

A RANDOMIZED CONTROLLED TRIAL OF PROTONICS® AND PATELLAR TAPING ON PATELLAR PAIN, POSITION, AND FUNCTION

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ABSTRACT

PURPOSE:

Patellofemoral pain (PFP) and abnormal patellofemoral congruence (PFC) are common orthopaedic problems whose treatment is controversial. This study examined the effects of a high volume of submaximal knee muscle exercise versus patellar taping and exercise on objective measures of PFP and PFC under a test-retest design.

METHODS:

A sample of 300 subjects was randomly divided into three groups: control, exercise, and taping. All subjects were tested for PFC, using a Merchant x-ray view, function, via Kujala patellofemoral score (KPS), and pain, through a visual analog scale (VAS), initially and then 4 weeks later. The control group did not receive treatment. The exercise group wore a Protonics[®] device during activities of daily living (ADL). The taping group received 12 sessions of McConnell patellar taping followed knee exercises. RESULTS: One-way analysis of variance tests found no difference between pretest and posttest results for the control group, significant changes in PFC, KPS, and VAS (all $P < 0.001$) for the exercise group, and a significant change in VAS ($P < 0.01$) for the taping group.

CONCLUSIONS/CLINICAL RELEVANCE:

It was concluded that Protonics[®] exercise reduced PFP and PFC as compared to the control. A high volume of submaximal knee exercise was useful for clinical patients with PFP and abnormal PFC. Patellar taping decreased PFP but had no significant effect on PFC and knee function.

KEY WORDS:

Patellofemoral Congruence Angle, Progressive Resistance Exercise, Knee Rehabilitation, Patellofemoral Pain, Patellar Biomechanics, Activities of Daily Living, Knee Taping.

Patellofemoral pain (PFP) is a common musculoskeletal problem which affects many athletes and orthopaedic patients. PFP typically presents as the insidious onset of peripatellar or retropatellar pain that is made worse by sports activities, by climbing or descending stairs, by squatting or kneeling, or by prolonged sitting with the knee flexed (the "movie" sign) (2,11,16,20,22). PFP Cannot be localized to a single, distinct anatomic structure (2,11). Other signs and symptoms include patellofemoral crepitation during knee movement, joint swelling, and an increased Q angle (9-11,16,20,22). The incidence of PFP ranges 30-33% in sports medicine clinics (2,7,17).

Abnormal patellofemoral congruence (PFC) of the patella on the femoral groove has been suggested as a routine Cause Of PFP (2,3,11,13,20). PFC may result from bony abnormalities of the patella or femur; tightness of the lateral retinacula, iliotibial band, hamstrings muscles, or gastrocnemius muscle; or malalignment of the lower extremity, such as genu valgum, genu recurvatum, femoral anteversion, external tibial torsion, or excessive subtalar pronation (3,9-11,20). An imbalance of strength, or neuromotor control, between the vastus medialis oblique (VMO) and vastus lateralis muscles (VL), or premature fatigue of the VMO, has also been suggested as a cause of PFC (5,11,13,20,21,24,26-29, 31).

The treatment of PFP from PFC remains controversial. Treatment methods have included biofeedback, bracing, closed kinetic chain exercise, electrical muscle stimulation, isometric exercise, and open kinetic chain exercise (2,4,5,9,10,16,18,20-22,24,26-29,31). The goal of these methods has been to functionally, through enhanced muscle activity, or mechanically, through external support, position the patella medially to correct PFC (2,4,5,9,10,16,18,20-22,24,26-29,31). Twelve clinic sessions have been suggested as an effective treatment duration (22).

Treatment results have been mixed. Exercise either increases or decreases PFC (2,9,10,15,20). Recent reviews have stated that quadriceps muscle exercises were an effective treatment (2,24) and that braces were not helpful for the relief of PFP (2). Also, while short-term success is found in 75% of patients (6,13), there are reports that up to 70% of patients have a return of PFP within 12 months following the end of clinical treatment sessions (8,13).

Patellar taping has also been suggested as a method for the treatment of PFP. McConnell (21) has developed taping procedures that are designed to improve patellofemoral tracking. Taping is used to glide, tilt, or rotate the patella in a desired direction, or set of directions, relative to the femur (21). This allows a patient to perform various rehabilitation exercises that will reinforce the anatomical position of the patella through the strengthening of the quadriceps muscle group (21). McConnell (21) reports patient success rates of 75-96% for the use of patellar taping as a treatment for PFP. However, other reports indicate that patellar taping either decreases both PFP and PFC or decreases PFP without an effect on PFC (2,4,18,20,21).

