2018-10-03

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Article type : Brief Report

Characteristics of Usual Physical Therapy Post-Total Knee Replacement and their Associations with Functional Outcomes

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Financial support: This study was supported in part from a grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (1-RO1-AR-054479-01A1).

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Conflict of Interest: none declared

Abstract

Objective. Although total knee replacement surgery (TKR) is highly prevalent and generally successful, functional outcomes post-TKR vary widely. Most patients receive some physical therapy (PT) following TKR, but PT practice is variable and associations between specific content and dosage of PT interventions and functional outcomes are unknown. Research has identified exercise interventions associated with better outcomes but studies have not assessed whether such evidence has been translated into clinical practice. We characterized the content, dosage and progression of usual post-acute PT services following TKR, and examined associations of specific details of post-acute PT with patients' 6-month functional outcomes.

Methods. Post-acute PT data were collected from patients undergoing primary unilateral TKR and participating in a clinical trial of a phone-based coaching intervention. PT records from the terminal episode of care were reviewed and utilization and exercise content data were extracted. Descriptive statistics and linear regression models characterized PT treatment factors and identified associations with 6-month outcomes.

Results. We analyzed 112 records from 30 PT sites. Content and dosage of specific exercises and incidence of progression varied widely. Open chain exercises were utilized more frequently than closed chain (median and interquartile range (21(4,49) vs 13(4,28.5)). Median (interquartile range) occurrence of progression of closed and open chain exercise was 0 (0,2) and 1 (0,3) respectively. Shorter timed stair climb was associated with greater total number of PT interventions and use and progression of closed chain exercises.

Discussion. Data suggest that evidence-based interventions are under-utilized and dosage may be insufficient to obtain optimal outcomes.

Significance and Innovation

- Although PT is widely used following TKR, treatment is extremely variable, lacking any standardized approach in practice. The contribution of “usual physical therapy” to functional outcomes is unknown.
- In the absence of evidence identifying optimal content and dosage of PT, new reimbursement models may reduce the use of PT post-operatively without an understanding of the impact of such changes on functional outcomes. Pragmatic studies to identify optimal PT practice may have significant impact on both PT practice and public policy.
- This is the first study to report the specific details of PT interventions provided in a clinical setting and preliminary analyses of associations with functional outcomes following TKR.
- Our data suggest that evidence-based PT interventions may be under-utilized in clinical practice and that the dosage of interventions may be insufficient to achieve optimal outcomes.

Over 690,000 primary total knee replacement surgeries (TKR) were performed in the United States in 2012 to relieve pain and restore physical function in patients with advanced knee arthritis (CDC). However studies suggest that more than one-third of patients receiving TKR report little or no improvement in function[1]. Following hospital discharge post-TKR, rehabilitation is a routine intervention, with 75-85% of patients receiving physical therapy

(PT).[2] Guidelines consistently include post-acute rehabilitation.[3-5] Yet there is no accepted standard program of PT care and little is known about the contributions of rehabilitation to long-term outcomes.

Wide variation exists in the amount and form of PT following TKR.[2, 6-8] Little information exists about, when or if PT should be provided, and which PT components are most beneficial. Evidence-based guidance is needed to decrease unwarranted treatment variation and optimize outcomes.

Consensus exists on the need to increase knee strength and ROM[3, 5], but little agreement exists on the kinds and amount of exercises used. No consensus was found among patients, therapists and surgeons on PT treatment duration, PT intensity or frequency in rehabilitation post-TKR.[3]. Clinical trials demonstrate improved functional outcomes with quadriceps strengthening following TKR[9], but assessment of strengthening regimens suggest that many PT exercise interventions following TKR lack sufficient intensity to produce physiologic benefits.[4, 10] Our own data demonstrated that the strengthening exercises documented in PT records following TKR varied widely and approximately 25% of records had no documentation of progressive quadriceps strengthening[7].

In the absence of clear evidence for the contributions of post-acute PT following TKR, new reimbursement models may incentivize a reduction in PT services. Studies suggest that patients following total hip replacement may not benefit from PT.[11] Anecdotal data suggest a similar pattern is emerging post-TKR.

Given the variability in amount, content and dosage of PT following TKR and trends toward reduction in PT services, the purpose of our study was to describe the content, dosage and progression of post-acute PT services across multiple PT facilities and to identify associations between specific details of the PT services and patients' 6 month self-reported functional outcomes and performance measures. We focused on the type and intensity of exercise content delivered and the number and timing of PT visits during the terminal episode of PT care following TKR surgery.

