Case Report: An Evidence-based Approach to Examination and Intervention Following Hip Fracture

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ABSTRACT

Background and Purpose: A majority of older adults with hip fracture retain longstanding disabilities following surgery. Research suggests that more aggressive treatment techniques can improve outcome. The purpose of this case report is to describe an evidence-based approach to guide physical therapy examination and intervention for a woman with significant frailty recovering from hip fracture.

Case Description: The patient is a 97-year-old woman residing in a skilled nursing facility 3 months status-postsurgical repair of an intertrochanteric hip fracture. She had received 2 ½ months of physical therapy care using conventional interventions, however, had not regained her prefracture mobility status. She agreed to participate in a progressive high-intensity resistance training program over a 2-month period to augment her lower-extremity strength and function. The 5-day training regimen emphasized resistance training with a weighted belt twice-weekly with endurance and balance training interposed on nonstrength training days. The patient's goal was to return to community dwelling.

Examination: Lower-extremity isometric force was measured using handheld dynamometry. Functional mobility was assessed via Timed Up and Go, Six-Minute Walk, Berg Balance, and gait speed tests. A 9-item Physical Performance Test gauged degree of frailty.

Results: Hip extension, hip abduction, and knee extension isometric force scores on the involved lower-extremity increased by 8 kg, 3 kg, and 7 kg, respectively. Balance, frailty, and gait speed indices improved from 14 to 45, 8 to 18, and 0.50 to 0.83 m/s, respectively.

Conclusion: Prescribed high-intensity resistance training was used to improve the patient's functional status 2 months after completing a conventional physical therapy program.

Key Words: hip fracture, elderly, frailty, resistance training

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INTRODUCTION

The consequences of hip fractures are significant in terms of health care cost and reduced quality of life. More than 300,000 hip fractures occur yearly in the US among persons over the age of 50[1] with an anticipated increase in incidence by several hundred thousand over the next few decades related to an expanding geriatric population.[2,3] An estimated $5.4 billion is spent annually in care following hip fractures.[4] High costs are related to the high degree of disability observed in a majority of individuals who have sustained hip fractures.[5] Most do not return to their preinjury level of function.[5,6] The majority of those who receive physical therapy return to community living;[7] however, most report difficulty climbing stairs at 1 year following surgical repair.[5] In a prospective study of 120 older adults with hip fracture, Marottoli et al[6] found that only 32% were able to perform independent standing transfers and only 15% could walk across a room independently within 6 months of the initial fracture. A description of physical therapy interventions the patients may have received was not provided.[6]

Typical physical therapy interventions include gait and locomotion training, instructions on weight bearing precautions, active and resistive exercises, balance and coordination training, and home management and task adaptation to address impairments and functional limitations associated with hip fracture.[3] Many questions still remain about the appropriate implementation of therapeutic exercise for patients with hip fracture.[3] A randomized controlled trial by Binder et al[8] reported significant reductions in frailty applying the principle of exercise overload in the treatment of 90 elderly community dwelling patients with hip fracture. Mangione and Palombaro[9] detailed a treatment plan and relatively successful outcome emphasizing overload and specificity principles in their case report on a 68-year-old woman who underwent high-intensity resistance training (RT) 3 months after hip fracture surgery. A randomized controlled trial by Host et al[10] reported significant improvements in strength and physical function among frail older adults who participated in a 3-month course of progressive RT. But very frail older adults were excluded from the study and the authors hinted at the possibility of earlier application of RT.[10]

Fried et al define frailty as a "biologic syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems, and causing vulnerability to adverse outcomes."[11(M146)] Possible contributors include diminished strength, reduced range of motion (ROM), impaired balance, and decreased endurance.[12] In their study of 10 frail elderly long-term care recipients, Fiatarone et al[13] demonstrated the potential for improved functional performance following a 10-week high-intensity RT program. The effects of high-intensity RT on severely frail nonagenarians with hip fracture have not been clearly explicated.

