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ORIGINAL RESEARCH

A RANDOMIZED TRIAL OF ISOKINETIC VERSUS ISOTONIC REHABILITATION PROGRAM AFTER ARTHROSCOPIC MENISCECTOMY

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ABSTRACT

Background: Although both isotonic and isokinetic exercises are commonly used in the rehabilitation of patients after arthroscopic meniscectomy no studies have compared their effect on strength recovery and functional outcomes.

Purpose: The purpose of this study was to investigate the effects of two rehabilitation programs (isotonic and isokinetic) on muscle strength and functional performance after partial knee meniscectomy. A secondary purpose was to assess the correlation between isokinetic strength deficits and hop test performance deficits.

Methods: Twenty male patients who underwent arthroscopic partial meniscectomy volunteered for the study. Both isotonic and isokinetic training were performed with the same equipment thereby blinding subjects to the mode of exercise. Main outcome measures were collected on the 14th and 33rd postoperative days and included isokinetic strength of the knee extensors and flexors, functional performance (single, triple, and vertical hopping) and the Lysholm questionnaire. Multivariate and univariate analyses of variance were used to assess the effects of the independent variables on the isokinetic variables, functional tests, and Lysholm score. Pearson's correlation was used to assess the relationship between isokinetic strength deficits and functional performance deficits.

Results: Isokinetic measures, functional tests, and the Lysholm score all increased between initial and final assessment ($p \leq 0.003$). However, there were no group or group*time effects on any of the outcome variables ($p \geq 0.33$). Functional tests were better predictors of isokinetic deficits in the 14th compared to the 33rd postoperative day.

Conclusion: No differences were found in the outcomes of patients treated using an isokinetic and an isotonic protocol for rehabilitation after arthroscopic meniscectomy. More than half of patients did not meet the 90% criterion in the hop tests for safe return to sports five weeks after meniscectomy. There were correlations between the hop tests and isokinetic deficits two weeks after meniscectomy but not at the fifth week.

Level of evidence: 1b

Key words: functional tests, isokinetic, isotonic, partial meniscectomy

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INTRODUCTION

The menisci of the knee are commonly injured during athletic activities that involve jump-landing and cutting tasks.[1] Although some meniscal tears are managed conservatively, those that are symptomatic and produce locking and instability are commonly treated surgically particularly in the young, athletic patient. As a direct result of the frequency of meniscal injuries, arthroscopic meniscectomy is currently the most commonly performed orthopaedic surgery in the United States.[2]

Arthroscopic meniscectomy may result in pain and joint effusion that lead to decreased range of motion, muscle atrophy, and decreased stability of the knee joint.[3,4] A variety of rehabilitation programs have been used to treat patients recovering from arthroscopic meniscectomy and allow them to return to premorbid activity level in a safe and timely manner.[5] Current literature on rehabilitation after meniscectomy has focused on comparing a structured rehabilitation to a home exercise group,[6,7] assessing the effect of adding electrical stimulation on muscle strength,[8] and the timing of introducing a strengthening program.[3] Strengthening is an integral part of rehabilitation programs as the importance of strength recovery after meniscectomy has been previously demonstrated.[9,10] Isotonic and isokinetic exercises are both options for strength recovery after arthroscopic meniscectomy.[9] However, to the authors' knowledge no studies have directly compared the outcomes of these two different types of strengthening.

Functional tests that can be easily used in the clinic to assess rate of recovery such as the hop tests have long been used in patients recovering from knee surgery.[11,12] Myer et al have demonstrated that hop tests are sensitive enough to detect deficits and readiness to return to sports after knee surgery when a cut-off score of 90% for the limb symmetry index (LSI) between the healthy and pathological side is used.[13]

Therefore, the main objective of this project was to compare the effectiveness of two commonly used strengthening programs (isotonic and isokinetic) by using traditional (isokinetic, Lysholm score) and more recent (hop test LSI with a 90% cut-off score) assessment measures. A secondary objective was to assess if isokinetic strength deficits correlate to hop test performance deficits. The authors hypothesized that no differences would exist between the outcomes after the two programs and that hop test deficits correlate highly with isokinetic peak torque deficits.

