# Modeling and Rehabilitation Following Anterior Cruciate Ligament Reconstruction

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## ABSTRACT

***Background/Purpose:*** *This study sought to examine the effectiveness of a modeling video to reduce preoperative perceptions of anxiety and pain, as well as to increase postoperative self-efficacy and functional outcomes after anterior cruciate ligament reconstruction.* ***Methods:*** *Following baseline assessment of state anxiety, perceptions of expected pain, injury severity, and knee function (International Knee Documentation Committee [IKDC] system), patients scheduled for surgical reconstruction of the anterior cruciate ligament were randomly assigned to either a modeling intervention or a control group. Psychological assessments were repeated preoperatively for expected pain and anxiety. Actual pain was assessed preoperatively, prior to discharge, and at 2 weeks postoperatively. Rehabilitation self-efficacy was assessed prior to discharge and at 2 and 6 weeks postoperatively. IKDC functional assessments were repeated at 6 weeks postoperatively, whereas range of motion was assessed at 2 and 6 weeks postsurgery.* ***Results:*** *Compared with the participants in the control condition, participants assigned to the modeling intervention reported significantly lower perceptions of expected pain preoperatively and significantly greater self-efficacy at predischarge to perform rehabilitation tasks. Those who received the modeling intervention also experienced significantly better IKDC objective functional outcome scores compared with their control counterparts. No psychological variables mediated relations between the intervention and functional outcomes.* ***Conclusions:*** *The data suggest that watching a modeling video may be an effective prophylactic treatment to decrease perceptions of expected pain, increase rehabilitation self-efficacy, and provide an early stimulus with respect to early function.*

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## INTRODUCTION

The role that psychology has to play in understanding the recovery of sport and recreation related injuries continues to grow (1,2). Various psychological interventions have been advocated or used in the injury recovery setting. These include imagery (3–5), goal-setting (6), electromyographic biofeedback (7), and stress inoculation training (8).

An intervention area that has received limited attention in the realm of athletic injury rehabilitation is observational learning or modeling (9). Despite this, modeling has been found to be a powerful instructional tool for the acquisition of motor skills, psychological responses, and behavior change in physical activity contexts (10,11). Moreover, a recent review of preparation interventions for adult patients undergoing surgery and/or invasive medical procedures found that modeling combined with instruction in coping strategies is highly effective in producing positive outcomes (12). Taken together, the theoretical and empirical support for modeling makes it a viable intervention strategy, particularly in the realm of athletic injury rehabilitation.

Only one study, by Flint (13), has explored the effectiveness of a modeling intervention to enhance physical and psychological rehabilitation outcomes in an athletic setting. This is unfortunate, because the extension of this technique into the "realm of sport injury rehabilitation affords motivation, injury-rehabilitation information, and behavioral cues for recovering athletes" (14, p. 221). In her innovative study, Flint examined the role of coping models compared to no models on psychological factors and functional outcomes following a rehabilitation program for anterior cruciate ligament reconstruction (ACLR) among 10 female basketball players. Results showed increased self-efficacy 3 weeks after surgery among those who watched a modeling videotape compared with the 10 matched controls. Differences in the expected direction were also noted for early attainment of functional milestones (i.e., walking, jogging, running, and return to full function), although these differences were statistically nonsignificant. Flint's study had a modest sample size and hence was underpowered, which may have accounted for the nonsignificant results for functional milestones. In addition, the modeling intervention was introduced postoperatively and did not provide an indication of its benefit for reducing preoperative anxiety.

Research findings have supported the effectiveness of modeling in reducing both anxiety and perceptions of pain preoperatively (15,16). Modeling as an intervention has the potential to help reduce a person's perception of pain and anxiety and to increase one's rehabilitation self-efficacy early on in the rehabilitation process. This is particularly important when one considers the comments of DeCarlo, Sell, Shelbourne, and Klootwyk (17), who suggested that if certain problems are allowed to develop early in the ACLR postoperative period, they will be very difficult to eliminate in the long term and will ultimately have a

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detrimental effect on the patient's outcome. DeCarlo et al. highlighted the following variables as important in the early postoperative period: (a) lack of full terminal extension equal to the contralateral side, (b) lack of quality straight leg raise and adequate leg control, and (c) significant hemarthrosis of the surgical knee.

The population examined by Flint also provides a suitable avenue for continued research, because acute disruption of the ACL is one of the more common and debilitating sport- and recreation-related injuries (18,19). Surgical ACLR is associated with an extensive period of rehabilitation (6–9 months) involving home- and clinic-based strength and flexibility exercises along with cryotherapy (icing) (17). Given the nature of rehabilitation associated with ACLR, opportunity exists to examine the potential utility of psychological interventions to augment the recovery process (20). The purpose of this study was to examine the effectiveness of a video coping modeling intervention in promoting early recovery following ACLR. It was predicted that athletes who received a coping modeling video intervention would report lower preoperative anxiety and perceptions of expected pain and would report greater self-efficacy for rehabilitation compared to the nonintervention group. It was also hypothesized that participants in the intervention group would show greater improvements in functional milestones (e.g., range of motion [ROM] and crutch use) than those in the nonintervention group.