An evidence-based examination is necessary to determine the appropriate physical therapy diagnosis and treatment plan for the patient.[14] Practicing in an evidence-based manner involves integrating the patient's values, best available evidence, and the clinician's expertise.[15] The purpose of this case report is to describe an evidence-based approach to guide physical therapy examination and intervention for a woman with significant frailty who is recovering from hip fracture.

CASE DESCRIPTION

AD was a 97-year-old resident of a skilled nursing facility (SNF). She was originally admitted to the SNF 1 ¼ years previous with left superior and inferior pubic rami fractures sustained in a fall at home. Prior to injury she lived independently in a local senior housing apartment, drove to and from physician appointments, ran errands in town, and ambulated independently without an assistive device. Her health status, post-fracture impairments, and functional limitations prevented return to community living, and she became a resident of the facility, ambulating independently with a wheeled walker.

Three months prior to the present episode of care, AD fell while standing from a bedside chair and sustained a left minimally displaced basilar femoral neck (intertrochanteric) hip fracture along with nondisplaced fractures of the left 6th, 7th, and 8th ribs. Her fractured ribs were thought likely to heal unassisted. Her hip fracture was surgically stabilized via open reduction internal fixation (ORIF) using an Arbeitsgemeinschaft für Osteosynthesefragen (AO) dynamic compression screw. Her orthopedic surgeon prescribed initial nonweight bearing on the left lower-extremity (LE) based on his clinical judgment regarding the severity of her osteoporosis.

AD received 2 ½ months of physical therapy in the SNF directly following her surgery with another therapist supervising. Interventions included ambulation training, transfer training, and bilateral LE open-chain ankle weight RT in five 30-minute treatment sessions each week. She performed multiple sets of at least 20 repetitions of knee extension and hip extension and abduction exercises with bilateral LE an average of 3 days each week. One month after surgery her weight bearing status was progressed to "weight bearing as tolerated" and aerobic training using a LE clinical restorator was initialized. Increased weight bearing eased her advancement from a bilateral platform rolling walker (RW) to a 2-wheeled RW during ambulation activities. She required supervision for all standing mobility activities using the 2-wheeled RW when her progress in physical therapy was said to have "plateaued."

High-intensity RT that targets weak LE musculature via personalized exercise prescriptions of 3 sets of 8 to 12 repetitions to fatigue has been shown to significantly improve physical function in younger less frail patients with hip fracture.[8] This mode of exercise had not been attempted with AD. Her chief complaint was not being able to walk by herself throughout the SNF. She also indicated a desire to return to her home. AD was apprised of the potential risks and benefits of undergoing high-intensity RT as well as the nature of this case report and she provided informed consent. Her attending physician and orthopedic surgeon each examined her and cleared her to participate.

EXAMINATION

Chart Review and History

AD was 1.40 m (55 in) tall and weighed 40.8 kg (89.8 lb) (BMI = 20.8). Recent x-rays showed moderate arthritic changes in both hip joints. One month after surgery her attending physician noted "depressive symptoms" that appeared to improve with a prescription of Remeron® (see Table 1). AD reported pain with prolonged ambulation as well as "morning stiffness" in both hips that temporarily abated with short morning walks. She had been experiencing this pain for over a year. This behavioral pattern and the results of her recent x-rays indicated chronic osteoarthritis as the etiology to her pain.[16] A 10-point Visual Analog Scale (VAS) was used to assess the severity of AD's pain at rest and with activity. She rated her right leg pain at 2.5 and her left leg pain at 1.0 sitting at rest.

