FIM change/day) for further evaluation. The change in total FIM score per day was significantly greater in patients with pelvic metastasis than in those without pelvic metastasis ( $P=0.015$ ) (**Table 4** and **Fig. 3**). In the motor component of the FIM score, two of the transfer items (toilet and tub/shower) and both locomotion items (walk/wheelchair and stairs) were significantly higher in patients with pelvic metastasis than in those without pelvic metastasis. For the cognitive component of the FIM score, the communication item of expression and the social cogni-

tion item of social interaction were significantly higher in patients with pelvic metastasis than in patients without pelvic metastasis. As shown in **Table 4**, the median and IQR values were similar although the ranges were different. Spine and limb bone metastases did not affect the FIM improvement when corrected for rehabilitation days (**Table 4**).

There were no significant differences between the SINS, Mirels score, and FIM items ( $P\geq 0.05$ ). Of the patients with pelvic metastases, those with acetabular metastases had significant improvements in dressing the upper body (0.03 [0.08–0]) than those without metastases (0.007 [0–0]) ( $P=0.047$ ).

The changes in FIM items of dressing-upper body, dressing-lower body, and social interaction were significantly lower in patients with a high Katagiri score (7–10 points) than in those with a low score (0–3 points or 4–6 points). The median and IQRs were similar for these data but the ranges were different (**Table 5**).

## DISCUSSION

The results of this study showed that FIM scores were improved by rehabilitation in patients with bone metastasis. Notably, improvements in FIM change per day were greater in patients with a pelvic metastasis than those with metastases in the spine or limbs. This result suggests that patients with pelvic metastases may receive more benefit from rehabilitation therapy. With the recent progress in cancer treatment, patients experience a longer survival period, and, concomitantly, the number of patients with metastatic bone tumors is increasing.<sup>14</sup> ADL status is decreased in patients with bone metastasis, and rehabilitation is required to improve patient QOL. We suspect that the effectiveness of rehabilitation in patients with metastatic bone tumors may differ depending on the site of bone metastasis and the general condition of the patient. This study examined the effects of rehabilitation in patients with metastatic bone tumors. Evaluation was based on the metastatic site, the Mirels score, SINS, the presence or absence of acetabulum metastases, the Katagiri score, and changes in FIM between admission and discharge based on the number of rehabilitation days (FIM change/day). We found a significantly higher FIM change/day in patients with pelvic metastasis than in those with metastases at other sites, especially in the FIM items of transfer and locomotion. Other FIM items, expression and social interaction, also showed a significantly greater FIM change/day in patients with pelvic metastasis. In this study the effectiveness of rehabilitation was evaluated by examining changes in the FIM index be-

**Table 1.** Baseline characteristics of included patients (n=92)

Variable	n (%), median [IQR]
Patients	
Male	55 (59.8)
Female	37 (40.2)
Age, years	69 [75–61]
Duration of rehabilitation, days	14 [23–8]
Bone metastasis	
Pelvis	44 (47.8)
Spine	68 (73.9)
Limb	14 (15.2)
Treatment of cancer and bone metastasis	
Chemotherapy only	18 (19.5)
Radiation therapy only	24 (26.1)
Chemotherapy and radiation therapy	41 (44.6)
Palliative care only	9 (9.8)
Bone modifying agents	8 (8.7)
SINS	
0–6	16 (23.5)
7–12	45 (66.1)
13–18	7 (10.2)
Mirels score	
≤7	4 (28.5)
8	1 (7.1)
≥9	9 (64.2)
Pelvic bone metastases in the acetabulum or elsewhere	
In the acetabulum	24 (54.5)
Not in the acetabulum	20 (45.5)
Expected prognosis	
Katagiri score	
0–3	2 (2.1)
4–6	42 (45.6)
7–10	48 (52.1)

Data displayed as number (percentage) or median [IQR].

fore and after rehabilitation. Not many studies have used the FIM items for this purpose and we consider it is possible to determine the specific effects of rehabilitation by using this scoring system.