## METHOD

### Participants and General Recruitment Procedure

Seventy-two participants scheduled for ACLR agreed to participate and were prospectively recruited from the Auckland Bone and Joint Surgical clinic. Eight did not have the operation as planned, 3 withdrew from the study, and 3 had postoperative complications that disrupted the standard rehabilitation protocol; hence, the final sample was 58 (see Figure 1). It was calculated that a sample of approximately 38 participants in each condition (modeling vs. control) would be needed to provide power of 80% ($\alpha$ = .05) and to detect a large effect (i.e., .40) between conditions on the variables of interest (21). Despite comprehensive attempts, we were unable to recruit the necessary 76 participants to fully power this study.

Participants ranged in age from 15 to 53 years (*M* = 30), with a greater distributions of males (68%) than females (32%). The following ethnic groups were represented: NZ Pakeha, 71%, NZ Maori, 14%, Pacific Islands, 5%, and other, 10%. Rugby was overrepresented as the major cause of injury (32%), followed by soccer (18%), snow sports (11%), netball (8%), water sports (5%), and miscellaneous activities (26%). Descriptive data are provided in Table 1.

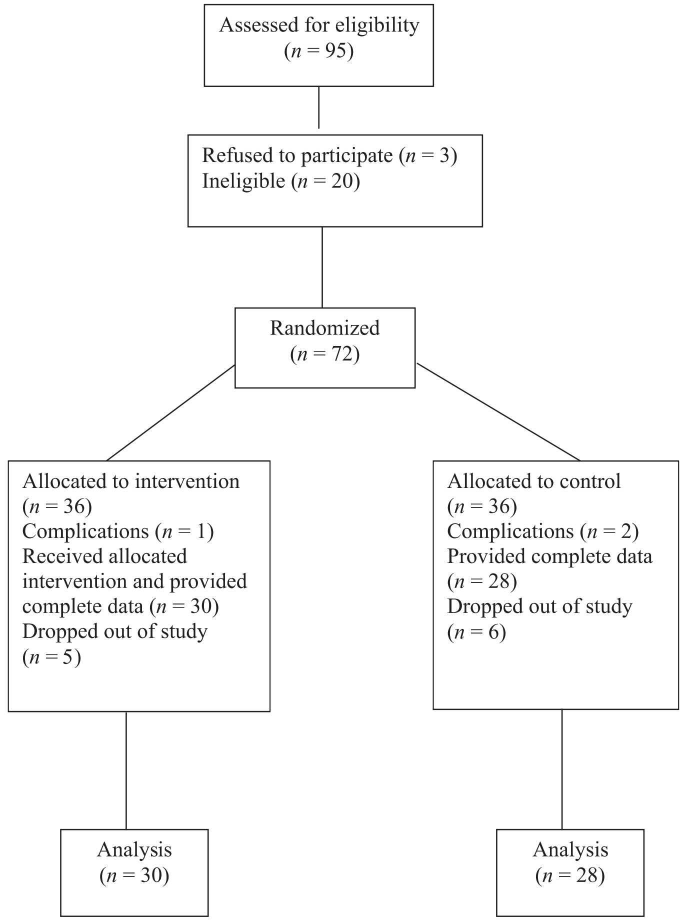


FIGURE 1 Participant recruitment flow chart.

### Psychological Measures

*Pain.* A single item assessed "perceptions of expected pain" and asked participants to "write down a number on a scale ranging from 0 (*no pain*) to 100 (*pain as bad as it could be*) that best describes how much pain you think you will experience after your knee surgery" (22). Assessments occurred at baseline and preoperatively. A similar scale was also used to assess perceptions of actual pain, preoperatively, predischarge and 2 weeks postoperatively. Participants were asked to "write down a number on a scale ranging from 0 (*no pain*) to 100 (*pain as bad as it could be*) that best describes how much pain you have right now" (22).

*Anxiety.* The State–Trait Anxiety Inventory (STAI) (23) was used to measure state anxiety at baseline and preoperatively. The STAI has been shown to have both construct validity and reliability (24). Participants were asked to respond to 20 statements that describe "how you are feeling right now" on a scale that ranged from 1 (*almost never*) to 4 (*almost always*). Reliability was acceptable for this scale at the two time points (baseline $\alpha$ = .90 and preoperative $\alpha$ = .91).

*Rehabilitation self-efficacy.* Three types of self-efficacy were assessed in the present study. The self-efficacy scales assessed confidence for performing knee rehabilitation exercises, as well as functional task outcomes (walking with and without crutches) progressively with increasing frequency and duration on a scale of 0% (*no confidence*) to 100% (*complete confidence*) (25).