Another potential method of treatment for PFP and PFC is Protonics[®] (Inverse Technology Corporation, Lincoln, Nebraska) exercise. This method is based on a theory that a high volume of submaximal concentric contractions of the quadriceps and hamstrings muscle groups will promote an appropriate alignment of the patella in the femoral groove to reduce both PFC and PFP (15). One study has indicated that this theory appears to be correct (30).

The purpose of this study was to determine the effects of Protonics[®] exercise and patellar taping on patella position and perceived pain in a clinical sample of patients with PFP through a randomized controlled trial. The null hypotheses under study were that Protonics[®] and

patellar taping would have no effect on patellar position and perceived pain, as measured through clinical assessment procedures. The study employed a pretest-posttest experimental design.

METHODS

SUBJECTS

Three hundred (N = 300) clinical patients participated as subjects in the study. The subjects were referred into the study by 17 different primary care physicians and orthopaedic surgeons: there was no treatment prior to referral. The subjects participated under the guidelines of informed consent (1). The study had been approved by the Institutional Review Board for St. Luke's Hospital, Saginaw, Michigan.

All subjects had to meet four PFP criteria for inclusion in the study: pain during ascending/descending stairs, pain when rising from sitting, pain during squatting, and pain with prolonged sitting (the "movie sign"). Potential subjects were excluded from the study by one or more criteria: pain with palpation of the quadriceps tendon or patellar ligament, snapping sensation or palpable pain in the area of a medial synovial plica, pain during palpation of the knee joint line or during the McMurray test for meniscus injury, joint effusion where the midpatellar girth was 105% or more than the noninvolved knee, bilateral complaints of PFP, history of patellar dislocation or subluxation, history of knee surgery, and confirmed or possible pregnancy. The criteria for subject inclusion or exclusion were based upon previous studies (26,28,30).

The subjects were randomly divided into three groups. Group 1 was designated as control, group 2 was the exercise treatment group, and group 3 was the taping treatment group. Randomization was achieved through sequential assignment (25): the first subject was assigned to group 1, the second subject was assigned to group 2, the third subject was assigned to group 3, and so forth through the 298th subject assigned to group 1, the 299th subject assigned to group 2, and the 300th subject assigned to group 3. The demographic information for all three groups appears in Table 1.

MEASUREMENTS

Patellofemoral congruence angle (PFCA), Kujala patellofemoral score (KPS)(19), and visual analog scale (VAS) score were the dependent variables. Pretest and posttest measurements were collected on all three variables for each subject. Merchant (23) x-ray views were used to measure PFCA. PFCA was obtained through bisecting the sulcus angle to establish a zero reference line. The sulcus angle was the angle from the highest point of the lateral and medial femoral condyles to the lowest point of the intracondylar sulcus. Another line was then drawn from the lowest articular point on the patella to the apex of the sulcus angle. The two lines form the PFCA (Fig. 1).

PFCA values medial to the zero reference line were designated as negative and values lateral to the zero reference line were designated as positive (3,4,9,10,16,20,23). Doucette and Goble (10) and Merchant et al. (23) report a mean PFCA of -6° (SD = 11°) in normal subjects, a mean PFCA of $+16^{\circ}$ as abnormal at the 95th percentile, and a mean PFCA of $+23^{\circ}$ with recurrent patellar dislocation. Significant differences did not exist for gender, age, and side of the body (9,23). PFCA measurement procedures were based on the methods reported in previous studies (3,4,9,10,16,20,30).

KPS data were collected through the Kujala Score questionnaire (Table 2) (3,19). Each subject completed a pretest and posttest questionnaire to yield a KPS. The KPS has been found to be a reliable and valid measure of functional status in subjects with PFP (3,19) and was used in a previous study (30).

The VAS is a reliable and valid measurement of pain intensity (4,28). A 10-cm horizontal line marked "no sensation of soreness" on the left and "worst sensation of soreness imaginable" on the right was used for both pretests and posttests. Each subject made a mark on the VAS line which corresponded to their perceived level of pain. The distance from the left end of the VAS line to the mark was measured (cm) and recorded as the VAS score. The subjects were asked to rate their PFP during the four activities used as inclusion criteria for the study: ascending/descending stairs, rising from sitting, squatting, and prolonged sitting (the "movie sign") (26,29). These procedures were similar to the methods used in previous studies (4,30).

