

# Weight-bearing impact after surgically treated proximal femur fracture in patients aged 65 years and older: systematic review

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## ABSTRACT

The incidence of proximal femur fractures is increasing among older adults. Although surgical treatment is often required to restore pre-fracture functional status, the optimal postoperative weight-bearing strategy remains controversial. This systematic review aimed to evaluate the impact of early weight-bearing after surgically treated proximal femur fractures in patients aged 65 years and older. A systematic search of Medline (via Ovid and PubMed), Embase, Scopus, Google Scholar, and the grey literature was conducted in accordance with the PRISMA 2020 guidelines for studies published between 1 January 2003 and 7 June 2024. Studies written in English or French including patients aged 65 years and older and comparing postoperative weight-bearing strategies following surgical treatment of proximal femur fractures were eligible for inclusion. The methodological quality of the included studies was assessed using the ROBINS-I and RoB tools. Of the 695 studies identified, seven met the inclusion criteria. The available evidence addressed functional outcomes, length of hospital stay, mortality, medical complications, and orthopaedic complications. Overall, early weight-bearing was associated with lower mortality, shorter hospital stay, fewer medical complications, and improvements in some functional outcomes, without an apparent increase in orthopaedic complications. However, the available evidence is limited, predominantly observational, and subject to substantial heterogeneity; therefore, causality cannot be established.

**Keywords:** Weight-bearing, hip fracture, elderly, complication, rehabilitation.

## INTRODUCTION

Globally, the total number of fall-related hip fractures continues to grow. In 2019, Dong et al. estimated the incidence at 9.85 million annual cases<sup>1</sup>. A recent epidemiological study has observed a doubling of this number since 1990, with a further doubling expected in the next 30 years due to the aging of the population<sup>2</sup>. Older people with comorbidities are particularly affected by this type of fracture, which represents a significant cause of loss of functional abilities and independence resulting in 2.94 million years of life with disability<sup>1</sup>.

The treatment of hip fractures is very often surgical and performed early to allow the patient to regain their pre-fracture functional status as quickly as possible<sup>3</sup>. Although the restriction of weight bearing in the post-operative period is only rarely appropriate, there is a certain disparity between rehabilitation protocols in this regard<sup>4</sup>.

The institutional culture, including the training and personal experience of the surgeon as well as that of

the physiotherapist, exerts a substantial influence on the mobilisation instructions<sup>5</sup>. Different authors have pointed out that elderly patients experience difficulties in correctly adhering to partial weight bearing instructions after surgery due to cognitive, physical, psychological, environmental and behavioural factors<sup>6,7</sup>. Therefore, these weight-bearing restrictions should be reviewed or even abandoned<sup>8,9</sup>.

Thus, in the absence of consensus on the rehabilitation protocol to be followed after a surgically treated hip fracture, this systematic review of the literature aims to determine the interest of early partial or full weight bearing in patients aged 65 and over, through the analysis of the duration of hospitalisation, orthopaedic and medical postoperative complications, functional scores, and mortality.

## MATERIALS AND METHODS

### Search strategy

The methodology of this systematic review was carried out according to the Preferred Reporting Items

for Systematic Reviews and Meta-analyses 2020 (PRISMA)<sup>10</sup>.

Inclusion criteria include articles written in French or English, studies conducted in humans, in patients aged 65 years and older, compared according to postoperative weight-bearing

status after surgical treatment of a fracture of the proximal femur. Exclusion criteria include animal or cadaver studies, conservative management, pathological fractures, periprosthetic or fractures on osteosynthesis material, and multiple fractures.

A comprehensive and reproducible search strategy was developed in collaboration with an experienced librarian. Electronic databases including MEDLINE (via Ovid and PubMed), Embase, and Scopus were systematically searched from January 1, 2003 to June 7, 2024. The final search was performed on June 7, 2024 for all databases. The search strategy combined controlled vocabulary (MeSH and Emtree terms) and free-text terms related to weight-bearing, hip fractures, and elderly populations. The full search strategies for each database are provided in Appendix 1 to ensure reproducibility. The protocol of this systematic review was prospectively registered in PROSPERO (registration number: CRD42024499576).

Due to their high level of evidence, the study designs retained are interventional studies such as randomised controlled trials as well as observational studies such as cohorts, both prospective and retrospective.

The final search strategy includes the terms: “weight-bearing/ or partial weight-bearing” “(early or partial) weight-bearing”; “femoral fractures”; “hip fractures/ femoral neck fractures”; “proximal femur fractures”; “aged”; “elderly”; “fracture fixation”; “surgical fixation”. Details of this strategy can be found in Annex 1 p. 26.

It should be noted that to make the search more exhaustive, the grey literature was consulted via OpenGrey and Google Scholar (first 5 pages). Reference lists of selected studies were also analyzed. On the other hand, systematic reviews and meta-analyses were excluded.

### **Selection of studies**

The search results were imported into Endnote by one of the reviewers and the duplicates removed. Subsequently, the identified studies were subject to an initial selection, based on their titles and abstracts, according to the eligibility criteria, by 2 independent reviewers via the Covidence tool.

The pooling of results has brought to light some disputes regarding the eligibility of certain articles.

These conflicts were resolved by consensus between the 2 reviewers. The studies selected after reading the full articles were subject to a similar process which made it possible to select the final studies for inclusion in the review (Figure 1).

### **Data extraction and data elements**

A scrupulous extraction of relevant data was carried out by one evaluator and verified by the second reviewer: the author and the year of publication, the design of the study, the number of patients, the characteristics of the populations (age, type of fracture, type of osteosynthesis or arthroplasty), the date of data collection, the type of weight-bearing applied for the study and the various results obtained.

### **Risk of Bias Assessment**

Included studies were assessed using the Risk Of Bias: In Non-randomised Studies - of Intervention (ROBINS-I) tools for both prospective and retrospective cohort studies and the Risk Of Bias (ROB) tools for randomised controlled trials. This analysis was carried out by 2 independent evaluators, without computer tools. Conflicts have been resolved by consensus. Such an assessment tends to ensure that evidence is used when writing this systematic review.

