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# The effect of continuous passive motion on knee flexion, pain, and function after total knee arthroplasty

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# The effect of continuous passive motion on knee flexion, pain, and function after total knee arthroplasty

**Disciplines**

Physical Therapy

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**Title:** The effect of continuous passive motion on knee flexion, pain, and function after total knee arthroplasty

**Brief Introduction:** I want to know if continuous passive motion (CPM) in conjunction with standard physical therapy for patients status post total knee arthroplasty (TKA) results in greater knee flexion range of motion (ROM), decreased pain, and/or increased function compared to patients who receive only standard physical therapy. Many of the patients I have seen in the skilled nursing setting that have had a TKA are no longer using CPM machines. I want to know if the research supports use of CPM machines both in the short term and long term.

**Clinical Scenario:** The patient who led me to pursue this question is a 64 year old female with a diagnosis of knee osteoarthritis who underwent a TKA. This patient has insufficient knee flexion ROM, pain, and has a decreased level of function.

**My Clinical Question:** Does CPM machine use increase knee flexion ROM, decrease pain, and increase function after a TKA?

**Clinical PICO:**

**Population:** Patients with a diagnosis of knee osteoarthritis status post TKA

**Intervention:** CPM use in conjunction with standard physical therapy

**Comparison:** Standard physical therapy alone

**Outcome:** Knee flexion ROM, pain, function

**Overall Clinical Bottom Line:** Based on the outcomes from Bruun-Olsen *et al.* and Beaupre *et al.*, providing CPM in addition to standard physical therapy does not increase active knee ROM, decrease pain, or increase function. Bruun-Olsen *et al.* (PEDro score 8/10 with 63 subjects) determined that CPM sessions did not influence knee ROM, pain, or function compared to a control group. The most significant threats to this study's internal validity were having more than one assessor and modifying the active exercises based on pain level. This decreased the level of standardization among subjects. Similarly, Beaupre *et al.* (PEDro score 8/10 with 120 subjects) determined that CPM treatments did not impact knee ROM, pain, or function compared to a control group. The most significant threats to this study's internal validity were reassigning some subjects to the CPM group, modifying the active exercises based on patient tolerance, and poor compliance with CPM use. Based on the results of these two studies there is moderate evidence to suggest that CPM use in addition to standard physical therapy does not increase knee ROM,

decrease pain, or increase function in patients with osteoarthritis status post TKA as compared with standard physical therapy alone.

**Search Terms:** Continuous passive motion, total knee arthroplasty, osteoarthritis, flexion, range of motion, pain, function

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### **Rationale for my chosen articles**

As a result of a Medline search, I found three articles pertaining to CPM use for patients after a TKA that were applicable to my patient. To help me decide which two articles to critique I first ranked the three articles using the Physiotherapy Evidence Database scale (PEDro scale).

(1) Bruun-Olsen V., Heiberg K.E., Mengshoel A.M. Continuous passive motion as an adjunct to active exercises in early rehabilitation following total knee arthroplasty – a randomized controlled trial. *Disability and Rehabilitation* 2009; 31(4): 277-283. PEDro score 8/10

Population: Included patients in the acute hospital setting who were similar to my patient based on inclusionary criteria

Intervention: CPM and active exercises

Comparison: Active exercises

Outcome measures: Pain measured on a 100 mm visual analogue scale (VAS), passive and active knee ROM, Timed “Up and Go” Test (TUG)

(2) Beaupre L.A., Davies D.M., Jones C.A., Cinats J.G. Exercise combined with continuous passive motion or slider board therapy compared with exercise only: a randomized controlled trial of patients following total knee arthroplasty. *Physical Therapy* 2001; 81(4): 1029-1037.

PEDro score 8/10

Population: Included patients in the acute hospital setting who were similar to my patient based on inclusionary criteria

Intervention: CPM and standardized exercises

Comparison: Standardized exercises

Outcome measures: Active knee ROM, the Western Ontario and McMaster

Universities (WOMAC) osteoarthritis index, Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36)

(3) Denis M., Moffet H., Caron F., Ouellet D., Paquet J., Nolet L. Effectiveness of continuous passive motion and conventional physical therapy after total knee arthroplasty: a randomized clinical trial. *Physical Therapy* 2006; 86(2): 174-185.

