Archives of Orthopaedic and Trauma Surgery (2019) 139:1253–1259
https://doi.org/10.1007/s00402-019-03193-9

TRAUMA SURGERY

Weight-bearing restrictions reduce postoperative mobility in elderly hip fracture patients

Daniel Pfeufer[1,2] · Anne Zeller[2] · Stefan Mehaffey[2] · Wolfgang Böcker[2] · Christian Kammerlander[2] · Carl Neuerburg[2]

Received: 16 January 2019 / Published online: 3 May 2019

Abstract

Background and purpose Reduced mobility is a severe threat to the clinical outcomes and survival of elderly hip fracture patients. These patients generally struggle to comply with partial weight bearing, yet postoperative weight-bearing restrictions are still recommended by nearly 25% of surgeons. Therefore, we hypothesized that weight-bearing restrictions in elderly hip fracture patients merely leads to reduced mobility, while transposing full weight to the fractured extremity remains unaffected disregarding the prescribed aftercare.

Patients and methods 41 equally treated patients with pertrochanteric fractures were enrolled consecutively in a maximum care hospital in a pre–post study design (level of evidence 2). A study group of 19 patients was instructed to maintain partial weight bearing (PWB), whereas the control group of 22 patients was instructed to mobilize at full weight bearing (FWB). All patients were asked to participate in a gait analysis using an insole force sensor (loadsol®, Novel, Munich, Germany) on the fifth postoperative day.

Results The postoperative Parker Mobility Score in the PWB group compared to the FWB group was significantly reduced (3.21 vs. 4.73, $p < 0.001$). Accordingly, a significantly lower gait speed in the PWB group of 0.16 m/s vs. 0.28 m/s was seen ($p = 0.003$). No difference in weight bearing was observed in between the groups (average peak force 350.25 N vs. 353.08 N, $p = 0.918$), nor any differences in the demographic characteristics, ASA Score, Barthel Index or EQ5D.

Interpretation Weight-bearing restrictions in elderly hip fracture patients contributed to a loss of mobility, while no significant differences in loading of the affected extremity were observed. Therefore, postoperative weight-bearing restrictions in elderly hip fracture patients should be avoided, to achieve early mobilization at full weight bearing.

Keywords Mobility · Hip fracture · Gait analysis

✉ Daniel Pfeufer
d.pfeufer@icloud.com

Anne Zeller
zeller.anne@gmx.de

Stefan Mehaffey
Stefan.mehaffey@med.uni-muenchen.de

Wolfgang Böcker
wolfgang.boecker@med.uni-muenchen.de

Christian Kammerlander
Christian.kammerlander@med.uni-muenchen.de

Carl Neuerburg
carl.neuerburg@med.uni-muenchen.de

1 Department of Orthopaedics, University of Utah, Salt Lake City, USA

2 Department of General, Trauma and Reconstructive Surgery, Munich University Hospital LMU, Munich, Germany

Introduction

Reduced mobility in hip fracture patients is a severe threat to the clinical outcome and survival of elderly hip fracture patients [10]. These patients benefit from early mobilization without any weight-bearing restriction [23]. Furthermore, every day of bed rest and immobilization can trigger complications such as urinary tract infections, pneumonia, thromboses or pressure ulcers [7, 9, 23]. Even a short-term muscle disuse can lead to substantial declines in muscle mass and function [4, 25].

Cut-out and fracture fixation failures are regularly observed in proximal femur fracture patients [12, 14, 17]. Fracture fixation failure, i.e., due to early weight bearing and reduced bone quality, is a concern many surgeons have, and therefore partial weight bearing is still recommended by nearly 25% of surgeons for the aftercare of hip fracture patients in an attempt to “protect the osteosynthesis” from overloading [3, 18]. A recent study by Ottesen et al. showed that in a cohort of nearly 5000 patients only 64% were allowed to weight bear as tolerated postoperatively and that the compliance with the evidence-based guidelines is still low. On the other hand, it has been shown that elderly patients do not comply with instructions they are given for partial weight bearing [11]. Braun et al. also showed a low compliance concerning weight-bearing restrictions in lower extremity fractures using an insole sensor [2].