Patients and Methods

This was a cross-sectional observational study of usual post-acute PT provided to patients after hospital discharge for TKR. Data were obtained from PT records of individuals enrolled in the Joint Action Randomized Clinical Trial study at the University of Massachusetts Medical School (UMMS) between 2008 and 2011 (NCT00566826). The trial was designed to examine the effects on 6-month functional outcomes following TKR of a behavioral intervention consisting of up to 12 telephone-delivered coaching sessions focusing on at-home self-management strategies to enhance post-T KR recovery. Neither the patient's surgeon nor PT providers were aware of the patients' random allocation. The intervention did not influence PT care.The methods have been described elsewhere[12]. The study was approved by the Institutional Review Boards of the UMMS and Arcadia University.

Participants were consecutively enrolled from all individuals 21 years of age or older scheduled for primary TKR surgery at the Arthritis and Joint Replacement Center of the UMass Memorial Medical Center, Worcester, MA. Subjects were eligible if they had a primary unilateral TKR for osteoarthritis. Exclusion criteria included inflammatory arthritis, co-existing conditions preventing functional improvement and cognitive impairments. More than 95% of eligible patients enrolled. Participants signed releases allowing review of their health records during the study period. Participants in the study received usual operative and rehabilitation care according to theirs and the clinicians' preferences.

Baseline variables were collected prior to surgery and included: age, sex, physical co-morbid conditions, and body mass index (BMI). Mental and physical health status and function were collected at baseline and 6-months post-surgery using the mental and physical component scores (MCS and PCS) of the SF-36 and the joint specific Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

Outcome measures at 6 months included the functional subscore of the WOMAC and knee performance measures consisting of the timed stair climb (TSC) and knee flexion ROM. The TSC was measured as the time in seconds required to ascend and descend a standard flight of stairs of 10 steps. Instructions to the patient were standardized and the patient was allowed to use the railing or assistive device as needed. ROM was measured in degrees using an inclinometer. With the patient lying supine, the hip on the side of the index knee was flexed to 90^{O}. The patient actively flexed the knee as far as tolerated. The inclinometer was placed on the medial surface of the mid shaft of the tibia. Flexion ROM equaled the inclinometer reading plus 90^{O}.

All performance measures were collected by one of two physical therapists, and inter-rater reliability of the performance measures was assessed using seven patients post-TKR or with knee osteoarthritis for the TSC reliability testing and nine subjects for the ROM test. ROM reliability was reassessed regularly throughout the study . Inter-rater reliability (ICC(2,1) for the TSC was 0.90. Inter-rater reliability of flexion ROM was 0.94 and remained > 0.85 for the entire study.

Three dedicated arthroplasty surgeons at one high volume center performed all TKR surgeries using a consistent peri-operative protocol for inpatient care. Patients chose their PT provider and received usual care PT as prescribed by their healthcare provider. At their 6-month study assessment, participants listed the facilities where they had received PT.

The trial enrolled 180 eligible patients. The Figure illustrates the disposition of the patients for this analysis. Sixteen patients were excluded due to no, insufficient or invalid PT facility information. PT records for the remaining 164 subjects were requested from the facility where they received their terminal episode of care, defined as care provided in the setting where the participant completed rehabilitation associated with the TKR. We focused on the terminal episode of care because studies demonstrate that quadriceps muscle strength decreases immediately following surgery and is less than pre-operative levels at four weeks post-TKR [13]. Rehabilitation directed toward functional improvement likely occurs in the final rehabilitation setting.

We performed a retrospective review of each record to determine the number of PT visits post-surgery and the type, frequency and dosage of each exercise provided over the entire episode of care. Each exercise was listed and exercises were grouped into three categories: open chain, closed chain and passive. In open chain exercises the patient actively moved the joint while the limb was non-weight bearing. In closed chain exercises the patient actively moved the joint while the limb was weight bearing. In passive interventions the therapist moved the limb or joint. Intervention frequency was the number of times that an intervention was delivered over the course of care. Intervention dosage was the number of times that an intervention was progressed. Progression was any increase in the level of difficulty of an exercise, by changing the form of the exercise or by increasing the resistance.

Investigators with advanced PT training extracted treatment data from the PT record. These extractors were trained to ensure that each exercise or progression was documented and classified in a consistent manner. Two investigators independently reviewed each record. Differences were resolved through discussion and if necessary adjudicated by the lead PT investigator (CO).

