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Pilot study

Pilot study: Post-operative rehabilitation pathway changes and implementation of functional closed kinetic chain exercise in total hip and total knee replacement patient

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ABSTRACT

Objective: The aim of this study was to assess the feasibility of introducing a functional closed kinetic chain exercise program to an acute care setting to reduce length of hospital stay and assess tolerance to exercise immediately following total hip or total knee arthroplasty.
Methods: A protocol change implementing a functional closed kinetic chain based exercise program, post total hip (n = 535) and total knee (n = 695) arthroplasty, was performed at Windsor Regional Hospital Ouellette Campus in Windsor, Ontario Canada. A chart review was performed to compare the length of stay, post-surgery, of the new protocol to the length of stay of the previous range of motion and open kinetic chain based protocols of the previous two years.
Results: A significant (P-value <0.05) number of total hip and total knee arthroplasty patients reduced the length of hospital stay to less than 4 days using the closed kinetic chain program.
Conclusion: Evidence suggests that closed kinetic chain exercises are tolerated in the acute care setting and may be useful in reducing hospital length of stay post total hip and total knee arthroplasty.

1. Introduction

Ontario acute care hospital facilities have had increasing demands in the recent years which have led to a daily shortage in hospital beds. This has resulted in numerous elective surgery cancellations in order to support acute care medical concerns. Elective total hip and knee arthroplasties are among the most common cancelled surgeries to accommodate this shortage. At Windsor Regional Hospital Ouellette Campus (WRHOC), the total hip replacement (THR) and total knee replacement (TKR) surgical pathways had consisted of 4 days, where the day of surgery was considered post-operative day (POD) 0 and day of discharge (DOD) was expected to be POD 4. Thus, the elective post-operative patient was holding an acute care bed for approximately 4 days. Other than acute post-operative medical concerns, this length of stay was primarily dependent on the patient's need to achieve specific physical therapy goals prior to discharge; especially when elective surgical patients had no acute medical concerns prior to surgery. Moreover, the hospital's daily costs associated with an acute care patient was significant enough, where the hospital would largely benefit from decreasing the length of stay for post-operative elective surgeries.

Once a post-operative elective THR and TKR surgical patient has been medically cleared by their surgeon, their discharge is dependent on the physical therapist's determination of safe return to home. The required goals upon discharge include; independent bed mobility, independent transfers and gait and stair mobility, with respect to their functional need at home. Patients are also required to have a good understanding of their self-directed exercises. In addition, most TKR patients must achieve a minimal range of motion (ROM) of the post-operative knee of 90° of knee flexion and 0° of knee extension. Therefore, discharge of the THR and TKR patients are dependent on physical therapy goals, and the faster these goals were achieved dictated the culmination of the pathway and the release of an occupied acute care bed. The goal to improve post-operative physical therapy and decrease length of stay, while maintaining functional discharge criteria, would ultimately decrease the post-operative pathway for THR and TKR length of stay.

The current clinical pathway with respect to physical therapy

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began on POD 1, where the therapist trained the patients on safe independent bed mobility, transfers and gait. The patients were educated on ankle dorsiflexion and plantar flexion circulation exercises to prevent blood clots. Patients were also educated on bed exercises completed in supine. THR exercises included static Quadriceps contraction, static Gluteus Maximus contraction, hip and knee flexion and hip abduction, while complying with the post-operative hip precautions. TKR patients completed knee ROM on a knee slider board, after 20 min of ice and concluded with a ROM measurement. TKR patients also completed static quadriceps contraction, quadriceps over roll knee extension and straight leg raise. On POD 2–3, patients continued with bed mobility, transfers and gait training. The physical therapist progressed the patients' gait aids, as required and increased repetitions of their bed exercises. On POD 4, patients were educated on stair climbing, if it was required for home mobility. If patients demonstrated independent and safe mobility and knee ROM requirements were met, they were discharged from physical therapy; and if medically cleared, were able to return home.

