OUTPATIENT PHYSICAL THERAPY INTERVENTION FOR A PATIENT POST NON-SURGICAL LATERAL TIBIAL PLATEAU FRACTURE UTILIZING THE NEUROCOM SMART BALANCE MASTER®

A Doctoral Project
A Comprehensive Case Analysis

Presented to the faculty of the Department of Physical Therapy

California State University, Sacramento

Submitted in partial satisfaction of
the requirements for the degree of

DOCTOR OF PHYSICAL THERAPY

by

Alexis Nicole Klesczewski

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by

Alexis Nicole Klesczewski

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Abstract

of

OUTPATIENT PHYSICAL THERAPY INTERVENTION FOR A PATIENT POST NON-SURGICAL LATERAL TIBIAL PLATEAU FRACTURE UTILIZING THE NEUROCOM SMART BALANCE MASTER®

by

Alexis Nicole Klesczewski

A patient post non-surgical lateral tibial plateau fracture was seen for student physical therapy treatment for 6 sessions from November 4th to December 16th, 2014 at CSU, Sacramento Department of Physical Therapy under the supervision of Lois Boulgarides, PT, DPT, MS.

The patient was evaluated at the initial encounter with the use of manual muscle testing, single leg stance time, a complete NeuroCom SMART Balance Master® assessment, and a plan of care was established. Main goals for the patient were to increase lower extremity strength, proprioception, and dynamic balance in order to safely return to recreational basketball, running and hiking with decreased risk of fall or re-injury. Main interventions used were perturbation training, lower extremity graded therapeutic exercises and activities in the form of both direct intervention and a home exercise program. The patient achieved the goals of increased lower extremity strength, a normal single leg stance time and weight bearing squat as measured by the Balance Master®, and achieved clinically meaningful change in all activity and participation-level outcome measures. The patient was discharged home with a home exercise program.

_____, Committee Chair
Clare Lewis, PT, PsyD, FAAOMPT, MTC

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Date

TABLE OF CONTENTS

Page

LIST OF TABLES

Tables Page

Chapter 1

General Background

Fractures of the lower extremity lead to the need for a cane, crutches or even wheelchair which can place a sudden loss of independence on the patient.[1] These spontaneous injuries often cause missed work, school or social activities. Recently, tibial plateau fractures have become more common due to an increase in more daring, alternative activities.[2] The incidence of these specific fractures account for 5-8% of all lower leg fractures.[2] Surgical procedures for fractures of the tibial plateau are common due to displaced fragments or ligamentous damage caused by the types of trauma often associated with these injuries.[3,4] In some cases though, conservative treatment is the optimal choice of rehabilitation after 4 to 6 weeks of weight bearing restrictions.[5]

Fracture risk is increased in the young female population due to factors such as low bone density, high body mass index and possibly the use of some hormonal contraceptives.[6] Weight bearing exercise is known to increase bone density but can also place a person at a higher risk of sustaining a fracture depending on the nature of the activity.[1]

The rehabilitation prescription after lower limb fractures often includes an emphasis on improving proprioceptive ability and postural control. The evaluation of postural control has been changing since the emergence of force plates and other computerized equipment. Although these technologies have existed for many years, the cost and training required to properly utilize them are often intimidating and, therefore, the technologies' benefits are overlooked. The NeuroCom SMART Balance Master® (BM) is a device utilizing force plates with real-time visual movement analysis allowing for computerized static posturography.[7] This specific piece of technology was used to provide objective data as a portion of a complete orthopedic physical therapy evaluation.

Chapter 2

Case Background Data

Examination - History

The patient was a 24 year-old female who suffered a right lateral tibial plateau fracture and bone bruise six weeks prior to the evaluation and treatment in this case study. The injury was sustained while hiking when the patient was struck by a running dog on her right leg, causing her to collapse onto her left side. The patient was given partial weight bearing clearance from her physician and was walking with a cane prior to referral to outpatient physical therapy. Once given permission for full weight bearing and receiving two sessions of physical therapy, the motivated patient was provided a home exercise program (HEP) and discharged, and to schedule more treatments if she deemed necessary. Her HEP at discharge from her initial physical therapy course of care included straight leg raises with ankle weights, quadricep and gluteal muscle sets, and the use of a stationary bike. This patient entered this case study no longer receiving physical therapy treatment and seeking right leg stability, improved strength and confidence in order to prevent subsequent injuries and falls. There was no other pertinent medical history. Her general health review was clear.

As a full-time graduate student, the patient was busy with classes as well as caring for her dog. Prior to the fracture she enjoyed staying active, playing basketball recreationally twice a week and participating in hiking and running three times per week for about 2-5 miles each outing. As a student, her daily activities included walking between classes, and to and from her car and house.