PEDro score 8/10

Population: Included patients in the acute hospital setting who were similar to my patient based on inclusionary criteria

Intervention: CPM and conventional therapy

Comparison: Conventional therapy

Outcome measures: Active knee ROM, TUG, WOMAC

Table 1 shows the breakdown of each article on the PEDro scale and the corresponding PEDro score. I personally ranked each article using PEDro criteria.

Table 1. Comparison of PEDro Scores

	Bruun-Olsen <i>et al.</i>	Beaupre <i>et al.</i>	Denis <i>et al.</i>
Random	Yes	Yes	Yes
Concealed allocation	Yes	Yes	Yes
Baseline comparability	Yes	Yes	Yes
Blind subjects	No	No	No
Blind therapists	No	No	No
Blind assessors	Yes	Yes	Yes
Adequate follow-up	Yes	Yes	Yes
Intention-to-treat	Yes	Yes	Yes
Between group	Yes	Yes	Yes
Point estimates & variability	Yes	Yes	Yes
Total score	8/10	8/10	8/10

Based on the above comparisons and the outcome measures of the three articles, I have chosen to write this critically appraised paper on the two articles by Bruun-Olsen *et al.* and Beaupre *et al.* All three articles matched my criteria for the population, intervention, and comparison of my clinical question. Due to the identical PEDro scores of the three articles, I chose based on the time points the authors measured outcomes. The articles I chose measured ROM, pain, and function at both discharge and three months. The reason I did not choose the article by Denis *et al.* was because the authors of this study only measured outcomes at discharge.

**Article:** Bruun-Olsen *et al.*, 2009.

**Clinical Bottom Line:** Based on this study of 63 subjects with knee osteoarthritis that underwent a TKA, one week of daily CPM use immediately post-op combined with standard therapy did not increase knee flexion ROM, decrease pain, or increase function compared with subjects who received only standard therapy. Both groups received active exercises and functional mobility training, and the intervention group also received CPM. Between group comparisons at baseline, one week, and three months were not statistically significantly different for any of the outcome measures of interest. The most significant threats to this study's internal validity were having more than one assessor and modifying the active exercises based on pain level. More than one assessor may lead to slight differences in measurement technique. Modifying active exercises reduces standardization among subjects. These threats may have influenced the results of this study. Because there were no differences between groups for the outcome measures of interest, investing in the use of CPM machines would not be worthwhile for patients with knee osteoarthritis after a TKA. The results of this study can be applied to a larger population.

**Article PICO:**

**Population** – Patients with osteoarthritis undergoing a TKA who demonstrated good cognitive function and who were fluent in Norwegian

**Intervention** – Standard active exercises and functional mobility with CPM machine use

**Comparison** – Standard active exercises and functional mobility alone

**Outcomes** – Pain measured on a 100 mm VAS, active knee flexion ROM, TUG

**Blinding:** The subjects and treating therapists were not blinded due to the nature of the interventions provided. However, the therapists responsible for assessing patient outcomes were unaware of which group the subjects belonged to. Given the nature of this study, I do not see any threats to validity based on blinding.

**Controls:** The control group received standard active exercises and functional mobility for 30 minutes each day. Exercises were adjusted for each patient based on pain. The intervention group received the same standard therapy as the control group, but also received CPM treatments. Since CPM machine use was the only difference between groups, the control group was an appropriate comparison group.

**Randomization:** Patients were randomly assigned to the intervention or control group by a physiotherapist who chose a sealed envelope containing group allocation for each patient. Randomization was concealed and successful. There were no statistically significant differences between groups at baseline.