TABLE 1
Descriptive Statistics of the Variables of Interest

| *Variable* | *Intervention*[a] *M* | *Intervention*[a] *SD* | *Control*[b] *M* | *Control*[b] *SD* | *Total* *M* | *Total* *SD* |
|---|---|---|---|---|---|---|
| Baseline expected pain | 62.17 | 17.06 | 64.24 | 22.76 | 63.17 | 19.86 |
| Preoperative expected pain | 56.33 | 18.04 | 66.79 | 15.73 | 61.38 | 17.62 |
| Preoperative actual pain | 13.33 | 12.61 | 23.24 | 24.28 | 18.11 | 19.63 |
| Predischarge actual pain | 33.51 | 26.02 | 40.32 | 22.46 | 36.80 | 24.40 |
| 2 weeks actual pain | 27.95 | 18.53 | 27.84 | 18.65 | 27.90 | 18.42 |
| Baseline state anxiety | 36.93 | 8.85 | 34.25 | 7.80 | 35.64 | 8.40 |
| Preoperative state anxiety | 38.17 | 10.19 | 37.52 | 6.52 | 37.58 | 8.55 |
| Discharge CSE | 72.85 | 16.72 | 57.17 | 29.28 | 65.28 | 24.72 |
| Discharge WSE | 59.20 | 22.17 | 44.04 | 24.48 | 51.88 | 24.34 |
| Discharge ESE | 87.38 | 11.94 | 76.38 | 23.44 | 82.08 | 19.07 |
| 2-week WSE | 69.68 | 23.30 | 72.73 | 23.02 | 71.15 | 23.01 |
| 2-week ESE | 84.25 | 12.36 | 84.66 | 16.90 | 84.54 | 14.60 |
| 6-week WSE | 93.09 | 8.66 | 89.42 | 10.81 | 91.32 | 9.84 |
| 6-week ESE | 88.66 | 10.70 | 85.48 | 13.40 | 87.12 | 12.07 |
| ROM baseline | 130.82 | 10.44 | 129.77 | 10.55 | 131.96 | 10.39 |
| ROM 2 weeks | 103.17 | 14.29 | 102.23 | 16.94 | 102.71 | 15.50 |
| ROM 6 weeks | 124.03 | 8.96 | 121.78 | 8.67 | 122.94 | 8.82 |
| IKDC (O) (baseline) | 3.03 | .61 | 3.28 | .53 | 3.15 | .58 |
| IKDC (S) (baseline) | 53.53 | 12.81 | 52.25 | 11.89 | 52.91 | 12.28 |
| IKDC (O) (6 weeks) | 2.24 | .43 | 2.56 | .48 | 2.42 | .48 |
| IKDC (S) (6 weeks) | 61.18 | 8.04 | 57.02 | 9.58 | 59.17 | 8.98 |
| Crutch use in days | 5.54 | 2.31 | 9.34 | 4.03 | 7.38 | 3.75 |

*Note.* All data presented are raw and uncorrected. CSE = crutches self-efficacy; WSE = walk self-efficacy; ESE = exercise self-efficacy; ROM = range of motion; IKDC = International Knee Documentation Committee; O = objective; S = subjective.
[a]$n = 30$. [b]$n = 28$.

A crutches self-efficacy (CSE) scale assessed confidence to walk with crutches for increasing periods (i.e., 10, 20, and 30 min) at two speeds (i.e., slow and moderate pace). The CSE scale was framed for the next 2-week period, and a key was provided to define the various intensity levels. Mean scores were derived from the six items, with higher values indicating greater efficacy to exercise for a longer time and at a faster pace. Reliability for the CSE scale was acceptable at the predischarge assessment ($\alpha = .95$).

A walking self-efficacy (WSE) scale assessed confidence to walk for increasing periods (i.e., 10, 20, and 30 min) at three speeds (i.e., slow, moderate, and moderately fast pace). The WSE scale was framed for the next 4-week period, and a key was provided to define the various intensity levels. Mean scores were derived from the nine items, with higher values indicating greater efficacy to exercise for a longer time and at a faster pace. Cronbach's alpha values were as follows: predischarge, $\alpha = .97$; 2 weeks postoperative, $\alpha = .97$; and 6 weeks postoperative, $\alpha = .95$.

An exercise self-efficacy (ESE) scale assessed confidence to complete rehabilitation exercise for increasing periods (i.e., 10 and 20 min) at three different times (i.e., once, twice, and three times a day). Mean scores were derived from the six items, with greater values indicating greater efficacy to perform rehabilitation exercises more frequently and for a longer time. Cronbach's alpha values were as follows: predischarge, $\alpha = .96$; 2 weeks postoperative, $\alpha = .93$; and 6 weeks postoperative, $\alpha = .95$.

### Functional Milestones

*Crutch usage.* Participants were questioned at 2 weeks post ACLR to determine the length of time they required the use of crutches to assist with walking (in days). Higher scores represented longer periods of crutch-assisted walking.

*Knee assessment.* The International Knee Documentation Committee (IKDC) system (26,27) was used to clinically evaluate the knee at two different times (baseline and 6 weeks postoperatively). The IKDC Standard Evaluation Form consists of eight groups, including patient's subjective assessment of function, symptoms, ROM, ligament examination, compartmental findings, harvest site pathology, x-ray findings, and functional tests, but only the first four groups are included in the final overall IKDC rating (28). Each group in the IKDC assessment is graded as A (normal), B (nearly normal), C (abnormal), or D (severely abnormal). The scale incorporates an objective (surgeon) and subjective (patient) assessment. Patient symptoms are evaluated at the following four activity levels: (a) strenuous activity (jumping, pivoting, and hard cutting), (b) moderate activity (heavy manual work, skiing, and tennis), (c) light activity (light manual work, jogging), and (d) sedentary (housework and daily living activities). Overall evaluation is determined by the worst grade in the following four categories: (a) patient subjective assessment, (b) symptoms (pain, swelling, and giving way), (c) ROM, and (d) ligament evaluation (Lachman test, pivot shift test, and anterior draw). Adequate construct and concurrent validity of the IKDC were reported by Irrgang et al. (28). In the present study, numerical values were allocated to each of the IKDC grades (e.g., A = 1, B = 2, etc.) to permit analysis.

