Early Extra-balance Exercises in the Conventional Physical Therapy Program for Athletes after Arthroscopic Partial Meniscectomy: A randomized Clinical Trial

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ABSTRACT

Objective: *To investigate the effect of early balance training as a component of the physical therapy program advocated to athletes who underwent arthroscopic partial meniscectomy on balance and strength.* ***Design:*** *A randomized clinical trial.* ***Setting:*** *Physical Therapy clinic of Sports Medicine Center.* ***Subjects:*** *Athletes underwent Arthroscopic partial meniscectomy (n=26), age ranged from 17-29 years.* ***Interventions:*** *Participants were randomized into control group receiving conventional physical therapy program and a balance group receiving early extra balance exercises in addition to the conventional physical therapy program.* ***Main measures:*** *Balance was assessed by the Biodex Stability System, using the dynamic single leg stability test. Isokinetic strength was measured as peak torque for quadriceps and hamstring at a velocity of 60°/sec and 180°/sec.* ***Findings:*** *Balance and peak torques of the quadriceps and hamstring were significantly improved in both groups from pre-test to post-test measures. However, there was no significant difference between both groups at all measured outcomes.* ***Conclusions:*** *Early extra balance training for 4 weeks has no additional benefit over the conventional physical therapy program in balance and isokinetic strength for athletes. Both programs can be used after Arthroscopic partial meniscectomy in athletic population.*

Key words: *Arthroscopic Partial Meniscectomy, Athletes, Balance, Isokinetic strength.*

INTRODUCTION

Meniscal injuries are reported to be the most common injury sustained by athletes. The patients with sports injuries account for 32.4% of all meniscal lesions[7]. The gold standard treatment in symptomatic torn meniscus has been arthroscopic partial meniscectomy (APM)[36], followed by a 2- to 6-week outpatient follow-up by the surgical team. Follow-up is used to detect postoperative knee complications and to assess symptoms eliminations that were present preoperatively. Recovery of the knee toward its pre injury level was one of the goals to be assessed after arthroscopic meniscectomy[3].

Although meniscectomy appears to be effective, patients who have had an arthroscopic partial meniscectomy often initially experience knee swelling, pain, muscle atrophy, decrease in muscle tone and strength specially the quadriceps and loss of range of motion (ROM). They may have increased joint laxity and osteoarthritis in the long term[2,3,9,12,29,38]. Recently, many studies have investigated the effect of arthroscopic partial menisctomy on knee proprioception and found deficit that may persist 1-2 year postoperatively. Al-Dadah and Donell[4] and Malliou et al.,[23] found that non athletic patients who underwent arthroscopic partial meniscectomy have a significant proprioceptive deficit as measured by single leg dynamic postural stabilometry (Biodex Balance SD System) when compared to their uninjured contra-lateral knee and to a control group. Magyar et al.,[21] found that even 1 year postoperatively, balance after sudden unidirectional perturbation on the operated side was weaker than of a control group. Other authors[17] using the angle reproduction test to document the proprioceptive capabilities of the knee, concluded that even a partial absence of menisci cause a deterioration of proprioceptive functions of the knee.

Current literature on rehabilitation after meniscectomy has focused on comparing a structured rehabilitation to a home exercise group[3,27,39], minimizing early postoperative complications by early supervised physical therapy program[36], assessing the effect of adding electrical stimulation on muscle strength[41], and comparing an isotonic to an isokinetic strengthening program[18]. All programs investigated have been advocated to minimize postoperative knee swelling, pain, muscle weakness and joint laxity in non-athletic population. However, early balance training has not given much attention although recent literatures have addressed the balance and proprioception deficit after APM.

Balance training has been defined as exercises designed to focus on postural awareness and equilibrium maintenance without changing the base of support[34] and has been incorporated into a variety of training programs. In a population with anterior cruciate ligament (ACL) tear, balance training was found to improve postural stability under both static and dynamic conditions[1,11,43]. A systematic review conducted by Zech et al.,[44] concluded that balance training is an effective intervention to improve static postural sway and dynamic balance in healthy population both athletes[31] and non-athletes. To our knowledge, no physical therapy program that focus on balance training and simultaneously measure single-leg dynamic postural stability was investigated in athletic population after APM. Therefore, the purpose of this study was to investigate the effect of early balance training as a component of the physical therapy program advocated to athletes who underwent arthroscopic partial meniscectomy on balance and strength. It was hypothesized that adding balance exercises to the physiotherapy program would improve overall stability index (OSI), anterior-posterior stability index (APSI), medial-lateral stability index (MLSI), quadriceps and hamstrings peak torque at 60^{o}\sec and 180^{o}\sec more than the conventional physical therapy program alone in athletic population after arthroscopic partial meniscectomy.