RADIOGRAPHIC PROCEDURES

Pretest and posttest Merchant view x-rays were taken of the knee with PFP from all subjects. A Picker Starlite G3255 (Picker International, Inc., Cleveland, OH) x-ray machine was used to take all views. The knee was held at 45° flexion by an Axial Viewer (Orthopaedic Consultants, Mountain View, CA). Goniometric measurement was used to verify knee position. The cathode ray tube was set 100.0 cm from the patella with a field size of 20.0 x 20.0 cm. The cross-hair illumination by the lamp was set on the most anterior aspect of the patella. The exposure variables were 100 mA, 0.05 s, and 70 kV. Both pretest and posttest x-rays were taken with the quadriceps contracted. Each subject performed an isometric contraction against a 2.0 kg weight without letting their heel lose contact with the x-ray table during both views. All views were taken by the same certified x-ray technician. These procedures followed the methods used in previous studies (4,16,30).

The PFCA for each x-ray view was determined through digitization using a Numonics model electronic digitizer (Numonics Corporation, Lansdale, PA) interfaced to a personal computer (Compaq Corporation, Houston, TX). All measurements were performed by the same blinded examiner. Reliability was examined through the re-measurement of 50 PFCAs randomly selected from the data. A paired t-test analysis failed to reveal a statistically significant difference between measurement sets (mean difference = 0.4°). The PFCA measurement method was deemed to be reliable. These procedures followed the methods used in previous studies (4,9,16,90).

TREATMENT PROCEDURES

The treatment procedures were similar to a previous study (30). Pretest and posttest data (PFCA, KPS, and VAS) were collected both before and after a 4 week treatment period for each subject. The 4 week period was based on the finding by McMullen et al. (22) that PFP can be resolved in about 12 clinic visits: three clinic sessions per week for four weeks is a common treatment format. The format was also selected because it matched the guidelines for managed health care that were in place during the period of investigation. This should have enhanced the external validity of the results (25). Group 1 was the control and did not receive any treatment between pretest and posttest measurements.

Group 2, the exercise group, was limited to two clinical sessions. The clinical sessions were separate from the pretest and posttest measurements sessions. For the first clinical session, each subject of group 2 was fitted with a Protonics® exercise device. The devices were similar to a hinged, long-leg knee brace (Fig. 2). However, the device was designed to provide

progressive resistance exercise (PRE) stimuli to the knee flexor and extensor muscle groups and not to restrain motion or to protect the knee ligaments (15). The hinges of the device held a Protonics® module, which provided a resistance against knee movement through the sagittal plane. When used, each subject received resistance against knee flexion and extension movements during walking. According to the manufacturer (15), resistance was selectable within a range of 2.7-34.4 N, was independent of joint velocity, but accommodated (became zero) when knee motion stopped.

Each device was configured to provide a "functional resistance setting" (FRS)(15) while worn by each subject. The FRS has been operationally defined as the lowest resistance setting that allows a subject to ascend and descend stairs with a normal gait, but without PFP (15). The physiological mechanism responsible for this effect is not known. The FRS was determined through a series of trials in which each subject climbed and then descended two flights of stairs (16 steps) while wearing the exercise device. The resistance was adjusted after each trial of stairs ascent and descent until an FRS was found.

An FRS for knee movement without PFP while wearing the exercise device was found for each subject. All subjects were then instructed in the independent self-use of the exercise device. The subjects were asked to wear the device as much as possible, but for at least four hours daily, during all routine activities of daily living (ADLs), especially those which involved walking, until the second clinical session.

The second clinical session occurred two to three days after the first clinical session. The second session was used to verify that the exercise device was fit correctly, working properly, and able to be used during ADLs for each subject. The FRS was examined to ensure that all subjects could walk without PFP while wearing the device. Each subject was then asked to continue wearing the exercise device as much as possible, but for at least four hours daily, during their ADLs through the remainder of the four week treatment period. All subjects signed a document in which they agreed to wear their exercise device for a period of at least four consecutive hours per day, each day, for the remainder of the treatment period. These procedures duplicated the methods of a previous study (30).