Data analysis

Linear regression models assessed associations of number of PT visits, PT intervention content and frequency with 6-month outcomes, with and without adjusting for sex, age, baseline PCS, and baseline WOMAC function. Descriptive statistics were used to describe patient sociodemographic and clinical characteristics, and the utilization and characteristics of PT.

Results

We received 159 (97%) PT records of the 164 requested. Records from 112 patients (70% of records received) contained sufficient intervention detail to analyze (Figure). Records lacked sufficient detail because they lacked initial or discharge evaluations or daily notes, referred to protocols not included in the record or were illegible. Of the 112 records analyzed, 91 records were from 27 outpatient facilities and 21 records were from 3 home care facilities.

Baseline characteristics of the 112 patients whose records were reviewed were similar to the national average of patients undergoing primary TKR[14]. Seventy percent of participants were women. Average age was 64 years and average BMI was 32.8. Average PCS and MCS scores were 33.3 and 52.8 respectively. (Scores can range from 0-100 with higher scores indicating better health.) Average WOMAC pain, stiffness and function were each approximately 5.0. WOMAC scores can range from 0-10, 10 being the worst. [14]

From the PT records, we identified a total of 34 different interventions, including 16 closed chain, 14 open chain, and 4 passive exercises. Four additional exercises (biking for ROM or endurance, and hamstring or plantar flexor stretches) were identified but lacked sufficient detail to categorize or quantify and were not included in the analysis.

Over the course of PT care, on average, patients had 14.5 PT visits and 12.8 different exercise interventions, including 4.5 closed chain exercises, 5.1 open chain exercises and 1.8 passive interventions (Table 1). Open chain exercises were utilized more frequently than closed chain (median and interquartile range: (21 (4,49) vs 13 (4,28.5)). On average progression of open chain exercises was documented 2.6 times over the entire episode of care and 1.4 times for closed chain exercises. The median number of progressions documented for open chain exercises was 1 (IQR 0,3) and for closed chain was 0 (IQR 0,2). Timing of the initiation of either closed or open chain exercises varied widely.

Considerable variation existed in the specific exercises documented in the PT records. Of the 16 closed chain exercises identified, only squats (or wall slides) and step-ups were documented in more than 50% of the records (71% and 63% respectively). Of the 14 open chain exercises identified, only straight leg raises, quadriceps sets, and short arc quadriceps exercises were documented in more than half the records (63%, 57%, and 55% respectively). Of the 4 passive exercises, passive ROM for knee extension and knee flexion were documented in 57% and 59% of the records respectively.

Shorter time to climb and descend stairs (Timed Stair Climb (TSC)) was associated with greater total numbers of PT interventions, closed chain interventions, PT visits in which closed chain exercises were performed, and closed chain progressions (Table 2). Better post-TKR knee flexion ROM was seen among patients having larger total number of closed chain progressions. Worse ROM was associated with total number of passive interventions and duration between surgery and the first post-operative day on which a passive intervention was provided.

Adjusting for baseline characteristics did not substantially alter the results although some associations were no longer statistically significant at the 5% significance level. Adjustment for sex, age, baseline PCS and WOMAC function did not alter the associations between the number of closed chain exercise progressions and TSC. We observed approximately a 1-second decrease in the time required to ascend and descend a flight of stairs for every closed chain progression. In contrast, the total number of PT visits was not associated with knee performance outcomes or with WOMAC function scores.

Discussion

Previous studies found little difference in effectiveness between "usual" PT and other interventions [15]. Our data show wide variation in the exercises patients receive during "usual" PT, and suggest that the details of the intervention may be important determinants of the functional outcomes following TKR. This is the first known study to examine specific details of usual PT intervention and their effect on functional outcomes 6 month after TKR.

Westby et al report little consensus among rehabilitation specialists regarding the timing, content, or quantity of physical therapy interventions for patients post-TKR surgery although there is general agreement that exercise to increase ROM and quadriceps strength is important [3]. There is considerable data supporting the effectiveness of progressive quadriceps strengthening to improve long term function following TKR[9]. Studies also support the use of weight bearing exercises to enhance functional outcomes following TKR. Medicare "Current Procedural Terminology" (CPT) data from a sample of Medicare TKR patients demonstrate that strength and range of motion (ROM) exercises and mobilization were the most commonly provided PT interventions post hospital discharge, but these data offer no details about exercise content or dosage.[6] The lack of such detail hampers the ability to assess the quality and effectiveness of routine PT practice.