Taking into account, that weight-bearing restrictions in elderly hip fracture patients will not prevent from full weight bearing to the affected extremity [11], we hypothesized that partial weight-bearing recommendations will lead to reduced mobility, which potentially causes further complications.

Methods

In this prospective cohort study (level of evidence 2), all patients meeting the following inclusion criteria were asked to participate: age > 75 years, written informed consent and a fracture of the trochanteric area. Exclusion criteria were: delirium, Mini-Mental State Examination Test < 26, language barrier, severe medical illness or comorbidities, and immobility prior to surgery. Thus, 41 patients gave their written informed consent and were enrolled in this cohort study (Fig. 1). Patients that underwent surgery before October 2017 were included in the partial weight-bearing group (PWB), while all successive patients were placed in the full weight-bearing group (FWB). All patients underwent intramedullary nailing of the proximal femur (Co. DePuy/Synthes; PFNA, Umkirch, Germany) in our maximum care hospital, and were treated by the same team of surgeons and nursing staff. Starting on postoperative day 1, all patients were treated by the physiotherapy staff and trained on the recommended mode of aftercare. If possible patients were mobilized directly into walking, otherwise maintaining a seated or standing position was the treatment goal on the first postoperative day. Mobilization with partial weight bearing (PWB) of the affected extremity (< 20 kg) was instructed for the first 19 patients by using a bathroom scale in five sessions following surgery. Mobilization with full weight bearing (FWB) for the following 22 patients was performed by the same PT staff. Gait analysis was performed after these training sessions. All postoperative radiographs showed good implant positioning (PFNA blade in a center–center position in the femoral head) and accurate fracture reduction. Neither revision surgery nor immediate postoperative complications occurred during the follow up of 5 days.

The standardized pain medication regimen according to WHO treatment guidelines was used for all patients. No local pain catheter was in use during gait analysis. Patients were asked to participate in a gait analysis on the fifth postoperative day. A walking aid of the patients’ choice was allowed.

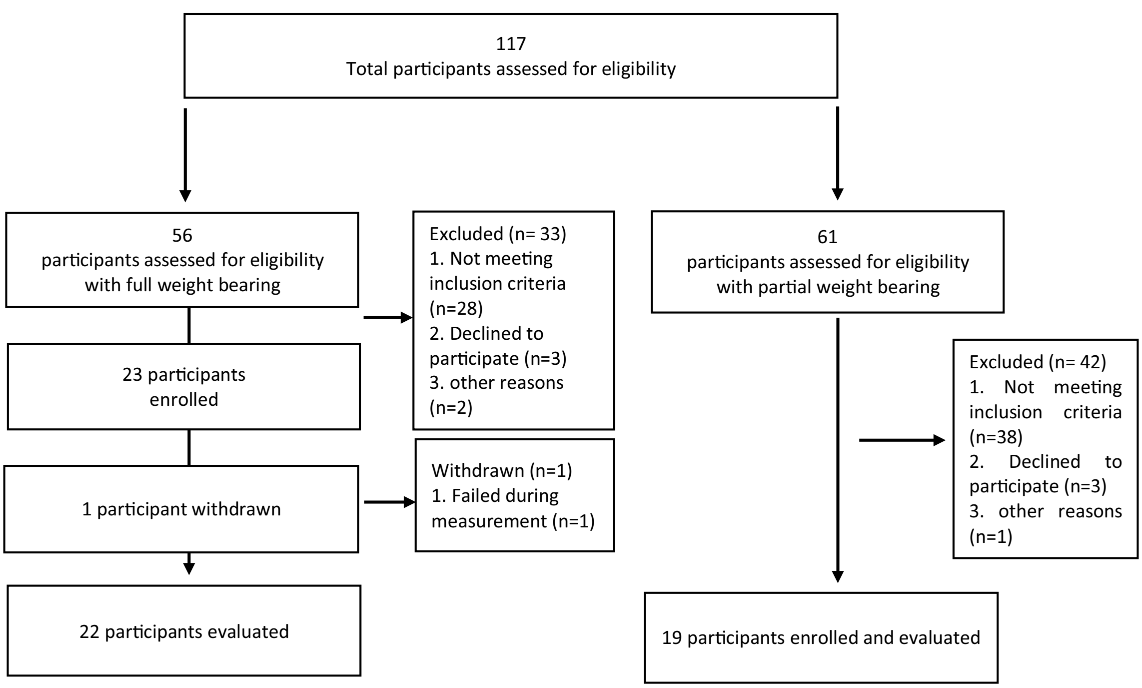

Fig. 1 The attrition flowchart depicting application of inclusion and exclusion criteria and withdrawal