Group 3, the taping group, received the patellar taping and the kn2e exercise sequence suggested by McConnell (21). All subjects were taped following the procedures described by Larsen, et al (20). The painful knee was shaved, cleaned with alcohol, and prepared with Tuf-Skin spray on tape adhesive (Cramer Products Inc., Gardner, Kansas). Each subject was asked to completely relax their quadriceps muscles as their knee was placed in a position of full extension. The knee was then taped with Hypafix and rigid strapping tapes (Smith and Nephew DonJoy, Carlsbad, California), using the McConnell medial glide technique (21). The medial glide technique was selected because of McConnell's (21) statement that most patients with PFP require a medial glide of the patella.

Patellar taping was followed by the exercises suggested by McConnell for the training of the VMO (21). Exercise was begun by having each subject stand in a walking-stance position with the painful knee forward and flexed to a position of 30 degrees (21), which was determined through the use of a standard goniometer. The subjects were instructed in the contraction of the VMO while the hamstrings and the VL were relaxed as much as possible (21). The position was held for 10 seconds, as measured by a digital stopwatch (Casio Corporation, Tokyo, Japan), as each subject was asked to supinate the foot from their stance position toward a neutral position of the subtalar joint (21). This exercise was performed in a format of

three sets of ten repetitions. Each subject was allowed to straighten their knee and rest for two minutes between each set.

This same exercise sequence of procedures, repetitions, sets, and rest was repeated with the knee positioned in 75 degrees flexion (21), also as measured by a standard goniometer.

A third exercise involved the McConnell plie technique (21). Each subject was taught to perform a squat exercise with the knees “turned out”, similar to the plie of ballet dancers, while the VMO was contracted and the VL and the hamstrings relaxed (21). The subjects were instructed to limit their squat to a position which avoided knee pain (21). The subjects were also instructed in the same foot supination activity that was used during the previous two exercises (21). This exercise also incorporated a format of three sets of 10 repetitions, with each repetition lasting 10 seconds, as measured by a digital stopwatch, with a rest period of two minutes between sets.

The final exercise involved stepping down from a nine inch-high clinical stepstool (Lumex Corporation, Shirley, New York). Each subject was asked to step down to the floor with the opposite leg, as the foot of the leg with PFP remained in place on the stepstool, and then to return to a position of upright standing on top of the stepstool (21). This action produced a cycle of eccentric then concentric contraction of the quadriceps in the knee with PFP (21).

All group 3 subjects were seen in a format of three sessions per week for four weeks (12 total treatment sessions), as per the suggestion of McMullen et al. (22). The subjects were also placed on a home program to complement their clinical sessions. The home program consisted of instruction in self-taping, so that each subject could apply the McConnell taping techniques between clinical sessions, if needed, and in the same exercises that were performed in the clinic. The subjects were instructed to perform their home program twice daily, including the days of their clinical sessions. The subjects were given a log in which to record each home program session, in an effort to facilitate compliance.

DATA ANALYSIS

Paired t-tests were used to compare pretest measurements between groups on each dependent variable (PFCA, KPS, and VAS). This was done to examine group similarity before treatment (control versus exercise versus taping). The differences between pretest and posttest measurements were recorded as gain scores (posttest - pretest = gain score)(25) for each dependent variable. One-way analysis of variance (ANOVA) with repeated measures tests were then performed on the gain scores. This was similar to the procedures reported by Doucette and Goble (10). The Tukey HSD test was used as a post hoc analysis to confirm the existence of any significant differences detected by ANOVA (25).

Alpha level of 5% ($P \leq 0.05$) was established prior to the start of data collection. However, the alpha level was adjusted to $P = 0.017$ ($0.05/3 = 0.017$), as per the recommendation of Greenfield et al. (14). The overall sample size ($N = 300$) provided the desired level of statistical power ($1 - \beta = 0.90$) with a medium effect size ($F = 0.25$) to minimize the chance of a type II error (25). The data analysis was similar to the methods of a previous study (30).

RESULTS

Pretest and posttest data for PFCA, KPS, and VAS scores appear in Table 3. Statistically significant differences did not exist between groups for any dependent variable at pretest, but did exist between groups at posttest (Table 3). One-way ANOVA results appear in Table 4.

Significant differences did not exist between pretest and posttest measurements for PCFA, KFS, and VAS in group 1, the control group.