*ROM.* ROM was considered independently as a functional milestone and was assessed at baseline and 2 and 6 weeks after ACLR using standardized goniometry procedures (29). To enhance the reliability for ROM assessment, the following steps were taken: (a) standardized assessment of the joint and (b) the use of a single trained assessor to ensure consistency between successive measurements of ROM. Values for knee extension and flexion were obtained. Difference values (i.e., extension minus flexion) were used in final analyses, with greater scores representing greater ROM.

### The Intervention

Two coping model videos (DVDs) were developed by Maddison to represent the first 6 weeks of rehabilitation post-ACLR. The first video (9 min) detailed the preoperative through to the 2-week postoperative period. This video was viewed preoperatively and prior to discharge from hospital (to reinforce the key points). The second video (7 min) addressed the 2- to 6-week postoperative period and was viewed at these time points, respectively. The video consisted of edited interviews and various action shots of the models performing a number of tasks (e.g., stair climbing and walking). During the videos, models were shown performing appropriate time-matched rehabilitation exercises. For example, in the first video (early stages), models were shown performing rehabilitation exercises to improve extension and flexion and walking with and without crutches. The second video showed the models demonstrating further improvement in ROM, cycling on a stationary bicycle, stair climbing, and so on. Consistent with social learning theory, and to enhance the attentional and motivational properties of the videos, four models (two men and two women) between 20 and 40 years of age, were filmed to ensure that observers would identify with at least one model with respect to age, gender, and so forth (30). During the edited interviews, models detailed how they had sustained their original injury, their thoughts and feelings associated with the injury, and the surgery they underwent. Models then detailed the types of problems they had faced during the various stages of the rehabilitation process (e.g., pain, frustration, transport, motivation, etc.) and provided strategies they used to overcome these issues (e.g., use of appropriate analgesia, using the cryocuff, setting targets or goals, and having adequate social support). Finally, the models detailed their original expectations and actual progress regarding functional outcomes (13). It was anticipated that observers of the video would glean relevant information and cues specific to their own stage of progression.

### Procedure

The present study incorporated a randomized, controlled, prospective, repeated measure design. Ethical approval was secured before proceeding. Participants were approached during their initial surgical consultation and received verbal and written information. Once written consent was obtained, participants provided demographic information (age, gender, ethnicity, and injury information). All participants were randomized to either an intervention (modeling video) or a control condition (Figure 1) using SPSS 11.5 software. Comparison of baseline group means for age, injury severity, and psychological variables revealed no differences, suggesting pretreatment group equivalence on these variables.

In our study, all participants underwent arthroscopic autograft hamstring-tendon ACL reconstruction. The procedure was performed as a day case, with participants admitted the morning of the procedure and then discharged later that evening. The same consultant orthopedic surgeon performed all of the ACLRs in the study.

*Baseline data collection.* Participants completed the IKDC subjective (S) form, STAI, and the expected pain assessment. ROM measurements and the IKDC objective (O) assessment were also obtained.

*Preoperative period.* On the day prior to their operation, participants in the intervention condition watched the modeling video before completing the STAI and actual and expected postoperative pain assessments, whereas the control group completed the psychological measures only.

*Predischarge.* Prior to discharge from hospital, the intervention group watched the modeling video before completing the psychological inventories (actual pain, CSE, WSE, and ESE scales), whereas the control group completed the psychological inventories only.

*Two weeks postoperative.* At the 2-week postoperative assessment, participants in the intervention group watched the modeling video before completing the psychological inventories (actual pain, WSE, and ESE scales). The control group completed only the psychological inventories. Functional milestones (ROM and crutch use) were also assessed.

*Six weeks postoperative.* At the 6-week postoperative assessment, those in the intervention group watched the modeling video before completing the psychological inventories (WSE and ESE scales). The control group completed the psychological inventories only. Functional milestones (ROM, IKDC subjective and objective) were also assessed.

## RESULTS

### Treatment of the Data

To address the main hypotheses, two forms of analyses were conducted. When baseline data were available to serve as a covariate, one-way (intervention vs. control) analyses of covariance (ANCOVAs) were performed on each of the psychological measures (actual and expected pain and anxiety). Prior to conducting these analyses, the assumptions underlying the use of ANCOVA (i.e., reliability of covariates, linear relationship between dependent variable and covariates, homogeneity of regression slopes) were tested and satisfied (31). The alpha level for the ANCOVA analyses was .05, with effect sizes reported ($\acute{\eta}^2$). All skewed data were subjected to logarithmic transformation to reduce a potential spurious influence of extreme scores (31).

When baseline data were not available, a series of repeated measure analyses of variance (ANOVAs) were conducted (rehabilitation self-efficacy). The alpha value for these ANOVA analyses was .05. Any significant interactions were examined with planned multiple comparison Bonferroni tests. Corresponding measures of effect sizes, $\acute{\eta}^2$ and Cohen's *d*, are reported. All data were assessed for the various requirements of ANOVA (32). All skewed data were subjected to logarithmic transformation to reduce a potential spurious influence of extreme scores.

Path analysis was also conducted to elucidate the degree to which the psychological variables mediated the relationship between the modeling intervention and functional outcome variables. For this form of analysis to take place, variables had to meet the conditions of mediation. Mediation requires a demonstration that (a) the independent, mediating, and dependent variables are significantly related and (b) the direct effects of the independent variables are significantly reduced when the mediator is introduced into the analysis (33).