The patient’s primary complaints included fear of falling and re-injury associated with right knee unsteadiness and fatigue. Upon initial evaluation she suffered from mild right knee

swelling and immediate sharp 5/10 stabbing pain at the fracture site when placing full body weight onto her right leg. She reported that this sharp pain eased immediately after shifting back evenly to her left side or sitting down. The patient also complained of soreness in the right knee towards the end of the day, especially after a full school day (about 6 hours). She was unable to quantify the pain but could relieve the ache with 5-10 minutes of ice. The patient recognized her condition was improving and was able to tolerate more walking each week. Her primary goals were to return to her normal gym activities such as leg press, running, playing basketball, hiking on weekends, and walking throughout the day without fatigue.

At the time of the evaluation, the patient used a single point cane when walking long distances, if she was feeling sore or if she was having general feelings of knee instability. The patient lived in a single story residence with no complaints of ambulation throughout the home. In the community, she utilized elevators or the handrails of stairs when necessary.

The only impaired system due to the patient's knee trauma was the musculoskeletal system.

Examination – Medications

The patient did not take any medications throughout evaluation and treatment. Upon initial injury, the patient was prescribed the non-steroidal anti-inflammatory drug Naprosyn by her physician but did not take it.

Table 1

Medication

MEDICATION	DOSAGE	REASON	PT SIDE EFFECTS
Naproxen (Naprosyn)[8]	250mg BID	Anti-inflammatory, pain management	Dizziness, drowsiness, nausea, thirst, tachycardia

Chapter 3

Examination – Test and Measures

The tests and measures used in this case study utilized all ICF categories including body structure and function impairments, activity limitations and participation restrictions.

In the impairment category, muscle strength as measured by manual muscle testing (MMT) was used due to its clinical relevance.[9] Manual muscle testing has been utilized in the clinical setting for decades and although it is not the most sensitive measure with an ordinal 0-5 point scale, it is a useful evaluation tool for the musculoskeletal system.[10] Benefits of using it in this case study include its high clinical implications[11] and the use of only one examiner, due to its good intra-rater reliability.[12] Cuthbert et al found a change of one full MMT grade to be a clinically significant change.[10]

As for activity limitations, the patient's single leg stance (SLS) and weight bearing squat on the BM were used. The SLS time has limited reliability but is a skill that plays an important role in proprioception as it relates to athletic function.[13] Normative values of SLS time shown for females ages 18-39 years old were averaged at 43.5 seconds eyes open and 8.5 seconds with eyes closed.[14] Golberg et al. found a change of 24.1 seconds (95% CI) during SLS to be a meaningful change in older adults.[15] Although this is not the population of interest and is only relevant in SLS with eyes open, it is the most relevant research available at this time and notable.

The patient's weight bearing squat goals were based on results studied in a population of normal adults. Normal adults are expected to maintain body weight within 5% of equal on the two legs.[7] Therefore, a goal of 50% ±5% on both right and left lower extremities was strived for.

Outcome measure surveys used at the level of activity limitations and participation restrictions included the Short Form-36 (SF-36), Lower Limb Functional Index (LLFI), and the Knee Outcome Survey Activities of Daily Living (KOS-ADLS).

The first of these is the SF-36. The Short Form (SF) health surveys are the most widely used patient-outcome surveys in the world[16] and view multidimensional health concepts. This particular SF health survey, the SF-36, looks at eight different health domain categories; including levels of well-being & personal evaluations of health.[17] In each category, a score of 50 is indicative of an average score with a standard deviation of 10 where higher scores represent better health.[18] Scores range from 0-100 in each of the Physical Component Score (PCS) and the Mental Component Score (MCS). According to SF-36.org, the measures' minimal detectable change (MDC_{95}) is 5.8 points and the minimally clinical important difference ($MCID_{95}$) is 13.2 points. These values will be used in this case study where the focus is on the PCS due to the patient's physical injury. Test-retest reliability (95% CI) was found to be 0.92 for the PCS, proving it a highly reliable measure.[17]

Secondly, the LLFI was used for a more region-specific outcome measure. The LLFI was originally created in 2012 using participants recruited from outpatient physical therapy clinics and no specific conditions or diagnostic subgroups were investigated.[19] Due to the lack of research on non-surgical interventions for patients suffering specifically from tibial plateau fractures, this can be seen as a positive quality. The LLFI has been proven to have comparable statistical power to the more frequently used Lower Extremity Functional Scale (LEFS).[19] The LLFI measure provides information regarding lower-limb, region-specific, frequent daily activities. Scores range from 0 to 25 points, with lower scores signifying fewer problems. The LLFI has been determined valid, reliable and assesses region-specific lower extremity function as opposed to the more

general SF-36. A MDC_{90} of 6.67% or 1.67 LLFI points has been established.[19] Items included in the LLFI include difficulty sleeping, difficulty with changing directions during ambulation and problems with balance due to the patient's injury or condition. Scoring occurs by either skipping a statement that does not apply to the patient, placing a check mark "√" to notify that the item does describe the patient fully or by marking it with a "½" mark to notify statement describes the patient partially.

