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ORIGINAL STUDY

Acute and chronic effects of early progressive resistance training on knee pain and knee joint effusion after unicompartmental knee arthroplasty

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To investigate if progressive resistance training initiated one week after unicompartment knee arthroplasty affect knee pain and knee joint effusion. Data from the progressive resistance training intervention group of a previous randomized control trail study was analysed. Knee pain was measured using a visual analogue scale, and knee circumference was used as an indication of knee joint effusion. Comparisons were made between the early (session 1+2) and late (session 15+16) phase of the 8-week intervention (chronic) and between the pre and post levels of single training sessions (acute).
Chronic effects : A significant decrease in pre- (55% SD 44% ; p=0.004) and post-training (47% SD 53% ; p = 0.002) pain was observed. Also, a significant decrease in pre- (4.1% SD 3.3% ; p = 0.0001) and post-training (2.9% SD 2.7% ; p = 0.0004) circumference was observed. Acute effects : A significant increase in pain was observed in session 5, while a significant increase in circumference was observed in session 6-8, 10 and 13-16. Progressive resistance training initiated in the early post-operative phase following unicompartment knee arthroplasty does not increase the pain level immediately after a training session, despite frequent increases in joint effusion. Furthermore, pre- and post levels of pain and joint effusion dropped significantly following the intervention period.

Keywords : Knee osteoarthritis ; knee pain ; knee joint effusion.

INTRODUCTION

Osteoarthritis (OA) is one of the most common chronic health problems affecting millions of people worldwide *(12)*. Especially OA of the knee is a common clinical condition that has a major impact on physical function, and daily routines such as walking, stair climbing and rising from

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seats *(2,3,12,21)*. Every year around 60.000 Danish patients contact their general practitioner with symptoms of knee OA, of which about half is referred to the hospital and a quarter of those end up undergoing knee arthroplasty *(19)*. Around 10% of the patients who undergoes arthroplasty are offered medial unicompartment knee arthroplasty (UKA) *(8,19)*. Although knee arthroplasty generally leads to alleviated knee pain and improved physical function, reduced lower body muscle strength has been reported following surgery *(3,4,11,20)*. Moreover, a reduction of the knee extensor strength of up to 80% has been reported in total knee arthroplasty (TKA) patients in the early post-operative phase *(8,16,17)*. Of note, the muscle loss and reduced function may persist for months or even years after knee surgery *(7)*.

One intervention that has been evaluated in the early post-operative phase is exercise therapy, and this is generally considered effective, despite limited evidence regarding type and dose parameters *(1,9)*. Nevertheless, the approach to rehabilitation has become more intensive over the past decade, and rehabilitations programs now often include progressive resistance training (PRT) in the early postoperative phase *(18)*. Given the substantial loss of skeletal muscle mass and muscle strength after knee arthroplasty, this seems relevant, and early onset of PRT may help to accelerate the recovery following knee arthroplasty *(8,9)*. However, it still remains to be investigated into more details, how early initiated PRT affects postoperative symptoms such as knee pain and knee joint effusion in patients after fast track UKA. Previous studies show no indication of increased knee pain and joint effusion following early commenced PRT, but these studies only include TKA patients *(8,9)*. Consequently, the purpose of the present study was 1) to investigate how a single session of PRT affects pain and joint effusion, when performed in the early post-operative phase following UKA, and 2) to compare pain and joint effusion pre and post exercise in the early and late phase of an 8-week PRT intervention initiated in the early postoperative state. It was hypothesized, that (i) PRT initiated one week after UKA would increase knee pain and knee joint effusion after a single PRT session, and (ii) that pain and joint effusion after a PRT session would drop during the course of an 8-week PRT program.

METHOD

The present study is prospective and a secondary analysis for the intervention group in a randomized controlled trial (RCT) that has been published elsewhere *(10)*. The RCT study was primarily performed to investigate if 8 weeks of physiotherapy-supervised PRT initiated in the early post-operative phase after UKA was more effective in improving muscle strength and physical function than a home-based exercise program, which is the standard rehabilitation program at the hospital. However, in the present study only data from the intervention group was analysed to investigate if PRT causes any substantial side effects related to knee pain and knee joint effusion.