The current post-operative protocol had many limitations. Primarily, it does not correlate with trends in evolving rehabilitation evidence. In addition to its daily non-progressive repetitive treatment, the post-operative exercises were non-functional and based on open kinetic chain movements. Open kinetic chain (OKC) exercises allow the distal limb to move freely and are not considered a functionally based exercise due to the lack of similarity to daily movements. This rehabilitation technique was specific to isolate joints or muscle groups and focused on concentric muscle contraction training. OKC exercises were traditionally incorporated in post THR and TKR rehabilitation due to the thought that these exercises were minimally aggressive for the new joint and decreased the load on the joint. However, OKC exercises may lead to many overlooked musculoskeletal issues as well as increased shear forces through the newly replaced joint. *'Analysis of tibiofemoral compression forces and electromyographic recruitment patterns revealed that the closed-kinetic-chain exercise produced significantly greater compression forces and increased muscular co-contraction at the same angles at which the open-kinetic-chain exercises produced maximum shear forces and minimum muscular co-contraction.'* (Lutz et al., 1993) Aside from the increased forces placed upon the joint, the lack of inherent functionally based movements performed by these exercises may have left patients with deficits post THR and TKR rehabilitation.

Research on THR and post replacement deficits revealed that, '*bed exercises were of no additional benefit to early mobilization after THR*' (Roos, 2003). In addition, surgical incision and pain caused by TKR inhibits the Quadriceps Vastus Medialis, a primary medial knee and patella stabilizer (Chmielewhi et al., 2004). Both muscles groups remain inhibited without proper activation and training, post THR and TKR. *'Quadriceps strength is related to functional performance and it is the single greatest predictor of function'* (Petterson et al., 2009; Mizner et al., 2005). *Following a TKR surgery, there is 'a mean extension strength loss of 80% and this loss is directly correlated to functional performance'* (Jakobsen et al., 2012). Quadriceps weakness would further decline with non-functional exercise, such as OKC. Furthermore, following TKR surgery, patients have exhibited lower extremity asymmetry for functional movements. Despite the testing conditions or time post-surgery, strength and load bearing asymmetry existed between affected and unaffected side. Patients are 'relying *on their unaffected side for completion of functional tasks*' (Rossi and Hanson 2004, Rossi et al., 2010).

During the design phase of this study, a telephone survey was conducted to major acute care hospitals in Ontario, which revealed the common post-operative exercise was OKC for THR and TKR surgeries. As OKC exercise is the current standard for post THR and TKR rehabilitation, a lack of functionality and activation of inhibited musculature has been noted, causing the aforementioned functional deficits. This is a traditional method of exercise and not an evidence based method of post joint replacement rehabilitation.

Closed kinetic chain (CKC) exercises fixate the distal portion of the limb, producing multi-joint and multi-muscle therapy. CKC exercises mimic commonly used movements and are considered functional exercise. According to Stensdotter et al. (2003), CKC exercises have many benefits. CKC produce co-contraction around the joint, increasing joint stability. These benefits, in reference to THR and TKR rehabilitation, seem to outweigh those of OKC regarding stabilization, functionality and muscular strength progression.

The current post-operative protocol had no CKC exercise to achieve the required post-surgical hospital discharge mobility goals: bed mobility, transfers, gait and stair training. Research has supported that after a TKR, the most difficult tasks to complete require '*entire lower limb force production*,' such as stair climbing and sit-stands (Jones et al., 2003; Rossi and Hanson 2004, Rossi et al., 2006, 2010; Walsh et al., 1998; Whitehouse et al., 2003). These are all closed kinetic chain tasks that should be trained with CKC functional specific rehabilitation (Rossi et al., 2010). In addition, the protocol had no functional progressions, besides increasing repetitions. Stair training was only initiated on the expected day of discharge, leaving no room for continued training. Furthermore, higher intensity exercise had been limited due to fear of prosthesis failure, which may have led to greater length of stay. Jakobsen et al. (2012) showed that patients can tolerate an intense progressive strengthening program 1–2 days follow TKR, without affecting ROM and while producing increased isometric knee extension strength by 147%, increased maximal walking speed by 112%, while maintained pain levels at mild to moderate during and after exercises. Therefore, *'progressive strength training initiated immediately after TKA is feasible and increases knee extension strength and functional performance without increasing knee joint effusion or knee pain'* (Jakobsen et al., 2012). These results seem to dispel the common myths that post-surgical patients cannot tolerate intensive post-operative exercise program. Roos, (2003), found that even elderly patients with co-morbidities can tolerate *'early intensive rehabilitation.'* In fact, exercises can start as early as in the recovery room (Andersen et al., 2008).