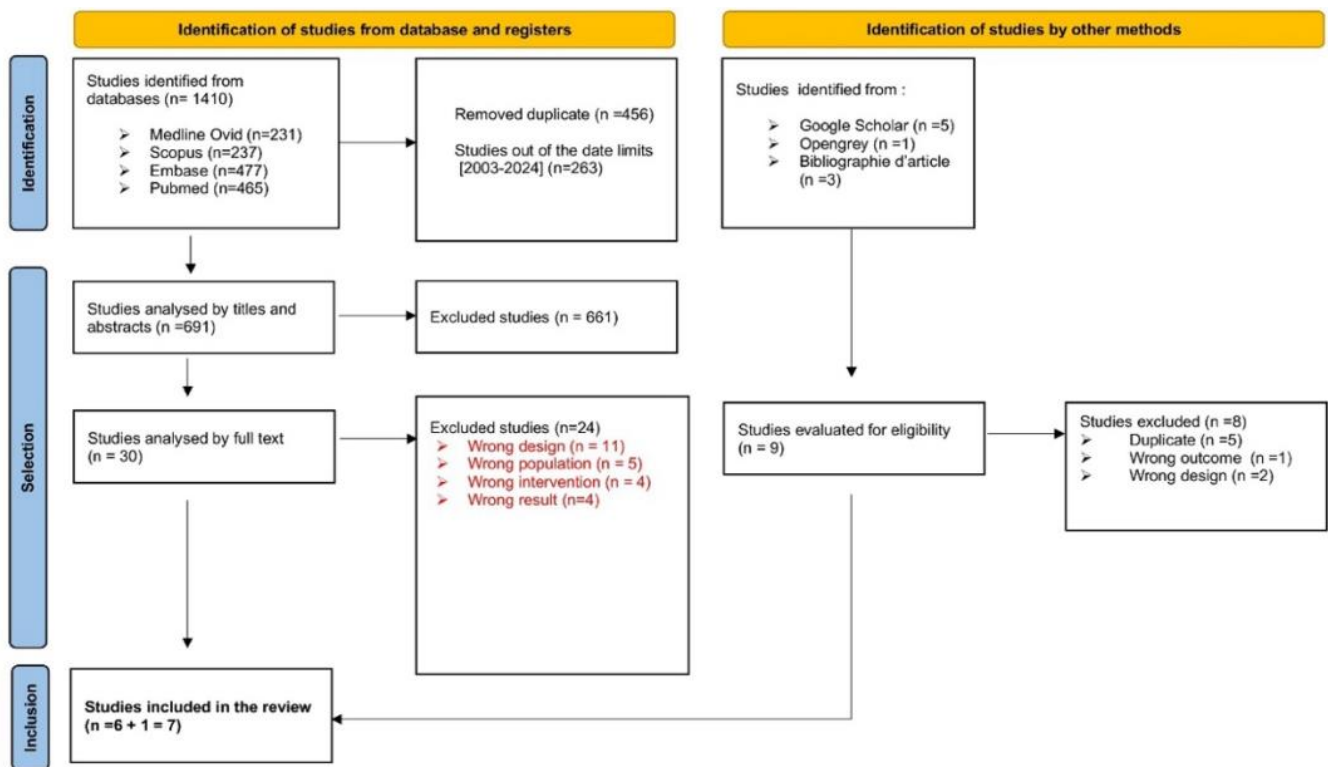
The use of the ROBINS-I tool allows for the assessment of risk of bias by considering various methodological aspects such as participant selection, confounders, classification of interventions, deviations from planned interventions, measurement and selection of outcomes, and missing data.

The ROB tool examines different areas of potential bias, such as randomisation, allocation concealment, participant and investigator blindness, outcome blindness, incomplete data management, and selectivity of outcome reporting, to determine the credibility of trial results.

### **Summary of results**

The extracted data were analyzed to provide conclusions regarding functional assessment, length of hospitalisation, carrying capacity, orthopaedic complications, medical complications, and mortality related to the surgical management of proximal femur fractures in patients aged 65 and older.

A major limitation of the present review is the lack of standardised definitions of weight-bearing across the included studies. Terms such as full weight-bearing, partial weight-bearing, and non-weight-bearing were inconsistently defined and often relied on subjective clinical instructions rather



Note: This diagram represents the flowchart PRISMA 2020 for systematic reviews. The article is available at: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews BMJ 2021;372:n71. doi : 10.1136/bmj.n71

Fig. 1 — Flowchart according to PRISMA 2020.

than objective quantification. In most studies, full weight-bearing was defined as “weight-bearing as tolerated”, whereas partial weight-bearing ranged from minimal contact to unspecified weight-bearing restriction, and was rarely quantified in terms of percentage of body weight. To improve clarity, we summarized the operational definitions of weight-bearing categories across studies (Table I). However, the absence of standardised measurement methods limits comparability and may contribute to heterogeneity in outcomes.

### Data Analysis

Due to the expected clinical and methodological heterogeneity across included studies, a quantitative

meta-analysis was not performed. Heterogeneity was related to differences in study design (randomised controlled trials versus retrospective cohorts), patient populations (age, comorbidities, fracture types), surgical techniques (osteosynthesis versus arthroplasty), and definitions of weight-bearing (full, partial, or non-weight-bearing, often inconsistently defined). In addition, outcome measures were heterogeneous and included functional scores, mortality at different time points, and various definitions of medical and orthopaedic complications. Statistical heterogeneity was considered too high to justify pooling of results. Therefore, a narrative synthesis of the results was conducted.