Our data confirm the wide variations in timing, content and amount of PT in current practice and support the use of weight bearing exercises and progressions to improve 6-month knee performance outcomes following TKR. Indeed, we demonstrated approximately a 1second decrease in the time required to ascend and descend a flight of stairs for every closed chain progression made. In contrast, open chain exercises, showed little or no association with performance outcomes.

Several plausible explanations exist for the associations of PT characteristics with functional outcomes observed in this study. Perhaps only fit patients perform closed chain exercises, and they would naturally have the best outcomes. However after adjustment for sex, age, baseline PCS and WOMAC function, the associations between closed chain exercise progressions and TSC persisted. Total number of passive interventions and the days from surgery to onset of passive interventions were associated with worse ROM outcomes. These data may suggest that patients struggling with pain or ROM received more passive treatments such as passive stretching. The data may also suggest that, with limited treatment time, spending time on passive interventions decreases the amount of time available for active exercises that would increase function. The small sample size and cross-sectional nature of our study limits our ability to adequately adjust for all patient baseline characteristics.

Despite published evidence supporting progressive quadriceps strengthening and weight bearing exercises for improved outcomes following TKR, our data show that 106 (95%) of the records documented the use of weight bearing exercises but only 35 (31%) documented progression of those exercises. Muscle strengthening requires progressively increased resistance to adequately overload the muscle. Our data suggest many patients may have exercised at a level insufficient to produce strengthening.

Our study has several limitations as well as strengths. Because we collected data from a single geographic area and participants were participating in a clinical trial, the study results may not be generalizable. However, the participants of the clinical trial represented over 95% of all subjects undergoing TKR who met the inclusion criteria, and baseline characteristics of subjects whose PT records were reviewed did not differ from the total sample. We believe selection bias is unlikely. Our data were derived from retrospective chart reviews, and not all facilities require the same documentation. Only 70% of records contained sufficient detail for review. However our review of over 100 records from 30 facilities provides considerable insight into what is meant by "usual" PT care. It is possible that the records reviewed did not include all exercises or progressions actually provided. However, we only reviewed those records that provided notes for every visit and detail about exercises and dosage. While it is possible that some details are lacking, we believe that the records are generally representative of the care provided. Finally, the independent assessors of knee performance measures assured independent endpoints across all treating PTs.

Our data collection system accounted for every exercise intervention and created a classification system that provides a theoretical framework to evaluate the content of PT interventions. Virtually no record contained enough detail to completely characterize the volume and intensity of the exercise intervention and many records lacked details to explain discharge decisions. Despite the limitations of the current study, it offers the first known insights into the actual details of usual physical therapy provided to patients following TKR and the associations found between the details of PT practice and long term functional outcomes.

Given the limitations of this study, the next step necessary to determine the value of physical therapy in post-TKR recovery is to create a PT documentation system capable of prospectively detailing the content, frequency and intensity of each PT visit and intervention . This documentation system is currently being deployed in a pragmatic study with a sufficient sample size of therapists and patients to identify the most effective treatment strategies within PT practice while accounting for individual characteristics of the patients.

Conclusion

The use of weight bearing exercises and the frequency of progression of these exercises following TKR surgery are associated with positive functional outcomes at 6 months post-surgery. Evidence suggests these interventions are underutilized in routine practice. Additional research is needed to fully understand the characteristics of PT interventions contributing to positive functional outcomes and to identify “best practice” adjusting for patient characteristics that lead to optimal functional outcomes following TKR surgery.

Acknowledgements

This study was supported in part from a grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (1-RO1-AR-054479-01A1). The study sponsor played no role in the study design, collection, analysis or interpretation of data, in the writing of the manuscript or in the decision to submit the manuscript for publication.

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Figure legends

Figure. Physical therapy records requested, obtained and analyzed from participants in clinical trial following TKR.