Patient inclusion criteria: Patients ≥ 18 years of age, diagnosed with primary OA of the medial knee compartment, and awaiting Oxford UKA, were offered inclusion. Furthermore, patients were not allowed to have pain levels exceeding 2 on the Visual analogue scale (VAS) in the non-affected leg in a period of 14 days prior to inclusion. Patients with rheumatoid arthritis, neuromuscular illness, dementia, alcohol or drug problems were also excluded. So were patients unable to speak Danish or patients having cognitive problems. Patients who fulfilled the criteria and who had signed consent to participate in the study were randomly allocated to the intervention group or the control group. A computer program in blocks of 10 patients generated the randomization sequence. To be enrolled in the data analysis of this study, participants had to complete ≥ 60% of the planned training sessions. Consequently, some patients were enrolled in the data analysis even though they dropped out of the study during the intervention period. A total of 27 patients were randomised into the PRT group after medial UKA. Of these, 7 patients dropped out during the study, but 22 completed >60% of the planned training sessions. Drop out reasons included advice from general practitioner, vacation, work, and problems with transportation to training facilities and knee pain. In these 22 patients a

total of 352 training sessions were planned, and of these 299 (85%) were completed. Reasons for missing sessions included pain, engaged in other activities and vacation. Also, some of the training sessions were not fully completed, because of pain, dizziness or other complications such as increased joint effusion and reduced flexion. In every assessed training session a minimum of 16 patients participated (73%). The mean number of sessions attended by the intervention group was 13.6 SD 1.8 sessions.

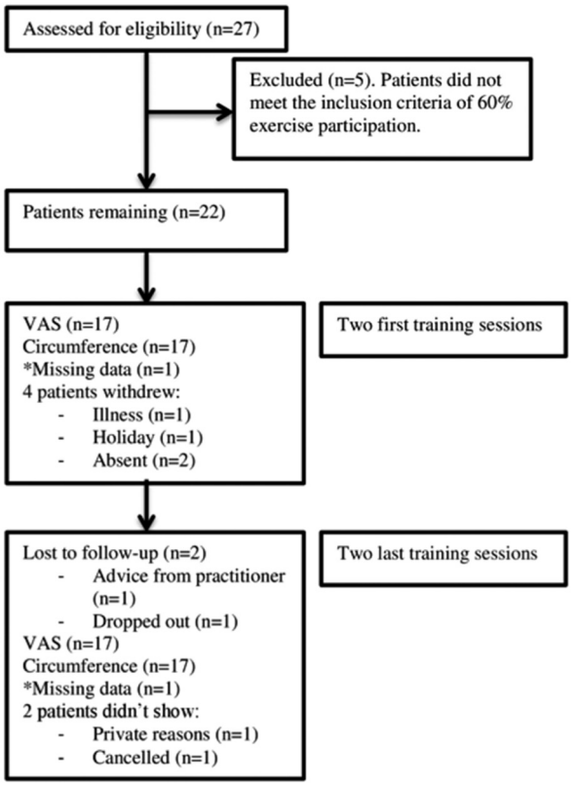

Fig. 1. — Flowchart

Table I. — Characteristic of the patients in the intervention group

Patients characteristic	Mean ± SD
Number (♀/♂)	27 (13/14)
Age (years)	67.5 SD 8.2
Height (cm)	172 SD 9
Weight (kg)	88.8 SD 16.3
BMI (kg/m²)	29.8 SD 4.5

SD: Standard deviation

Intervention: The patients in the intervention group performed two weekly PRT sessions supervised by a specialised physiotherapist. The supervised training was combined with a home-based exercise program, which the patients were instructed to perform on the days, they did not perform supervised PRT. The PRT was initiated one week after UKA and lasted 8 weeks, giving a total of 16 supervised training sessions. The supervised training took place in a fitness center at the hospital. The training session started with a 10-minute warm-up on a bicycle ergometer followed by the PRT program. As shown in table II, the program of week one consisted of two exercises (leg press and knee extension), which was expanded to three exercises from week three (knee flexion was added). The training intensity started in week one at a loading of 12 repetition maximum (RM), which was increased towards 8 RM at the end of the training period. During the first week of intervention two sets of each exercise were completed progressing towards four sets of each exercise at the end of the intervention period. Rest periods between sets were 2-3 minutes. The PRT was executed in strength training machines (Technogym®, Cesena, Italy) and all exercises were completed unilaterally.