Table I. — Operational definition of weight-bearing categories across included studies.

| Category                     | Definition (general)                    | Definition included in studies                           | Measurement method                                                          |
|------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------|
| Full weight-bearing (FWB)    | No restriction on weight-bearing        | “As tolerated”, “full loading”, “maximum tolerated load” | Usually not quantified; based on patient tolerance or clinician instruction |
| Partial weight-bearing (PWB) | Restricted loading of the operated limb | “Partial loading”, “toe-touch”, “contact weight-bearing” | Rarely quantified; sometimes described as < 50% body weight                 |
| Non-weight-bearing (NWB)     | No load allowed on operated limb        | “No weight-bearing”, “complete discharge”                | Instruction based; no objective measurement                                 |

## RESULTS

### *Selection and characteristics of included studies*

1419 studies, including 461 duplicates, were identified through the different databases and the other methods: Medline Ovid (231), Scopus (237), Embase (477), Pubmed (465), Opengrey (1), bibliography (3), Google Scholar (5). 263 studies were excluded due to their anteriority as of January 2003. According to

the application of the inclusion and exclusion criteria, of the 695 studies assessed based on their title and abstract, 30 were analyzed in full text and finally only seven studies met inclusion criteria<sup>11–17</sup>. It should be noted that no studies meeting the inclusion criteria were excluded. The key information contained in the 7 selected studies was extracted and is presented in Tables I, II, IIIa, IIIb, **IIIc, IIId and IIle**.

The results of this systematic review are particularly interesting for functional assessments, length of

**Table II.** — Characteristics of included studies.

| 1st author;<br>Year of publication | Study design                                                                                                                                                                       | Population (description, sample size, gender and average age)                                                                                                                                                                                                                                                                | Primary outcomes                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sherrington<br>2004 [11]           | Randomised controlled study<br>(group 1: exercise with full weight bearing; group 2: exercise without weight bearing; group 3: no intervention)<br>Follow-up : at 1 and 4 month    | <b>120</b> patients at home (82%) or living in MRS<br>(group 1 n = 40; group 2 n = 40; group 3 n = 40):<br>96 women – 24 men<br>Average age in years: 79                                                                                                                                                                     | <b>1-Functional performance:</b><br>➤ Strength (knee extension; hip flexion and abduction on the operated side)<br>➤ Balance (sway distance; functional reach; step test)<br>➤ Walking speed over 6m<br>Functional performance with PPME score                                                                                                                                                                                       |
| Moseley<br>2008 [12]               | Randomised controlled study in a single blind<br>(group 1: intensive exercise under load; Group 2: Low-intensity exercise without weight bearing)<br>Follow-up : at 4 and 16 weeks | <b>160</b> inpatients in rehabilitation<br>(group 1 n = 80; group 2 n = 80):<br>130 women – 30 men<br>Average age in years: 84<br>Under analysis: 54 patients with cognitive impairment: Short Portable Mental Status ≥ 3 erroneous answers<br>(group 1 n = 30; group 2 n = 24)                                              | <b>1-Functional performance:</b><br>➤ Strength (Knee extension on the operated side)<br>➤ Walking speed over 6m<br>➤ Balance (sway distance; functional reach; step test)<br>➤ Functional performance with PPME score<br>➤ Use of aids for walking<br><br><b>2-Duration of stay</b>                                                                                                                                                  |
| Ottesen<br>2018 [13]               | Retrospective study<br>Via la database NSQIP                                                                                                                                       | 4918 patients from the NSQIP database<br><b>3668 full weight bearing:</b><br>- 2061 women – 1067 men<br>- Average age in years: 83<br><b>1250 partial weight bearing:</b><br>- 913 women – 337 men<br>Average age in years: 84                                                                                               | <b>1-Minor medical complications at 30 days</b> (superficial skin infection; pneumonia; urinary tract infection; renal failure)<br><br><b>2-Severe medical complications at 30 days</b> (deep tissue infection; sepsis; intubation; severe renal failure; new intubation; DVT; PE; cardiac arrest or infarction; stroke)<br><br><b>3- Length of hospital stay</b> ≥ 75th percentile (≥ 7 days)<br><br><b>4- Mortality at 30 days</b> |
| Atzmon<br>2021 [15]                | Retrospective cohort study<br>Minimum follow-up of 24 months                                                                                                                       | 2104 patients operated on by the same doctor. 3 cohorts:<br><b>1791 full weight bearing:</b><br>- 1130 women/ 561 men; Average age in years: 78,82<br><b>127 Partial weight bearing:</b><br>- 89 women/38 men; Average age in years: 79,48<br><b>186 No weight bearing:</b><br>140 women/46 men; Average age in years: 83,07 | <b>1-Severe medical complications</b> (stroke; PE; TVP)<br><br><b>2-Duration of stay</b><br><br><b>3-Mortality</b><br><br><b>4-Passage to a rehabilitation center</b>                                                                                                                                                                                                                                                                |

**Table IIIa.** — Evaluation of biases according to the ROBINS-I tool.

|                                                   | Ortesen <i>et al.</i> [13] | Warren <i>et al.</i> [14] | Alzmon <i>et al.</i> (15° | Bouché <i>et al.</i> (16) | Takemoto <i>et al.</i> (17) |
|---------------------------------------------------|----------------------------|---------------------------|---------------------------|---------------------------|-----------------------------|
| Confounding bias                                  |                            |                           |                           |                           |                             |
| Selection bias of participants in the study       |                            |                           |                           |                           |                             |
| Intervention Classification Bias                  |                            |                           |                           |                           |                             |
| Bias due to deviations from planned interventions |                            |                           |                           |                           |                             |
| Bias in outcome measurement                       |                            |                           |                           |                           |                             |
| Bias due to missing data                          |                            |                           |                           |                           |                             |
| Bias in the selection of reported outcomes        |                            |                           |                           |                           |                             |

**Table IIIb.** — Assessing bias using the ROB tool.

|                                     | Sherrington <i>et al.</i> [11] | Mosley <i>et al.</i> [12] |
|-------------------------------------|--------------------------------|---------------------------|
| Randomisation                       |                                |                           |
| Secret Assignment                   |                                |                           |
| Blindness of participants and staff |                                |                           |
| Blindness to results                |                                |                           |
| Incomplete outcome data             |                                |                           |
| Selectivity of reports              |                                |                           |
| Other biases                        |                                |                           |

| Legend tables 3a and 3b |  |
|-------------------------|--|
| Low risk of bias        |  |
| Moderate risk of bias   |  |
| High risk of bias       |  |

hospitalisation, mortality, quantification of weight-bearing, and orthopaedic complications (cut-out or screw migration, non/malunion, lack of consolidation, implant breakage) and medical complications (minor and severe). Severe complications include: deep tissue infections, sepsis, severe kidney failure, thromboembolic events (pulmonary embolism or deep vein thrombosis), cardiac arrest, severe heart failure, stroke. Minor complications include: superficial tissue infections, pneumonia, urinary tract infection, moderate kidney failure, pressure ulcers, delirium and anemia requiring transfusion.