Statistically significant gains occurred in group 2, the exercise group. PFCA changed from lateral toward medial ($P < 0.001$), which indicated an improvement in PFC. Patellofemoral function as measured by KPS improved ($P < 0.001$). PFP as measured by VAS decreased ($P < 0.001$). Group 2 subjects wore their exercise devices an average of 6 hours each day (mean 6.2 hrs, SD = 2.1 hrs), according to self-reports.

One statistically significant gain occurred in group 3, the taping group. PFP as measured by VAS decreased ($P < 0.01$). Significant differences did not exist between pretest and posttest measurements for PFCA and KPS in group 3. The Tukey HSD analysis confirmed the results of ANOVA procedures (Table 5).

DISCUSSION

The results indicate that Protonics[®] exercise had an important effect on PFP and PCA as compared to both the control and the taping treatment. The subjects' pain decreased an average of 57% as measured by VAS (pretest = 7.31; posttest = 3.14; Table 3). Joint function as measured by KPS increased an average of 121% (pretest = 39.95; posttest = 88.43; Table 3). Lastly, patellofemoral biomechanics as measured by PFCA improved by an average of 17.44° (pretest = 13.08°; posttest = -4.36°; Table 3). The overall result was an improvement of PFP, which was not present in the control group. These results serve to validate the finding of the previous study of Protonics[®] exercise (30).

However, similar results were not found with group 3, the taping group. While the subjects experienced a significant decrease in PFP as measured by VAS (pretest = 7.40; posttest = 4.28; 42% average decreased; Table 3), the changes in joint function and patellofemoral biomechanics were not statistically significant. Joint function as measured by KPS increased an average of 33% (pretest = 40.07; posttest = 53.21; Table 3). Patellofemoral biomechanics as measured by PFCA increased by an average of 3.96° (pretest = 13.23°; posttest = 9.27°; Table 3). These results indicate that patellar taping followed by exercises had the important result of decreasing a subject's PFP, but did not effect changes in knee function or patellofemoral biomechanics.

The results of this study are similar to the findings of previous investigations. Regarding the effect of patellar taping on PFP, Bockrath et al. (4) reported a significant decrease in pain, but without an effect on PFC. Neural inhibition via an increase in large nerve fiber input, which would override the transmission of pain signals to the brain, was suggested as the mechanism for pain decrease. Larsen et al. (20) found that taping did not improve PFCA after a PRE session. Kowall et al. (18) found that patellar taping offered no additional benefit to a knee rehabilitation program. Powers et al. (26) reported that patellar taping does reduce PFP, but has no effect on patellofemoral biomechanics during functional gait activities (27). These findings contrast with the reports of McConnell (21) and Gilleard et al. (12) that patellar taping does have an important effect on patellofemoral biomechanics and knee function. However, neither study measured PFCA or KPS.

Regarding exercise, Natri et al. (24) report that PRE is effective for improving PFP, overall knee function, and patellofemoral biomechanics. Cerny (5) and Souza and Gross (29) also found that PRE reduces PFP and improves knee joint function. The suggested mechanism for improvement was an enhanced VMO:VL muscle performance ratio (5,12,29). Doucette and

Child (9) had a similar result for PRE, but suggest that closed chain exercises are preferred during knee joint motion of 0-30° flexion and that open chain exercises are better beyond 30° knee flexion (9). This study, and a previous study (30), indicates a similar effect from a high volume of submaximal PRE through the use of a Protonics® device during a subject's routine ADLs.

The clinical question raised by the previous study remains unanswered: Could a home exercise program replace clinical methods for the effective treatment of PFC and PFP2. The finding that a high volume of submaximal PRE during ADL was an effective treatment for PFC and PFP does suggest that a clinical regimen could be trimmed to two sessions and a program of patient self-management. This format was an effective treatment strategy in the present study while 12 clinical sessions of patellar taping and exercise, plus a home exercise program, were not completely effective. This finding has important functional and economic implications for the clinician.

Although the results serve to validate the findings of the previous study (30), experimental limitations did exist in the present study. There was no direct measurement of group 2 subject compliance for wearing the exercise device and of group 3 subject compliance with the program of home activities. Also, there was no measurement of the PRE dosage for the subjects of group 2. As compared to the control group, the data from groups 2 and 3 could reflect a Hawthorne or placebo effect of better-than-actual KPS and VAS scores (25). Also, the results are limited to the static measure of PFCA at a specific joint angle, which may not translate to dynamic methods of knee joint measurement. Finally, this study examined a relatively short-term time frame of four weeks; only data from a single study exist for a long-term outcome (24). However, since these limitations would have had an equal effect on both groups 2 and 3, they do not alter the result that a high volume of submaximal exercise is preferable to patellar taping for the treatment of PFP and PFC.