**Study:** This study was a randomized, controlled, single-blind study. There were 33 participants in the intervention group and 30 participants in the control group. Inclusionary criteria consisted of patients admitted to a hospital for a TKA secondary to a diagnosis of knee osteoarthritis that agreed to participate in the study. Subjects were required to have good cognitive function and be fluent in Norwegian. Exclusionary criteria consisted of patients who had rheumatoid arthritis or a prosthesis in the ipsilateral hip. Subjects in the control group received standard exercises and functional mobility each day beginning the day after surgery. Physiotherapists instructed subjects in assisted and active hip and knee flexion/extension, isometric contraction of the quadriceps, gait training with an assistive device, and stair training. Patients in the intervention group received the same standard exercises and functional mobility with additional CPM sessions. CPM use began the day of the operation and was administered twice, two hours each session, with the machine set to 70-100 degrees. Each day afterward until discharge, CPM was administered three times a day, two hours each session with the machine set to 0-100 degrees. Subjects remained in the hospital for one week before being discharged, at which point they stopped using CPM machines and began outpatient therapy that was not standardized.

Outcome measures: Knee flexion ROM measured by a goniometer, pain based on a 100 mm VAS, and function as measured by a TUG test are the outcome measures relevant to my clinical question. The authors did not discuss the reliability or validity of these measures. There was no mention of a threshold for minimally clinically important difference (MCID) for the VAS or TUG and there were no MCIDs specific to this population found in the literature. The authors did state a clinically relevant difference of 15 degrees for knee flexion ROM. It makes sense that the MCIDs may be the greatest flexion ROM, least amount of pain, and greatest function without an increase in adverse effects. To increase the reliability of the knee flexion ROM measurement, the two assessing therapists practiced beforehand and discussed any discrepancies between measurements to refine the technique. Similarly, the TUG tests were administered twice to each patient and results of the second trial were used.

Study losses: Three of the 70 subjects invited to participate in the study declined. Of the 67 participants, there were four subjects that were not measured at three months. Two of them passed away and two did not attend the follow-up

consultation. Ninety-four percent of the subjects completed the study. The study losses were not a threat to validity because the percentage loss was small and the sample size was still large enough to detect any differences between groups. The authors determined that a total of 55 subjects were needed to show a clinically relevant difference, and therefore chose not to use an intention-to-treat analysis. Rather, the data from those four subjects was simply withdrawn from the study. All subjects were analyzed in the groups to which they were assigned. It does not appear that the study losses were related to the interventions. Visual inspection of the data does not reveal any missing or questionable data.

**Summary of internal validity:** Overall, the internal validity of this study is good (PEDro score 8/10). Patients were randomized, assessors were blinded, and the outcome measures that I am interested in (knee flexion ROM, pain, and function) are valid. Based on the power analysis the sample size was large enough to detect any differences between groups. The baseline characteristics were similar between groups. The most significant threats to internal validity include the fact that more than one physiotherapist performed assessments, and that exercises were modified based on individual patient tolerance (pain).

**Evidence:** I want to know if active knee flexion ROM, pain, and function differed between the intervention and control groups. Table 2 shows the mean active knee flexion ROM for subjects in the intervention and control groups at baseline, one week, and three months. Table 3 shows the mean pain intensity for subjects in the intervention and control groups at baseline, one week, and three months. Table 4 shows the mean TUG test scores for subjects in the intervention and control groups at baseline and three months.

Table 2. Mean active knee flexion ROM (degrees)

Mean knee active ROM	Intervention (n = 30)	Control (n = 33)
Baseline	121 ± 14	127 ± 12
One week	85 ± 13	83 ± 16
Three months	105 ± 18	109 ± 14

Table 3. Mean pain intensity (VAS 0-100)

Mean pain intensity	Intervention (n = 30)	Control (n = 33)
Baseline	52 ± 17	47 ± 19
One week	40 ± 23	40 ± 21
Three months	20 ± 22	19 ± 15

Table 4. Mean TUG score (seconds)

Mean TUG score	Intervention (n = 30)	Control (n = 33)
Baseline	12 ± 4	13 ± 6
Three months	11 ± 5	12 ± 6

There were no significant differences between groups at any time points for knee flexion ROM, pain, or function.