### Population characteristics

All 7 studies include 15626 patients between 2004

and 2023. The average age of patients is over 70 years. Follow-up varies from 1 month to 5 years. All studies involve a distribution of patients according to their postoperative weight-bearing status, i.e.: full weight-bearing (FWB) or maximum tolerated by the patient, partial weight-bearing (PWB), also including contact weight-bearing and non-weight-bearing (NWB) (Table I).

### Functional outcomes

Of the 7 studies included, 2 considered the functional assessment of patients using various tools<sup>11,12</sup>.

Sherrington *et al.* compared two rehabilitation protocols to a control group : one with full-weight-bearing exercises, the other with non-weight-bearing

exercises<sup>11</sup>. Four months after the start of the program, they observed a significant improvement in balance and functional assessment, with better results in the FWB group for the functional reach test (mean difference: 7.1 cm; 95% CI 3.4-10.9;  $p=0.001$ ), the step test on the affected leg (mean difference: 2.9 steps; 95% CI 0.9-4.8;  $p=0.01$ ) and the step test on the nonaffected leg (mean difference: 3.1 steps; 95% CI 1.3-4.8;  $p=0.003$ ) and the duration of 5 repeated sit-to-stand positions from the sitting position (mean difference of 8.1 s; 95% CI 3.4-12.8;  $p<0.001$ ). 36% of the FWB group was able to wean themselves off technical aid compared to 6% of patients in discharge ( $p<0.001$ ).

Moseley et al., on the other hand, applied a relatively similar study protocol, with the added particularity of increasing the duration and load of the FWB group (HIGH group)<sup>12</sup>. As for Sherrington et al., repeated standing from the seated position is improved in the weight-bearing group. Nevertheless, the assessment of equilibrium remains insignificant. None of these studies found any significant differences in lower limb strength and walking speed.

### Medical and orthopaedic complications

Five studies investigated the risk of medical complications in relation to weight-bearing status<sup>13-17</sup>. However, there is some disparity in the results. Indeed, the retrospective study by Ottesen et al.<sup>13</sup> identified a 34% increase in the risk of severe medical complications at one month for patients with partial restriction of weight-bearing, regardless of the operative modality. The study by Warren et

al.<sup>14</sup>, for its part, specifies that this increase concerns severe and minor complications but only applies to patients treated with centromedullary nail and dynamic hip screw (DHS). This difference is not marked in patients treated with arthroplasty. It should be noted that there is also no difference for one-month surgical revisions<sup>13,14</sup> (Tables IVb, IVc, IVd).

Bouché et al.<sup>16</sup> observed similar results, with a reduction in complications at 45 days, although this trend reversed at 90 days. As for Atzmon et al.<sup>15</sup> and Takemoto et al.<sup>17</sup>, they did not find a significant difference in medical complications based on weight-bearing status. However, they only investigated certain complications such as thromboembolic episodes, strokes, heart failure, lung and urinary tract infections, while Ottesen et al.<sup>13</sup>, Warren et al.<sup>14</sup> and Bouché et al.<sup>16</sup> analyzed most complications by system. Orthopaedic complications are a key concern when evaluating postoperative weight-bearing strategies, yet they were inconsistently reported across the included studies, only Takemoto et al. systematically specifically assessed implant-related complications and found a higher rate of failure in the restricted weight-bearing group<sup>17</sup>. In contrast, larger database studies (Ottesen et al., Warren et al.) did not report significant differences in revision rates between weight-bearing strategies (Tables IVb, IVc, IVd, IVe).

### Mortality rate

Ottesen et al.<sup>13</sup> reported a 58% risk of increased mortality at 30 days for the group with partial weight-bearing restriction compared to the group with full weight-bearing weight (OR 1.58;  $p=0.005$ ). Like

**Table IVa.** — Difference between HIGH vs LOW and cognitive impairment groups<sup>a</sup>. Significant results and follow-up at 16 weeks. Study by Moseley et al. [12].

|                                                    | OR [ 95% CI] p value <sup>a</sup> |                              |
|----------------------------------------------------|-----------------------------------|------------------------------|
| Walking speed (m/s)                                | 0,2                               | [0,05-0,44] <b>p : 0,015</b> |
| PPME                                               | 1,9                               | [0,3-3,4] <b>p : 0,019</b>   |
| Sit-to-stand from the seated position (number/sec) | 0,1                               | [-0,01-0,15] p : 0,098       |
| Barthel Index                                      | 17                                | [6-27] <b>p : 0,002</b>      |
| Max balance range test (mm)                        | 36                                | [7-66] <b>p : 0,016</b>      |
| Step test (stair step)                             | 3,5                               | [0,07-6,8] <b>p : 0,046</b>  |
| Modified Falls Efficacy Scale - M-FES fr           | 28                                | [7-49] <b>p : 0,009</b>      |
| EQ5D - Health-Related Quality of Life              | 0,2                               | [0,02-0,39] <b>p : 0,034</b> |
| Walking without auxiliary means                    | 6,0                               | [1,4-26,7] <b>p : 0,018</b>  |
| Absence or slight pain                             | 5,3                               | [1,3-22,1] <b>p : 0,024</b>  |
| Fall during the study                              | 0,2                               | [0,1-1,1] p : 0,074          |

<sup>a</sup>Mean difference adjusted by ANCOVA and OR: Odds Ratio, 95% CI: 95% confidence interval, p: p-value (statistically significant if  $< 0.05$ , bold). PPME: Physical Performance and Mobility Examination.