Bone metastases are common in patients with cancer of the prostate, breast, lung, or kidney. These four primary sites account for 80% of bone metastases.<sup>15)</sup> In this study, lung cancer (32.6%) and esophageal cancer (21.7%) were the most common primary lesions. Spinal metastasis was the most frequent (73.9%), followed by metastasis in the pelvis (47.8%). Only a few hospitals perform operations for esophageal cancer near our hospital. In addition, there are many cases

with various complications that have a high surgical risk. For the above reasons, we consider that there are many cases of bone metastasis treated in our hospital whose primary origin was esophageal cancer.

The Rizzoli Archived Metastatic Lesion Institute reported that pelvic metastasis occurred in 833 of 4431 cases (18.8%).<sup>16)</sup> The reason for the dissociation of this proportion was considered to be that this study targeted patients who were not indicated for surgery. Formerly, management of bone metastasis was not considered as important as it is today because it was deemed palliative and not associated with prognosis.<sup>4)</sup> However, over the past few decades, advances

**Table 2.** Primary lesions of bone metastases (n=92)

Primary lesion site	n (%)
Lung cancer	30 (32.6)
Esophageal cancer	20 (21.7)
Breast cancer	8 (8.7)
Hepatocellular carcinoma	7 (7.6)
Gastric cancer	4 (4.3)
Prostate cancer	3 (3.3)
Pharynx cancer	2 (2.2)
Thyroid cancer	2 (2.2)
Bile duct cancer	2 (2.2)
Renal cell carcinoma	2 (2.2)
Ovarian cancer	2 (2.2)
Uterine cancer	2 (2.2)
Colon cancer	2 (2.2)
Tongue cancer	1 (1.1)
Pancreatic cancer	1 (1.1)
Skin cancer	1 (1.1)
Synovial sarcoma	1 (1.1)
Cancer of unknown primary site	2 (2.2)

in chemotherapy, immunotherapy, and hormone and radiation therapy have significantly improved life expectancy in patients with metastatic cancer.<sup>17)</sup> As a result, this has led to an increase in the number of patients at risk of developing bone metastases and experiencing pathological fractures.<sup>18)</sup> In the current study, surgery was not indicated in any patient with pelvic metastases, with chemotherapy and palliative care provided instead. Determining whether it is acceptable for patients with pelvic metastases to bear weight is often difficult because of the lack of an evaluation method, particularly in those with acetabular metastases. As a consequence, these patients require more reliable rehabilitative treatment.

Rehabilitation in patients with spinal metastases improves pain, analgesic use, and depression.<sup>19)</sup> Rehabilitation in patients with metastatic spinal cord tumors also significantly improves the FIM and prolongs survival.<sup>13)</sup> However, no study to date has explored the effectiveness of rehabilitation for those with pelvic bone metastases. In our study, four of the FIM motor items and two of the FIM cognitive items, as reported by FIM change/day, were significantly greater in patients with pelvic bone metastases than in those with other bone metastases. We observed improvements not only in physical parameters, but also in psychological ones, based on the FIM score in patients with pelvic metastases.

SREs are complications associated with bone metastases, such as bone pain, hypercalcemia, pathological fractures, and

spinal cord compression.<sup>20)</sup> These complications affect rehabilitation efficacy. A previous study showed that emotional functioning significantly declined after the occurrence of an SRE.<sup>21)</sup> Additionally, acetabular metastasis led to a worsened ECOG-PS.<sup>22)</sup> Of the different kinds of SREs, pathological fractures are estimated to occur in 9%–29% of patients with bone metastases.<sup>23,24)</sup> Pathological fractures worsen the patient's ADL status and reduce the survival rate.<sup>25,26)</sup> Therefore, this may cause patients to be fearful of fractures and limit their daily activities. In addition, unnecessary rest instructions from doctors regarding the primary site may increase these limitations. In the current study, significant improvement was observed in psychological parameters of FIM change/day for patients with pelvic metastases. This indicates that transfer and locomotion training by rehabilitation staff may help remove fear and improve ADL status.