### Psychological Variables

*Descriptive data.* As can be seen in Table 1, participants appeared to have relatively low levels of state anxiety. In general, walking and jogging self-efficacy increased across time. Correlations between the variables of interest revealed a number of patterns between the psychological variables (see Table 2). State anxiety at baseline was inversely related to exercise self-efficacy at predischarge ($r = –.28$, $p < .05$). Baseline perceptions of expected pain was inversely related to walking self-efficacy at 6 weeks ($r = –.36$, $p < .01$). Actual pain (preoperative and discharge) was inversely related to exercise self efficacy at discharge (*r*s = –.27 and –.26, *p*s < .05, respectively), whereas actual pain (preoperative) was inversely related to walking self-efficacy at 6 weeks ($r = –.35$, $p < .01$).

*Anxiety and pain.* No condition effect (control vs. intervention) was found for preoperative anxiety, $F(1, 56) = 85$, $p = .36$, $\acute{\eta}^2 = .02$. A general increase in state anxiety from baseline to the preoperative assessment was observed in both groups. With respect to expected pain, a significant condition effect was found, $F(1, 56) = 5.42$, $p < .05$, $\acute{\eta}^2 = .10$. As can be seen in Figure 2, participants in the modeling condition reported fewer per-

TABLE 2

Correlations for the Variables of Interest

| *Variable* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* | *16* | *17* | *18* | *19* | *20* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Anxiety (B) | — | .74** | .07 | .03 | .03 | .21 | .41** | –.18 | .01 | –.28* | –.22 | –.13 | –.19 | –.06 | .03 | –.20 | .08 | –.11 | –.03 | –.13 |
| 2. Anxiety (P) | | — | .22 | .13 | –.10 | .18 | .32* | –.19 | –.10 | –.23 | –.09 | –.08 | –.12 | .01 | .12 | –.14 | .06 | .05 | .17 | –.03 |
| 3. Ex Pain (B) | | | — | .34** | .37** | .37** | .21 | –.05 | –.11 | –.14 | –.13 | –.04 | –.36** | .18 | .25 | –.35** | .08 | –.07 | .23 | –.12 |
| 4. Ex Pain (P) | | | | — | .40** | .39** | .11 | –.21 | –.24 | –.25 | –.00 | –.14 | –.11 | .05 | .04 | –.12 | .06 | .03 | .02 | –.01 |
| 5. Pain (P) | | | | | — | .42** | .45** | –.06 | –.07 | –.27* | –.16 | –.12 | –.35** | –.01 | –.35 | –.12 | –.01 | –.25* | .05 | .10 |
| 6. Pain (D) | | | | | | — | .36** | –.21 | –.18 | –.26* | –.13 | –.02 | –.15 | .03 | –.08 | .08 | .18 | .03 | .10 | .01 |
| 7. Pain (2W) | | | | | | | — | –.06 | .01 | –.18 | –.24 | –.17 | –.17 | –.16 | .01 | –.11 | –.04 | –.17 | –.08 | .02 |
| 8. CSE (D) | | | | | | | | — | .70** | .60** | .24 | .17 | .08 | .13 | –.15 | .18 | –.18 | .11 | .06 | –.10 |
| 9. WSE (D) | | | | | | | | | — | .51** | .16 | .11 | .02 | .06 | –.01 | .13 | –.43** | .12 | .13 | –.08 |
| 10. ESE (D) | | | | | | | | | | — | .33* | .36** | .30* | .14 | –.17 | .19 | –.18 | .21 | –.08 | –.13 |
| 11. WSE (2W) | | | | | | | | | | | — | .62** | .39** | .37** | –.07 | .02 | –.00 | .06 | .14 | .05 |
| 12. ESE (2W) | | | | | | | | | | | | — | .29* | .63** | –.10 | .06 | –.07 | .07 | .10 | .04 |
| 13. WSE (6W) | | | | | | | | | | | | | — | .13 | –.17 | .11 | .03 | –.01 | –.26* | .11 |
| 14. ESE (6W) | | | | | | | | | | | | | | — | –.15 | –.02 | –.22 | .05 | –.01 | .02 |
| 15. IKDC (O) (6W) | | | | | | | | | | | | | | | — | –.67** | .09 | .02 | –.04 | –.51** |
| 16. IKDC (S) (6W) | | | | | | | | | | | | | | | | — | –.15 | .19 | .18 | .34** |
| 17. Crutch use | | | | | | | | | | | | | | | | | — | .05 | –.16 | –.24 |
| 18. ROM (B) | | | | | | | | | | | | | | | | | | — | .10 | –.06 |
| 19. ROM (2W) | | | | | | | | | | | | | | | | | | | — | .18 |
| 20. ROM (6W) | | | | | | | | | | | | | | | | | | | | — |

*Note.* B = baseline; P = pre-operation; Ex Pain = expected pain; Pain = actual pain; D = predischarge; 2W = 2 weeks; CSE = crutches self-efficacy; WSE = walking self-efficacy; ESE = exercise self-efficacy; 6W = 6 weeks; IKDC = ; International Knee Documentation Committee; O = objective; S = subjective; ROM = range of motion.

$^{*}p < .05$. $^{**}p < .01$.