Table 1. Current Medications

Medication	Class	Dose	Indication
Fosamax ®	Bis-phosphonate	35 mg (1 tablet every Friday)	Treatment of osteoporosis
Tylenol ®	Non-narcotic analgesic	325 mg (2 tablets once-daily)	Pain
Ultram ®	Opioid analgesic	50 mg (1 tablet as requested)	Pain
Calcium/ Vitamin D	Vitamin/mineral	500 mg (1 tablet thrice-daily)	Treatment of osteoporosis
Detrol ®	Urinary anti-spasmodic	2 mg (1 tablet once-daily)	Urinary frequency
Remeron ®	Anti-depressant	15 mg (1 tablet once-daily)	Depression

Tests and Measures

Physical examination revealed normal blood pressure (BP), heart rate (HR), oxygen saturation (SpO_2), and respiration rate (RR) at rest and normal exercise response after a Six-Minute Walk test (6MW) described later (Table 2).[17-19]

Table 2. Initial Vital Signs

Test	Rest	After Six-Minute Walk
BP	105/70 mmHg	136/72 mmHg
HR	72 beats · min^{-1}	84 beats · min^{-1}
RR	18 breaths · min^{-1}	24 breaths · min^{-1}
SpO_2	97%	92%

Range of motion was assessed using a universal goniometer (Sammons Preston Roylan, Boilingbrook, Ill) for all measurements. Because she could not tolerate prone lying hip extension was measured in a sidelying position. All other LE ROM measurements were obtained with AD lying supine. Bilateral hip flexion, extension, abduction, and internal and external rotation ROM, as well as right knee extension and left knee flexion were limited compared to reported norms[20] (Table 3). AD cited "intolerable"

Table 3. Impairment Measures

	ROM (o)			Isometric Force Production (kg)						
	Initial			*Initial*		*4 wks*		*8 wks*		*weeks*
Motion	**L**	**R**	**Normal[a,20]**	**L**	**R**	**L**	**R**	**L**	**R**	**Normal[38]**
Knee extension	5	-5	NR[b]	9	10	10	12	16	20	23.0
Knee flexion	97	106	132	NT	NT	NT	NT	NT	NT	14.0
Hip extension	-10	-7	17	12	14	16	16	20	18	16.4[37]
Hip flexion	70	79	118	11	9	NT	NT	NT	NT	10.6
Hip abduction	20	12	39	9	9	9	9	12	12	17.5
Hip IR[c]	16	22	30	NT	NT	NT	NT	NT	NT	NR
Hip ER	11	9	29	NT	NT	NT	NT	NT	NT	NR

[a] Normative data age ranges: ROM = 60-74 yrs, strength = 70-87 yrs
[b] NR = not recorded, NT = not tested
[c] IR = internal rotation, ER = external rotation

pain in both hips and knees when gentle overpressure was applied to the active end-range of the restricted joints. A definitive hard end-feel impeded further movement.

AD's limb strength was initially screened via manual muscle testing.[21] Deficits (<4/5) were observed with bilateral knee extenssion, hip extension, and bilateral hip abduction. A Jamar hydraulic hand-held dynamometer (HHD) (model # PC-5030J1, Sammons Preston Roylan, Boilingbrook, Ill) was used, as described by Sherrington and Lord,[22] to quantify force capacity of the weak LE muscle groups. The HHD has been shown to be a reliable measure of LE isometric force among patients with hip fractures with intraclass correlation coefficients (ICC) ranging from 0.69 to 0.929 for test-retest reliability.[22,23]

The 3 m Timed Up and Go test (TUG)[24] and Berg Balance Scale (BBS) were used to assess postural control and risk of falling (Table 4). Both instruments have strong estimates of intra-rater reliability (*r*) at 0.99.[24,25] AD's initial scores were 24 s and 14 for the TUG and BBS, respectively. A score below 20 s on the TUG is indicative of independent mobility.[24] A BBS score less than or equal to 48 has been shown to be 84% sensitive and 78% specific in determining the necessity for balance training and other physical therapy interventions among residents of a SNF.[26]

Table 4. Outcomes of Functional Tests

Functional Test	Initial	4 wks	8 wks
TUG (3 m)	24 s	21 s	18 s
BBS	14	34	45
MPPT	8	13	18
6MW	121.9 m	182.9 m	197.2 m
Gait speed (10 m)	0.50 m/s	0.75 m/s	0.83 m/s
5RSTS[a]	Unable	35 s	14 s

[a] 5RSTS = without arm support, 16-in seat height

A 9-item Modified-Physical Performance Test (M-PPT) was used to assess functional performance and degree of physical frailty.[12,27] Scores on the M-PPT range from 0 to 36. Test items have been previously validated as objective measures of frailty[28,29] and test-retest reliability (r_s) is estimated at 0.96.[30] A score of 32 implies an absence of frailty while a score of 17 is the suggested threshold value for determining the need for SNF placement.[12] AD's initial score was 8.