METHODS

Patients

This prospective randomized trial was performed in a large outpatient physical therapy clinic with a group of recreational male athletes (Table 1). Twenty-eight consecutive volunteers who presented to the clinic after arthroscopic partial meniscectomy and met the following inclusion criteria: a) surgery within 90 days from injury b) no other knee injury or pathology and c) no neuromuscular or systemic disease were offered participation in the study. Eight of those chose a home exercise program instead of physical therapy leaving 20 volunteers who were randomly allocated by computer generated random numbers to the isotonic or isokinetic group (Fig. 1) using the "matched pair" method where age and weight were the extraneous variables. Blinding of the volunteers to group allocation was maintained throughout the study. However, assessors were not blinded to group allocation.

Procedures

After completing an informed consent form that was approved by the primary author's institution, the participants were randomly assigned into the isokinetic or isotonic rehabilitation group. The common part of the rehabilitation programs started on the 4th post-operative day for both groups and consisted of five sessions of electrotherapy, joint mobilizations, proprioception exercises, isometric exercises for the quadriceps, straight leg raises, 8-10 min of stationary biking, and cryotherapy. On the 6th session (14th post-operative day) they were tested for baseline isokinetic and functional measurements and completed the Lysholm questionnaire. The Lysholm questionnaire assesses functional impairment in terms of limping, need for walking aid, instability, pain, muscle atrophy, swelling, stair climbing, and squatting. It has been validated for patients with meniscal lesions[15-17] and demonstrated to be an effective measurement of disability[18] with high reliability (ICC = 0.97).[19]

As in common clinical practice for patients after arthroscopic meniscectomy, structured rehabilitation