The need for an abbreviated pathway, including progressive functional based CKC exercise was determined. The goal of this analysis was to identify if a higher intensity, abbreviated CKC rehabilitation program could produce shorter length of stay, with the same discharge criteria, while introducing a functional based exercise program to elective THR and TKR patients.

2. Method

A change in hospital protocol was designed to implement a new rehabilitation pathway for post-surgical THR and TKR patients at WRHOC, in order to: decrease length of stay and promote increased functionality for the patients at DOD without modifying patients' discharge criteria. . Due to limitations in resources and time in the acute care setting, more than one sample group could not be tested consecutively. All subjects that received a TKR ($n = 381$) and THR ($n = 274$) at WRHOC in 2013, were subject to the new rehabilitation protocol and data collected underwent a chart review, comparing the DOD of the average number of TKR ($n = 314$) and THR ($n = 261$) from 2011 to 2012.

The new post-operative rehabilitation pathway (NPORP) was chosen to incorporate functionally based exercises. The functionally specific CKC exercises were geared towards helping patients meet their discharge mobility goals of independent bed mobility,

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transfers, gait and stair mobility, efficiently; decreasing the hospital post-operative length of stay. Table 1, describes a simplified overview of the differences and similarities of the current pathway and the NPORP.

Due to limited clinical information, in the acute phase of rehabilitation for THR and TKR, a CKC and functional based program was developed specifically for this protocol change. The CKC exercise program selection process was based on expected mobility requirements, independent bed mobility, transferring, ambulation, stair mobility and simplicity of integration in to a hospital setting. Due to variation in exercise education, standardized biomechanical cueing (Table 2) was taught to each physical therapist and rehabilitation assistant (RA) to ensure quality.

The NPORP was implemented by rehabilitation staff, beginning January 2013, to all post-operative elective THR and TKR surgeries, eliminating the previous post-operative OKC exercise protocol. A physical therapist and RA completed the program with every new joint replacement patient. As described in Table 2, 3–5 of the NPORP exercises were performed each session based on patient tolerance, therapist caseload and staff availability. Table 3 outlines the administration and timeline of the NPORP.

All patients that received a THR or TKR in 2011, 2012 and 2013 were included in the study. Patients that met the exclusion criteria (Fig. 6) during the chart review, were excluded from the study. The exclusion criteria was the same from 2011 to 2013 and included any reason that a patient's discharge may have been delay for any reason outside of the scope of physiotherapy, with the exception of data collection error. Exclusion rates and effective sample sizes are noted in Fig. 4.

3. Data collection

The physical therapist post-operative data collection consisted of data collected on POD 1 (Fig. 1) and DOD (Figs. 1 and 2). Fig. 2 data was collected from January 2011 to December 2012, under the previous OKC exercise program, for comparison.

Data for this initial analysis was organized into two major categories, THRs and TKRs. Categorical groups were created based on the DOD of less than 4 days or greater than or equal to 4 days. Sample sizes (Fig. 3) were calculated using exclusion criteria (Fig. 6) and the average samples were calculated for THR and TKR for 2011 and 2012, in order to be compared to 2013. A chi-square analysis was performed to compare the number of patients in 2013, discharged from the hospital less than 4 days post arthroplasty to the average number of patients discharged less than 4 days post arthroplasty in 2011/2012.