A 6MW was used to assess endurance and exercise tolerance using distance and physiological response as markers.[31] Test-retest reliability has been reported, r = 0.93 – 0.95.[32] Normal distances covered for community dwelling elderly females are reported to range from 392 to 538 m.[33] AD walked up and down a 30.49-m hallway as many times as she could within 6 min using a 2-wheeled RW with the handles set at an equivalent height to her trochanters. Standardized verbal encouragement was offered at the 1-, 3-, and 5-minute marks. On initial examination she was able to walk 121.9 m in just under 4 minutes before she succumbed to dyspnea and sat down to rest, unable to resume walking.

An individualized gait speed test was used to assess AD's ability to cross a signalized traffic intersection because she would probably have to do so when she returned home.[34,35] Intra-rater reliability ICC for gait speed are reported to be 0.90.[36] AD walked from a motionless standing position in a straight line past a marked finish line 10 m away. A digital stopwatch was used to measure time. Time started with her first foot-fall across the start line and ended with her first foot-fall across the finish line. She was instructed to walk as fast as she safely could using the same walker described for the 6MW. A practice trial was allowed, followed by 2 additional timed trials. The shortest time of the 2 latter trials was recorded as her gait speed. Her initial recorded gait speed was 0.50 m/s.

EVALUATION

AD had several remaining impairments and functional limitations following her previous course of physical therapy. Meager right LE and comparatively diminished left LE isometric force production[37,38] indicated a need for LE strengthening. Initial TUG and BBS scores revealed her high risk for falls[24,26] and a score of 8 on the M-PPT designated her as extensively frail.[12] Her gait speed was well below the reported average (1.2 m/s) necessary to walk across a timed traffic intersection.[34,35]

Triangulation of multiple tests and measures helped confirm the appropriate physical therapy diagnosis from the *Guide to Physical Therapist Practice,*[39] "Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated With Bony or Soft Tissue Surgical Procedures." Based on her current performance, her apparent motivation for recovery, and the expectation her impairments and functional limitations would improve with exercise training, goals of returning to independent facility ambulation within 3 months, and returning to community dwelling status within 6 months were established.

INTERVENTION

Physical therapy interventions focused on AD's identified impairments and functional limitations. Consistent with the literature, exercise prescription emphasized high-intensity LE

strength training twice a week, with endurance and balance interventions interposed on nonstrength training days.[9,40,41] Additionally, a multi-faceted treatment strategy has been shown to reduce the risk of future falls and improve the functional mobility of older adults with a history of falls.[42]

Muscle strengthening

Because of AD's hip and knee extension weakness, and based on the principle of exercise specificity, strength training began with sit-to-stand (STS) exercises to develop her knee and hip extension strength while directly addressing her difficulty rising from a chair. Her arms were crossed to avoid using them to help stand and sit repeatedly from an 18-in Midland High/Low Table (Sammons Preston Roylan, Boilingbrook, Ill). Enhanced stair climbing ability,[43] improved balance,[44] and increased LE power[45] have been reported among older adults undergoing functional resistance training using a weighted vest. A weighted vest was trialed and caused AD significant discomfort related to her left rib fractures. Alternatively, a Power Systems (Power Systems, Inc.) weighted belt was well tolerated. A presumptive argument was made to use the belt for overloading in lieu of the vest. The belt could hold up to 20 lbs with individual cells containing 2 lb bags that could easily be removed.