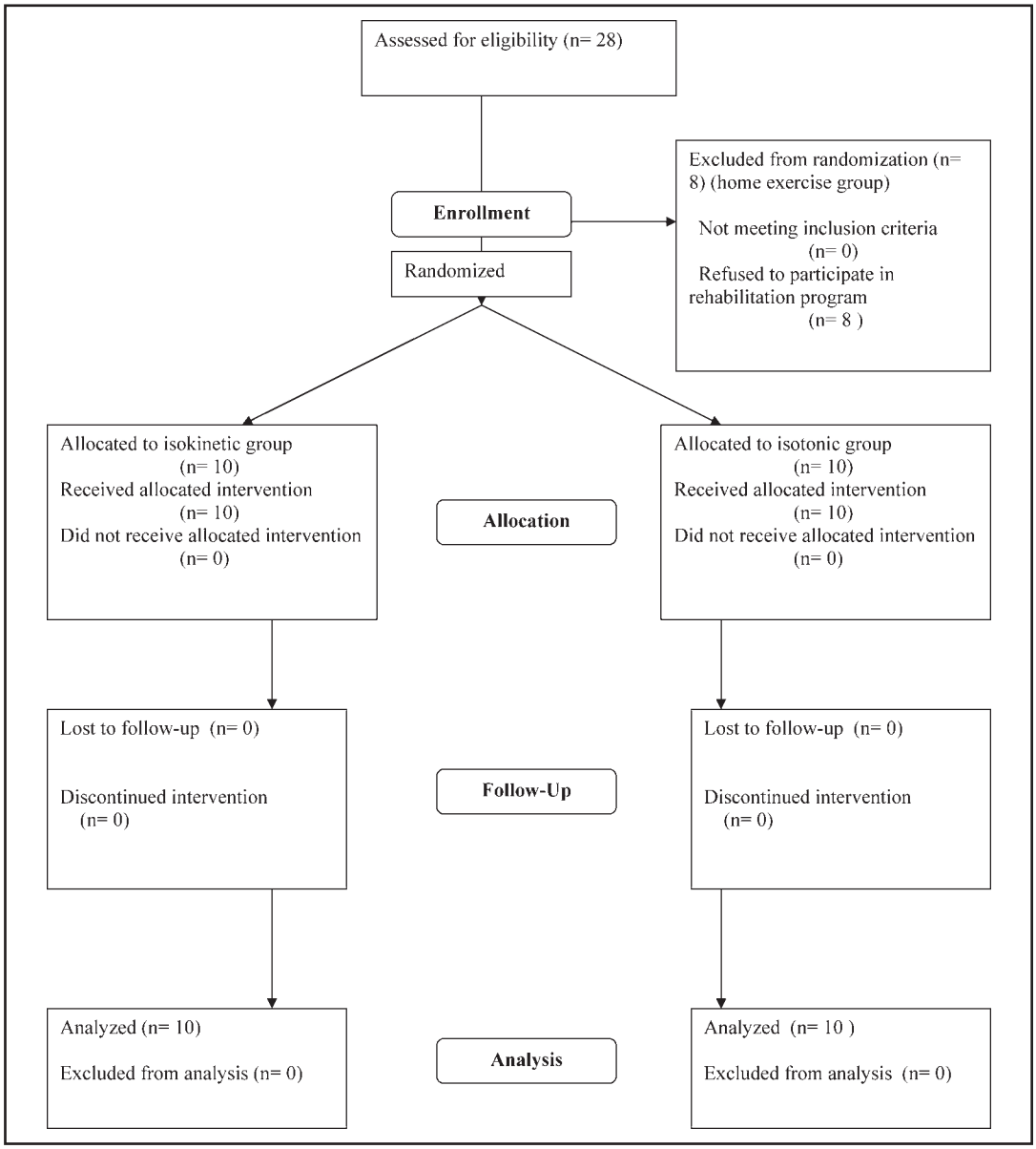

Figure 1. *CONSORT flow diagram.*

started on the 4th post-operative day; however, it was deemed necessary for safety reasons to wait until the 14th day for baseline isokinetic and functional testing. After baseline testing, isokinetic or isotonic training was introduced for a total of nine sessions until the 33rd postoperative day when isokinetic and functional testing were repeated. Both isokinetic and isotonic training were performed on the Cybex Norm 770 (Medway, MA) and therefore subjects were blinded to treatment group allocation. The isokinetic training protocol started with a session of two sets of 10 repetitions at 150, 180 and 210°/sec on the 15th postoperative day and gradually progressed to a session of three sets of 15 at 180, 210 and 240°/sec, two sets of 10 at 120 and 150°/sec and two sets of six at 60 and 90°/sec on the 30th postoperative day. The protocol was created based upon the clinical experience of the authors. Similarly, each session of the isotonic training program started with establishing the actual one repetition maximum (1 RM). The first session consisted of two sets of 10 repetitions at 60, 65 and 70% of one repetition maximum (1 RM) and progressed to a session of two sets of 15 at 60, 65 and 70% of 1 RM, two sets of 10 at 75 and 80% of 1 RM, and one set of six at 85 and 90% of 1 RM on the 30th postoperative day. It has been previously demonstrated that performance of the healthy leg after meniscectomy changes over time,[14] therefore we selected to test both lower extremities at each evaluation session to

allow for normalization. All patients were instructed to inform the tester if pain was experienced in either lower extremity during testing.

The outcome measures consisted of the Lysholm questionnaire, isokinetic, and functional testing. Prior to the isokinetic test, subjects warmed up by riding a stationary bike for 8 min at 65 rpm and 0.8 Watt and by self-stretching the quadriceps and hamstrings of both lower extremities from the standing position. Placement of subjects was standardized by placing their hip at 90°, their trunk and upper thigh was stabilized by belts, and the distal end of the moving arm was attached immediately superior to the lateral malleolus. The axis of the dynamometer was aligned with the axis of the knee and allowed a range of motion from 0° to 105° of flexion. Gravity correction was applied to allow accurate comparisons between subjects. All subjects attended two practice sessions on the isokinetic device in the two days preceding the initial test in order to minimize any learning effects. The protocol included three submaximal extension/flexion concentric trials followed by three maximal trials with the dynamometer set at 60°/sec. After a 30 sec break three submaximal and three maximal trials at 180°/sec were performed. The maximum torque for knee extension and flexion in each angular velocity (average of three trials) was calculated.