Figure

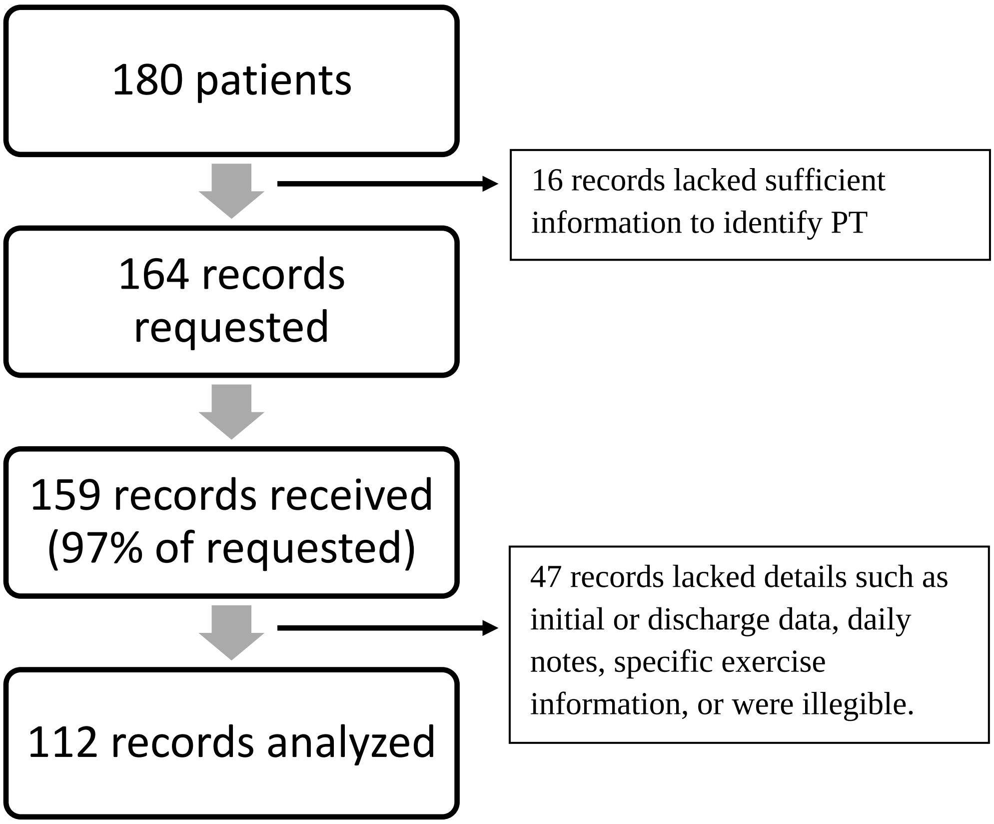

Table 1. Dosage of PT interventions by content

Dosage	Mean (SD)	Median (Interquartile range)
Number of PT visits	14.5 (8.4)	12 (9.3, 17.0)
Number of PT interventions	12.8 (5.3)	13 (9, 17)
Closed Chain (CC)		
Total number of CC interventions	4.5 (2.5)	4 (3, 7)
Frequency of CC exercises performed	20.7 (23.2)	13 (4, 28.5)
Total number of CC progressions	1.4 (2.5)	0 (0, 2)
First day of CC intervention initiation	33.7 (23.7)	36 (19, 43.5)
Average number of CC exercises per visit	1.5 (1.7)	1.2 (0.4, 2.3)
Open Chain (OC)		
Total number of OC interventions	5.1 (3.8)	5 (2, 8)
Frequency of OC exercises performed	30.45 (30.9)	21 (4, 49)
Total number of OC progressions	2.6 (3.9)	1 (0, 3)
First day of OC intervention initiation	30.2 (15.0)	32 (17.3, 42)
Average number of OC exercises per visit	2.5 (2.8)	1.8 (0.3, 4.0)
Passive interventions (PS)		
Total number of PS interventions	1.8 (1.2)	2 (1, 3)
Frequency of PS performed	13.9 (20.2)	7 (1, 19)
Total number of PS progressions	0.05 (0.3)	0 (0, 0)
First day of PS intervention initiation	28.12 (17.5)	32 (16, 40.8)
Average number of PS per visit	0.85 (0.86)	0.6 (0.1, 1.5)

Table 2. Associations of overall and content-specific dosage of PT interventions with functional improvement 6 months post-TKR (regression coefficients (95% CI))