A defined level walking distance of 40 m with an insole device in the patients' shoe was analyzed. The loadsol® insole by Novel (Munich, Germany) was fitted to the individual´s foot size and placed in each shoe. The insole communicates via Bluetooth with a tablet computer. A real-time data transmission allows immediate analysis and storage on the tablet. Both feet were recorded separately and parameters such as average peak force, average loading rate, and gait speed were determined. The plantar force in static and dynamic situations was measured with up to 200 Hz. The complete plantar surface of the foot was covered with the capacitive sensor.

Cognitive impairment was evaluated with the Mini-Mental State Examination (MMSE). Pre-fracture and postoperative mobility and activities of daily living were assessed using the Parker Mobility Score (PMS) and the Barthel Index (BI). By explicit inquiry on the pre-fracture mobility, we double checked that the questionnaires were answered correctly.

The local universities ethical review committee (Ref. No.: 214-16) approved the study, which was registered online under DRKS00012800.

Statistical analysis

Prior to the main analysis, all data were checked for normal distribution; therefore, the Shapiro–Wilk-Test was used. Depending on the outcome of this test, either the Mann–Whitney *U* test or the *t* test was performed to identify significant differences between groups. The Mann–Whitney *U* test was used for Parker Mobility Score for pre-fracture gait speed (m/s) and average loading rate (N/s). The t test was used for Parker Mobility Score for postop and average peak force (N). To check if the sample size in both groups was sufficiently large, a post hoc analysis with the program G*Power Version 3.1 (Heinrich-Heine-University, Düsseldorf) was performed [5, 6]. This analysis showed an effect size of 1.28 for the postoperative Parker Mobility Score. Gait speed had an effect size of 1.08. In conclusion, the sample size of 19 patients in the partial weight-bearing group and 22 patients in the full weight group is sufficient and leads to reliable results. The level of significance was set at $p < 0.05$.

Graphs and statistical analysis were calculated with IBM SPSS Statistics Version 25 (IBM Germany GmbH, Ehningen, Germany).

Results

The PWB group ($n = 19$) had a mean age of 84.37 years, (SD ± 6.65) with 14 female and 5 male patients, an average bodyweight of 65.15 kg (SD ± 19.06), and an average body mass index of 20.73 (SD ± 5.04). The FWB group ($n = 22$) had a mean age of 84.18 years, (SD ± 5.86) with 14 female and 8 male, an average bodyweight of 65.59 kg (SD ± 8.68) and an average body mass index of 23.70 (SD ± 2.23). The Fracture type was AO/OTA 31 A1—A3 and distributed equally as shown in Table 1.

The average ASA Score in the PWB group was 2.84 (SD ± 0.38) and 2.77 (SD ± 0.69) in the FWB group, showing no significant difference (p value 0.551, Table 1). In the FWB Group 18 patients were walking with a large walking frame, 3 on crutches and 1 with a walker. In the PWB group 16 patients were walking with a large walking frame and 3 with a walker.

Pre-fracture

The PWB group had a Barthel Index prior to fracture (BI pre) of 96.84 (SD ± 4.15), a Parker Mobility Score prior to fracture (PMS pre) of 8.53 (SD ± 0.84), and an EQ5D pre of 93.68 (SD ± 8.31).