Outcome measures

Knee pain: Knee pain was measured using VAS, comprising a 100-mm horizontal line where the endpoints indicate "no pain" and "worst imaginable" pain, respectively. At each training session pain was measured before and right after training. The data was analyzed and the mean ± standard deviation (SD) of pain pre and post each training session was found.

Knee joint effusion: Knee joint effusion was assessed measuring the knee joint circumference. With the patient in a supine position, knee joint circumference was measured 1 cm above the base of patella with a non-elastic measure. Before and right after each training session knee circumference was measured twice on each patient, and the mean of the two measurements was calculated. The data was analysed and the mean ± SD of the

Table II. — Progressive resistance training program

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Intensity	12RM	12RM	10RM	10RM	10RM	8RM	8RM	8RM
Sets	2	3	3	3	3	3	4	4
Exercises	LP,KE	LP,KE	LP,KE, NF	LP,KE NF	LP,KE, NF	LP,KE, NF	LP,KE, NF	LP,KE, NF

LP: leg press, KE: knee extension, NF: knee flexion. RM: repetition maximum

circumference pre and post each training session was found.

Statistical methods: The statistical analysis was performed in Microsoft Excel and GraphPad Prism 6.05. The level of significance was set at $p \leq 0.05$. A paired t-test was used to determine if there was any significant difference when comparing pre- to post-training pain and circumference after a single session (acute effect). Similarly, average pre- and post-training pain and circumference of the first two training sessions were compared by paired t-tests to the two last training sessions (chronic).

RESULTS

Pain

Acute effects of PRT: As depicted in figure 2, the average knee pain score at rest were not higher than 2.9 SD 2.5 following PRT throughout the training period (maximal value observed at the post test following the first PRT session, see figure 2). The lowest average knee pain score at rest was measured near the end of the 8-week training period and was 0.6 SD 0.5 (lowest value observed at the pre test before PRT session no. 13, see figure 2). There was a significant difference between VAS-pre and VAS-post at training session 5 (p=0.02), but no significant differences were found between VAS-pre and VAS-post in any of the other training sessions.

Chronic effects of PRT: As shown in figure 3, pain measured by VAS generally decreased following 8 weeks of PRT. The average VAS score pre-training decreased significantly from the two first training sessions to the two last training sessions (2.3 SD 2.1 vs. 0.7 SD 0.2; p = 0.004). The average VAS score post-training also decreased significantly from the two first training sessions to the two last training sessions (2.7 SD 2.4 vs. 0.8 SD 0.9; p = 0.002).

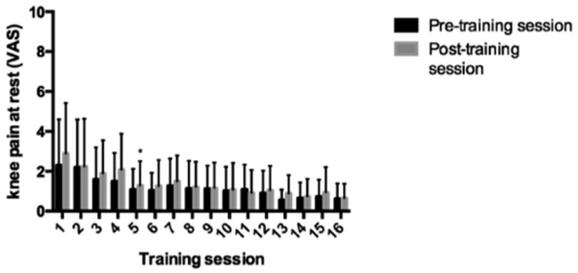

Fig. 2. — Knee-pain pre-training and post-training over 16 PRT sessions. Values are shown as mean ± SD. *Significant change between pre and post score.