Lastly, the KOS-ADLS survey was used because it was developed specifically for the knee and has demonstrated statistical power. This measure shows to what degree the knee and knee symptoms impart functional limitations in daily activities. Most scholarly articles containing the KOS-ADLS refer to translating the measure into various languages, noting its value worldwide. In a systematic review viewing self-administered questionnaires for the knee, the KOS-ADLS was found to have high reliability, high responsiveness to change and low measurement error.[20] Scores of the KOS-ADLS range from 0-100%, a MDC_{95} is a change of 8.3%, a $MCID_{95}$ is a change of 13.6%, and an ICC of 0.92.[20,21] A higher percentage score indicates greater functional ability.

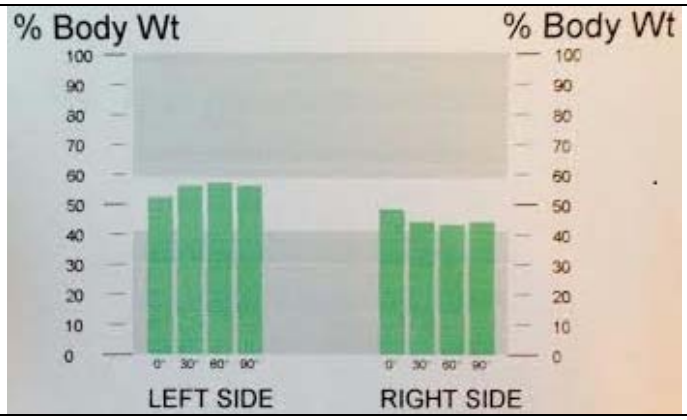
Table 2

Examination Data

INITIAL EXAMINATION			
BODY FUNCTION OR STRUCTURE IMPAIRMENTS			
Active Range of Motion		Left	Right
	Knee Flexion	WNL	WNL; empty end feel/pain before resistance (3/10 pain at fx location)
	Knee Extension (performed supine with 3 green soft blocks under heel)	0-10°	0-2°
	Dorsiflexion	0-8°	0-8°
	Plantarflexion	0-85°	0-90°
Strength			
	Knee Extension	5/5	4+/5
	Knee Flexion	5/5	4/5
	Hip Flexion	4/5	3+/5
	Hip Extension (HS;glut)	4+/5; 4+/5	4+/5; 3+/5
	Hip Abduction	4+/5	3+/5
	Hip Adduction	4+/5	3+/5 (pain limiting)
	Dorsiflexion	5/5	5/5
	Plantarflexion (manual, supine)*	5/5	4/5
*not tested in standing due to weight bearing limitations			
Muscle Length Tests			
	Straight Leg Raise	0-80°	0-78°
	DF with Knee Straight	0-8°	5° of PF
Special Tests/Joint Play			
	Thomas Test	WNL	WNL
	Ober's Test	WNL	WNL
	Varus @ 0°	(-)	(-)
	Valgus @ 0°	(-)	(-)
	Posterior Sag Sign	(-)	(-)
	VMO Coordination	(-)	(-)
Other			
	Q angle (in supine)	14°	15°
	Fick's angle	-2°	8°

Palpation			
	R Knee Tender points	- medial tibial plateau (about 2 cm) - lower lateral tibial plateau	
Swelling (measured by circumference)		Left	Right
	Mid-patella*	34.5 cm	35.5 cm
	2" above¥	37	36.5
	2" below	32	32
	4" above	43	42
*Swelling appeared to be inferior to patella on medial & lateral sides ¥Visual atrophy of VMO on R			
Gait/Posture Observational Analysis: (gait observed with single point cane)			
- Limited weight bearing shows uneven hips/ASIS; R superior to L - R knee crease less defined than L - Slight bilateral genu valgum - Decreased weight bearing during R stance - Shortened stance on R; decreased L step length - Slight R lateral lean onto cane (with shoulder hike); decreasing the height of the cane improved this slightly - Patient complains of being unable to walk for 10 minutes without needing to rest 2° to discomfort or feelings of unsteadiness			
ACTIVITY LIMITATIONS			
Gait	Independent in gait with single point cane, weight bearing restrictions per physician's orders.		
Transfers	Independent in all transfers.		
Single Leg Stance (SLS) ~Performed once given FWB clearance		Left	Right
	SLS eyes open (e/o)	60"	60"
	SLS eyes closed (e/c)	29"	16" *
*More ankle instability and associated movements on R; R SLS e/c test was stopped to prevent fall			
Balance Master Assessment:			

Weight Bearing Squat %BW at:	Left (%)	Right (%)
0°	52	48
30°	56	44
60°	57	43
90°	56	44



Limited in walking endurance and feelings of instability when walking		
LLFI	13.5 points (46%)	Decreased lower limb function
KOS-ADLS	66%	Decreased function due to knee
PARTICIPATION RESTRICTIONS		
Unable to hike, run, play basketball nor use strengthening machines at the gym secondary to feelings of instability and fear of falling or re-injury		
SF-36	PCS: 27.4 MCS: 57.8	Decreased physical health Average mental health