4. Results

Fig. 3 displays that the number of THR and TKR patients discharged less than POD 4 significantly increased in 2013, when compared to the mean number of patients discharged less than POD 4 in 2011/2012. The sample sizes for 2013 THR and TKR and mean samples sizes for 2011/2012 (Fig. 3) were compared and rates of exclusion noted (Fig. 4). Statistical analysis results were summarized (Fig. 5) comparing P-values for THRs and TKRs. Reasons for patient exclusion from the new pathway (Fig. 6) were the same for the data from 2011/2012 and 2013.

5. Discussion

5.1. Strengths

This study was innovative in effectively implementing a realistic, clinically applicable and functionally based CKC exercise protocol in an acute care setting. It was hypothesized that with the new CKC exercise protocol, patients would have decreased functional limitations, decreased lower extremity asymmetry and increased strength of the affected limb, post rehabilitation. Long term outpatient follow up and future studies investigating the outcome of functionality and strength symmetry from 6 months to years post-surgery would be beneficial to validate this hypothesis. This study also supported the hypothesis that the CKC exercise protocol allowed patients to meet their discharge requirements; profitably decreasing post-operative hospital length of stay.

The rehabilitation staff at WRHOC, consists of various physical therapists and RAs, rotating through the orthopedic floor every 8–12 weeks, depending on the time of the year. Thus, many physical therapists and RAs participated in this study. This variability was included in the study, as long as the biomechanical cueing was consistent during exercise, to replicate feasibility and the time constraints associated with the acute care setting. Even with these variations among staff, positive findings and significant P-values were noted. The same group of rehabilitation staff was responsible for data collection from 2011 to 2013. Due to the obligated rotation of orthopedic staff every 3 months, different individuals were collecting data. This method of data collection was unavoidable due to the rotation of therapists. However, this collection method was standardized by using Figs. 1 and 2. It should also be noted that the researchers had no part in data collection, eliminating bias. In a realistic rehabilitation setting, adherence to a stringent protocol becomes a difficult task, due to variation and comorbidities within the patient population, and differences between rehabilitation professionals. Methodological guidelines that create

Table 1
Differences between current pathway and NPORP.

Rehabilitation Training	Current Pathway		NPORP	
Bed mobility	X		X	
Transfers	X		X	
Gait training	X		X	
Stair Training	X		X	
	THR	TKR	THR	TKR
Ice knee, knee ROM on slider board, knee ROM measured		X		X
Bed OKC exercises: Quadriceps over roll, Straight Leg Raise, Static Quadriceps, ankle circulation exercises		X		
Bed OKC exercises: Static Gluteus Maximus, Static Quadriceps, hip and knee flexion, hip abduction (surgeon-specific), ankle circulation exercises		X		
CKC exercises at railing: end range knee extension				X
CKC exercises at railing: hip and knee flexion combined with end range knee extension (marching), bilateral plantar flexion, mini squats, partial/full step ups			X	X

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Table 2
THR and TKR exercises.