The full weight-bearing group (FWB group) had a Barthel Index prior to fracture (BI pre) of 96.59 (SD ± 6.05), a Parker Mobility Score prior to fracture (PMI pre) of 8.09 (SD ± 1.63), and an EQ5D pre of 95.00 (SD ± 10.12). There

Table 1 Patient characteristics and results of daily living scores

Characteristic	Partial weight bearing ($n = 19$)	Full weight bearing ($n = 22$)
Body weight (N)	639.08 ± 187.14	633.64 ± 85.18
BMI (kg/m^2)	20.73 ± 5.04	23.70 ± 2.23
Age (years)	84.37 ± 6.65	84.18 ± 5.86
Female sex, *n* (%)	14 (73.7)	14 (63.6)
Barthel Index (pre/postop)	96.84 ± 4.15/67.37 ± 10.59	96.59 ± 6.05/66.36 ± 13.11
PMS (pre/postop)	8.53 ± 0.84/3.21 ± 1.03[a]	8.09 ± 1.63/4.73 ± 1.32[a]
ASA score	2.84 ± 0.38	2.77 ± 0.69
AO/OTA classification	AO 31-A1 $n = 7$ (36.8%) AO 31-A2 $n = 11$ (57.9%) AO 31-A3 $n = 1$ (5.3%)	AO 31-A1 $n = 9$ (40.9%) AO 31-A2 $n = 12$ (54.5%) AO 31-A3 $n = 1$ (4.5%)

[a]The Parker Mobility Score (PMS) dropped significantly more from pre-fracture to postop in the partial weight-bearing group ($p < 0.001$)

were no significant differences concerning these parameters between the groups prior to fracture (p values in Table 1).

Postoperative

The PWB group had a postoperative Barthel Index (BI postop) of 67.37 (SD ± 10.59), a Parker Mobility Score postoperative (PMS postop) of 3.21 (SD ± 1.03), and an EQ5D postoperative (EQ5D postop) of 48.42 (SD ± 18.64).

The full weight-bearing group had a postoperative Barthel Index (BI postop) of 66.36 (SD ± 13.11), a Parker Mobility Score postoperative (PMS postop) of 4.73 (SD ± 1.32), and an EQ5D postoperative (EQ5D postop) of 51.36 (SD ± 10.37).

The differences in the Parker Mobility Scores between the pre-fracture and postoperative measurements were significantly higher in the PWB group compared to the FWB group (Loss in PMS −5.32 versus −3.36, $p < 0.001$, Fig. 2). Both the Barthel Index and the EQ5D dropped postoperatively in each group, but no significant difference between the groups were seen.

Gait analysis

A significantly higher gait speed was observed in the FWB group of 0.28 m/s (SD ± 0.14) compared to the slower PWB group with 0.16 m/s (SD ± 0.07), $p = 0.003$, Fig. 3.

Loading of the affected limb was on average 350.25 N (SD ± 61.90) peak force in the FWB group, while the PWB group presented with 353.08 N (SD ± 103.39 N) average peak force ($p = 0.918$, Fig. 4). The loading rate in the FWB group was 645.55 N/s (SD ± 291.68), while the PWB group presented with 625.53 N/s (SD ± 394.01), ($p = 0.425$). There was no significant difference concerning the applied loading rate or the applied load between the two groups.

Discussion

A hip fracture is a life changing event for ortho-geriatric patients [15, 16, 22]. Mobilization in the early postoperative phase is of superior importance, as a delay is associated with diminished physical function at 2 months and a worse survival rate at 6 months [24]. Further, additional physiotherapy during acute care reduces falls in the first 12 months after hip fracture [8]. Perracini et al. stated that physiotherapy plays a vital role in the recovery of elderly patients from a hip fracture [20]. Reduced mobility, gait disturbances and falls might often be compounded by a fear of falling [13]. A cohort study investigating the risk of secondary hip fractures revealed, that patients having suffered a fracture of the hip are at a twofold risk of further hip fractures and the subsequent mortality is highly increased [21]. Furthermore, the authors reported that the cumulative incidence of secondary hip fracture was 9% after 1 year and 20% after 5 years. Subsequently, Lauretani et al. stated that a fear of falling further immobilizes patients and affects their quality of life and physical performance [13]. Thus, all restrictions on aftercare will reduce mobility in these patients.

The present study goes in line with the observations of previous groups. Thus, a significant correlation between weight-bearing recommendations and mobility, obtained via gait speed, and PMS, was observed.