METHODS

Subjects:

Participants were identified and recruited over 12-month period. Thirty consecutive athletic patients (22 males and 8 females) referred from orthopaedic surgeons after performing arthroscopic partial meniscectomy were examined for eligibility in the study (Figure 1). Athletes who met the following inclusion criteria were asked to participate in the study: (1) their ages ranged from 17 to 29 years. (2) Underwent arthroscopic partial meniscectomy due to traumatic meniscal injury. Subjects were excluded from the study if they had (1) associated chondromalacia patella or cruciate ligament injury (2) Previous knee surgeries (2) significant history of hip or ankle pathology (3) both meniscus injury (4) neuromuscular or systemic disease.

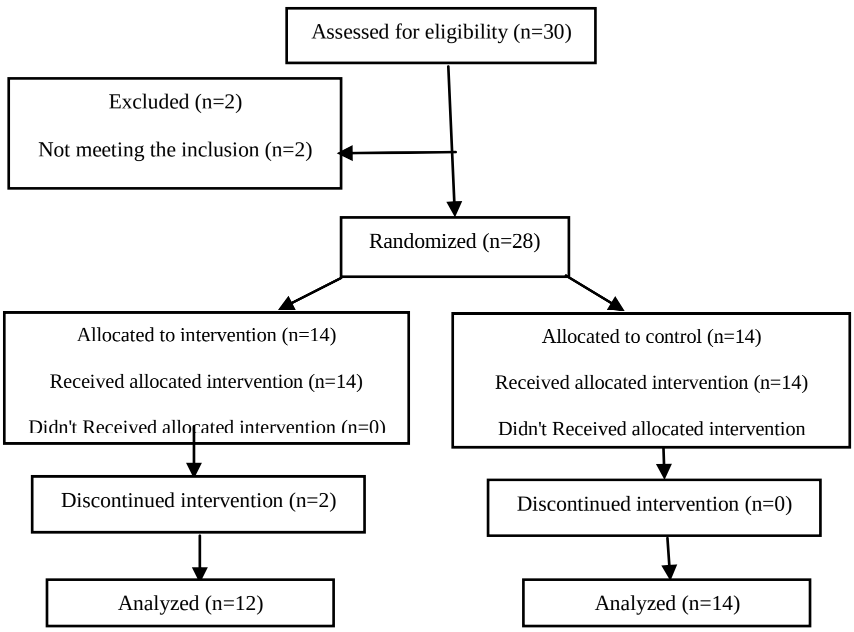

Fig. (1): Participant flow diagram.

Of the initial 30 athletes that were evaluated, two were excluded due to history of recurrent ankle sprain. After our protocol was approved by the Institutional Review Board, 28 subjects signed an informed consent. The subjects were randomly assigned into two groups by a blinded and independent research assistant who opened sealed envelopes that contained a computer generated randomization card. From the 14 allocated to the control (CO) group who received a conventional physical therapy program, two subjects were lost at follow up, as they were involved in intensive training in preparation for competition. From the 14 allocated to the balance (Bal) group all were analyzed at the end of the 4 weeks of training.

Muscle strength assessment:

The dynamic muscle strength was measured before and after the 4-week training period for both groups using Biodex System 3 Dynamometer and Biodex Advantage Software Package (Biodex Medical Systems, Inc, New York, NY) to determine isokinetic peak torque values for concentric knee extension and flexion movements. Biodex dynamometers allow precise and reliable measurement and storage of data from isokinetic muscular action of knee extension and flexion. It provides valid measurement regarding angular position, torque and velocities with higher reliability (ICC = 0.99)[8].