Table 2.THR and TKR Exercises		
Exercise	**Position**	**Patient Biomechanics**
1. CKC End Range Knee Extension 	Patient standing with the support of their standard walker or crutches as required, facing therapist, with chair behind patient for safety The Theraband is anchored around mid-thigh and therapist is holding it anterior to patient, while palpating the Vastus Medialis for activation. RA next to patient for safety	Upright posture, with feet shoulder width apart Affected knee did not pass their toes Proper hip and knee flexion while maintaining neutral spine Toes pointed forward to avoid hip rotation with knee flexion
2. Hip and knee flexion combined with end range knee extension (marching) 	Patient standing, facing and holding onto railing for support as needed, chair behind patient for safety. Therapist and RA on either side of patient	Upright posture, with feet shoulder width apart Proper hip and knee flexion while maintaining neutral spine Therapist guides and/or controls hip and knee movement to avoid hip rotation and to stimulate proper Gluteus Medius activation
3. Bilateral Plantar flexion 	Same as above	Upright posture, with feet shoulder width apart Toes pointed forward to avoid hip rotation Patient rose from heels in neutral ankle alignment to avoid rolling on their ankle and improper muscle activation through lower extremity
4. Mini squats 	Same as above	Upright posture, with feet slightly wider than shoulder width apart and toes pointed approximately 15 degrees outward Proper hip and knee flexion while maintaining neutral spine Patient descended into a mini squat to not exacerbate their pain and their knees did not pass their toes Patient's knees did not turn in to ensure proper Gluteus Medius activation
5. Partial/Full Step Ups 	Patient standing with the support of their standard walker or crutches, as required, facing therapist, with chair behind patient for safety The step is placed in front of patient Therapist and RA on either side of patient for safety	Upright posture, with feet shoulder width apart Toes pointed forward to avoid hip rotation Patient placed affected foot on step: - If patient was non weight bearing -partial weight bearing: patient placed foot back on ground - If patient was full weight bearing: patient used affected limb to bring unaffected limb on step, using gait aid as required Patient's knee did not turn medially and their toes pointed forward to ensure proper Gluteus Medius activation
*Hip precautions were maintained with all exercises		

Table 3
NPORP administration and timeline.

POD0	Day of surgery; No rehabilitation performed
POD1	Bed mobility, transfer, gait and stair training with appropriate gait aid NPORP began with CKC exercises as outlined in Table 1 as tolerated
POD2-DOD	Progression to above regimen in preparation for discharge

a dynamic pathway for therapy seems a better alternative with various groups of patients, and therapists. This study created a guideline methodology with real world application, showing that CKC exercises can be easily applied by other rehabilitation staff at other facilities.

Statistical analysis revealed p-values < 0.05, indicating statistically significant results (Fig. 5). There was strong evidence showing efficacy in decreasing the length of stay after THR and TKR surgeries, without decreasing discharge criteria.

5.2. Limitations

Due to the nature of this study design, many limitations and variables were present that may make future reproducibility a

Fig. 1 Data Collection Chart 1					
Name/Acct #	age	Co-morbidities	Exercise tolerated POD1	Exercise tolerated DOD	Type of anaesthesia
			□ End Range Knee Ext □ Marching □ PF □ Mini squats □ Partial/Full step up	□ End Range Knee Ext □ Marching □ PF □ Mini squats □ Partial/Full step up	□ spinal □ PCA □ nerve block

Fig. 1. Data collection chart 1.

Fig. 2 Data Collection Chart 2				
Surgery Date	Surgeon	Surgery (THR/TKR)	Day of Discharge	Reasons why pathway was not met

Fig. 2. Data collection chart 2.

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Fig. 3 Samples sizes and percent of patients discharged < POD 4		
POD of Discharge for THR Patients for 2011/2012 and 2013		
Year	Sample Size	POD < 4 Days
2011/2012	261	75
2013	274	210
POD of Discharge for TKR Patients for 2011/2012 and 2013		
Year	Sample Size	POD < 4 Days
2011/2012	314	93
2013	381	323
*Sample Size: Total # of Joints- # of Joints Excluded		
** Mean Sample size of Patients was used for 2011 and 2012		

Fig. 3. Samples sizes and percent of patients discharged < POD 4.

concern. Until further analysis of this kind can be reproduced at other facilities, with other therapists, the validity cannot be truly verified. The initial limitation of this study is the selection criteria of patients whom underwent THR and TKR was solely completed by the surgeons. Commentary on the selection process of surgeons could not have been made; however, if the orthopedic staff at WRHOC was more conservative in the selection process of patients who undergo THR and TKR surgeries than other facilities or if more complex cases were referred to other hospitals due to the complexity of the surgery, it would affect significance of patient tolerance to the NPORP exercises. However, this selection criteria and list of orthopedic surgeons remained consistent between 2011 and 2013. With respect to the orthopedic staff and the inclusion of knee flexion and extension exercise using the slider board for TKR patients; although, the focus of this study was to change the current exercise pathway to include functional CKC exercises, the surgeons had requested that ROM exercises continue in the NPORP. Due to the fact that this variable could not be removed from therapy, makes it difficult to isolate the CKC exercises as the sole reason for improved progression with TKR. Further study is required to determine the effectiveness of CKC functional based exercises without flexion and extension ROM exercises. There were no ROM exercises included in the NPORP for THR patients because this was not an orthopedic surgeon concern with the current pathway. In addition, it must be noted that during the NPORP, exercises were completed while remaining within the limits of the surgeon specific hip precautions.