**Applicability of study results:**

Benefits vs. Costs: Subjects in the intervention group did not have more knee flexion ROM, less pain, or increased function compared to subjects in the control group. Based on the results of this study, the costs of implementing CPM for patients after a TKA is not worthwhile when considering these outcome measures. CPM use results in higher rehabilitation costs secondary to purchasing and maintaining CPM machines. Also, more time is required of the rehabilitation and nursing staff to help the patient facilitate CPM machine use.

Feasibility of treatment: Providing CPM for patients after a TKA is feasible but would require additional funds, space, training and time. Study procedures were explained well enough that they could be reproduced. Based on this study, CPM use for patients after a TKA did not result in increased knee flexion ROM, decreased pain, or increased function when compared with standard therapy.

**Summary of external validity:** The internal validity only slightly compromises the ability to apply these results to a larger population. Limiting the number of

assessors to one physiotherapist would have made the outcome measurements more valid by eliminating any discrepancies in technique. Also, modifying the exercises based on the subject's level of pain means there were slight variations in treatment among participants that could have influenced the results of this study. The fact that this study took place outside of the U.S. does not influence the ability to apply the results because a protocol was in place and there are no known differences between this population and the US population that might influence outcomes. The subjects and results of this study can be applied to the larger population of patients with knee osteoarthritis undergoing a TKA.

**Article:** Beaupre *et al.*, 2001.

**Clinical Bottom Line:** Based on this study of 120 subjects who underwent a TKA, CPM starting post-op day two and used daily until hospital discharge combined with standard exercises did not increase knee flexion ROM, decrease pain, or increase function compared with subjects who received only standard exercises. Both groups received active exercises and functional mobility training, and the intervention group also received CPM. Between group comparisons at baseline, discharge (5-7 days), and three months for knee flexion ROM, and comparisons at baseline and three months for pain and function resulted in no statistically significant differences for any of the outcome measures of interest. The most significant threats to this study's internal validity were reassigning some subjects to the CPM group, modifying the active exercises based on patient tolerance, and poor compliance with CPM use. These threats may have influenced the results of this study. Based on the results of this study there is no evidence to justify investing in CPM machines for use in the acute care setting for patients after a TKA. The results of this study may be applied to a larger population; however it is important to note that increased compliance with CPM use may provide benefits not found in this study.

**Article PICO:**

**Population** – Patients at one hospital undergoing a TKA who were able to attend post-operative visits

**Intervention** – Standard exercises with CPM machine use

**Comparison** – Standard exercises alone

**Outcomes** – Active knee flexion ROM, WOMAC

**Blinding:** The subjects and treating therapists were not blinded due to the nature of the interventions provided. However, the therapists responsible for assessing patient outcomes were unaware of which group the subjects belonged to. Given the nature of this study, I do not see any threats to validity based on blinding.

**Controls:** The control group received standard exercises beginning the third day after the TKA for approximately 30 minutes each day. The intervention group received the same standard exercises as the control group, but also received CPM treatments beginning on the second day after the TKA. Since CPM machine use was the only difference between groups, the control group was an appropriate comparison group.

**Randomization:** Patients were assigned to the intervention or control group by computer generated randomization codes that were placed in envelopes. An envelope containing group allocation was given to each subject after the enrollment visit. Randomization was concealed and successful. There were no statistically significant differences between groups at baseline.

**Study:** This study was a randomized, controlled, single-blind study. There were 40 participants in both the intervention and control groups. Inclusionary criteria consisted of patients undergoing a TKA that were able to attend post-operative visits. Exclusionary criteria consisted of patients receiving a revision or a unicompartmental knee replacement. Subjects in the control group received standard exercises beginning on post-operative day three, which included gait training with an appropriate assistive device, knee active ROM exercises using a slider board, strengthening of the quadriceps femoris with emphasis on knee extension, straight leg raises, and stair training. All standard exercises were modified to patient tolerance. Each session lasted approximately 30 minutes per day (excluding ice application). Ice was applied before and after each treatment. Patients in the intervention group received the same standard exercises with additional CPM sessions. CPM use began on post-operative day two with subjects receiving three two-hour sessions per day and lasted until discharge from the hospital (usually 5-7 days). The CPM was set from 0 – 30 degrees to start and was increased as often as possible to patient tolerance. Once subjects were discharged from the hospital they returned home with either outpatient or home health physical therapy, or were admitted to a sub-acute facility for continued physical therapy. Physical therapy received after discharge from the hospital was not standardized.