The standard open kinetic chain isokinetic test protocol for knee extension/ flexion at testing velocities of 60^o/sec and 180^o /sec was used with five repetitions. Subjects were tested seated on the dynamometer chair, with the hip and knee in 90^o flexion. The subjects were stabilized in the chair, adjusting the chair height and the back support inclination angle at 85^o, with straps securing the shoulder, chest and waist. The knee was positioned in about 90^o with proper alignment of the axis of the patient's tested leg to ensure accuracy in torque measurements. The distal part of the moving arm was attached proximal to the lateral malleolus and secured with a strap. Range of motion was set from 90^o to 0^o and vice versa. Subjects were instructed to provide maximal effort throughout the repetitions and were given standardized verbal and visual feedback and encouragement.

Balance assessment:

Balance was assessed by the Biodex Stability System (BSS), (Biodex, Shirley, NY) using the dynamic single leg stability test. The BSS with specialized software (Version 3.1) enables to measure the deviation of the center of pressure (COP) during static conditions, and measuring the degree of tilt during dynamic conditions. The COP can be used to evaluate the amount of sway of the center of gravity over the foot during stance. Balance was measured by overall, anterior–posterior, and medial–lateral stability indices (OSI, APSI and MLSI, respectively). A high score indicates poor balance The BSS was shown to be reliable in previous studies. Schmitz and Arnold[35] reported intraclass correlation coefficient (ICC) values for dominant single limb stance ranging from 0 .8 to 0 .43,using a decreasing stability level from 8 to 2 over 30 sec. Reliability of BSS was also confirmed during the pilot study of Moezy et al.,[26] as ICC ranged from 0.60-0.98. The subject was asked to centralize the foot on the platform in a position that was level and stable. This position was used as the level reference point from which degree of displacement was measured. The testing procedure consisted of single leg stance at three level of platform firmness performed each in 20 sec with opened eyes. Level 7 as a stable condition, level 4 as a medium stability condition and level 2 as the least stability provided. During testing, no verbal feedback was given and the patient was instructed not to hold the handle bars to minimize their use in attaining balance and to maintain the cursor at the center of the screen. The test was repeated 3 times, for each platform firmness level. Average total stability index (APSI, MLSI and OSI) was recorded and reported.

Treatment procedure:

The rehabilitation program used in this study was designed according to the previous literatures and programs that have been used for the treatment of partial meniscectomy[16,27,32], quadriceps strengthening after total knee arthroplasty[25]; and proprioceptive and balance training after anterior cruciate ligament reconstruction[6,33].

All athletes in both groups received 12 sessions of physical therapy program after arthroscopic partial meniscectomy. They received 3 sessions per week for 4 weeks. Rehabilitation started 3-7 days after surgery. The program was divided into 4 weeks. The balance group received additional balance exercises progressed in each week, the aim of which is to maintain stable balanced position for periods of 20 seconds or greater using double and single leg support on even flat surface, progressed to balance board in the second week and to trampoline in the third and the fourth week (Fig. 2, 3, & 4). Program characteristics are shown in table 1. Goals in the1st week of rehabilitation were to reduce swelling and inflammation, restore range of motion and reestablish quadriceps muscle activity. Goals in the second week were to regain active non painful range of motion (ROM) and to restore muscle strength. In the third week the exercise program is directed toward the improvement of muscle strength in order to return to normal functional activities through the use of closed kinetic chain exercises and elastic tubing. The last week exercises was designed to increase endurance through increasing the number of repetitions.

Table (1): The physical therapy program for both groups performed during 4 weeks starting from the 3rd to the 7th day postoperative.

Time (week)	Control group		Balance group
	Intervention	Frequency	Intervention
1st	Ice and compression. Knee slides on table up to 90° flexion using towel. Superior, inferior, medial and lateral patellar mobilization. Quadriceps sets in 0° extension and 20° flexion. Straight leg raises in sagittal plan	15 min, every session. 10 repetitions. 10 repetitions by therapist in each direction. 5 sets, 10 repetitions each. 3 sets, 10 repetitions each.	The same as CO group + double leg balance with body weight shift from side to side, and from back to front.
2nd	Knee slides on table for full flexion. Straight leg raises with abduction, adduction and extension. Quadriceps chair exercises for knee flexors and extensors.	 3 sets, 15 repetitions each. 3 sets, 15 repetitions starting by 10 RM.	The same as CO group +single leg balance progressed to single leg reach leg balance.
3rd	Mini squat starting from 45° and progressed to 90° with back support on ball at the wall. Calf raise. Terminal knee extension in standing against elastic tube resistance.	3 sets, 15 repetitions each 3 sets, 15 repetitions each. 3 sets, 15 repetitions each	The same as CO group +Single leg reach arm balance exercise progressed to double leg wobble board balance then Mini trampoline double leg balance.
4th	All previous exercises.	5 sets, 15 repetitions each.	The same as CO group+ single leg wobble board balance. Mini trampoline single leg balance. Mini trampoline single leg balance with ball throwing and catching.