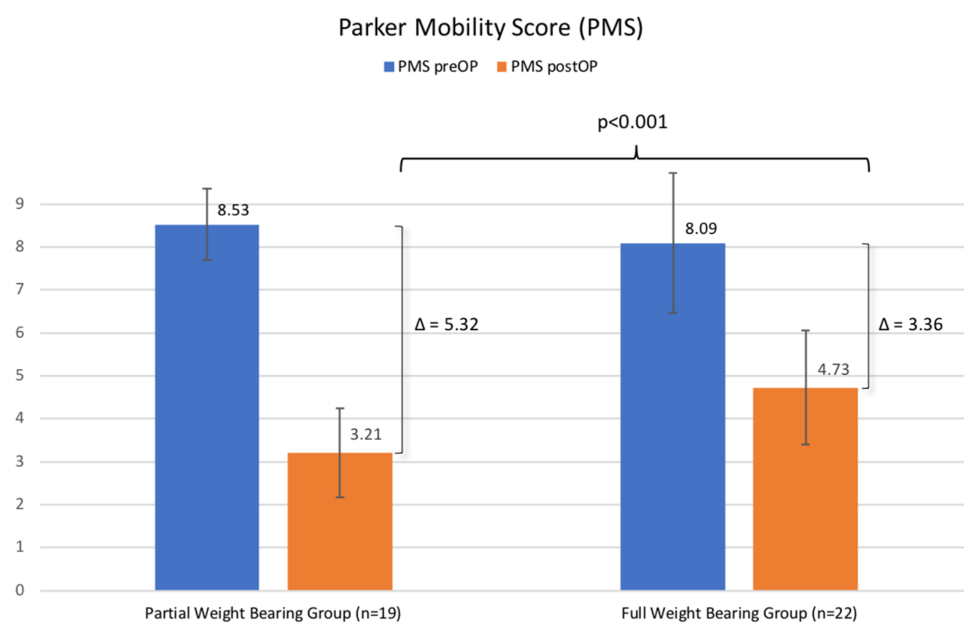

Fig. 2 The Parker Mobility Score prior to fracture and postoperatively for both groups. The partial weight-bearing group drops significantly lower in the PMS postoperative than the full weight-bearing group

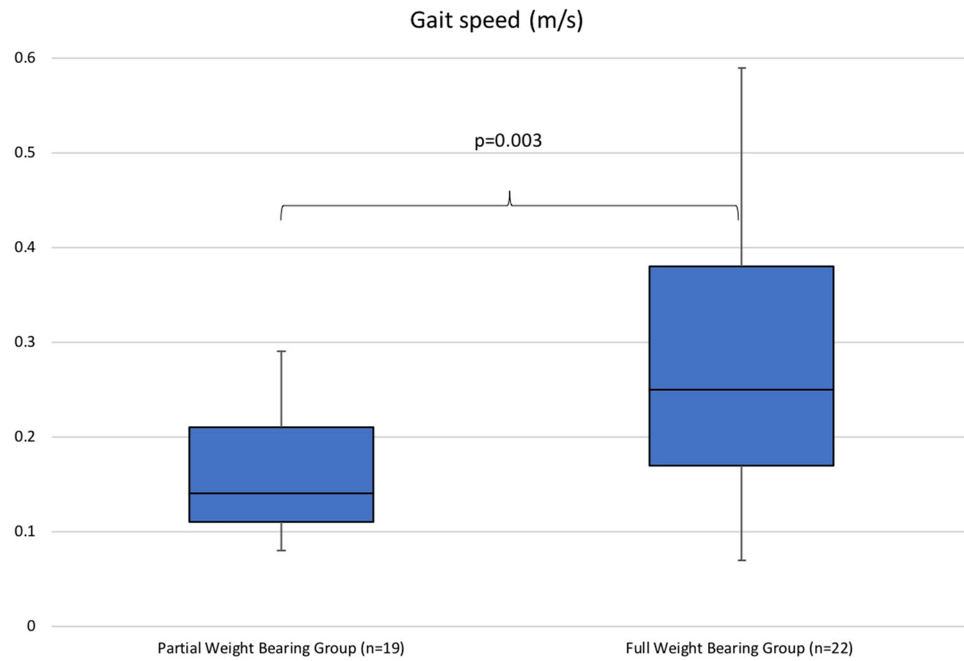

Fig. 3 The gait speed in meter/second during gait analysis for the partial weight-bearing group at the left and the full weight-bearing group at the right