CONCLUSION

Based on the results, but within the stated limitations, it was concluded that the Protonics® exercise program reduced PFP and improved PFC, as measured by PFCA, KPS, and VAS, as compared to the control group. Patellar taping and exercise reduced PFP, but had no significant effect on patellofemoral biomechanics or function, also as compared to the control group.

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TABLE 1: Subject demographics

	Group 1: Control (N = 100)	Group 2: Exercise (N = 100)	Group 3: Taping (N = 100)
Gender			
Men	40	38	42
Women	60	62	5g
Knee			
Left	52	47	41
Right	48	53	59
Age (yr)			
Mean	28.7	29.3	27.6
SD	9.2	7.2	8.4
Range	19-46	20-44	21-48
PFP history [wk]			
Mean	13.3	12.7	13.1
SD	5.5	5.1	4.9
Range	8-20	6-17	8-22

TABLE 2: Kujala Score (19) Maximum 100 Points Activity Points

1. Limp	
a. None	5
b. Slight or periodic	3
c. Constant	0
2. Support	
a. Full Support without pain	5
b. Painful	3
c. Weight bearing impossible	0
3. Walking	
a. Unlimited	5
b. More than 2 km	3
c. 1-2 km	2
d. unable	0
4. Stairs	
a. No difficulty	10
b. Slight pain when descending	8
c. Pain both when descending/ascending	5
d. Unable	0
5. Squatting	
a. No difficulty	5
b. Repeated squatting painful	4
c. Painful each time	3
d. Possible with partial weight bearing	2

e. Unable	0
6. Running	
a. No difficulty	10
b. Pain after more than 2 km	8
c. Slight pain from start	6
d. Severe pain	3
e. Unable	0
7. Jumping	
a. No difficulty	10
b. Slight difficulty	7
c. Constant pain	2
d. Unable	0
8. Prolonged sitting with knees flexed	
a. No difficulty	10
b. Pain after exercise	8
c. Constant pain	6
d. Pain force knees to extend	4
e. Unable	0
9. Pain	
a. None	10
b. Slight and occasional	8
c. Interferes with sleep	6
d. Occasionally severe	3
e. Constant and severe	0
10. Swelling	
a. None	10
b. After severe exertion	8
c. After daily activities	5
d. Every evening	4
e. Constant	0
11. Abnormal painful patellar movements	
a. None	10
b. Occasionally in sports activities	6
c. Occasionally in daily activities	4
d. At least one documented dislocation	2
e. More than two dislocations	0
12. Atrophy of thigh	
a. None	5
b. Slight	3
c. Severe	0
13. Flexion deficiency	
a. None	5
b. Slight	3
c. Severe	0

Table 3: Pretest and Posttest Data

	Pretest		P*	Posttest	
	Control	Treatment		Control	Treatment
PFCA					
Mean	12.44°	13.10°	0.31	12.58°	-4.58°
SD	5.10°	4.67°		6.84°	8.64°
KPS					
Mean	41.42	41.72	0.03	41.20	86.76
SD	3.87	4.21		3.95	6.65
VAS					
Mean	6.54	6.50	0.82	6.74	3.54
SD	0.97	1.07		1.05	0.97

* P = Result of paired t-test (critical P=0.017).

Table 4: One-way ANOVA Results

	Measured Results Source				
	SS	df	MS	F	P
PFCA					
Group	6939.390	1	6939.390	1232.4532	<0.001
Error	551.794	98	5.631		
KPS					
Group	50199.299	1	50199.299	466147.217	<0.001
Error	10.554	98	0.108		
VAS					
Group	190.385	1	190.385	34495.612	<0.001
Error	0.541	98	0.006		

Table 5: Tukey HSD Analyses (Based on Table 4)

	Control	
	Exercise	Taping
PFCA		
Control	P<0.001	NS
Exercise		P<0.001
Taping		
KPS		
Control	P<0.001	NS
Exercise		P<0.001
Taping		
VAS		
Control	P<0.001	P<0.01
Exercise		P<0.001
Taping		