	Times Stair Climb (TSC)		WOMAC Function Subscale		Knee Flexion ROM	
Predictors	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
Number of PT visits	-0.11 (-0.38, 0.16)	-0.14 (-0.38, 0.09)	0.14 (-0.13, 0.42)	0.18 (-0.11, 0.46)	-0.28 (-0.64, 0.08)	-0.27 (-0.62, 0.08)
Number of PT interventions	-0.49 (-0.87, -0.10) *	-0.20 (-0.57, 0.17)	-0.05 (-0.49, 0.39)	-0.04 (-0.51, 0.44)	0.10 (-0.44, 0.63)	0.03 (-0.53, 0.59)
Close Chain (CC)						
Total number of CC interventions	-0.97 (-1.81, -0.14) *	-0.46 (-1.25, 0.32)	-0.36 (-1.29, 0.57)	-0.47 (-.147, 0.53)	0.23 (-0.95, 1.40)	-0.06 (-1.25, 1.13)
Total number of visits completing CC	-0.09 (-0.18, -0.01) *	-0.05 (-0.13, 0.03)	-0.03 (-0.13, 0.07)	-0.02 (-0.13, 0.08)	0.06 (-0.05, 0.18)	0.03 (-0.10, 0.15)
Total number of CC progressions	-0.99 (-1.78, -0.20) *	-0.70 (-1.38, -0.02) *	-0.83 (-1.78, 0.12)	-0.96 (-1.97, 0.05)	1.49 (0.44, 2.54) #	1.53 (0.48, 2.58) #
First day of CC intervention initiation	0.06 (-0.10, 0.22)	0.04 (-0.10, 0.18)	0.08 (-0.02, 0.19)	0.11 (-0.01, 0.22)	-0.14 (-0.34, 0.06)	-0.18 (-0.39, 0.04)
Ratio of CC visits to total # of visits	-1.45 (-3.08, 0.17)	-0.54 (-2.07, 0.99)	0.009 (-1.40, 1.42)	-0.03 (-1.54, 1.48)	1.99 (-0.17, 4.13)	1.57 (-0.65, 3.78)
Open Chain (OC)						
Total number of OC interventions	-0.30 (-0.87, 0.27)	-0.06 (-0.59, 0.47)	0.08 (-0.55, 0.70)	0.09 (-0.56, 0.74)	0.24 (-0.54, 1.03)	0.30 (-0.49, 1.09)
Total number of visits completing OC	-0.02 (-0.08, 0.05)	-0.01 (-0.07, 0.05)	0.04 (-0.03, 0.12)	0.05 (-0.03, 0.13)	0.03 (-0.06, 0.12)	0.04 (-0.05, 0.13)
Total number of OC progressions	-0.16 (-0.75, 0.42)	-0.40 (-0.89, 0.08)	0.04 (-0.60, 0.68)	0.02 (-0.64, 0.69)	0.39 (-0.36, 1.13)	0.46 (-0.30, 1.23)
First day of OC intervention initiation	0.08 (-0.08, 0.24)	0.07 (-0.07, 0.22)	0.16 (-0.01, 0.34)	0.16 (-0.01, 0.34)	-0.06 (-0.27, 0.15)	-0.12 (-0.34, 0.11)
Ratio of OC visits to total # of visits	-0.09 (-1.08, 0.90)	0.03 (-0.84, 0.91)	0.41 (-0.41, 1.24)	0.43 (-0.42, 1.28)	0.67 (-0.66, 2.00)	0.89 (-0.39, 2.17)
Passive interventions						
Total number of PS interventions	-1.27 (-3.07, 0.53)	-0.97 (-2.61, 0.67)	-0.53 (-2.43, 1.38)	-0.32 (-2.31, 1.66)	-2.73 (-5.14, -0.33) *	-2.94 (-5.32, -0.56) *
Total number of visits completing PS	-0.05 (-0.16, 0.07)	-0.02 (-0.13, 0.079)	0.02 (-0.09, 0.14)	0.03 (-0.09, 1.50)	-0.02 (-0.18, 0.14)	-0.03 (-0.19, 0.12)
Total number of PS progressions	1.28 (-6.58, 9.13)	0.68 (-6.06, 7.43)	-4.01 (-14.3, 6.25)	-3.30 (-13.9, 7.31)	1.50 (-8.65, 11.65)	2.75 (-7.73, 13.2)
First day of PS intervention initiation	-0.005 (-0.15, 0.14)	-0.015 (-0.14, 0.11)	0.07 (-0.07, 0.21)	0.07 (-0.08, 0.22)	-0.23 (-0.41, -0.06) #	-0.24 (-0.42, -0.06) #
Ratio of PS visits to total # of visits	-1.62 (-4.40, 1.17)	-0.41 (-2.90, 2.01)	-0.96 (-3.69, 1.77)	-0.99 (-3.85, 1.88)	0.29 (-3.51, 4.09)	-0.38 (-4.08, 3.32)

* p<0.05; # p<0.01