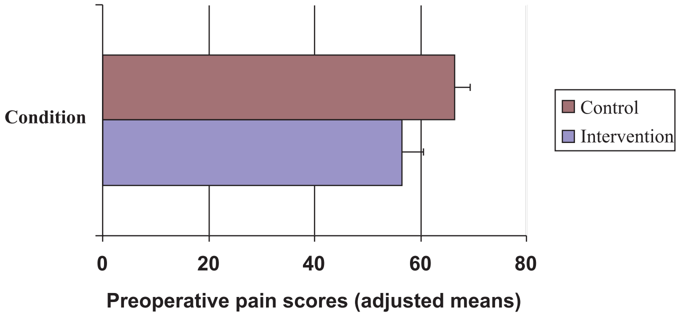


FIGURE 2 Perception of preoperative expected pain condition effect (adjusted means and standard error).

ceptions of expected pain compared to those in the control condition. Of interest, those in the modeling condition showed a decrease from baseline to preoperative, whereas the control participants showed an increase from baseline to preoperative (Table 1). No condition effect was found for actual pain, $F(2, 54) = 0.66$, $p = .52$, $\eta^2 = .02$. For both groups, actual reported pain generally increased from the preoperative to the predischarge period, before decreasing at 2 weeks (Table 1).

### Rehabilitation Self-Efficacy

*Crutches self-efficacy.* Because crutch self-efficacy was assessed only at predischarge, a one-way ANOVA was performed. Results revealed significant group differences, $F(1, 56) = 6.38$, $p < .01$, $d = .53$. The modeling group reported greater confidence to walk with crutches compared to the control group at the predischarge assessment (Table 1).

*Walking self-efficacy.* Repeated measures ANOVA results revealed a significant time effect, $F(2, 55) = 79.50$, $p < .01$, $\eta^2 = .74$, and a nonsignificant "trend" toward a Time × Condition interaction for self-efficacy to walk without crutches, $F(2, 55) = 2.70$, $p = .07$, $\eta^2 = .08$. As can be seen in Figure 3, the modeling group reported greater self-efficacy after viewing the video at predischarge than did the control group. Follow-up analyses revealed significant group differences at predischarge, $t(56) = 2.47$, $p = .01$, $d = .05$, but not at the 2-week, $t(56) = –0.50$, $p > .05$, $d = .13$, and 6-week assessments, $t(56) = 1.43$, $p > .05$, $d = .33$.

*Exercise self-efficacy.* No significant time effect, $F(2, 55) = 2.18$, $p = .12$, $\eta^2 = .07$, was seen for exercise self-efficacy, but a significant Time × Condition interaction effect, $F(2, 55) = 3.07$, $p = .05$, $\eta^2 = .10$, was evident. Follow-up analyses revealed significant differences at predischarge, $t(56) = 2.27$, $p < .05$, $d = .47$, but not at the 2-week, $t(56) = –0.12$, $p = .90$, $d = .03$, and 6-week, $t(56) = –0.10$, $p > .05$, $d = .26$, assessments. The modeling group reported greater efficacy to perform rehabilitation exercises after watching the video compared to the control group at predischarge only (Figure 4).

### Functional Outcomes

*Descriptive data.* As can be seen in Table 1, IKDC objective and subjective scores improved, whereas ROM scores began to return to baseline values for all participants across respective assessment periods. Correlations between the functional outcome variables showed the following pattern of relationships (see Table 2). Range of motion at 6 weeks was related to IKDC objective and subjective scores ($r = –.51$, $p < .01$, and $r = .34$, $p < .01$, respectively).

*IKDC measures.* The ANCOVA results revealed a significant condition effect for IKDC objective scores, $F(2, 55) = 6.53$, $p = .01$, $\eta^2 = .11$. The modeling condition scored significantly lower (better function) at 6 weeks compared to the control condition (Figure 5). The condition effect for IKDC subjective scores approached significance, $F(2, 55) = 3.01$, $p = .08$, $\eta^2 = .05$. The modeling group reported higher scores on the IKDC (S) scale (i.e., less disability) at 6 weeks compared to the control group (Figure 6).

*ROM.* The ANCOVA results showed no significant condition effects for ROM at 2 weeks, $F(1, 56) = 0.09$, $p < .76$, $\eta^2 = .01$, or at 6 weeks, $F(1, 56) = 0.85$, $p = .36$, $\eta^2 = .02$.

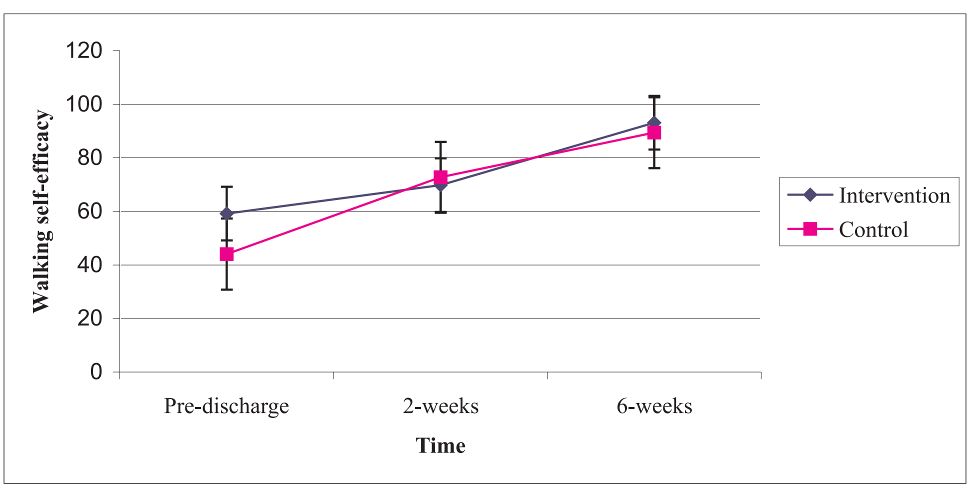


FIGURE 3 Walking self-efficacy condition effect (raw means and standard error).