In order to approximate AD's 1RM for STS she stood and sat in the manner described above, first with no weight and then with incrementally added resistance each successive attempt. A 1 min rest period was allotted between attempts. Resistance could be increased at ½ lb increments via attaching ankle weights to the belt. A load of 4 lbs was recorded as her 1RM. Performing 3 sets of an exercise at 80% of 1RM has been shown to effectively increase LE strength in individuals of comparable age to AD.[13] She performed 3 sets of STS with 3 lb (80% of 1RM to the nearest ½ lb) added resistance during her first strength training session, accomplishing 10, 8, and 7 repetitions to fatigue, respectively. 1RM was reassessed during the first strength training session each week so that resistance could be appropriately adjusted as strength increased.

By 4 weeks bilateral knee extension strength did not appreciably improve, increasing from 9 to 10 kg and 10 to 12 kg for the left and right LE, respectively. Research on older adults with hip fracture has established good functional outcomes with strengthening programs that target knee extension among other LE muscle groups.[8,9,41] Unilateral open-chain knee extension exercises were incorporated into AD's strength training regimen in the 5th week, via the use of a Cybex Cable Column pulley system (Cybex Inc, New York, NY). She sat in a chair identical to the one she used to perform the TUG test. The front edge of the seat served as a fulcrum with a resistance strap attached just above the malleoli. During the exercise bout AD was secured to the chair with a gait belt to check compensatory hip rise and the chair was held in place by the therapist to prevent it from slipping. A towel was used to pad her ankle and prevent injury while exercising. 1-RM was approximated in a similar progression to that described for STS, sequentially added resistance with 1 min rest periods between attempts. 1-RM for the right and left knees equaled 55 and 50 lbs, respectively. Because the pulley system could only be increased at 5 lb increments an approximate 80% value of 45 and 40 lbs was used for the right and left knees, respectively. A rest period of 2 min was allotted between successive sets of all RT exercises.

Endurance training

AD began aerobic training using a Saratoga Cycle upper body ergometer (UBE) (Saragoa Access and Fitness, Ft. Collins, Colo) twice weekly. Despite an emphasis on specificity throughout the whole of the program's design, it was thought exercise tolerance would be enhanced if her legs were rested on aerobic training days. Resistance and revolutions-per-minute (rpm) could be calculated using the UBE. AD's age-predicted-maximal HR equaled 140 bpm using a linear regression equation ($208 - 0.7 \cdot \text{Age}$) reported to have a stronger correlation with echocardiographically measured HR than the traditional linear regression equation ($220 - \text{Age}$).[46] A training zone of 40% to 60% of her Heart Rate Reserve (HRR)[40] ranged between 95 and 113 bpm. A Datex-Ohmeda pulse oximeter (Model 3775, Madison, Wisc) with an ear probe was used to monitor her HR and SpO_2 while she exercised. She was assessed for normal return to baseline HR following cessation of exercise each session.[17] The load was initially set at 0 and she was instructed to propel the cycle at a rate of 30 rpm. She was able to maintain this rate for 7 minutes and her HR did not exceed 100 bpm. The plan was to gradually increase her training time to a total of 20 minutes of continuous aerobic exercise to elicit improved aerobic capacity.[40]

During the 4th aerobic training session (2 weeks), AD indicated her preference to practice walking versus exercising with the UBE and walking became the main mode of endurance exercise beginning the 5th week. An attempt was made to add a distance of 15.24 m (50 ft) each consecutive walking session to foster improved stamina reflective in longer duration walks at similar gait speeds. This ultimately translated into increased time requirements for successive aerobic-training sessions. The Datex-Ohmeda pulse oximeter was found to give inconsistent HR readings related to AD's body movement. HR was therefore monitored by taking her radial pulse each time she paused in standing rest and 1 min after sitting to ensure appropriate return.[17] AD's HR ranged from 92 to 104 bpm during walks. BP was measured as described by Pickering and colleagues[47] and remained within a normal range throughout all exercises.[19] She averaged 3 successive walks during each aerobic training session. Farthest distance and longest duration walked were 258.5 m and 10 min, 31 s, respectively.