Using scoring methods to classify patients' baseline functional abilities is important prior to safely initiating rehabilitation for those with bone metastases. Prognosis prediction and risk assessment of pathological fractures and paralysis due to spinal compression can clarify the goals of rehabilitation for each patient and maximize the effect of rehabilitative treatment. Prognosis prediction methods include the Katagiri score, Tomita score, and Tokuhashi score.<sup>5,27,28)</sup> In this study, the Katagiri score was used and correlated to the improvement of selected components of the FIM achieved through rehabilitation, including dressing-upper body, dressing-lower body, and social interaction. This finding should be noted as an improvement in FIM items in patients with a high survival rate. SINS is an evaluation for predicting the risk of pathological fractures and paralysis due to spinal cord compression in patients with bone metastases,<sup>7)</sup> whereas the Mirels score is used to evaluate the risk of pathological fracture caused by metastases in long bones.<sup>8)</sup> In recent years, analysis for bone metastases has been conducted using CT-based structural rigidity analysis,<sup>29–31)</sup> finite element analysis methods,<sup>32–34)</sup> <sup>18</sup>F-fluorodeoxyglucose PET/CT,<sup>35)</sup> and parametric response mapping,<sup>36)</sup> but these are not widely available because they require specialized equipment, software, and expertise to implement.<sup>37)</sup> For pelvic metastasis, anatomical classification can be made using the Enneking classification.<sup>38)</sup> This system divides the pelvis into four different zones. Lesions in zone 2 are associated with an increased risk of mechanical failure, because they correlate to a progressive destruction of the hip joint. However, the Enneking classification is used mainly for surgical treatment. Recently, maximum 2D diameter was identified as a significant prognostic factor for pelvic metastatic prostate cancer

**Table 3.** FIM scores before rehabilitation and after rehabilitation (n=92)

Item	Before rehabilitation	After rehabilitation	P value
Self-care			
Eating	6 [7–5]	7 [7–5]	0.0043
Grooming	5 [6–3.25]	5 [7–4]	0.0001
Bathing	3 [4–1]	4 [5.75–1]	<0.0001
Dressing-upper body	4 [6–3]	5 [7–4]	0.0003
Dressing-lower body	4 [6–2.25]	4 [6–3]	0.0004
Toileting	4 [6–1.25]	5 [6–3]	<0.0001
Sphincter control			
Bladder management	5 [7–1]	6 [7–2]	0.0023
Bowel management	6 [7–2]	6 [7–3]	0.0023
Transfers			
Bed, chair, wheelchair	4 [5–1]	5 [6–3]	<0.0001
Toilet	4 [5–1]	5 [6–2]	<0.0001
Tub, shower	1 [5–1]	4 [6–1]	<0.0001
Locomotion			
Walk/wheelchair	1 [5–1]	4 [6–1]	<0.0001
Stairs	1 [1–1]	1 [5–1]	<0.0001
Motor subtotal score	51.5 [67–25.7]	59.5 [78–35.25]	<0.0001
Communication			
Comprehension	7 [7–5]	7 [7–5]	0.419
Expression	7 [7–6]	7 [7–6]	0.415
Social cognition			
Social interaction	7 [7–6]	7 [7–5.25]	0.507
Problem solving	7 [7–6]	7 [7–5.25]	0.507
Memory	7 [7–6]	7 [7–5.25]	0.413
Cognitive subtotal score	35 [35–28.2]	35 [35–25.75]	0.307
Total FIM score	85.5 [102–57]	92.5 [112–60.25]	<0.0001

Data displayed as median [IQR]. P values from Wilcoxon matched-pairs signed-rank test.

patients.<sup>39)</sup> Given that pelvic metastases often occur in multiple sites, an indication for surgery is unlikely. Therefore, in many cases, detailed examinations such as CT or MRI focusing on the pelvis have not been performed, and even in the current study pelvic metastases were not classified in detail. Therefore, it was only possible to classify individual patients depending on whether there were bone metastases in the acetabulum based on different imaging examinations. Those with acetabular metastases had significantly improved dressing of the upper body than those without metastases. This finding is presumed to be the result of intensive upper limb training through rehabilitation because of the difficulty of bearing weight on the lower limbs.