**Table IVb.** — Medical and orthopaedic complications, length of stay and mortality (incidence) and comparison of groups. Ottensen et al (13) and Atzmon et al. (15).

|                           | Ottensen et al (13)                    |                                        |                                       | Atzmon (15)                                                    |                                                                  |                                                                |                                                             |
|---------------------------|----------------------------------------|----------------------------------------|---------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------|
|                           | FWB                                    | PWB                                    | OR [95% CI]<br>p value <sup>a</sup>   | FWB                                                            | PWB                                                              | NWB                                                            | OR [95% CI]<br>p value <sup>a</sup>                         |
| n patients                | 3668                                   | 1250                                   | -                                     | 1791                                                           | 127                                                              | 186                                                            | -                                                           |
| Minor complications       | 24 (6,5%)                              | 104 (8,3%)                             | 1.23 [0,96-1,57].<br><i>p</i> : 0,106 | /                                                              | /                                                                | /                                                              | /                                                           |
| Severe complications      | 361 (9,8%)                             | 168 (13,4%)                            | 1,34 [1,10-1,64]<br><i>p</i> : 0,004  | AVC : NC<br>(3,7%)<br>EP : NC<br>(1,1%)<br>TVP : NC.<br>(2,4%) | AVC : NC.<br>(3,9%)<br>EP : NC.<br>(1,6%)<br>TVP : NC.<br>(7,1%) | AVC : NC<br>(2,1%)<br>EP : NC.<br>(1,6%)<br>TVP : NC<br>(1,6%) | NR <i>p</i> 0,055<br>NR <i>p</i> 0,690<br>NR <i>p</i> 0,070 |
| Orthopaedic complications | RC : 79<br>(2,1%)                      | RC : 27<br>(2,2%)                      | 0.95 [0,60-1.50]<br><i>p</i> : 0,814  | /                                                              | /                                                                | /                                                              | /                                                           |
| Length of stay            | ≥ 7 jours :<br>793 patients<br>(21,6%) | ≥ 7 jours :<br>398 patients<br>(31,8%) | 1.59 [1,37-1,85].<br><i>p</i> < 0,001 | 9 days<br>(on average)                                         | 9,5 days<br>(on average)                                         | 7,5 days<br>(on average)                                       | NR <i>p</i> < 0,0001                                        |
| Mortality rate            | 117 patients<br>(3,2%)<br>to 30 days   | 69 patients<br>(5,5%)<br>to 30 days    | 1.58 [1.15-2.17]<br><i>p</i> : 0,005  | 38,9 %<br>to 3,5 years                                         | 52,0 %<br>to 3,5 years                                           | 64,7%<br>to 3,5 years                                          | NR <i>p</i> < 0,001                                         |

FWB: Full weight bearing; PWB: partial weight bearing; SR: surgical revision within 30 days; NWB: non weight bearing; NR: not reported; PE: pulmonary embolism; DVT: deep vein thrombosis; Group Comparison a: OR: Odds Ratio; 95% CI: 95% confidence interval; p = p-value (statistically significant if < 0.05 – above in bold); /: not studied by the authors.

**Table IVc.** — Medical and orthopaedic complications, length of stay and mortality (incidence) and group comparison. Bouché et al. (16) et Takemoto et al. (17).

|                                   | Bouché et al. (16)                                       |                                                          |                                              | Takemoto et al (17) |                     |                                   |
|-----------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------|---------------------|---------------------|-----------------------------------|
|                                   | FWB                                                      | PWB                                                      | OR 95% CI p<br>value                         | FWB                 | PWB                 | OR 95% CI<br>p value <sup>a</sup> |
| n patient                         | 184                                                      | 70                                                       | —                                            | 82                  | 41                  | —                                 |
| Unspecified medical complications | The MEAN<br>APRETAR Score<br>d45: 5,6<br><br>at d90: 4,4 | The MEAN<br>APRETAR Score<br>d45: 5,9<br><br>at d90: 0,2 | NR <i>p</i> < 0,01<br><br>NR <i>p</i> : 0,02 | 5 (6,1%)            | 1 (2,4%)            | NR<br><i>p</i> : 0,662            |
| Orthopaedic complications         | /                                                        | /                                                        | /                                            | EC : 2 (2,4%)       | EC : 5<br>(12,2%)   | NR..<br><i>p</i> : 0,041          |
| Length of stay                    | /                                                        | /                                                        | /                                            | 41 days (median)    | 40 days<br>(median) | NR..<br><i>p</i> : 0,735          |
| Mortality rate                    | 20 (10.9%) at 1<br>year                                  | 10 (14.3%) at 1<br>year                                  | NR <i>p</i> : 0,54                           | /                   | /                   | /                                 |

FWB: full weight bearing; PWB: partial weight bearing; SR: surgical revision within 30 days; CN: centromedullary nail DHS: dynamic hip screw HA: hemi-arthroplasty; NR: not reported; NWB: non weight-bearing; EP : pulmonary embolism; DVT: deep vein thrombosis; APRETAR score: unvalidated score of medical complications developed by Bouché et al. [16] ranging from 0 to 46 (46 corresponding to the patient's death); EC: surgical failure; OR: odds ratio; 95% CI: 95% confidence interval; p = p-value (statistically significant if < 0.05 – above in bold). /: not studied by the authors.

Atzmon et al.<sup>15</sup> who observed up to 25% difference in mortality at 3.5 years between the FWB and NWB groups. Finally, Warren et al. observed a lower mortality at 1 month (*p*<0.001) in the group in full weight-bearing operated with centromedullary nail<sup>14</sup>. This difference is not found in patients treated with

arthroplasty. Bouché<sup>14</sup> et al., on the other hand, did not find any difference between groups in the mortality rate<sup>16</sup> Bouché et al.<sup>16</sup> observed similar results, with a reduction in complications at 45 days, although this trend reversed at 90 days. As for Atzmon et al.<sup>15</sup> and Takemoto et al<sup>17</sup>, they did not find a significant

**Table IVd.** — Medical and orthopaedic complications, length of stay and mortality (incidence) and group comparison. Warren et al. (14).