Three functional tests were also performed: a) the single leg hop is a unilateral maximal hop for distance with the arms behind the back and has been shown to have high reliability (ICC = 0.96),[20] b) the triple hop as described by Risberg et al[21] consists of three hops for distance starting with a bilateral jump-unilateral landing, followed by a unilateral hop and landing, and ending by a unilateral hop to a bilateral landing. It has also been shown to be highly reliable (ICC = 0.92).[21] and c) the modified unilateral vertical hop test for height[15] was measured with a tape measure secured around the subject's belt who was then instructed to jump vertically and maximally while keeping his arms by his side. Three trials were performed for each one of the hop tests and the best trial was used for the statistical analysis. The non-operated leg was tested first followed by the operated leg for all measurements. The limb symmetry index (LSI) was calculated for all isokinetic and functional measurements as per the following formula: value of involved leg/value of uninvolved leg *100.[13] With this method each value is presented as a proportional deficit (percentage) of the operated compared to the non-operated leg.

Statistical Analysis

The effect of the independent variables time (initial measurement vs. final measurement) and group (isokinetic vs. isotonic) on the Lysholm score was evaluated with an analysis of variance test (ANOVA). The effects of the independent variables on the isokinetic variables and functional tests were evaluated with the use of two separate multivariate analysis of variance (MANOVA) followed by univariate tests when statistically significant differences were found. The α level was set *a priori* at 0.05. Post-hoc power analysis revealed that for an α level of 0.05 and power of 80% the current study was powered to detect effect sizes that were medium or higher.[22] For the second objective of the study Pearson's correlation coefficients were calculated for the LSI of each of the three hop tests and the LSIs for each of the four isokinetic measurements at both assessment time points. Correlations with R^2 lower than 0.1 were defined as "none", higher than 0.1 and lower than 0.3 as "small", higher than 0.3 and lower than 0.5 as "medium", and higher than 0.5 as "large".[22]

RESULTS

Descriptive statistics for the characteristics of the subjects are presented in Table 1. Subjects in both groups had similar mean ages (Isokinetic 28.0 yrs and Isotonic 28.1 years), had similar weights (Isokinetic 77.9 kg, Isotonic 78.7 kg), and were similarly represented by which leg was operated on (Isokinetic group 5 right, 5 left; Isotonic group 4 right, 6 left). There was minimal variation between groups regarding surgical treatment for medial, lateral, or both menisci being treated.

Descriptive data regarding the dependent variables were grouped into three categories: a) the Lysholm score b) isokinetic variables (peak torque of knee extensors and flexors at 60°/sec and 180°/sec) and c) functional tests (single, triple and vertical hop tests), and are reported in Table 2.

The statistical tests were performed on the Lysholm scores and the LSI of the isokinetic and hop test variables. The results of the ANOVA revealed that time ($p < 0.001$) but not group or the interaction of group*time

Table 1. *Characteristics of volunteers.*

	Isokinetic group	Isotonic group
Age in yrs. (SD)	28.1 (9.0)	28.0 (11.0)
Weight in kg (SD)	77.9 (10.5)	78.7 (15.1)
Operated leg (right/left)	5/5	4/6
Meniscectomy (medial/lateral/both)	7/2/1	6/2/2

Table 2. *Means (standard deviations) and 95% confidence intervals for the outcome variables.*