Balance training

Balance training consisted of practicing specific items from the BBS and the M-PPT assessments. Items with the poorest performance on the BBS included unsupported static single limb and tandem standing, 360° standing turns, and alternating unsupported LE step-ups (6 in). Items with the poorest performance M-PPT included donning and doffing a coat without upper-extremity support and picking up a nickel from the floor, a more difficult task for AD than picking up a shoe from the floor as required by the BBS. Once-weekly balance training has been reported to significantly reduce occurrence of falls among older adults.[48] Balance training occurred in the middle session of the week. AD practiced each item for approximately 10 min with rest breaks as needed. The duration of each session was approximately 45 min and the order of items varied from 1 session to the next.

OUTCOMES

AD had a total of 31 treatment sessions over the course of 2 months. By and large the intended schedule was adhered to, a

single balance training session sandwiched between 2 sessions of strength and aerobic training each week. She missed 2 sessions due to acute 24-hr dysentery on separate occasions. Outcome measures were assessed at 4 and 8 weeks. The initial gamut of tests and measures took an entire week to perform (5 sessions of approximately 30 min) given rapid onset of fatigue. The 4 and 8 weeks' assessments required 3 and 2 days to complete, respectively. Range of motion measurements were excluded at 4 and 8 weeks per the patient's wishes vis-à-vis discomfort she experienced during the initial ROM assay.

Knee extension and hip extension and abduction isometric force scores improved between 0 and 8 weeks. At 8 weeks proportionate gains of 40% and 37.5% were observed in right and left knee extensors, respectively, following the start of open chain knee exercises at 5 weeks. Bilateral hip abduction force, although not directly addressed with RT, increased in the second half of the treatment program.

AD's functional test results improved at both reassessments. She was able to ascend and descend 2 flights of 12 stairs supervised using a handrail, improving her final M-PPT score to 18. She had initially only been able to step up and down 4 stairs. The Timed 5 Repetition Sit-To-Stand test (5RSTS) included in the M-PPT improved from "unable" to 14 s. Gait speed increased by 0.25 m/s and 0.18 m/s by 4 and 8 weeks, respectively, exceeding the minimal clinically important difference (MCID) (0.1m/s) in older adults after hip fracture.[49] The MCID is the degree of improvement a patient perceives as relevant in a given activity.[50] AD indicated she was pleased with her walking speed at 4 and 8 weeks and continued to walk with a 2-wheeled RW, saying she felt more "confident." Distance covered in 6MW improved to 197.2 m (38.2%) by 8 weeks, suggesting a degree of improvement in her endurance. A MCID of 54 m for 6MW is reported in patients with chronic obstructive pulmonary disease.[51] AD surpassed this mark at 4 weeks with a 61.0 m improvement and reported she was satisfied being able to walk further distances throughout the SNF.

End scores on the TUG (18 s) and BBS (45) suggested she was ready for independent mobility[24,26] and she was started on a self-reliant ad libitum walking program. The minimal detectable change (MDC), as described by Stratford et al,[52] is the amount of improvement required to distinguish true change from measurement error. A MDC of 6 on the BBS is reported in elderly patients with strokes.[53] AD exceeded this indicator at both reassessments.

At 8 weeks AD reported muscle soreness in bilateral thighs (VAS = 4.0) and fatigue and requested to stop high-intensity RT and balance training. She had been taking regularly scheduled Tylenol® but consistently declined Ultram® because of its constipating effects. She began an independent walking program but did not achieve her goal to return to community living.

DISCUSSION

Though no causal relationship can be demonstrated with this type of research, it is clear AD's strength and function were enhanced. High-intensity, more so than moderate- or low-intensity, RT has been reported to improve functional mobility in older adults.[54, 55] The precise mechanism(s) by which high-intensity RT may have induced these effects is unknown.[13, 55] Neural adaptations [55] and muscle hypetrophy[13] are advocated as plausible options. Other potential explanations AD's improved level of function include patient-client interaction, additional rehabilitation interventions, and the passage of time.