Chapter 4

Evaluation

Evaluation Summary and Diagnostic Impression

Patient was a 24 year-old female status post right lateral tibial plateau fracture secondary to a traumatic impact. Due to the nature of her fracture she was not a candidate for surgical intervention and had achieved full weight bearing clearance by the time of treatment, 6 weeks after her initial injury. Impairments included mild right knee swelling, sharp 5/10 pain when placing full body weight on the right leg that eased immediately upon rest, and decreased right lower extremity strength in comparison to her uninjured left side. Limitations included unequal weight bearing at rest and while performing a squat, decreased single leg stance time indicative of poor balance, and impaired lower extremity function as measured by the LLFI and the KOS-ADLS. Restrictions included the inability to perform all activities of daily living and recreational activities as per prior level of function such as playing basketball and ambulating to and from classes without soreness. The patient's primary goals were to safely return to recreational sports and gym activities, which included the need for strengthening of the lower extremities, as well as neuromuscular reeducation and proprioceptive control. At the time of the evaluation the patient's condition was improving and she was not irritable.

Physical Therapy Guide Practice Pattern

The patient follows the Physical Therapy Guide Practice Pattern of Pattern 4G: Impaired Joint Mobility, Muscle Performance, and Range of Motion Associated With Fracture.

G-Code

The patient is impaired in walking and moving around. Based on the SF-36 PCS, the patient scored 27.4 points out of 50 points. Therefore, the patient was 45.2% impaired at the time of the initial evaluation and the appropriate G-code is G8978 CK (45%).

Chapter 5

Plan of Care – Goals and Interventions

Table 3

Evaluation and Plan of Care

<table>
<tr><td rowspan="2">PROBLEM</td><td colspan="5">PLAN OF CARE</td></tr>
<tr><td colspan="2">Short Term Goals
(Anticipated Goals)
2 weeks</td><td colspan="2">Long Term Goals
(Expected Outcomes)
6 weeks</td><td>Planned Interventions
Interventions were direct (1hr/wk) unless used in the home exercise program marked (HEP)</td></tr>
<tr><td colspan="6">Note: Home Exercise Program (HEP) shown in Table 4.
SMART Balance Master® (BM) activity explanations in Table 5.</td></tr>
<tr><td colspan="6">BODY FUNCTION OR STRUCTURE IMPAIRMENTS</td></tr>
<tr><td rowspan="4">1. Decreased lower extremity (LE) strength; worse on right</td><td>Left</td><td>Right</td><td>Left</td><td>Right</td><td rowspan="4">Instruct patient on progressive resistive exercises including monster walks, leg press and lunges. (HEP)</td></tr>
<tr><td>Hip flx 4→ 4+/5</td><td>Knee ext 4+ → 5/5</td><td rowspan="3">Hip flx 4→ 5/5</td><td>Knee ext 4+ → 5/5</td></tr>
<tr><td rowspan="2">Hip ext, abd, add 4+ →5/5</td><td>Knee flx 4→4+/5</td><td>Knee flx 4→5/5</td></tr>
<tr><td>Hip flx, ext, abd, add 3+ →4/5</td><td>Hip flx, ext, abd, add 3+ →4+/5</td></tr>
<tr><td></td><td>PF 4→4+/5</td><td>PF 4→5/5</td></tr>
<tr><td colspan="6">ACTIVITY LIMITATIONS</td></tr>
<tr><td>2. Abnormal weight bearing in squat (worse at deeper angles; Left>Right)</td><td colspan="2">In 30° knee flx:
Left: 56% → 50-55%
Right: 44% → 50-55%</td><td colspan="2">In 60° knee flx:
Left: 57% → 50-55%
Right: 43% → 50-55%</td><td>- BM weight bearing squat
- Monster walks (HEP)
- BOSU ball squats & perturbations (ie: nudges or ball throw</td></tr>
<tr><td>3. Decreased R LE proprioceptio</td><td colspan="2">Left e/c: 29”
Right e/c: 16” → 22”</td><td colspan="2">Left e/c: 29”
Right e/c: 16” → 29”</td><td>- Practice SLS w/BM weight-tracing feedback</td></tr>
</table>

	n and balance as measured by single leg stance (SLS) time: Eyes closed (e/c) on R < L						eyes open progressing to e/c (1 min. each) - SLS on BOSU Ball incorporating catching/throwing - Progress BM level 1-5 activities (50%-100% R WB): Figure 8 and Pin-wheel
4.	Decreased LE function as measured by the Lower Limb Functional Index (LLFI) and Knee Outcome Survey – Activities of Daily Living Scale (KOS-ADLS)	Item	Pretest	+MDC	Item	Pretest	+MCID	See above interventions.
		LLFI	13.5pts	11.83 points	LLFI	13.5pts	<11.83 points (no MCID)	
		KOS-ADLS	66%	74.3%	KOS-ADLS	66%	79.6%	
PARTICIPATION RESTRICTIONS								
5.	Increased risk of falls and subsequent injury as measured by impaired Short Form-36 (SF-36) Physical Component score (PCS)	Item	Pretest	+MDC	Item	Pretest	+MCID	See above interventions.
		SF-36	PCS= 27.4	PCS= 33.2	SF-36	PCS= 27.4	PCS= 40.6	