|                           | CN                             |                                |                                                  | DHS                         |                                   |                                           | HA                             |                                   |                                          |
|---------------------------|--------------------------------|--------------------------------|--------------------------------------------------|-----------------------------|-----------------------------------|-------------------------------------------|--------------------------------|-----------------------------------|------------------------------------------|
|                           | FWB                            | PWB                            | OR [95% CI]<br>p value                           | FWB                         | PWB                               | OR [95% CI]<br>p value                    | FWB                            | PWB                               | OR [95% CI]<br>p value                   |
| n patients                | 2858                           | 1182                           | —                                                | 823                         | 315                               |                                           | 2164                           | 605                               | —                                        |
| Minor complications       | 1437<br>(50,3%)                | 788<br>(66,7%)                 | 0,62<br>[0,53-0,72]<br><i>p &lt; 0,001</i>       | 361<br>(43,9%)              | 189<br>(60,0%)                    | 0,71<br>[0,52-0,95]<br><i>p : 0,023</i>   | 874<br>(40,4%)                 | 301<br>(49,9%)                    | 0,83<br>[0,68-1,02]<br><i>p : 0,074</i>  |
| Severe complications      | 394<br>(13,8%)                 | 235<br>(19,9%)                 | 0,75<br>[0,62-0,90]<br><i>p : 0,002</i>          | 90 (10,9%)                  | 65<br>(20,6%)                     | 0,59<br>[0,41-0,87]<br><i>p : 0,007</i>   | 320<br>(14,8%)                 | 102<br>(16,9%)                    | 0,96<br>[0,75-1,24]<br><i>p : 0,783</i>  |
| Orthopaedic complications | RC : 51<br>(1,8%)              | RC : 23<br>(1,9%)              | 1,08<br>[0,65-1,80]<br><i>p : 0,774</i>          | SR : 14<br>(1,7%)           | SR : 13<br>(4,1%)                 | 0,45<br>[0,20-1,02]<br><i>p : 0,057</i>   | SR : 5<br>(2,6%)               | SR : 13<br>(2,1%)                 | 1,31<br>[0,70-2,44]<br><i>p : 0,402</i>  |
| Length of stay            | -1,7 days                      | +1,7<br>jours                  | NR<br>[-1,51-<br>(-0,63)]<br><i>p &lt; 0,001</i> | -1.5 days                   | +1,5<br>jours                     | NR<br>[-2,41- 0,56]<br><i>p : 0,002</i>   | -0,5 days                      | +0,5<br>days                      | NR<br>[-1,01 – 0,05]<br><i>p : 0,079</i> |
| Mortality rate            | 84 (2,9%)<br><br>to 30<br>days | 81 (6,9%)<br><br>to 30<br>days | 0,53<br>[0,38-0,74]<br><i>p &lt; 0,001</i>       | 23 (2,8%)<br><br>to 30 days | 19<br>(6,0%)<br><br>to 30<br>days | 0,59<br>[0,30 – 1,16]<br><i>p : 0,127</i> | 83 (3,8%)<br><br>to 30<br>days | 27<br>(4,5%)<br><br>to 30<br>days | 1,07<br>[0,67-1,71]<br><i>p : 0,771</i>  |

CC: centromedullary nail DHS: dynamic hip screw HA: hemiarthroplasty; FWB: full weight-bearing; PWB: partial weight-bearing; SR: surgical revision within 30 days; NR: not reported; Group comparison a: OR: odds ratio; 95% CI: 95% confidence interval; p = p-value (statistically significant if < 0.05 – above in bold); /: not studied by the authors.

**Table IVe.** — Orthopaedic complications according to weight-bearing status.

| STUDY           | Type of fracture /<br>implant | FWB complications               | PWB/NWB complications | Main findings              |
|-----------------|-------------------------------|---------------------------------|-----------------------|----------------------------|
| TAKEMOTO ET AL. | Trochanteric fractures        | Lower implant failure           | Higher failure        | Significant difference     |
| WARREN ET AL.   | CN / DHS / HA                 | No difference in revision rates | No difference         | No significant association |
| OTTESEN ET AL.  | Mixed                         | Similar revision rates          | Similar               | No difference              |

CN: centromedullary nail; DHS: Dynamic hip screw; HA: Hemiarthroplasty.

difference in medical complications based on weight-bearing status. However, they only investigated certain complications such as thromboembolic episodes, strokes, heart failure, lung and urinary tract infections, while Ottesen et al.<sup>13</sup>, Warren et al.<sup>14</sup> and Bouché et al.<sup>16</sup> analyzed most complications by system. Orthopaedic complications are a key concern when evaluating postoperative weight-bearing strategies, yet they were inconsistently reported across the included studies, only Takemoto et al. systematically specifically assessed implant-related complications and found a higher rate of failure in the restricted weight-bearing group<sup>17</sup>. In contrast, larger database studies (Ottesen et al., Warren et al.) did not report significant differences in revision rates between weight-bearing strategies (Tables IVb, IVc, IVd, IVe).

### Length of stay

The length of hospital stay has also been analyzed in several studies<sup>12–15,17</sup>. It appears that full and early weight bearing is associated with a shorter length of stay, according to Ottesen et al.<sup>13</sup>. Warren et al.<sup>14</sup> made the same observation for patients treated with centromedullary nailing (-1.1 days;  $p < 0.001$ ) and DHS (-1.5 days;  $p = 0.002$ ). In contrast, Atzmon et al. observed an increase in the length of stay in the partial weight-bearing group (+0.5 days;  $p < 0.0001$ ), through their study which distinguishes between partial, full and non-weight-bearing<sup>15</sup>. As for Takemoto et al.<sup>17</sup> and Moseley et al.<sup>12</sup>, they report no differences between groups in this regard (Tables IVa, IVb, IVc, IVd, IVe).

## DISCUSSION

While current recommendations for verticalization and early weight bearing of elderly patients who have suffered a fracture of the proximal femur tend to harmonize towards early mobilisation without restriction<sup>3,9,19</sup>, there are nevertheless significant variations in the rehabilitation protocols proposed in this context<sup>4</sup>. This systematic review of the literature based on seven studies<sup>11-17</sup> aims to determine the value of total or partial weight-bearing via different outcomes such as functional outcomes, medical and/or orthopaedic complications, mortality rate and length of stay.

In terms of functional outcomes, the included studies indicate that weight-bearing exerts a favorable but very limited influence. This influence is mainly manifested in certain functional tests such as the repetitions of standing from the sitting position. Early mobilisation has been shown to preserve functional status and reduce hospitalisation duration in elderly hip fracture patients, supporting the rationale for early weight-bearing strategies<sup>20</sup>. The systematic review by Lizano-Diez et al. on unstable pertrochanteric fractures concluded that there was no improvement in functional results at one year<sup>4</sup>. However, one study states that in patients with mild cognitive impairment, unrestricted weight-bearing results in substantial improvement in functional scores<sup>12</sup>. The evidence regarding functional outcomes remains particularly limited, as only two studies addressed this endpoint.