Predetermined rote verbal encouragement was offered for all testing. However, nonstandardized positive verbal feedback was given throughout all strength, balance, and aerobic training sessions. During treatments AD routinely indicated she was surprised she could perform as well as she did. She may have been more motivated to train harder because of her obvious improvements and the encouragement she received. Gait practice was used to directly address some of AD's impaired aerobic capacity. Research has shown that endurance training can facilitate improved aerobic power in older adults into the 9th and 10th decades of life[56] and it is possible her improved 6MW evolved more from an improved aerobic capacity than an increase in LE strength. Theoretically, a period of 5 months could have allowed AD enough healing time to account for improvements in her mobility. However, this is unlikely in view of the declines related to inactivity. By program's end significant deficits remained that prevented AD's independent reentry to the community. She still needed help putting her shoes on related to diminished hip ROM. The farthest distance she walked (258.5 m) was well below the average distance (304.5 m) reported necessary for collecting groceries, attending medical appointments, and various other activities involved with community dwelling.[57] AD's 6MW was well below the 392 m norm reported by Steffen et al[33] for older adults near her age, indicating improved yet still compromised level of endurance. A final gait speed of 0.83 m/s helped to improve her overall M-PPT score (18) but fell short of community reentry standards.[34, 35]

The 5RSTS has been shown to be a valid and reliable measure of LE strength and functional performance in older adults.[23] Manually testing AD's LE muscle groups using HHD proved to be a more physically demanding and time-consuming effort than the 5RSTS. An accurate and quicker strength test like the 5RSTS would be desirable for clinicians looking to enhance the productivity of their examinations. AD was unable to complete a single STS repetition during the initial examination. Her weakness and limited functionality were clearly evident and presented an opportunity to specifically address her deficits with high-intensity STS exercises. AD's final 5RSTS score (14 s) edged her past the 14.8 s norm reported by Bohannon[58] for individuals near her age. Descriptions of adverse effects from high-intensity RT in older adults are sparsely reported.[54] AD cited fatigue and sore muscles as the main reasons to stop strength training. During an interview 2 weeks after the program's completion (5 ½ months status postsurgery), AD said her soreness had "pretty much gone away." She was taking regular walks each day, ostensibly maintaining the ambulatory gains she had made in the high-intensity RT program. Overreaching has been defined as "an accumulation of training and/or nontraining stress resulting in a short-term decrement in performance capacity"[59(p 969)] and may explain AD's symptoms and reasonably expeditious recovery. Multiple-set and single-set strength training programs have been reported to produce similar strengthening outcomes among the middle-aged but this concept has not been thoroughly studied in older adults.[60] Speculatively, a lower number of sets may have elicited equivalent strength gains in AD with less risk of overreaching.

Limitations to this case report lie in 3 core areas. First, AD may have had an uncharacteristically high level of motivation

despite her long-term residency in a SNF and diagnosis of hip fracture.[61,62] Other similarly impaired patients in this facility have been far less willing to extend themselves to the degree this program required. Second, her relative lack of comorbidities may not be typical among her age-matched peers within the hip fracture cohort. Cardiovascular conditions, for example, are more prevalent in older adults and can hinder the safe application of high-intensity RT.[63] AD had no history of cardiovascular disease.

Third, there is no concrete evidence in the literature indicating a "best" time to begin using high-intensity RT following hip fracture. Endosteal calluses at the site of the fracture are formed in the repaired hip 4 to 6 weeks following surgery and are reported to be moderately stable by 8 to 12 weeks.[3] Conceivably, earlier implementation of high-intensity RT could have lead to faster functional recovery in this woman. Conversely, later application could have produced significant improvements in mobility with fewer side-effects. The select time to introduce high-intensity RT following hip fracture is an area for further research.

CONCLUSION

This case report presents an evidence-based approach to examining and treating a significantly frail nonagenarian with hip fracture. A prescribed high-intensity RT program was used to improve her functional status 2 months after she concluded a conventional physical therapy program.

Administration and tolerance of high-intensity RT programs can vary among the very old. This patient eventually requested to stop RT related to complaints of muscle soreness and fatigue. Further investigation into appropriate prescription, efficacy in strength building, and negative side-effects of high-intensity RT in aged patients with hip fracture is supported.

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