Outcome measures: Knee flexion ROM measured by a goniometer and pain and function as measured by the WOMAC (measured at discharge and after three months) are the outcome measures relevant to my clinical question. The authors reported intratester reliability for goniometric knee measurement to be .91 to .99, and intertester reliability for knee flexion to be .88 to .97. The authors did not discuss a threshold for minimally clinically important difference (MCID) for knee ROM and there was no MCID found in the literature. However, given that there is about a five degree error for goniometric measurements, a clinically important difference would need to be at least more than five degrees. The authors stated an MCID for the WOMAC was a 10 point difference. It makes sense that the MCIDs may be the greatest flexion ROM, least amount of pain, and greatest function without an increase in adverse effects. The same therapist performed all of the knee flexion ROM measurements to increase reliability.

**Study losses:** There were 120 subjects in this study, 40 in each of three groups. I chose to analyze data from only two groups as the third group was not relevant to my clinical question. The authors performed an intention-to-treat analysis because six subjects were reassigned by their surgeons to the CPM group secondary to poor knee ROM. The authors determined that 120 participants were needed to observe a five degree knee ROM difference between groups. Of the 120 subjects 27 were unable to complete follow up visits, however 10 were able to participate via telephone. Seventy-eight percent of the subjects completed follow-up visits in person. With a 22% study loss, the lack of an intention to treat analysis is a threat to internal validity. All subjects were analyzed in the groups to which they were assigned. It does not appear that the study losses were related to the interventions. Visual inspection of the data does not reveal any missing or questionable data.

**Summary of internal validity:** Overall, the internal validity of this study is good (PEDro score 8/10). Patients were randomized, assessors were blinded, and the outcome measures that I am interested in (knee flexion ROM, pain, and function) are valid. The baseline characteristics were similar between groups. The sample size was large enough to detect any differences between groups. The most significant threats to internal validity include the fact that six subjects were reassigned, and that exercises and CPM sessions were modified based on individual patient tolerance (pain). In fact, subjects in the CPM group were supposed to have three two-hour CPM sessions per day, but nursing reported subjects received an average of 1.8 sessions per day with an average time of 1.7 hours. This wide variability of CPM use among subjects in the CPM group makes the intervention less valid.

**Evidence:** I want to know if active knee flexion ROM, pain, and function differed between the intervention and control groups at any of the measured time points. Table 5 shows the mean active knee flexion ROM for subjects in the intervention and control groups at baseline, discharge (5-7 days), and three months. Table 6 shows the mean WOMAC pain score for subjects in the intervention and control groups at baseline and three months. Table 7 shows the mean WOMAC function score for subjects in the intervention and control groups at baseline and three months.

Table 5. Mean active knee flexion ROM (degrees)

Mean knee active ROM	Intervention (n = 40)	Control (n = 40)
Baseline	115 ± 16	112 ± 15
Discharge (5-7 days)	61 ± 14	65 ± 13
Three months	94 ± 11	91 ± 11

Table 6. Mean pain score (WOMAC)

Mean pain score	Intervention (n = 40)	Control (n = 40)
Baseline	47 ± 14	51 ± 15
Three months	73 ± 17	73 ± 18

Table 7. Mean function score (WOMAC)

Mean function score	Intervention (n = 40)	Control (n = 40)
Baseline	51 ± 14	53 ± 15
Three months	73 ± 13	72 ± 17

There were no statistically significant differences between groups for active knee flexion ROM, pain, or function at any of the time points.