It is assumed that patients may not perform ADL for fear of pathological fractures, and, for this reason, rehabilitation staff may not be able to perform active rehabilitation. The

findings of this study suggest that rehabilitation is effective even when surgery is not indicated for pelvic metastasis. In addition, no pathological fractures occurred during rehabilitation in our study cohort. However, there are only a small number of reports on the site of pelvic metastasis and the effect of rehabilitation, with no clear consensus on this relationship. A report confirming the relationship between detailed classification of pelvic metastases and the effects of rehabilitation could lead to safer rehabilitation programs. Pelvic bone metastases are a growing concern in the field of rehabilitation. Rehabilitation is considered minimally invasive care that can improve ADL status and QOL. Every patient needs careful evaluation and staging prior to starting rehabilitation. Ultimately, we believe that ADL status could be improved by evaluating pelvic metastases and performing appropriate rehabilitation treatment.

**Table 4** . FIM change grouped according to the length of rehabilitation in days (FIM change/day)

Item	Total n=92	Bone metastasis						P value
		With pelvic meta <sup>a</sup> n=44	Without pelvic meta <sup>b</sup> n=48	With spine meta n=68	Without spine meta n=24	With limb meta n=14	Without limb meta n=78	
<b>Self-care</b>								
Eating	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0.024-0]	0 [0-0]	0 [0-0]	0.20
Grooming	0 [0.49-0]	0 [0.047-0]	0 [0.051-0]	0 [0.051-0]	0 [0.042-0]	0 [0.013-0]	0 [0-0]	0.47
Bathing	0 [0.009-0]	0.010 [0.116-0]	0 [0.07-0]	0 [0.101-0]	0 [0.030-0]	0.07 [0.16-0]	0 [0.07-0]	0.06
Dressing-upper body	0 [0.059-0]	0 [0.06-0]	0 [0.059-0]	0 [0.052-0]	0 [0.086-0]	0 [0.08-0]	0 [0.52-0]	0.94
Dressing-lower body	0 [0.049-0]	0 [0.066-0]	0 [0.025-0]	0 [0.04-0]	0 [0.061-0]	0 [0.058-0]	0 [0.52-0]	0.92
Toileting	0 [0.47-0]	0 [0.069-0]	0 [0.019-0]	0 [0.044-0]	0 [0.058-0]	0 [0.08-0]	0 [0.045-0]	0.33
<b>Sphincter control</b>								
Bladder management	0 [0.015-0]	0 [0.04-0]	0 [0-0]	0 [0.03-0]	0 [0-0]	0 [0-0]	0 [0.03-0]	0.80
Bowel management	0 [0.015-0]	0 [0.02-0]	0 [0.015-0]	0 [0.044-0]	0 [0-0]	0 [0-0]	0 [0.03-0]	0.79
<b>Transfers</b>								
Bed, chair, wheelchair	0 [0.079-0]	0.023 [0.123-0]	0 [0.061-0]	0 [0.087-0]	0 [0.076-0]	0 [0.83-0]	0 [0.08-0]	0.62
Toilet	0 [0.075-0]	0 [0.119-0]	0 [0.052-0]	0 [0.097-0]	0 [0.0613-0]	0 [0.10-0]	0 [0.07-0]	0.73
Tub, shower	0 [0.09-0]	0 [0.123-0]	0 [0.045-0]	0 [0.1137-0]	0 [0.033-0]	0 [0.09-0]	0 [0.09-0]	0.57
<b>Locomotion</b>								
Walk/wheelchair	0 [0.178-0]	0.066 [0.23-0]	0 [0.079-0]	0 [0.1883-0]	0 [0.033-0]	0.02 [0.17-0]	0 [0.19-0]	0.78
Stairs	0 [0.0941-0]	0.287 [0.287-0]	0 [0-0]	0 [0.16-0]	0 [0-0]	0 [0.41-0]	0 [0.08-0]	0.14
Motor subtotal score	0.29 [1.081-0]	0.51 [1.185-0.112]	0.133 [1.0219-0]	0.208 [0.714-0]	0.35 [1.114-0]	0.21 [1.31-0]	0.3 [1.07-0]	0.81
<b>Communication</b>								
Comprehension	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0.31
Expression	0 [0-0]	0 [0-0] [-0.026, 0.363]	0 [0-0] [-0.22, 0.3]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0.98
<b>Social cognition</b>								
Social interaction	0 [0-0]	0 [0-0] [-0.166, 0.272]	0 [0-0] [-0.33, 0.66]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0.93
Problem solving	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0.96
Memory	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0.47
Cognitive subtotal score	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0.45
Total FIM score	0.319 [1-0]	0.5 [1.142-0.11]	0.11 [0.755-0]	0.344 [1.223-0]	0.2 [0.5-0]	0.21 [1.6-0]	0.33 [0.96-0]	0.80