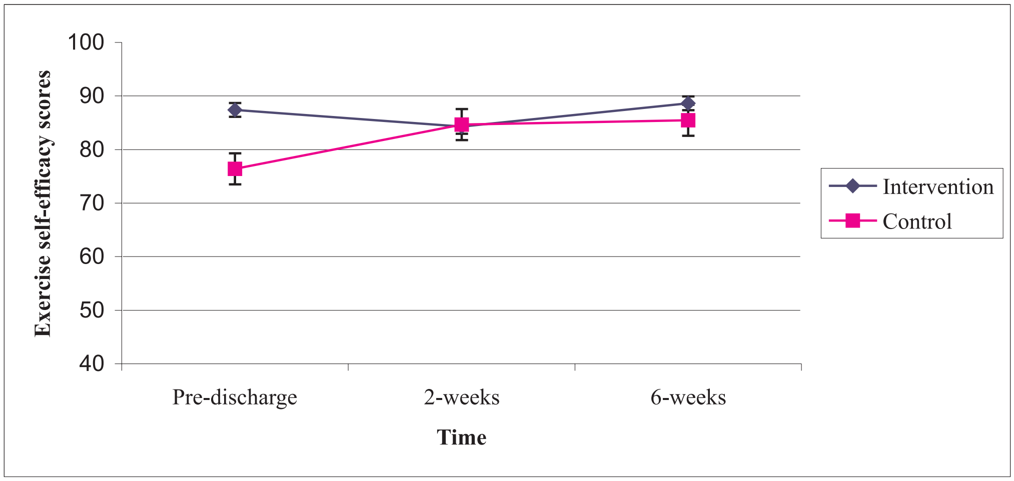


FIGURE 4 Exercise self-efficacy condition effect (raw means and standard error).

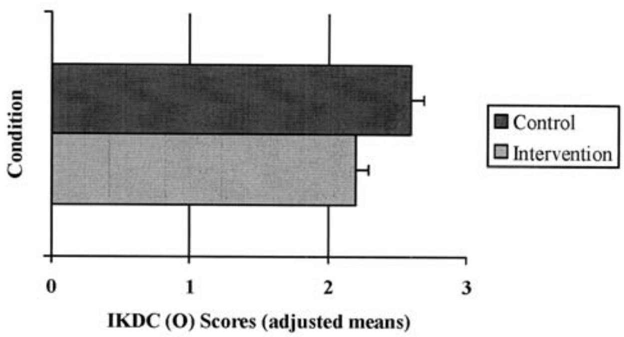


FIGURE 5 International Knee Documentation Committee (IKDC) objective condition effect (adjusted means and standard error).

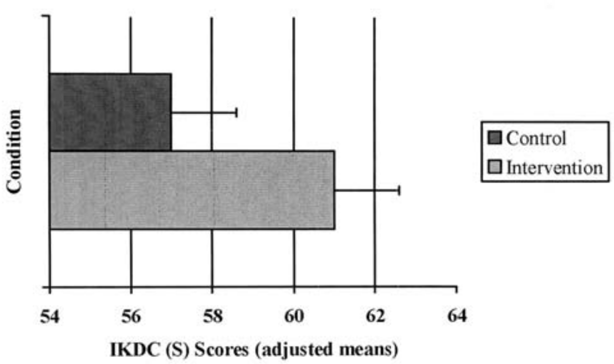


FIGURE 6 International Knee Documentation Committee (IKDC) subjective condition effect ($p = .08$; adjusted means and standard error).

*Crutch use.* Time spent walking on crutches was assessed at one point only, so a one-way ANOVA was performed. Significant group differences, $F(2, 56) = 19.65$, $p < .01$, $d = .94$, were found, suggesting that the modeling group spent significantly less time on crutches compared to the control group (Table 1).

### Testing for Mediation

Walking self-efficacy (discharge) and crutch use were the only variables that met the criteria for mediation (33). Results showed that the intervention was related to both discharge walking self-efficacy (path coefficient, .35) and crutch use (.43). Walking self-efficacy was also related to crutch use (.31). However, the indirect effect of the intervention to crutch use through walking self-efficacy (.11) was less than the direct effect of the intervention to crutch use. Hence, no support for mediation was found.

## DISCUSSION

The present study sought to examine the effectiveness of a coping modeling video intervention to reduce preoperative anxiety and perceptions of pain (expected and actual) as well as to increase self-efficacy to rehabilitate after ACLR. We also examined the effectiveness of the modeling video to facilitate improvements in functional outcomes post-ACLR. Overall, results provide support for these propositions. Beyond these general observations, a number of issues related to specific results need to be highlighted.

First, the results did not support a condition (modeling) effect on preoperative anxiety. This is surprising given the existing body of knowledge that has found modeling to be effective in this area (15,16). Possible explanations for this lack of effect are that the video did not highlight any preoperative procedural aspects, whereas previous research (34,35) for reducing anxiety has focused specifically on the procedural and coping aspects of distressful hospital procedures. The proximity of the state anxiety assessment may also account for the lack of effect. Participants completed the STAI the day before their operation, rather than in a more proximal time frame, which may have elicited a different response.