Fig. (2): (a) Single leg balance exercise, (b) Single leg reach, (c) Single leg reach arm.

Fig. (3): Wobble board exercises, (a) Double leg balance exercise,(b) Single leg balance exercise.

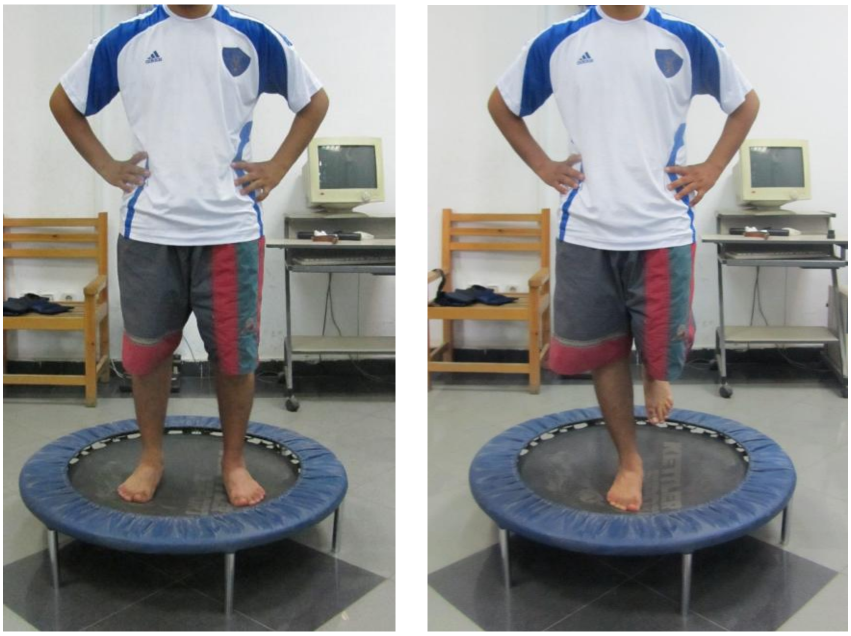

Fig. (4): Mini– trampoline balance exercise, (a) Double leg balance (b) Single leg balance.

Data Analysis

To determine similarity between the groups at baseline, subject age, height and body weight, were compared using independent t tests. Descriptive statistics on gender and sport was compared using chi square tests for homogeneity. Knee extensors and flexors isokinetic peak torque, OSI, MLSI, APSI, were analyzed using separate 2 factor mixed model analysis of variance (ANOVA) (2 groups by 2 time points), with time as the repeated factor to determine the effects of the intervention programs. Statistical significance was defined as $P < 0.05$. Parametric tests were justified, based on the data being normally distributed and the variance being equal between groups. For statistical analysis SPSS version 18.0 software was used.

RESULTS

Subjects:

Demographic data for the 26 subjects who completed the study are presented in Table 2. There was no significant difference between subjects in both groups concerning age, weight, height, gender, and sport activities ($P > 0.05$). There were also no statistically significant differences between groups for any of the outcome variables at baseline (pre-intervention) (table 3).

Table (2): Comparison of subject's characteristics at baseline by group

Subjects characteristics	CO group	Bal group	P value
Age (y)*	24.46±5.4	24.8±4.12	0.85†
Weight (Kg)*	78.66±13.65	70.26±12.94	0.09†
Height (cm)*	171.53±8.65	169.93±7.99	0.6†
Gender (females, males)	3, 9	4, 10	0.83‡
Sports activity			
Basketball	2	1	
Soccer	8	9	0.63‡
Judo	2	4	

Muscle strength

Table 3 shows the baseline and final results of the all measured variables of isokinetic peak torque for both groups. The ANOVAs evaluating changes in knee extension and flexion peak torque from baseline to the end of the 4-week intervention revealed non-significant group-by-time interaction in all measured isokinetic tests (P= 0.54 and P=0.47 for Quadriceps at 60°/sec and 180°/sec respectively. For hamstring at 60°/sec P= 0.81 and at 180°/sec P= 0.69. There was a significant main effect across time in all measured isokinetic tests while there was no group main effect.