	Isokinetic group		Isotonic group	
	14th post-operative day	33rd post-operative day	14th post-operative day	33rd post-operative day
Lysholm (score 0-100, 100= best)	76(7), 70-81	94(5), 90-98	74(12), 66-83	91(8), 85-97
Knee flexion at 60°/sec (Nm/kg)	1.17(0.4), 0.89-1.45	1.40(0.4), 1.08-1.72	1.14 (0.4), 0.85-1.43	1.46(0.4), 1.19-1.73
Knee flexion at 180°/sec (Nm/kg)	0.90(0.4), 0.64-1.15	1.15(0.3), 0.90-1.40	0.89(0.2), 0.73-1.05	1.17(0.3), 0.99-1.35
Knee extension at 60°/sec (Nm/kg)	1.80(0.5), 1.41-2.17	2.22(0.6), 1.81-2.62	1.90(0.5), 1.53-2.29	2.27(0.4), 1.95-2.58
Knee extension at 180°/sec (Nm/kg)	1.36(0.4), 1.04-1.68	1.58(0.4), 1.27-1.88	1.33(0.3), 1.11-1.55	1.64(0.3), 1.43-1.85
Single hop (cm)	112(31), 90-135	146(32), 123-169	123(30), 101-145	149(32), 126-172
Triple hop (cm)	397(118), 312-481	487(85), 426-548	429(94), 362-496	481(72), 429-533
Vertical hop (cm)	18(5), 15-22	26(8), 20-32	17(6), 13-21	21(4), 18-24
Single hop LSI (%)	76(15), 65-87	90(10), 83-98	80(11), 72-87	93(6), 88-97
Triple hop LSI (%)	86(10), 79-93	95(5), 91-99	90(6), 85-95	96(4), 92-99
Vertical hop LSI (%)	72(13), 63-82	92(10), 84-99	76(13), 66-85	91(7), 86-96
LSI= limb symmetry index; Note: Isokinetic and hop variables are for the involved leg				

($p \geq 0.55$) had a significant effect on the Lysholm score. The Lysholm score increased from 75% at the initial measurement to 92% at the final measurement (average for both groups). However, it is important to note that at 33 days after surgery 30% of patients had Lysholm scores below 90% which is the threshold for safe return to sports.

The MANOVAs revealed that time ($p \leq 0.001$) but not group or the interaction of group*time ($p \geq 0.33$) had a significant effect on the LSI of the isokinetic and hop test variables. Univariate tests revealed that for both groups between the initial and final measurements, the LSI for peak flexion torque at 60°/sec increased from 80 to 92%, for peak flexion torque at 180°/sec increased from 84 to 97%, for peak extension torque at 60°/sec increased from 69 to 86%, and for peak extension torque at 180°/sec increased from 77 to 88% ($p \leq 0.003$). Additionally, the LSI for the single hop increased from 78 to 92%, for the triple hop from 88 to 95%, and for the vertical hop from 74 to 92% ($p < 0.001$). Only 45% of patients had ≥90% LSI for all three hop tests at final assessment.

Linear regression Pearson's correlations revealed in the 14th post-operative day there were significant

Table 3. *P-values (coefficients) for the correlation between the lower limb symmetry indices of the isokinetic and hop tests.*

	14th post-operative day			*33rd post-operative day*		
	Single hop	Triple hop	Vertical hop	Single hop	Triple hop	Vertical hop
Knee flexion 60°/sec	0.017 (0.42)*	0.310 (0.20)	0.049 (0.38)*	0.198 (0.25)	0.122 (0.30)	0.358 (0.18)
Knee flexion 180°/sec	0.001 (0.61)*	0.442 (0.15)	0.080 (0.34)	0.586 (-0.11)	0.355 (-0.18)	0.651 (0.09)
Knee extension 60°/sec	0.138 (0.13)	0.826 (-0.04)	0.042 (0.37)*	0.614 (0.10)	0.800 (0.05)	0.056 (0.37)
Knee extension 180°/sec	0.021 (0.43)*	0.949 (0.01)	0.064 (0.35)	0.797 (0.05)	0.717 (-0.07)	0.122 (0.30)
*Statistically significant at p≤0.05						

correlations between isokinetic LSI and the single and vertical hop LSI while in the 33rd post-operative day there were no significant correlations (Table 3).