In addition, heterogeneity in outcome measures and study design further limits comparability. As such, any apparent benefit of early weight-bearing on functional recovery should be considered exploratory and hypothesis-generating rather than conclusive. Although early weight-bearing is widely advocated to facilitate functional recovery after hip fracture surgery, the available evidence supporting this recommendation remains largely indirect. Only two studies specifically evaluated functional outcomes, and both used different assessment tools, limiting the strength and generalizability of their findings.

Medical complications are mentioned in most of the selected studies, although definitions and reporting varied considerably<sup>13-17</sup>. Unrestricted weight bearing is associated with a lower incidence of both minor and major complications in the acute phase of hospitalisation, especially for patients treated with centromedullary nailing<sup>13,14,16</sup>. On the other hand, two authors find no significant difference according to the weight-bearing status<sup>15,17</sup>. This discrepancy may be

explained by differences in study design and the scope of complications assessed, with some studies focusing on a limited number of outcomes. Similarly, medical complications may be underestimated in studies that do not involve a geriatric or internal medicine teams. More broadly, the early mobilisation of elderly patients after surgery allows a reduction in complications related to the prolonged immobilisation, particularly in older patients with multiple comorbidities<sup>21</sup>. However, none of the authors of the included studies systematically collected the comorbidities and/or medical history of the participants included in their study. Causality cannot be established, and it remains unclear if the reduction in complications detected in our references is solely related to early weight-bearing. In addition, the restriction of weight-bearing does not seem to protect against orthopaedic complications<sup>17</sup> as reported in the literature<sup>22</sup>. Moreover, most included studies were not specifically designed or adequately powered to detect relatively uncommon orthopaedic outcomes such as implant failure, loss of fixation, or mechanical complications. Therefore, the absence of significant differences should not be interpreted as definitive evidence of equivalent safety. As for the discharge, it would on the contrary increase the time needed to obtain a good bone callus by 37 days<sup>23</sup> and could induce a lack of consolidation due to the lack of the mechanical stimulus<sup>24</sup>. Overall, the current evidence does not support that early full weight-bearing increases the risk of orthopaedic complications. However, the limited number of studies specifically addressing this outcome, as well as the heterogeneity in definitions and reporting, prevents definitive conclusions.

From a biomechanical perspective, early weight-bearing may even promote bone healing through mechanical stimulation, although this hypothesis remains insufficiently supported by clinical data in this population. Importantly, the decision to restrict weight-bearing does not primarily depend on the surgical technique itself, but rather on biomechanical factors such as fracture stability, quality of reduction, fixation parameters (e.g., tip-apex distance), and bone quality. Therefore, attributing delayed or restricted weight-bearing to the surgical technique alone may be overly simplistic and potentially misleading. These factors represent major confounders, as they are independently associated with mechanical failure risk, thus introducing significant indication bias in observational studies. The impact of weight-bearing on mortality remains a key but controversial outcome. Some authors<sup>13-15</sup> report an increase in the

risk of death in groups with weight-bearing restriction of up to 64.7% at 3.5 years<sup>15</sup>. A more pronounced reduction in mortality was observed following early mobilisation in elderly patients treated with centromedullary nailing or DHS compared to patients treated with arthroplasty<sup>15</sup>. Bouché et al.<sup>16</sup> do not observe a significant difference in mortality at 1 year according to the weight-bearing status and even go so far as to conclude that deferral of weight bearing can be proposed, if necessary, with an acceptable level of medical risk. Meesen et al., on the other hand, emphasized that mortality after hip fracture is primarily driven by patient-related factors, including age, male sex, and comorbidity burden, rather than postoperative weight-bearing protocols<sup>25,26</sup>. Overall, mortality following hip fracture surgery appears to be multifactorial and may be influenced by treatment strategy as well as patient selection, as previously reported in studies comparing fixation and arthroplasty techniques<sup>27</sup>.

Regarding the length of stay, according to Warren et al.<sup>14</sup>, it appears to be shorter in cohorts treated with osteosynthesis that benefit from early weight-bearing, whereas this association was not observed in those undergoing arthroplasty<sup>14</sup>. This observation agrees with the systematic review by Lizano-Díez et al.<sup>4</sup> carried out in 2020 but is in opposition to the study by Atzmon et al. which highlights a shorter length of stay for patients with weight bearing restriction<sup>15</sup>. Early stabilization techniques enabling rapid mobilisation have also been associated with shorter hospital stay and facilitated rehabilitation in elderly patients<sup>28</sup>. Weight-bearing status should not be considered the sole determinant of length of stay. Multiple factors contribute to prolonged hospitalisation, including baseline clinical and demographic characteristics, as well as the occurrence of medical complications during the hospital stay. In addition, discharge planning, particularly the need for transfer to a rehabilitation or nursing facility, plays a key role in determining hospital length of stay<sup>29,30</sup>.

Notably, this systematic review has several limitations. Only studies in French and English were analyzed. In addition, there is a lack of homogeneity in outcomes, study designs, sample sizes and follow-up duration among the included studies, making the results difficult to compare. In addition, there is a lack of systematic data collection on comorbidities, complications and causes of death. A lack of information on the weight-bearing protocols and the rationale underlying these decisions was also noted. These variations hinder the ability to draw firm

conclusions. Therefore, further studies will be needed to support and validate the results obtained through full and early weight-bearing. However, despite the lack of certainty about the benefits of this practice, this is the current trend in the management of patients operated on for a proximal femur fracture, thus aligning with international recommendations<sup>3,9,19,31</sup>. More effort is needed to define the populations for which full weight-bearing is appropriate, leaving the choice of support status to the surgeon's own sometimes subjective assessment. In addition, "weight-bearing as tolerated" remains an inherently subjective prescription. None of the included studies objectively quantified postoperative weight-bearing using validated monitoring techniques such as force sensors, instrumented insoles, or gait analysis, making compliance difficult to assess. It is also important to manage the specific medical complications of older people<sup>32</sup>. To achieve this objective, the establishment or optimisation of orthogeriatric courses is necessary<sup>33</sup>. The integration of geriatric doctors into rehabilitation services could be a promising approach for comprehensive care.