Prognostic Considerations

Positive prognostic indicators include the young age of the patient, her education level, strong family support system and her motivation to return to her normal amount of walking and exercising on a daily basis. Research shows that tibial plateau fractures that do not cause

mediolateral instability of the knee joint are more likely to have a positive outcome.[22] A positive valgus or varus test, depending on the patient's side of fracture, is a poor prognostic indicator. These tests indicate damage to the medial or lateral collateral ligaments or a displaced fracture allowing the femoral condyle to extend into the tibial plateau of the side tested.[22] The patient showed a negative varus and valgus stress test upon initial evaluation (less than 10° of laxity with the knee fully extended) suggestive of lateral or medial ligamentous stability, respectively, and the lack of a displaced fracture. Lastly, decreased single leg stance time, also known as unipedal stance, with eyes open is a predictor of falls.[14] The patient was only limited in SLS time with eyes closed, therefore is not at risk for falls as measured by the SLS but instead is limited in neuromuscular motor control and sensory integration in the absence of vision. Negative prognostic indicators for this patient do include a busy, full-time school schedule and the inability to control the amount of walking necessary in a day of classes. Because of this she could experience undue fatigue or further swelling. Also a negative prognostic indicator for tibial plateau fractures is the amount of articular cartilage damage sustained with the fracture. Unfortunately, there are no known procedures used to measure this indicator of the severity of the fracture and, therefore, rehabilitation potential.[22]

It was the patient's responsibility and desire to adhere to the home exercise program as well as attend therapy sessions once per week in order to return to her prior level of function, despite her busy schedule. The patient was discharged to her prior living situation, living and transporting herself independently.

Plan of Care- Interventions

See Table 3 Evaluation and Plan of Care

Overall Approach

The patient participated in both a direct therapy intervention and a home exercise program. She demonstrated great rehabilitation potential due to her motivation and positive prognostic indicators. The HEP focused primarily on lower extremity strengthening and was supplemental of the direct treatment. The HEP is listed in Table 4 below. The direct intervention occurred once per week for 6 weeks and focused primarily on regaining dynamic stability and balance. The BM was used in each direct treatment session as well as various other exercises when indicated. The BM exercises are listed in Table 5. Other equipment used included TheraBand, a BOSU ball and a medium sized rubber ball. A brief follow-up assessment was performed six months after completion of treatment.

A direct intervention was used to address goals #1, 2, and 3, with some HEP overlap. Each direct intervention, seen in Table 5, was performed during each week's therapy session for a total of 6 weeks. The goals addressed by the HEP are listed in the previous Plan of Care boxes.

Therapeutic exercises and activities including TheraBand resisted squat walks (5 sets of 10m walks with red TheraBand) and BM weight-bearing squats (1 session) were included during direct therapy sessions, time permitting, to increase lower extremity functional strength, addressing goal #1.

The BM weight bearing squat with visual feedback on monitor and squats on the BOSU ball (3 sets of 10 reps) were used to address goal #2. During these activities, the patient was cued on becoming aware of and improving postural compensations in order to normalize bilateral weight bearing and squatting form. The patient also performed perturbation and stabilization training on the BOSU ball such as nudges or catching and throwing a medium sized rubber ball with varying placement and speed in order to challenge her balance.

Limited balance and proprioception as measured by right SLS time with eyes closed, goal #3, was addressed directly via SLS performed on the BM firm surface with eyes open and eyes closed. Each SLS condition was performed bilaterally for one minute counting each “fall” or touch of the non-weight bearing leg. The BOSU ball was also incorporated for SLS with eyes open, done for the amount of time tolerated, averaging about a minute or two on each leg.

In combination, the direct interventions and HEP listed below was used to treat the dynamic stability of the patient in order to decrease risk of falls, re-injury and to increase the patient’s ability to return to her prior level of function.