DISCUSSION

One of the main findings of this project is that there was no difference in outcome measures between patients who followed either an isokinetic or an isotonic rehabilitation protocol. Since no difference is found between the two programs, physical therapists should consider using either type or incorporating a combination of both types of exercises in the rehabilitation of patients who had arthroscopic meniscectomy. In practical terms, it probably also means that the absence of an isokinetic device in physical therapy clinics does not compromise the recovery of patients.

Although quick recovery was observed in both groups, it needs to be highlighted that more than half of patients were still below the 90% limb symmetry cutoff score in the functional tests that is considered safe for return to sports.[13] Pressure is commonly placed on athletes to return to sports very quickly after knee arthroscopy, however, based on the current results it seems that less than half of them are ready for a safe return to sports 33 days after surgery. Additionally, the present study extends recent findings in anterior cruciate ligament (ACL) recovery research[13] to arthroscopic meniscectomy patients showing that the unilateral hop tests are more sensitive in detecting deficits than the Lysholm score, that classified 70% of this group of patients as normal.

It needs to be emphasized, however, that the rehabilitation program in both groups were rather accelerated. Gapeyeva et al.[23] utilized a much more conservative program that resulted in isokinetic knee extension deficits that were 2-3 times higher than those found in the present study. Although the long-term effects of the accelerated rehabilitation program on patients after arthroscopic meniscectomy cannot be evaluated by this study, it is encouraging that the authors did not observe any adverse effects of either program on pain, edema, or range of motion. St. Pierre et al.[3] suggested that introducing isokinetic training at 2 weeks after surgery does not produce better outcomes compared to introducing the same program 6 weeks after surgery. As in the current study, St. Pierre et al.[3] found no increase in adverse effects in the accelerated rehabilitation group. The findings of the current study are consistent with previous research that found that introducing an accelerated strengthening program early after surgery results in reasonable strength recovery within a month.[6]

Although isokinetic devices do not appear to be a necessary rehabilitation tool for a good outcome after arthroscopic meniscectomy their role as assessment tools may not be completely replaced by functional tests in those patients in need of an accurate assessment of strength deficit. The results of the current study demonstrate that in the 2nd week after surgery there are strong correlations between strength deficits and hop performance but by the 5th week of the rehabilitation program the correlations diminish. Although, to the authors' knowledge, this if the first study to examine the correlation between functional hop tests and isokinetic deficits in patients who underwent arthroscopic meniscectomy, an abundance of similar studies exists for healthy subjects or patients who underwent ACL reconstruction. The results vary with some authors reporting high correlations[24,25] while others reported low correlations.[26-28] It appears that the correlations between the functional hop and isokinetic measurements depend not only on the population and the methodology but also on the time that has elapsed after the surgical procedure. It is possible that as patients develop more equal side-to-side performance, functional tests become less sensitive in detecting strength deficits.

Limitations

Several limitations are acknowledged in this study. The sample size of only 10 patients per group may have increased the possibility of having insufficient power to detect differences between the groups. However, all measurements revealed remarkably similar mean values between the two groups suggesting that the lack of statistically significant differences is due to lack of effect and not due to lack of power. The current study did not discriminate between the surgeons who performed the procedure. Five surgeons performed all 20 meniscectomies, thereby making the sample less homogeneous. The authors acknowledge that the current results cannot be extrapolated to female patients as all patients in this sample were males. Finally, the current sample consisted of consecutive patients presenting at a large outpatient rehabilitation center and, therefore, may not be representative of the general population of patients who undergo arthroscopic meniscectomy.

CONCLUSIONS

No differences were found in the strength and functional testing outcomes of patients who had undergone arthroscopic meniscectomy when rehabilitated using an isokinetic and an isotonic protocol. More than half of patients did not meet the 90% criterion in the hop tests for safe return to sports five weeks after meniscectomy. Additional skilled rehabilitation may be necessary for athletes to safely meet return to sports criteria. There were correlations between the hop tests and isokinetic deficits two weeks after meniscectomy but they were diminished by the fifth week.

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