Data displayed as median [IQR]. Data for Expression and Social interaction include [minimum, maximum]. P values from Wilcoxon matched-pairs signed-rank test.

<sup>a</sup> Patients with bone metastases including pelvic metastases.

<sup>b</sup> Patients with bone metastases except pelvic metastases.



**Table 5.** FIM change/day in Katagiri score categories

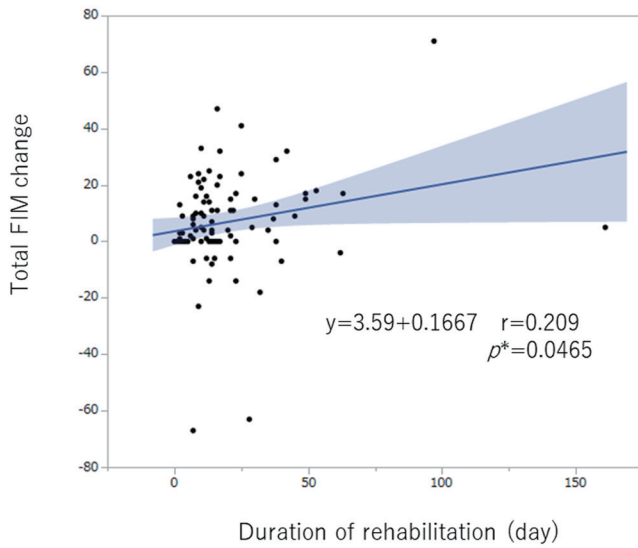
Item	Katagiri score		P value
	0–3 and 4–6 points n=43	7–10 points n=49	
<b>Self-care</b>			
Eating	0 [0.02–0]	0 [0–0]	0.07
Grooming	0 [0.09–0]	0 [0–0]	0.04
Bathing	0 [0.08–0]	0 [0–0.1]	0.36
Dressing-upper body	0.02 [0.08–0]	0 [0–0]	0.011
Dressing-lower body	0 [0.08–0]	0 [0–0]	0.004
Toileting	0 [0.05–0]	0 [0.019–0]	0.14
<b>Sphincter control</b>			
Bladder management	0 [0.03–0]	0 [0–0]	0.36
Bowel management	0 [0.027–0]	0 [0–0]	0.64
<b>Transfers</b>			
Bed, chair, wheelchair	0.02 [0.09–0]	0 [0.061–0]	0.09
Toilet	0.018 [0.09–0]	0 [0.061–0]	0.15
Tub, shower	0 [0.09–0]	0 [0.1–0]	0.48
<b>Locomotion</b>			
Walk/wheelchair	0.02 [0.1–0]	0 [0.23–0]	0.9
Stairs	0 [0.12–0]	0 [0–0]	0.05
Motor subtotal score	0.36 [1.07–0]	0.18 [1.112–0]	0.39
<b>Communication</b>			
Comprehension	0 [0–0]	0 [0–0]	0.07
Expression	0 [0–0]	0 [0–0]	0.38
<b>Social cognition</b>			
Social interaction	0 [0–0] [–0.14, 0.2]	0 [0–0] [–0.3, 0.6]	0.021
Problem solving	0 [0–0]	0 [0–0]	0.1
Memory	0 [0–0]	0 [0–0]	0.7
Cognitive subtotal score	0 [0–0]	0 [0–0]	0.21
Total FIM score	0.34 [1–0]	0.26 [1.10–0]	0.47