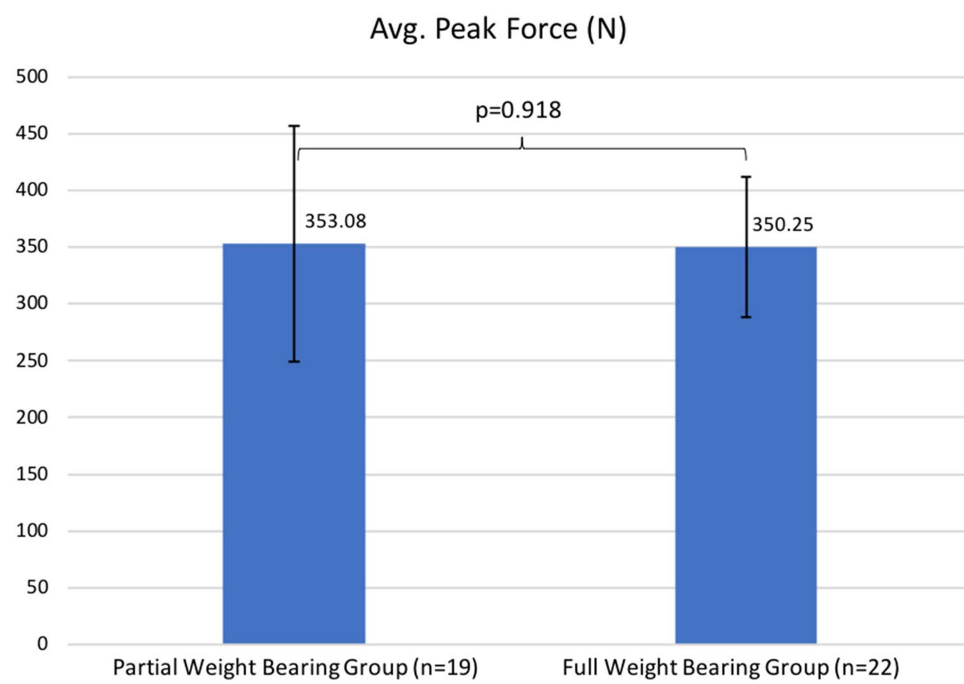

Fig. 4 The load on the affected limb in newton for the partial weight-bearing group at the left and the full weight-bearing group at the right

Key finding 1: significant reduction of Parker Mobility Score in the PWB Group

Although the patients received the same surgical treatment and care, the PWB group showed a significantly reduced postoperative Parker Mobility Score. For elderly hip fracture patients, the PMS has a high predictive value for the 1 year mortality [22]. The fact that many surgeons continue to instruct patients not to fully load the operated leg delays mobilization [18]. Patients might be afraid of overworking the operated leg, or feel unable to follow the given weight-bearing restrictions, and therefore rather rest than walk.

This reduction in mobility is not caused by the fact that these patients must use a walking aid to follow the weight-bearing restrictions, as the FWB group uses the same types of walking aids. Barthel Index and EQ5D both indicate a significant drop in the activities of daily life between the pre-fracture and postoperative time points.

No differences between the two groups were seen in BI and EQ5D. This is comprehensible, as both scores detect mobility and gait only in a few items of the entire questionnaires. Gait speed is significantly reduced in the PWB group compared to the FWB group. Minimal clinically important difference (MCID) is assumed to be 0.10 m/s by Palombaro et al., and in a review by Bohannon et al. the MCID is estimated to be between 0.10 and 0.20 m/s [1, 19]. The present study showed a difference of 0.12 m/s. This finding further emphasizes the negative impact that weight-bearing restriction can have on mobility.

Key finding 2: weight-bearing restrictions do not prevent from loading the affected limb

Load bearing between the two groups shows no significant difference with regards to average loading rate and the average peak force. Although the PWB group walks significantly slower, the applied forces remain the same. These findings are similar to the results of a previous study, in which it was observed that elderly patients were unable to comply with partial weight bearing [11].

A limitation of this study is the short time period observed, with postoperative measurements being carried out at the fifth postoperative day only. However, this gait analyses took place within the most vulnerable time frame. A 2- and 6-week follow-up, or ideally a continuous measurement, will be needed in future studies. But the first step was to detect a difference in mobility within a clinical setting in the early stage following hip fracture surgery, as early weight bearing should be the goal of treatment in elderly hip fracture patients.