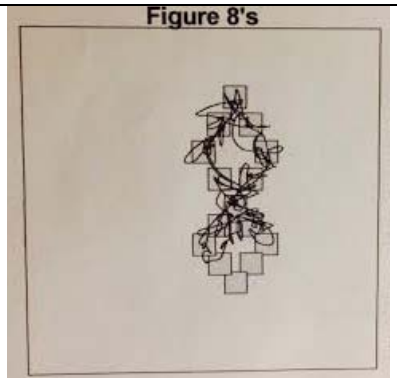
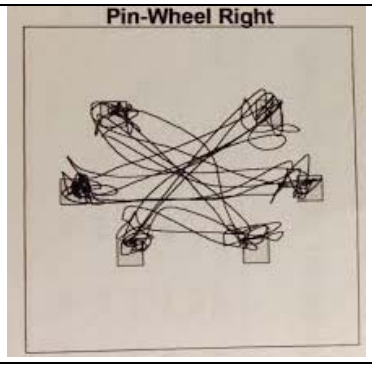
Table 4

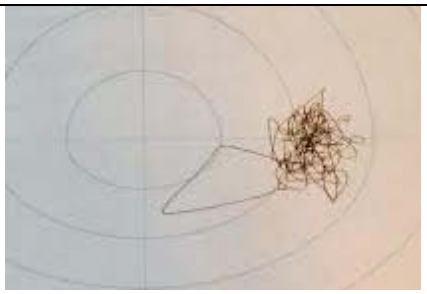
Home Exercise Program

This home exercise program (HEP) is supplemental to the direct intervention due to limited one-on-one treatment time. It is a modification and progression of the original physician-ordered physical therapy exercises. The patient is an extremely busy, first semester full-time graduate student but nonetheless is highly motivated.			
HEP: 3-7x/week, time permitting	Weeks 1-4	Weeks 4-6	6+/Post-Intervention
Monster walks	When full weight bearing (FWB): No resistance Perform 3 sets, 100 ft.	Green Mini Band Perform 3 sets, 100ft.	Grey TheraBand
Leg Press	When FWB: bilateral (BI) 10#; 3 sets, each until failure/loss of appropriate body mechanics	20-30#, 3 sets, each until failure or loss of form	40#-100#, based upon patient discretion. 3 sets, each until failure or loss of form
Standing Lunges	When FWB: 3 sets, 10-20 reps	w/5 lb. handheld dumbbells. 3 sets, 10-20 reps.	w/10 lb. handheld dumbbells. 3 sets, 10-20 reps.
BI Straight Leg Deadlift	When FWB: 5#, 3 sets, 10 reps	10-20#, 3 sets, 10 reps	20-40+#, 3 sets, 10 reps
Single Leg Stance (daily)	When FWB: 30 seconds, 5x each	30 seconds or until failure, e/c, 5x each	On BOSU: 30 seconds-1min+ (or until failure), 5x each

Table 5

Balance Master Activities

One session of the Balance Master included each activity listed below, performed once.			
SMART Balance Master® (BM) Activity:	Activity Explanation	Progression	Print (after activity)
Figure-8	This exercise involves many small boxes which form a figure-8 diagram. One small box at a time illuminates randomly for a number of seconds. The patient shifts his or her weight in order to occupy and stay in the illuminated box for the given period of time, usually 10 seconds. As the pt moves on the force plates to reach each box the computer draws a line and the printed results show the patient's movement pattern.	The figure-8 diagram is placed, in this case, where the majority of the weight shift occurs on the right side of the force plate. Each level (levels 1-5) increases the activity's intensity. This means the percentage of space between the boxes can increase, therefore increasing difficulty of weight shift.	
Pinwheel	This exercise, similar to the figure-8, uses a "pinwheel" diagram instead. The illuminated boxes are also random and change based on programmed time.	Same as the figure-8 but using the pinwheel diagram instead.	

Weight-Bearing Squat	This exercise is simply a bilateral squat on the BM force plates. Progressing from 0° to 30°, 60° then 90°, it tracks the weight present in each limb during the movement.	N/A	
Single Leg Stance (SLS)	Single Leg Stance is the same test performed on the ground but the benefit of performing it on the BM is the ability to set it up as a custom exercise and to track the patient's exact movement/ weight shift during the activity. A print out may be ordered after the activity.	N/A	 (the single, large protrusion away from the scribbled bunch signifies 1 "fall" during this SLS activity)

PICO question

Is the use of the NeuroCom SMART Balance Master® (ie: force plates with visual biofeedback) along with a conventional home exercise plan (I), compared to conventional treatment alone (C), an effective treatment to restore proprioception and stability in order to return safely to pre-morbid exercise state (O) in a young, 24 year-old, female post non-surgical tibial plateau fracture and bone bruise (P)?

Few items in current research study post-tibial plateau fracture interventions yet many do involve post-anterior cruciate ligament (ACL) injury interventions, both of which qualify as traumatic knee injuries. Fitzgerald et al[23] provides strong evidence of positive results using the BM for stability and balance treatment following knee injuries that do not require surgical interventions. This is strong, fitting evidence as many traumatic knee injuries such as torn/injured ACL's usually do require surgical intervention and therefore are not applicable to this case.