Data displayed as median [IQR]. Data for Social interaction include [minimum, maximum]. P values from Wilcoxon matched-pairs signed-rank test.

A major strength of this study is that the changes in FIM were examined item by item. To the best of our knowledge, this is the first time that such an analysis has been reported. In particular, improvements in the FIM motor and cognitive items for those with pelvic metastases were the main outcomes of active rehabilitation. These results suggest that it is effective to incorporate toilet and bath transfer training and walking and stair training into rehabilitation plans, instead of giving up attempts to improve ADL status because of the presence of pelvic metastasis. Our findings also suggested that it is important for therapists to interact and communicate with patients during rehabilitation. This study makes it

possible to optimize rehabilitation planning.

This study has several limitations. First, we could not categorize patients by a single metastatic site because multiple bone metastases were often present; therefore, it was not possible to evaluate rehabilitation effects for patients with only pelvic metastases. Second, in many cases, detailed examination of pelvic metastasis was not performed, and it was not possible to evaluate FIM by the specific pelvic metastasis site. Instead, we classified whether bone metastases were present in the acetabulum. Third, the study was unable to assess psychological changes caused by rehabilitation treatment using indices such as the Quick Inventory of Depressive



**Fig. 2.** The duration of rehabilitation (day) correlated significantly with FIM changes. (\* $P < 0.05$ ).

Symptomatology or the Beck Depression Inventory-Second Edition.

### CONCLUSION

This study examined the effects of rehabilitation on patients with bone metastases. Patients with pelvic metastases showed a significantly greater improvement in ADL status than patients with other metastasis sites. Patients with pel-

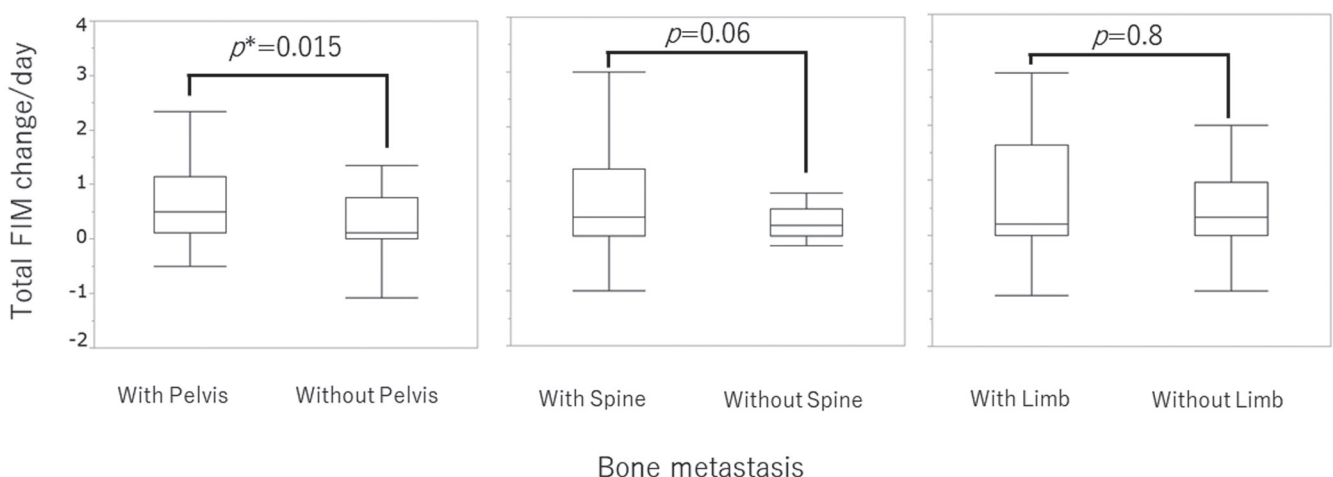
vic metastases may be afraid of pathological fractures and may limit their ADL. After rehabilitation, the FIM items of transfer, locomotion, communication, and social cognition in patients with pelvic metastases improved significantly. We believe that rehabilitation removed the fear of movement and transfer and improved mental depression. However, patients with pelvic metastases are unlikely to have a surgical indication and are often not evaluated in detail because of this reason. This study demonstrated the effectiveness of rehabilitation in patients with pelvic metastases. To maximize the effect of rehabilitation and to prevent a decrease in ADL status as a consequence of the patient's fear, there is significant need for confirmation of the relationship between detailed classification of pelvic metastases sites and the effect of rehabilitation. Such an advance would allow rehabilitation to be performed in these patients more safely.