If the patients were not adequately mobilized by this time point, consecutive complications would be more likely [24].

Conclusion

Weight-bearing restrictions in elderly hip fracture patients reduce mobility as observed in a limited gait speed and reduced PMS, while no substantial reduction of loading was observed compared to a control group with similar treatment at full weight-bearing. Thus, elderly hip fracture patients appear to be unable to follow weight-bearing restrictions which potentially cause immobility and loss of autonomy associated with a higher 1 year mortality rate and risk to suffer further complications.

Therefore, early mobilization with loading of the affected hip as tolerated is highly recommended and the surgical strategy should be adapted accordingly.

Acknowledgements We are grateful to Dr. Crispin for his help with the statistical analysis. We also want to thank Marissa Stagg and Leo Adolf Lisitano for help in realizing this paper.

Funding Funding was received from Friedrich-Baur-Foundation, (Ref. No. 29/16). Deutsche Forschungsgemeinschaft/Max Kade Foundation, Postdoctoral Research Fellowship (PF 939/1-0).

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to declare.

Ethics approval The local universities' ethics committee approved this study (Ref. No.: 214-16). All participants gave written informed consent before data collection began.

References

1. Bohannon RW, Glenney SS (2014) Minimal clinically important difference for change in comfortable gait speed of adults with pathology: a systematic review. J Eval Clin Pract 20(4):295–300. https://doi.org/10.1111/jep.12158
2. Braun BJ, Veith NT, Rollmann M, Orth M, Fritz T, Herath SC, Holstein JH, Pohlemann T (2017) Weight-bearing recommendations after operative fracture treatment—fact or fiction? Gait results with and feasibility of a dynamic, continuous pedobarography insole. Int Orthop 41(8):1507–1512. https://doi.org/10.1007/s00264-017-3481-7
3. Brumback RJ, Uwagie-Ero S, Lakatos RP, Poka A, Bathon GH, Burgess AR (1988) Intramedullary nailing of femoral shaft fractures. Part II: fracture-healing with static interlocking fixation. J Bone Jt Surg Am Vol 70(10):1453–1462
4. Dirks ML, Wall BT, van de Valk B, Holloway TM, Holloway GP, Chabowski A, Goossens GH, van Loon LJC (2016) One week of bed rest leads to substantial muscle atrophy and induces whole-body insulin resistance in the absence of skeletal muscle lipid accumulation. Diabetes 65(10):2862–2875. https://doi.org/10.2337/db15-1661
5. Faul F, Erdfelder E, Buchner A, Lang A-G (2009) Statistical power analyses using G*power 3.1: tests for correlation and regression analyses. Behav Res Methods 41(4):1149–1160. https://doi.org/10.3758/BRM.41.4.1149
6. Faul F, Erdfelder E, Lang A-G, Buchner A (2007) G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 39(2):175–191
7. Frenkel Rutenberg T, Vitenberg M, Haviv B, Velkes S (2018) Timing of physiotherapy following fragility hip fracture: delays cost lives. Arch Orthop Trauma Surg 138(11):1519–1524. https://doi.org/10.1007/s00402-018-3010-1
8. Hill K (2010) Additional physiotherapy during acute care reduces falls in the first 12 months after hip fracture. J Physiother 56(3):201. https://doi.org/10.1016/S1836-9553(10)70027-8
9. Kamel HK, Iqbal MA, Mogallapu R, Maas D, Hoffmann RG (2003) Time to ambulation after hip fracture surgery: relation to hospitalization outcomes. J Gerontol Ser A Biol Sci Med Sci 58(11):1042–1045
10. Kammerlander C, Gosch M, Kammerlander-Knauer U, Luger TJ, Blauth M, Roth T (2011) Long-term functional outcome in geriatric hip fracture patients. Arch Orthop Trauma Surg 131(10):1435–1444. https://doi.org/10.1007/s00402-011-1313-6
11. Kammerlander C, Pfeufer D, Lisitano LA, Mehaffey S, Böcker W, Neuerburg C (2018) Inability of older adult patients with hip