Fitzgerald et al[23] states that with the use of the BM and perturbation training, young active athletes can return to sport quicker than with conventional treatment alone. The BM perturbation exercises used in Fitzgerald's study for treatment are very similar to the exercises used in this case study, all involving the ability to weight shift. Also in this piece of literature are descriptions of successful exercises similar to the items used here not involving the BM. Successful treatment was determined by subjects returning to previous activity and with no reports of their knee giving out during the follow-up encounter (i.e. free of falls). This was the goal in this case study intervention, to return to recreational basketball, hiking and normal gym activities. The BM intervention group had a 92% success rate, 11 out of 12 subjects, compared to 7 of 14, a 50% success rate in subjects who received conventional treatment alone. Similar to this case study, this research used the Knee Outcome Survey – Activities of Daily Living Scale (KOS-

ADLS) as an outcome measure to predict successful outcomes in the subjects. The perturbation group had a smaller decline in outcome measure scores upon the six month follow up compared to the group with conventional treatment alone. This evidence suggests that the use of the BM for treatment in conjunction with conventional therapy is successful in returning patients with non-surgical traumatic knee injuries back to high-level activity safely. Subjects who received the perturbation training were 4.88 times more likely to have a successful outcome with non-operative treatment than subjects who did not receive the perturbation training.[23] Therefore, this patient was shown to benefit from the combination of perturbation training with the use of the BM and conventional therapy, the majority of which is in the form of a HEP.

Research shows that use of force plates with visual biofeedback such as the BM is a valid and reliable way to measure balance, proprioception and stability.[23] In this patient case, the goal is to not only measure but to also treat these areas with the BM's many programs. In order to address all of the patient's deficits it was unrealistic to treat solely using the BM, therefore conventional treatment was included as a supplement. As a full time student and previous athlete, the patient was busy but also highly motivated to return to her prior level of function and activity. The majority of the conventional treatment was in the form of a HEP and because the patient had received a HEP from her previous physical therapist, these exercises were utilized and progressed as necessary.

In order to maximize the amount of conventional treatment, the patient performed additional exercises utilizing various types of equipment in conjunction with the HEP. These were used to target the patient's lower extremity strength and stability during the direct intervention meetings. For example, one exercise incorporated a BOSU ball, adding perturbations to the patient in an athletic stance on top of the uneven side of the BOSU ball. These

perturbations included catching and throwing a medium sized ball in various directions. Secondly, forward and backward resisted squat walks were used with TheraBand resistance around the patient's waist to increase the neuromuscular challenge. Before the fracture and bone bruise, the patient enjoyed hiking and various sports activities. These activities involve uneven surfaces and quick changes in direction requiring lower extremity strength and balance, all which were addressed in the above mentioned intervention.

Chapter 6

Outcomes

Table 6

Outcomes

<table>
<tr><td colspan="7">OUTCOMES</td></tr>
<tr><td colspan="7">BODY FUNCTION OR STRUCTURE IMPAIRMENTS</td></tr>
<tr><td>Outcome</td><td colspan="2">Initial</td><td colspan="2">Follow-up</td><td>Change</td><td>Goal Met</td></tr>
<tr><td rowspan="4">Lower Extremity (LE) Strength as measured by manual muscle testing (MMT)</td><td>Left</td><td>Right</td><td>Left</td><td>Right</td><td rowspan="4">Patient gained 1 or more MMT levels in bilateral (BI) LE. Completed strong, 5/5 BI LE MMT without pain.</td><td rowspan="4">Yes</td></tr>
<tr><td>Hip flx 4/5</td><td>Knee ext 4+/5
Knee flx 4/5</td><td rowspan="3">Hip flx, ext, abd, add
5/5</td><td rowspan="2">Knee ext, flx
5/5</td></tr>
<tr><td>Hip ext, abd, add 4+/5</td><td>Hip flx, ext, abd, add 3+/5</td></tr>
<tr><td>PF 4/5</td><td>PF 5/5</td></tr>
<tr><td colspan="7">ACTIVITY LIMITATIONS</td></tr>
<tr><td>Outcome</td><td colspan="2">Initial</td><td colspan="2">Follow-up</td><td>Change</td><td>Goal Met</td></tr>
<tr><td>Weight Bearing Squat</td><td colspan="2"><table><tr><td></td><td>Left</td><td>Right</td></tr><tr><td>0°</td><td>52%</td><td>48%</td></tr><tr><td>30°</td><td>56%</td><td>44%</td></tr><tr><td>60°</td><td>57%</td><td>43%</td></tr><tr><td>90°</td><td>56%</td><td>44%</td></tr></table></td><td colspan="2"><table><tr><td></td><td>Left</td><td>Right</td></tr><tr><td>0°</td><td>52%</td><td>48%</td></tr><tr><td>30°</td><td>52%</td><td>48%</td></tr><tr><td>60°</td><td>49%</td><td>51%</td></tr><tr><td>90°</td><td>52%</td><td>48%</td></tr></table></td><td><table><tr><td>0°</td><td>No Change</td></tr><tr><td>30°</td><td>2% off 50/50</td></tr><tr><td>60°</td><td>1% off 50/50</td></tr><tr><td>90°</td><td>2% off 50/50</td></tr></table></td><td>Yes</td></tr>
<tr><td>Single Leg Stance (max 60 sec.)</td><td colspan="2">L e/c: 29”
R e/c: 16”</td><td colspan="2">L e/c: 40”
R e/c: 30”</td><td>L: +11”
R: +14”, >29”</td><td>Yes</td></tr>
<tr><td colspan="7">Outcome Measures:</td></tr>
<tr><td>LLFI</td><td colspan="2">13.5pts (46%)</td><td colspan="2">4.2pts (82%)</td><td>-9.3pts</td><td>Yes</td></tr>
<tr><td>KOS-ADLS</td><td colspan="2">66% (46/70pts)</td><td colspan="2">90% (63/70pts)</td><td>24% (17pts)</td><td>Yes</td></tr>
<tr><td colspan="7">PARTICIPATION RESTRICTIONS</td></tr>
<tr><td>Outcome</td><td colspan="2">Initial</td><td colspan="2">Follow-up</td><td>Change</td><td>Goal Met</td></tr>
<tr><td>SF-36</td><td colspan="2">PCS = 27.4</td><td colspan="2">PCS= 49.0</td><td>+22pts</td><td>Yes</td></tr>
</table>