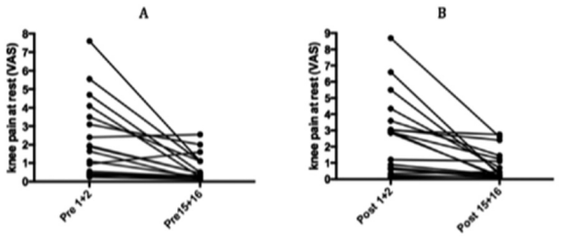

Fig. 3. — VAS score for each patient who participated in exercise session 1, 2, 15 and 16. The VAS score is a mean of pre- or post-training $_{1+2}$ and a mean of pre- or post-training $_{15+16}$.
A: VAS score pre-training $_{1+2}$ vs.VAS score pre-training $_{15+16}$.
B: VAS score post-training $_{1+2}$ vs.VAS score post-training $_{15+16}$.

Joint effusion

Acute effects of PRT: As depicted in figure 4, the highest average of knee circumference was 48.1 SD 3.3 cm (maximal value observed at the post test following the first PRT session, see figure 4) and the

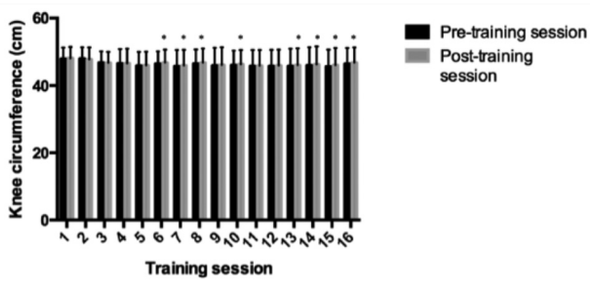

Fig. 4. — Knee circumference pre-training and post-training over 16 PRT sessions. Values are shown as mean ± SD. *Significant change between pre and post score

lowest average score was 45.6 SD 5.0 cm (lowest score observed at the pre test before session no. 15). A significant difference between pre circumference and post circumference was observed in 8 of the 16 training session (session 6; p = 0.0001, 7; p = 0.05, 8; p = 0.003, 10; p = 0.001, 13; p = 0.007, 14; p = 0.006, 15; p = 0.00002, 16; p = 0.003).

Chronic effects of PRT: As depicted in figure 5, the thigh circumference generally decreases following 8 weeks of PRT. The average circumference pre-training decreased significantly from the two first training sessions compared to the last two training session (47.8 SD 3.6 vs. 45.9 SD 4.5; p = 0.0001). The average circumference at post-training also decreased significantly from the two first training sessions compared to the last two training sessions (46.8 SD 4.0 to 45.5 SD 4.2; p = 0.0004).

DISCUSSION

The present study investigated the effects of a PRT program on pain and effusion in patients

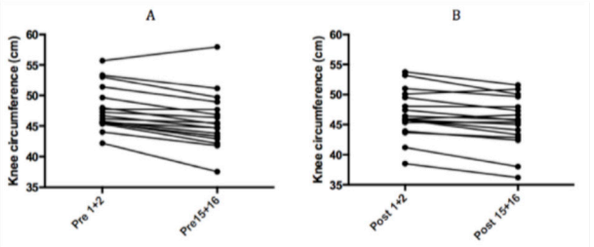

Fig. 5. — Circumference for each patient who participated in exercise session 1, 2, 15 and 16. The circumference is a mean of pre- or post-training$_{1+2}$ and a mean of pre- or post-training $_{15+16}$. A: Circemference pre-training$_{1+2}$ vs. pre-training$_{15+16}$. B: Circumference post-training$_{1+2}$ vs. post-training$_{15+16}$

following fast track UKA. This study suggests that PRT initiated in the early post-operative phase following UKA does not increase the pain level immediately after a PRT session, despite frequent increases in joint effusion. Furthermore, pre- and post PRT pain and joint effusion levels dropped significantly following the intervention period.

Effects on pain

As depicted in figure 2, a significant increase in pain level was only found after one out of 16 PRT sessions, suggesting that PRT only have minor, if any, acute effects on the pain level.