Table (3): Pre and post-training mean± standard deviation and P value of isokinetic peak torque in both group.

Variables	CO group	Bal Group	P value (group effect)
Quad 60°/sec (Nm)			
Pre	84.7±39.25	90.0±43.29	0.9
Post	145.0±46.29	143.5±37.6	
	P value (time effect)	0.001	
Quad 180°/sec(Nm)			
Pre	66.8±26.7	64.58±36.3	0.65
Post	101.89±31.44	93.89±25.13	
	P value (time effect)	0.001	
Ham 60°/sec(Nm)			
Pre	50.98±30.8	43.92±22.6	0.54
Post	88.15±28.7	83.30±26.44	
	P value (time effect)	0.001	
Ham180°/sec(Nm)			
Pre	42.0±19.3	35.57±20.8	0.29
Post	66.89±21.2	58.28±15.5	
	P value (time effect)	0.001	

Balance variables

Table 4 shows the baseline and final results of the all measured variables of balance assessment for both groups. The ANOVAs revealed that time (P<0.05) but not group or the group-by-time (P>0.05) had a significant effect on the OVSI, APSI and MLSI at all measured level (7,4 and 2).

Table (4): The pre and post training means ± standard deviation and P value of balance assessment measures in both group.

Stability index (level)	CO group	Bal group	P value(group effect)
OVSI (7)			
Pre	3.41±1.0	2.96±0.86	0.08
Post	2.72±0.71	2.22±0.52	
	P value (time effect)		0.001
OVSI (4)			
Pre	4.15±1.73	4.04±2.01	0.27
Post	3.09±0.95	2.28±0.45	
	P value (time effect)		0.001
OVSI (2)			
Pre	6.58±2.93	5.83±2.44	0.37
Post	3.83±1.21	3.59±0.87	
	P value (time effect)		0.001
APSI (7)			
Pre	2.71±0.93	2.54±1.28	0.2
Post	2.20±0.74	1.62±0.40	
	P value (time effect)		0.003
APSI (4)			
Pre	3.57±1.5	3.26±1.91	0.27
Post	2.45±0.7	1.9±0.43	
	P value (time effect)		0.001
APSI (2)			
Pre	5.99±2.9	5.15±2.29	0.4
Post	3.04±1.04	2.98±0.81	
	P value (time effect)		0.001
MLSI (7)			
Pre	2.14±0.66	1.82±0.74	0.33
Post	1.56±0.45	1.49±0.49	
	P value (time effect)		0.002
MLSI (4)			
Pre	2.55±1.53	2.11±1.22	0.18
Post	1.96±0.78	1.53±0.44	
	P value (time effect)		0.04
MLSI (2)			
Pre	3.5±1.41	2.7±1.30	0.13
Post	2.71±0.98	2.3±0.89	
	P value (time effect)		0.029

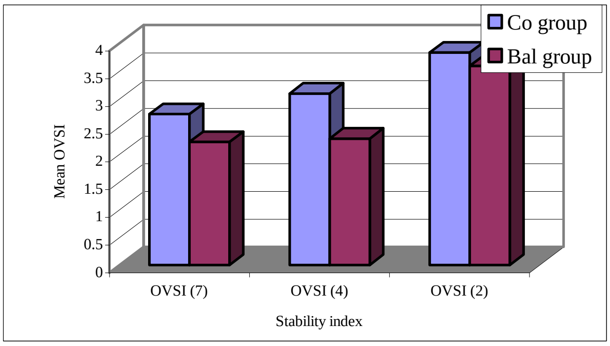

Fig. (5): The overall stability index (OVSI) at level 7, 4 and 2 of the control (CO) and Balance (Bal) group after the 4 weeks of training.