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### CONFLICTS OF INTEREST

The authors report no conflicts of interest.



**Fig. 3.** Comparison of total FIM change/day in those with pelvic metastases and those without (left). With pelvis: patients with bone metastases, including pelvic metastases. Without pelvis: patients with bone metastases, except pelvic metastases. (\* $P < 0.05$ ). Comparisons are also shown for patients with and without spine metastases (middle) and for patients with and without limb metastases (right).

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**Appendix 1.** FIM of bone metastasis before rehabilitation

Item	FIM before rehabilitation		P value
	With pelvic meta <sup>a</sup> n=44	Without pelvic meta <sup>b</sup> n=48	
Self-care			
Eating	6 [7–5.25]	6 [7–4]	0.3
Grooming	5 [6.75–4]	4.5 [6–3]	0.4
Bathing	3 [4–1]	2.5 [4–1]	0.9
Dressing-upper body	5 [7–3.25]	4 [5–3]	0.9
Dressing-lower body	5 [6–3]	4 [5–1.25]	0.1
Toileting	5 [6–3]	4 [5.75–1]	0.1
Sphincter control			
Bladder management	6 [7–3.25]	4 [7–1]	0.9
Bowel management	6 [7–5]	4 [7–1]	0.02
Transfers			
Bed, chair, wheelchair	5 [5.75–3]	4 [5–1]	0.1
Toilet	5 [5–3]	4 [5–1]	0.2
Tub, shower	2 [5–1]	1 [4.75–1]	0.9
Locomotion			
Walk/wheelchair	1 [5–1]	1 [5–1]	0.3
Stairs	1 [1–1]	1 [1–1]	0.7
Motor subtotal score	55 [67.75–40.5]	47 [63–25]	0.1
Communication			
Comprehension	7 [7–5]	7 [7–5.25]	0.9
Expression	7 [7–5.25]	7 [7–6]	0.7
Social cognition			
Social interaction	7 [7–5.25]	7 [7–6]	0.8
Problem solving	7 [7–5.25]	7 [7–6]	0.7
Memory	7 [7–6]	7 [7–5.25]	0.5
Cognitive subtotal score	35 [35–26.25]	35 [35–28.25]	0.9
Total FIM score	89.5 [102–63.5]	79.5 [98.75–55.25]	0.4

Data displayed as median [IQR]. P values from Wilcoxon matched-pairs signed-rank test.

<sup>a</sup> Patients with bone metastases including pelvic metastases.

<sup>b</sup> Patients with bone metastases except pelvic metastases.