A critical limitation of the present review lies in the risk of bias inherent to the included studies. Most of the evidence is derived from observational designs, which are particularly prone to confounding and selection bias<sup>13-17</sup>.

In clinical practice, weight-bearing prescriptions are not randomised, which further increase the risk of selection bias. As a result, patients allowed early full weight-bearing are likely to represent a selected subgroup with a more favorable baseline profile<sup>13-15,17</sup>. This may partly explain the observed association between unrestricted weight-bearing and lower mortality or complication rates, independently of the mechanical or biological effects of weight-bearing itself<sup>13-15</sup>. Furthermore, the heterogeneity in outcome definitions and the lack of systematic adjustment for confounding variables across studies limit the ability to draw causal inferences<sup>13-17</sup>. Therefore, the results of this review should be interpreted with caution, and the apparent benefits of early weight-bearing should not be considered definitive evidence of superiority, but rather as an association requiring confirmation in well-designed randomised controlled trials. Future prospective studies should prioritize validated functional outcome measures and patient-reported outcome measures (PROMs) to better determine the true functional impact of postoperative weight-bearing protocols.

The absence of meta-analysis represents a limitation of this review but reflects the substantial

heterogeneity across included studies<sup>11–17</sup>. Differences in study design, patient characteristics, surgical techniques, and definitions of weight-bearing, as well as variability in outcome reporting, precluded meaningful quantitative pooling of results<sup>11–17</sup>. Performing a meta-analysis under such conditions could have led to misleading conclusions due to the combination of non-comparable data. Future studies with standardised definitions and outcome measures are needed to allow quantitative synthesis.

Although several studies suggest that unrestricted weight-bearing is associated with lower mortality and fewer complications<sup>13–15</sup>, these findings should be interpreted with caution.

Most of the included studies are observational and therefore subject to confounding and selection bias<sup>13–17</sup>. In clinical practice, the decision to allow early full weight-bearing is not random but depends on multiple factors, including patient frailty, comorbidities, cognitive status, and fracture stability<sup>13–15,17</sup>. Therefore, the observed benefits of early weight-bearing likely reflect selection bias rather than a true causal effect. This limitation is inherent to most observational studies included in this review and significantly restricts causal interpretation.

## CONCLUSION

The results of this systematic review suggest that early weight-bearing may be associated with lower mortality, reduced medical complications, and shorter hospital stay in elderly patients following surgically treated proximal femur fractures. However, the level of evidence is low to moderate, and causality cannot be established.

Early weight-bearing does not appear to increase orthopaedic complications and may facilitate improved clinical outcomes. However, these findings are likely influenced by patient selection and fracture-related factors rather than weight-bearing alone.

Future research should focus on well-designed randomised controlled trials using standardised weight-bearing protocols, validated functional outcome measures, and patient-reported outcomes, while incorporating patient stratification based on fracture stability, fixation quality, and bone quality to better determine the independent effect of postoperative weight-bearing.

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## Appendices

### Appendix 1. Database and search equations

The literature search was conducted in several bibliographic databases: MEDLINE (via Ovid), Embase and Scopus database. A date limit has been introduced (between 01.01.2003 and 04.06.2024).

#### MEDLINE Database via Ovid (Search Equation):

Database: Ovid MEDLINE(R) ALL <1946 to June 03, 2024>

- 1 weight-bearing/ or partial weight-bearing/
- 2 ((early or partial) adj2 weight-bearing).ti,ab,kf.
- 3 ((early or partial) adj2 weight bearing).ti,ab,kf.
- 4 1 or 2 or 3
- 5 Femoral Fractures/
- 6 (femoral adj2 fracture\*).ti,ab,kf.
- 7 hip fractures/ or femoral neck fractures/
- 8 proximal femur fracture\*.ti,ab,kf.
- 9 Proximal Femoral Fractures/
- 10 5 or 6 or 7 or 8 or 9
- 11 Aged/
- 12 elderly.ti,ab,kf.
- 13 aged.ti,ab,kf.
- 14 11 or 12 or 13
- 15 fracture fixation/ or fracture fixation, internal/
- 16 fracture fixation\*.ti,ab,kf.
- 17 surgical fixation\*.ti,ab,kf.
- 18 15 or 16 or 17
- 19 4 and 10 and 14 and 18

#### PubMed (MEDLINE) search strategy:

("Weight-Bearing"[Mesh] OR "weight bearing"[tiab] OR "partial weight bearing"[tiab] OR "early weight bearing"[tiab]) AND ("Hip Fractures"[Mesh] OR "Femoral Fractures"[Mesh] OR "proximal femur fracture"[tiab] OR "femoral neck fracture"[tiab]) AND ("Aged"[Mesh] OR elderly[tiab] OR aged[tiab]) AND ("Fracture Fixation"[Mesh] OR "surgical fixation"[tiab])  
Filters: Humans, English or French, publication date from 2003/01/01 to 2024/06/07

#### Scopus Database (Search Equation):

(TITLE-ABS-KEY(early or partial w/2 weight-bearing)) AND ((TITLE-ABS-KEY("femoral fracture\*")) OR (TITLE-ABS-KEY("hip fracture\*")) OR (TITLE-ABS-KEY("femoral neck fracture\*")) OR (TITLE-ABS-KEY("proximal femur fracture\*"))) AND ((TITLE-ABS-KEY("aged")) OR (TITLE-ABS-KEY("elderly"))) AND ((TITLE-ABS-KEY("fracture fixation\*")) OR (TITLE-ABS-KEY("surgical fixation\*")))

#### Embase Database (Search Equation):

('weight bearing'/exp OR 'weight bearing' OR 'partial weight bearing' OR 'early weight bearing') AND (femur fracture' OR 'hip fracture' OR 'femoral neck fracture' OR 'proximal femur fracture') AND ('aged' OR 'very elderly' OR elderly) AND ('fracture fixation' OR (surgical AND fixation))