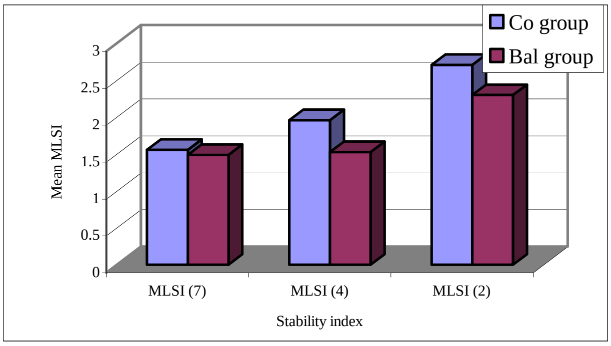

Fig. (6): The medial-lateral stability index (MLSI) at level 7, 4 and 2 of the control (CO) and Balance (Bal) group after the 4 weeks of training.

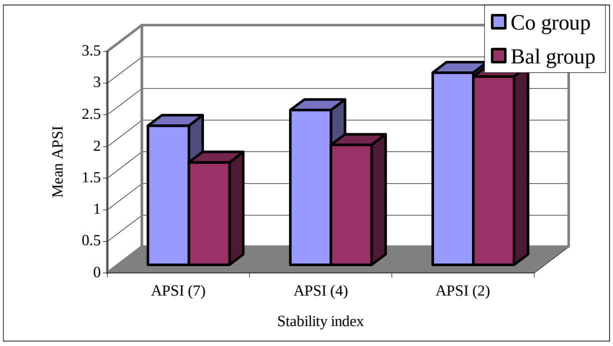

Fig. (7): The anterior-posterior stability index (APSI) at level 7, 4 and 2 of the control (CO) and Balance (Bal) group after the 4 weeks of training.

DISCUSSION

Analysis of the results showed that there were no significant differences between the control group and the balance group in all stability indices at all levels measured. No previous studies have investigated the effect of early extra balance training on stability indices in athletic population after APM. However, studies was conducted by Malliou et al.,[22] and Gioftsidou et al.,[13] on healthy young soccer players to investigate the effect of balance training on stability indices measurement and found significant difference between pre and post training measures. Based on previous studies[4,17,23] detecting proprioception and balance deficit after APM, our program of rehabilitation was designed to introduce balance training from early period of rehabilitation and to investigate its effect on stability indices for athletes. Our results revealed a similar significant decrease in stability indices in both groups indicating that early extra-balance training in athletic population has no additional benefit on stability. This result was in contrast to that of Maillou et al.,[22] who reported that extra balance training in healthy soccer player improve postural sway more than a control group who received their usual training with no extra balance training. The difference between our results and that of Maillou et al.,[22] perhaps come from the difference in the balance training performed by the healthy soccer players. They used the same device (Biodex Stability System) for both test and training and hence the experimental group was trained well using the device. Other difference is population characteristics. Our population is athletes (Soccer, Judo and basketball) after APM while Maillou et al.,[22] studied healthy soccer players during the competition period. Their healthy status could giving them the opportunity of good performance, high repetitions all over the competition period. The lack of significant difference between the control and the balance group in the present study can also be attributed to the minimal balance deficit that could be present after APM resulting in no need for extra balance training. Some authors[22] found stability indices in healthy soccer players ranged from 8.1 to 4.2 (level 1), and Maillou et al.,[23] found stability indices in patient after arthroscopic meniscectomy ranged from 4.9 to 2.9 at level 2. They reported a balance deficit when compared to the contra lateral limb and recommended proprioceptive training. Although, our athletes had a range of 6.5- 2.7 stability indices (level 2), the conventional physical therapy program was enough to improve balance. The conventional program included some exercises that affect proprioception and balance like heel raise as our athlete do not use chair or wall support during exercises. The heel raise required not only strong calf muscle but also balance. Other exercise included in the training program is wall mini squat. The wall mini squat is a closed kinetic exercises that stimulate knee proprioceptors improving sense of position, sense of movement and balance[5,20,31]. Other reason is the training that athletes always perform to enhance stability and dynamic balance for better performance. This can produce less damage to proprioceptors function after APM. Soccer players must have training for kicking and headers that enhance balance[13]. Judo players must have balance training in the form of weight shift moving around the mat looking for the opportunity to throw each other, and agility to improve performance and avoid imbalance that is always the goal of his opponent. Many traditional training exercises can be used for teaching the judoka techniques of balance and re-balance (yaku soku geiko, kakari geiko) and interdependent balance in judo (kumi-kata)[24].