Discharge Statement

The patient was seen, in addition to the initial evaluation, for one hour once per week for six weeks, for a total of seven patient visits. During this time, the patient was able to meet all long term goals relating to lower extremity (LE) strength as measured by MMT, proprioception and balance as measured by SLS time with eyes closed and all outcome measure goals as measured by the SF-36, LLFI and KOS-ADLS. The patient's LE strength, self-reported confidence and general ability are measured to be at her prior level of function allowing for a predicted safe return to sport. The patient was able to reach long term activity limitation goals of increasing LE proprioception and balance as measured by decreased SLS time on the right LE as compared to the left. There was still a difference between the left and right ability in SLS eyes closed but the initial goal was met. This discrepancy may signify the need for either continued practice, different practice or suggestive that more time is needed to equal these values, or a combination of these. The patient did indeed return to recreational basketball after the intervention and upon a six-month follow-up she was injury free and had no complaints of right knee instability. The patient had also been able to return to her prior level of running and hiking abilities, also without complications. The discharge G-code as measured by the post-test PCS portion of the SF-36 (49.0/50) shows the patient with 2% impairment therefore a code of G8980 CI.

Chapter 7

Discussion

General outpatient physical therapy services utilize measures such as MMT, SLS and patient surveys on a daily basis. In relating the majority of this case study to items such as those, it became apparent how scarce research supporting the validity and reliability of these measures are, and that they may not be the most consistent measures available. The use of the BM was added to incorporate the value of ever growing technology as a clinically applicable tool to provide the patient real-time movement pattern tracings and augmented knowledge of results. Although the BM may generally have a higher sensitivity to change due to the use of force plates, this was not an advantage due to lack of research of clinically meaningful change in the BM measures.

The treatment prescribed to the patient allowed for flexibility in the form of a HEP as well as the added benefit of a small time commitment of having to come into clinic for only one hour once per week. Although this was an advantage for the patient due to her busy schedule it may have been a disadvantage towards patient progress due to the decreased time of direct intervention.

Overall I did expect the patient to improve in strength measures due to her determination to return to her prior level of function and her frequency of reported exercise, about 5-7x/week. I did not predict the difficulty in restoring balance ability in the patient's lower extremities, showing the difficulty in neuromuscular reeducation, even in a patient with a sound neurological system. Although equality between the patient's bilateral lower extremity SLS time with eyes closed was not reached, the original goal was indeed met.

If I were to treat the same patient in the future there are many items I would reconsider. First of those would be to place a greater focus on the weight bearing squat activity in the intervention because of its high importance as a sport specific activity. I believe the patient would benefit from adding a more dynamic component to this activity to portray the sports specific aspect. Although the patient did ultimately reach the desired goals for weight bearing, the BM measure is insufficient in its inability to measure weight bearing squat in a dynamic setting. Next, I would have added further objective examination measures to the six month patient follow-up. The patient had a limited amount of time to commit to a follow-up assessment but I would have performed a full BM re-assessment as well as all of the patient outcome measure surveys if there had been the time. This would have revealed any decrease in function, improvement or no change six months following treatment in all ICF categories. In a true outpatient clinical setting I feel that it is rare to have any sort of follow-up, therefore, I would have liked to take greater advantage of the opportunity this case study enabled me.

Throughout this case study I have realized the minimal prevalence of non-surgical interventions following tibial plateau fractures in current physical therapy research. If this condition was more prevalent there would be additional research to pull from to support or refute certain outcome measures and interventions. This simply reinforces the importance of treating the patient as a whole. A patient's intervention should include a balance of evidenced based practice to address his or her impairments, limitations and restrictions as well as the inclusion of the patient's personal goals and motivating factors.

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