Second, a significant condition effect was found for perception of expected pain but not for actual pain. With respect to expected pain, results support an immediate effect for participants who watched the modeling video (Figure 2) and provide some insight into the utility of modeling for altering perceptions of expected pain preoperatively. Although a number of studies have supported the effectiveness of modeling in reducing discomfort and responses to stressful medical stimuli (12), few have shown support for modeling in reducing pain (34) . This is surprising because perceptions of pain have been highlighted as one of the most stressful medical aspects for hospital patients (36). Although the present results offer support that vicarious information provided through a modeling video can help to ameliorate perception of expected pain, other research is warranted to explore whether the nature of pain (i.e., intensity and frequency) can be altered through modeling. For example, nonpharmacological pain management techniques used during pain focusing (association and disassociation) and pain reduction (relaxation training and meditation) (37,38) might be presented using a modeling format.

Third, the modeling video was effective in increasing early rehabilitation self-efficacy (i.e., crutches and predischarge walking and exercise self-efficacy). Despite viewing a video at different times, no differences in later self-efficacy (2- and 6-week walking self-efficacy) were found. Taken together, these findings suggest that although the vicarious experience of the modeling video was valuable in providing early sources of efficacy, the enactive mastery experience gained over time was a more powerful source of efficacious beliefs, thus diminishing the effect of the modeling video. These findings are consistent with Bandura's (9) suggestion that enactive mastery experience is the most powerful source of self-efficacy. Of importance, inspection of the descriptive data suggests that a ceiling effect was present for the respective measures of self-efficacy. Thus, once a person's confidence to perform a given task is high, whether by viewing the modeling video or from past experience, further increases in efficacy are difficult to achieve.

Fourth, with respect to functional outcomes, the modeling group reported significantly less time using crutches and better scores on the IKDC assessments. These improvements in outcomes support the use of a modeling video in the first 6 weeks after ACLR. The obvious question is whether these differences in function would persist across time. It is plausible that the early differences in functional outcomes found at 6 weeks might provide an early stimulus to improved strength and functional outcomes later in the rehabilitation process. This possibility should be examined in future studies. We urge some caution when interpreting the IKDC objective results. The IKDC objective assessment is designed as a rating scale (A–D) and is not a scoring system for knee function. However, in our study a nominal scale was created to represent varying degrees of function.

Results did not support a condition effect for ROM. An a priori proposition was that increased confidence to perform rehabilitation exercises and to walk with and without crutches would be reflected in ROM differences. It is possible that the current sample size was not large enough to reflect small-group differences in ROM. In addition, it is possible that noticeable differences in ROM may not present themselves in the time frame examined. In general, 6 weeks is a modest period in which to assess ACLR outcomes (28).

Fifth, unfortunately, our path analysis failed to show that the psychological factors mediated relations between the modeling intervention and functional outcome variables. Other psychological processes that were not assessed in this study (e.g., rehabilitation motivation) may have proven to be more powerful mediators. The mechanisms for why modeling works warrants future investigation.

Sixth, as with all empirical research, the present study is not without limitations. Maddison developed and implemented the intervention, which may have influenced the results through experimenter bias (expectancy effect). Although our design cannot rule this out, it is highly unlikely that the differences found between groups were not a result of the modeling intervention. The same investigator met with the both the intervention and control participants to assess the respective variables as well as to show the video. Apart from viewing the video, these sessions did not differ, which suggests that the modeling video was the overriding factor. Moreover, a person is less likely to rehabilitate quicker because his interventionist expects him to. This logic is not as robust as the traditional "Pygmalion in the classroom phenomenon." Furthermore, there is evidence from recent psychologically based intervention studies (20) that the inclusion of a placebo group to control for nonspecific treatment factors, such as attention, caring, and support, does not produce the same positive effects on psychological processes and functional outcome as the intervention group's receipt of imagery and relaxation training. In short, we believe the supporting information is sufficient to argue that the intervention was the defining factor in the present study. In addition, despite considerable attempts to recruit a sufficient sample, and within the constraints of this project, our study was not sufficiently powered to detect small effects, like those observed for walking and exercise self-efficacy at 2 and 6 weeks postsurgery, or for IKDC subjective functional outcome. Finally, the present findings represent data from a group of patients with ACL injury and may therefore not be reproducible in patients with differing types of orthopedic injuries.

Seventh, the role of modeling in the athletic rehabilitation setting is a fertile area for future research, with opportunities available to examine self-modeling techniques. For example, the use of self-modeling during a specific rehabilitation exercise (knee extension) might be associated with improved functional outcomes (i.e., knee strength) post-ACLR. Another area that has not been examined is the use of modeling on behavior such as adherence to rehabilitation programs. It is plausible that compliance to rehabilitation could be improved by altering psychological variables previously shown to affect behavior (i.e., intention and perceived behavioral control).

Results from this study suggest that there may be temporal limitations to the effectiveness of modeling interventions for ACL rehabilitation. Future research might look to strengthen this intervention modality to increase its impact. For example, as the individual progresses through rehabilitation, separate modeling videos might be employed that detail specific aspects of that process (e.g., model is shown performing rehabilitation exercises with the physiotherapist while verbalizing concerns, thoughts, etc.). Alternatively, more interactive media formats might be used, in which the observer chooses from a selection of models with whom they best associate, thereby maximizing the model similarity relationship.

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