The feasibility of the study in an active acute care hospital was a major limitation when trying to design a change in exercise methodology. Lack of previous research, variation in orthopedic assigned therapists, patient treatment time, and weekend scheduling all played a part in limiting effective delivery of the NPORP. At WRHOC, all patients were required to perform the same therapy protocol during the protocol change and the ability to perform simultaneous pathways was not an option. It was agreed by the rehabilitation department that a 4 month pilot be performed (January 2013 to April 2013), abandoning the current pathway for the NPORP, to determine progress and continuity of the new protocol for the entire 2013 year. Due to the success and the ease of integration of the pathway, it continued for the entire duration of the 2013 year. The nature of physical therapy clinical studies created problems in design, especially in this protocol change, due to inability to utilize a double blinded, randomized and controlled environment. It was impossible to perform any type of sham exercise in an acute care setting, due to ethical and safety issues regarding patient care. From a feasibility perspective, the consensus

THR: Total Number of Joint Surgeries, Samples sizes and Exclusion Rates				
Year	Total # of Joints	Sample Size (Total # of Joints-# of Joints Excluded)	% Excluded Due to Data Collection Errors	% Excluded Due to Other Reasons
2011	263	231	0.00%	9.58%
2012	321	291	0.00%	9.35%
2013	313	274	2.88%	12.17%
TKR: Total Number of Joint Surgeries, Samples sizes and Exclusion Rates				
Year	Total # of Joints	Sample Size (Total # of Joints-# of Joints Excluded)	% Excluded Due to Data Collection Errors	% Excluded Due to Other Reasons
2011	307	277	0.65%	9.12%
2012	387	350	0.00%	9.56%
2013	414	381	0.97%	9.12%

Fig. 4. Samples size and exclusion rates for THR and TKR.

	P-value
THR patients discharged <POD 4	1.23546E-28
TKR patients discharged < POD 4	2.52049E-49
*Refer to Fig. 4 for sample size	

Fig. 5. Statistical Analysis for number of THR and TKR Discharges Less than POD 4.

Pre-surgical dementia and hospital acquired dementia
Uncontrolled pain
Came from or waiting for placement into nursing home or other facility with a wait list
Surgically acquired nerve damage (foot drop)
Blood loss/anemia requiring blood transfusions
Patient fell in hospital post-surgery
Any complications that arose during surgery (myocardial infarction, stroke, bone fracture etc.)
Any post-surgical medical complications (small bowel obstruction, deep vein thrombosis, pulmonary emboli, infection, etc.)
Data collection error (incomplete or inaccurate completion of data in Fig.1 and/or 2)

Fig. 6. Reasons for exclusion: Any concerns outside the scope of physical therapy.

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was determined to replace the current pathway with the NPORP without changes to the discharge criteria and exclusion criteria, for study evaluation. Although this scenario is not the gold standard for a testing situation, it was the only feasible option for a preliminary study in an active acute care setting.

Due to scheduled staff rotation on the orthopedic floor at WRHOC, it was difficult to create complete standardization of technique between therapists. This variation was also evident in record keeping. Although data collection error was insignificant in affecting the validity of data, it must be mentioned that due to therapist rotation and a limited period of assimilation to the NPORP, data recording errors were made and accounted for.