fracture to maintain postoperative weight-bearing restrictions. J Bone Jt Surg Am Vol 100(11):936–941. https://doi.org/10.2106/JBJS.17.01222
12. Knobe M, Münker R, Sellei RM, Schmidt-Rohlfing B, Erli HJ, Strobl CS, Niethard FU (2009) Unstable pertrochanteric femur fractures. Failure rate, lag screw sliding and outcome with extra- and intramedullary devices (PCCP, DHS and PFN). Zeitschrift Fur Orthopadie Und Unfallchirurgie 147(3):306–313. https://doi.org/10.1055/s-0029-1185349
13. Lauretani F, Meschi T, Ticinesi A, Maggio M (2017) 'Brain-Muscle Loop' in the fragility of older persons: from pathophysiology to new organizing models. Aging Clin Exp Res 29(6):1305–1311. https://doi.org/10.1007/s40520-017-0729-4
14. Lenich A, Vester H, Nerlich M, Mayr E, Stöckle U, Füchtmeier B (2010) Clinical comparison of the second and third generation of intramedullary devices for trochanteric fractures of the hip–blade vs screw. Injury 41(12):1292–1296. https://doi.org/10.1016/j.injury.2010.07.499
15. Magaziner J, Simonsick EM, Kashner TM, Hebel JR, Kenzora JE (1989) Survival experience of aged hip fracture patients. Am J Public Health 79(3):274–278
16. Morris AH, Zuckerman JD, AAOS Council of Health Policy and Practice, USA. American Academy of Orthopaedic Surgeons (2002) National consensus conference on improving the continuum of care for patients with hip fracture. J Bone Jt Surg Am Vol 84-A(4):670–674
17. Murena L, Moretti A, Meo F, Saggioro E, Barbati G, Ratti C, Canton G (2018) Predictors of cut-out after cephalomedullary nail fixation of pertrochanteric fractures: a retrospective study of 813 patients. Arch Orthop Trauma Surg 138(3):351–359. https://doi.org/10.1007/s00402-017-2863-z
18. Ottesen TD, McLynn RP, Galivanche AR, Bagi PS, Zogg CK, LE Rubin, Grauer JN (2018) Increased complications in geriatric patients with a fracture of the hip whose postoperative weight-bearing is restricted. Bone Jt J 100-B(10):1377–1384. https://doi.org/10.1302/0301-620X.100B10.BJJ-2018-0489.R1
19. Palombaro Kerstin M, Craik Rebecca L, Mangione Kathleen K, Tomlinson James D (2006) Determining meaningful changes in gait speed after hip fracture. Phys Ther 86(6):809–816
20. Perracini MR, Kristensen MT, Cunningham C, Sherrington C (2018) Physiotherapy following fragility fractures. Injury 49(8):1413–1417. https://doi.org/10.1016/j.injury.2018.06.026
21. Ryg J, Rejnmark L, Overgaard S, Brixen K, Vestergaard P (2009) Hip fracture patients at risk of second hip fracture: a nationwide population-based cohort study of 169,145 cases during 1977–2001. J Bone Miner Res 24(7):1299–1307. https://doi.org/10.1359/jbmr.090207
22. Schnell S, Friedman SM, Mendelson DA, Bingham KW, Kates SL (2010) The 1-year mortality of patients treated in a hip fracture program for elders. Geriatr Orthop Surg Rehabil 1(1):6–14. https://doi.org/10.1177/2151458510378105
23. Schwachmeyer V, Damm P, Bender A, Dymke J, Graichen F, Bergmann G (2013) In vivo hip joint loading during post-operative physiotherapeutic exercises. PLoS One 8(10):e77807. https://doi.org/10.1371/journal.pone.0077807
24. Siu AL, Penrod JD, Boockvar KS, Koval K, Strauss E, Morrison RS (2006) Early ambulation after hip fracture: effects on function and mortality. Arch Intern Med 166(7):766–771. https://doi.org/10.1001/archinte.166.7.766
25. Wall BT, Dirks ML, van Loon LJC (2013) Skeletal muscle atrophy during short-term disuse: implications for age-related sarcopenia. Ageing Res Rev 12(4):898–906. https://doi.org/10.1016/j.arr.2013.07.003