**Applicability of study results:**

Benefits vs. Costs: Subjects in the intervention group did not have more knee flexion ROM, less pain, or increased function compared to subjects in the control group. Based on the results of this study, the costs of implementing CPM for patients after a TKA is not worthwhile when considering these outcome measures. CPM use results in higher rehabilitation costs secondary to purchasing and maintaining CPM

machines. Also, more time is required of the rehabilitation and nursing staff to help the patient facilitate CPM machine use.

Feasibility of treatment: Providing CPM for patients after a TKA is feasible but would require additional funds, space, training and time. Study procedures were explained well enough that they could be reproduced. Based on this study, CPM use for patients after a TKA did not result in increased knee flexion ROM, decreased pain, or increased function when compared with standard exercises.

**Summary of external validity:** The internal validity slightly compromises the ability to apply these results to a larger population. Keeping all subjects in the groups to which they were assigned would have improved study results. Also, modifying the exercises based on the subject's level of pain means there were slight variations in treatment among participants that could have influenced the results of this study. More importantly, there were discrepancies regarding CPM use that decreased the validity of the intervention group. The results of this study may be applied to the larger population of patients undergoing a TKA, however it is important to note that it is unknown if increased compliance regarding CPM use would result in some benefit.

**Synthesis:** According to the two articles by Bruun-Olsen *et al.* and Beaupre *et al.*, use of CPM in the acute hospital setting does not increase knee ROM, decrease pain, and increase function in patients status post TKA when compared with standard physical therapy alone. My patient was in the skilled nursing setting, but I think these results still apply because the protocol for CPM use was similar. Also, the hospital length of stay for the subjects in these two studies was about one week. The typical hospital length of stay for patients status post TKA in the U.S. right now is about three days. Often patients will be admitted to skilled nursing facilities if they are not ready to return home from the hospital for additional rehabilitation. Therefore I believe the results of this study can be applied to patients in skilled nursing facilities using CPM machines during the first week post TKA.

The results of these two studies agree, however both studies had threats to validity. In both studies the standard physical therapy treatments were modified to patient tolerance, which decreases standardization. In the study by Bruun-Olsen *et al.* more than one assessor took knee ROM measurements, which decreases accuracy. In the study by Beaupre *et al.* CPM use among the intervention group was varied at best secondary to low compliance. Both studies had relatively low usage times set for subjects in the CPM group with varied ROM settings. Bruun-Olsen *et al.* requested that their subjects use the CPM for four hours per day starting at 70-100 degrees and progressing to 0-100 degrees, whereas Beaupre *et al.* recommended a total of

six hours a day with the machine set from 0-30 degrees to start and increasing based solely on patient tolerance. It would be interesting to see if longer CPM durations and more aggressive ROM settings would produce statistically significant results. Although the results of these two studies do not support CPM use, it is worthwhile to note that many patients find using CPM machines beneficial for preventing stiffness prior to participating in physical therapy. They feel it is easier to participate in physical therapy and perform their exercises if they have used the CPM machine first to “loosen up” the knee joint. Even though these two studies show no statistically significant benefits from CPM use, some patients feel that it facilitates their physical therapy sessions from a comfort standpoint. Since no harm was reported from use of the CPM, it is reasonable to use patient preference to justify use of a machine.

The outcome measures used in these studies addressed my clinical question. Knee flexion ROM, pain, and function are the three main outcomes pertinent to patients who have had a TKA. Both studies addressed these outcomes with appropriate measurement tools.

Further research is needed to determine if different protocols would result in improved outcomes. Specifically, how important the frequency and duration of CPM use is in regards to knee flexion ROM, pain, and function. Additional research pertaining to continued CPM use after patient discharge is needed to determine if there is any benefit from using CPM machines longer than one week. Also, it would be helpful to determine if there is a sub-set of patients (patients with specific characteristics) that would benefit from the use of a CPM machine during the rehabilitation process.

## References

PEDro Physiotherapy Evidence Database. Available at: <http://www.pedro.org.au/english/downloads/pedro-scale/>. Accessed November 17, 2010.