The lack of previous CKC functionally based exercises for acute care THR and TKR was a limitation in developing a standardized set of exercises, as one had not previously existed. Few studies had shown that during the acute phase post THR and TKR surgeries, patient could tolerate intense exercises, but the exercise protocols varied and were time consuming and not feasible for an acute care hospital. The development of the 4 month pilot period was an assessment process to determine if the NPORP was significant in producing expected outcomes. At the culmination of the pilot period, the outcomes were satisfactory to continue with the NPORP as initially developed.

In order to ensure the NPORP was fully effective, the entire post-surgical pathway must be amended. This article only addressed the rehabilitation staff's role in the pathway; it did not incorporate the entire multidisciplinary team, which would be more realistic. Primarily, patient mobility is a team effort and not the sole role of the rehabilitation staff. Nurses who transport patients for toileting and dressing require a better understanding of physical therapy guided patient mobility, as opposed to transferring the patient in a non-functionally progressive manner. The patients' required mobilization to chairs for all meals, as well as frequently throughout the day, will limit post-surgical deconditioning and assist the body to adapt to the post-surgical changes in blood pressure. However, many hospitals will dispute this as time consuming and not appropriate for their staffing limitations.

There are many psychosocial factors that affect discharge and these should be addressed and resolved prior to surgery. For example, it would not be an appropriate use of resources if the patient was discharged from acute care needs, but remained in hospital waiting for a convalescence bed in the community. This should be arranged by the patient prior to surgery. Issues such as these and other psychosocial factors should be noted and solved in the total joint clinic, which is a day session to educate patients on their surgery and post-operative expectations.

Weight bearing status was also a limitation to post-operative mobility, especially non weight bearing to partial weight bearing. Patients that were morbidly obese or had upper extremity co-morbidities suffered a limitation in their endurance and ability to independently and safely mobilize according to discharge requirements. In addition, routinely, the complete blood count (CBC) was measured POD 1 and POD 3, and most often the hemoglobin dropped to a significantly low number requiring blood transfusions on POD 3. If CBC was measured POD 1 and 2, the extra day required for blood transfusion could result in a POD 3 discharge and not a POD 4 discharge. This further emphasizes the multidisciplinary approach to effectively and efficiently change a post-operative pathway.

It must be noted that in addition to the inclusion of CKC exercises, other reasons for early discharge may have affected the results of this comparison. Improvements in patients' pain control through advanced techniques, an administrative push for lowered health cost and a greater availability of convalescent facilities may have an effect on DOD. The fact that data collection occurred over years may have created changes outside of the control of rehabilitation which could change the patient's DOD, regardless of exercise protocol.

Complete pathway changes are a team effort and the focus of this study addressed only the physical therapy applications. Future studies could look at the involvement of administration, surgeons, nurses and unit managers.

5.3. Conclusions

Although this was a pilot study in the effectiveness and tolerance of the NPORP in an acute care THR and TKR setting, results supported the implementation of CKC exercises in an expedited therapy pathway to decrease length of stay at WRHOC. Long term follow up and further clinical studies are required to determine the functional improvement of patients at least six months post THR and TKR surgery. The majority of THR and TKR patients seek outpatient rehabilitation, after discharge from the hospital as expressed by the surgeon, and further variability exists between therapists and interventional techniques which also plays a role in patient functionality past six months post replacement. This protocol change seems to correlate with past evidence that the replacement of OKC exercises may not limit the discharge and functionality of acute THR and TKR patients. Further replication of pathway changes are required at different acute care facilities to determine efficacy of the NPORP due to variable conditions, such as further variation among therapists, variation in surgical technique and patient population. The results and significance of this study are impressive, yet due to a lack of research in CKC and functional exercise for acute phase post joint arthroplasty, a shift in the rehabilitation paradigm is not yet supported, and further study is required to validate and replicate these results.

Conflict of interest

The authors of this article would like to declare that there were no conflicts to report in this study. It should be noted that the authors of this study and therapist responsible for the creation of the NPORP exercise program did not participate in patient care or data collection.

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