Furthermore, figure 2 and 3 shows that the VAS score generally decreased throughout the 8 weeks of PRT, suggesting that PRT does not introduce severe pain problems, even when performed in the early post-operative phase following UKA, which is an important message to clinicians. This suggestion is in line with a pervious randomized study by Jakobsen et al. *(9)*, who compared rehabilitation with PRT to rehabilitation without PRT in patients after TKA. One of the secondary outcomes in the study was knee pain at rest, and no significant between-group difference was found, suggesting that PRT can replace or supplement rehabilitation without PRT, without affecting the pain level.

Jakobsen et al. *(8)* explored the feasibility of PRT commenced immediately after TKA and found that patients experienced mild to moderate knee pain at rest after TKA. The level of knee pain was unchanged pre-training ($p < 0.1$), but knee pain post-training decreased significantly ($p < 0.01$) during the course of six PRT sessions. This partially supports the present study results from UKA patients showing a drop in pain following PRT. However, the unchanged knee pain level observed pre-training by Jakobsen et al. does not correspond to the drop seen in the present study, but may be caused by the short training period, which only lasted 2 weeks (3 weekly sessions) as compared to the present PRT intervention lasting 8 weeks. Mikkelsen et al. *(13,14)* investigated the pain level pre and post PRT in patients who had undergone total hip arthroplasty and found that pain scores pre training decreased significantly over time as did

pain scores after the PRT sessions. Furthermore, Mikkelsen et al. observed the highest scores at the third training session (median: 13 mm-VAS) and the lowest score at last session (session no. 8, median 2.5 mm-VAS). These findings are in line with the results of the present study.

Effects on joint effusion

Knee circumference both pre- and post-training decreased significantly over time. Figure 4 indicates that knee circumference often increases from pre-training to post-training. Moreover, a significant increase in circumference was observed post-training in 8 of the 16 PRT sessions. This partially supports the hypothesis that PRT increase knee joint effusion after a single PRT session. However, the fact that knee joint effusion only increases following 50% of the sessions may be explained by low responsiveness of the applied assessment, the small sample size and/or by other factors that trigger knee joint effusion. The applied method used to indicate joint effusion may not be as valid as estimates based on for example magnetic resonance imaging (MRI). However, knee circumference is an often-used assessment to determine if joint effusion is present, probably because it is accessible, fast and easy compared to MRI. In this case knee circumference was the best alternative, because the study needed a fast, cheap and on location measurement/solution *(5,6,18)*.

The existing evidence on how PRT influences knee joint effusion is limited. Jakobsen et al. *(8)* investigated the effects of 2 weeks of PRT on knee joint effusion in TKA patients. Knee joint effusion was assessed by knee circumference as in the present study. The study reported a significant decrease in knee joint effusion following the six training sessions, supporting the results of the present study. However, no single session pre- and post-training comparison of knee joint effusion was performed. Another study compared rehabilitation with PRT to rehabilitation without PRT. Here it was shown that no significant difference existed between the two groups, suggesting that PRT can supplement standard rehabilitation without worsening joint effusion *(9)*.

Taken together the effects of a single session of PRT may worsen knee joint effusion, whereas joint effusion does not seem to be chronically affected by a period of regular PRT.

Limitations

Several aspects need to be kept in mind when interpreting the present study results.

First, the study included only a small sample size and also no prior power calculation was made for the applied outcomes, which increases the risk of type 2 errors.

Second, the present study was not blinded, and the therapists and patients were aware of the study hypotheses. This is of importance as a review by Moher et al. *(14)* shows that trials without blinding have a tendency to report higher effects than blinded trials. However, double blinded studies are very difficult to perform when evaluating exercise *(17)*.

Third, no between-group comparisons were performed, as no comparable data from the control group were collected. Moreover, comparisons to group following the standard rehabilitation program would have strengthened the study markedly, as the "natural history" of the post UKA course, would expectedly involve changes in pain and joint effusion *(15)*.

Finally, the applied knee joint effusion outcome measure is not the gold standard measure leaving room for future RCT studies that apply better methodologies and larger samples.

CONCLUSION

This study finds that PRT initiated in the early post-operative phase following UKA does not increase the pain level immediately after a PRT session, despite frequent increases in joint effusion. Furthermore, pre- and post PRT pain and joint effusion levels dropped significantly following the intervention period.

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