Basketball players training include individual balance and quickness. The six fundamental positions and movements of basketball (stance, starts, steps, turns, stops and jumps) required balance and even weight distribution from side to side[19]. Our subjects are 17 soccer players, 6 judo and 3 basketball players. Other reason why balance training does not provide added benefits in early stage of rehabilitation after APM is the time needed for proprioceptive and balance training to improve the nervous system's ability to synchronize muscular activity around the knee and to enhance the functional stability of the knee. Functional knee joint stability is not confronted until patients return to sports that require quick change of direction or rotation through the knee[6]. The current study was conducted and assessed in the early phase of rehabilitation, with no participants reaching this functional level at the time of assessment (4 weeks following surgery). Our intervention was limited to 4 weeks duration because it is the time at which patients following APM can return to sports activities[36]. However, recently, koutras et al.,[18] found more than 50% of their patients at 33rd day of strengthening program were still below the recommended score of functional tests considered safe for return to sports[30]. The rehabilitation process may takes longer if a higher stability outcomes are need. Proprioceptive and balance training may be more appropriate at a later stage in rehabilitation; however, this requires further experimental investigation. Introducing other type of exercises like plyometric training but late in the rehabilitation program could produce a significant difference between groups. We have chosen this balance exercises as they are simple, easy and safe in the first 4 weeks after APM.

The results of the present study showed that there were no significant differences between the control group and the balance group in peak torque of knee extensors and flexors at both speeds tested (60^o/s and 180^o/s) .However, there was a significant increase of the peak torque values from pretest to post test for both groups. This improvement can be explained by the effect of many items in the rehabilitation program that was similar in both groups. The ice application decrease pain and swelling that were found to influence muscle strength and inhibit muscle activation[35]. This was in agreement with Koutras et al.,[18] and Moffet et al.,[27] who started the rehabilitation program of their patients undergoing APM by methods to relief pain as cryotherapy then strengthening exercise and found improvement in isokinetic measures of the knee extension and flexion. Our program of rehabilitation includes many exercises that strengthen quadriceps and hamstring muscles as SLR in all planes, elastic tubing for terminal knee extension, progressive resistive exercises using quadriceps chair[42]. Mini squat also produce co-activation of the hamstring and quadriceps muscles[40]. It is likely that improvements in strength are mainly due to neuro-motor learning as morphological changes in the muscles need longer time than the 4 weeks of our rehabilitation program[27,28]. It was found that quadriceps weakness after APM is mainly due to neuromuscular impairment[14]. Our program is initiated by quadriceps setting that improve neuromuscular coordination in various knee angle (0^o and 20^o) then progressed to progressive resistive exercises using the quadriceps chair. In accordance with our results many authors used different exercises to enhance muscle strength recovery like Koutras et al.,[18] who investigated the effect of isotonic and isokinetic rehabilitation program after APM and found similar improvement in both group. Other investigators[37] used isokinetic training and found quadriceps and hamstrings muscle strength recovery to the preoperative value by week 6.

Our study has some limitations, one of which is the small sample size which may imply a lack of power for some outcomes. Another limitation of our investigation is the lack of balance deficit measurement before training. We suggest that if balance deficit is present, it may be temporary and can be recovered with the conventional physical therapy program. Furthermore, lack of control group that receive no intervention, but this type of study was considered unethical. Future research is recommended to determine if longer duration of early balance training in a large sample size of athletic population underwent APM would produce additional benefit in balance measures.

Conclusion

Early extra-balance training has no additional benefit over the conventional physical therapy program in balance and muscle strength in athletic population. During the first 4 weeks after APM, either program can be used to enhance muscle strength and balance. Athletes could not have balance deficit after APM as is the case in other population.

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الملخص العربي

تمرينات الاتزان المبكرة المضافة على برنامج العلاج الطبيعي التقليدي للرياضيين بعد الاستئصال الجزئي من الغضروف الهلالي للركبة بالمنظار: تجربة إكلينيكية عشوائية

الهدف : الهدف من هذه الدراسة هو فحص تأثير تمرينات الاتزان المبكرة كجزء من برنامج العلاج طبيعي المخصص للرياضيين بعد الاستئصال الجزئي للغضروف، على قوة العضلات و الاتزان. **الوسائل :** شارك في هده الدراسة 26 مريض ، وتم تقسيمهم لمجموعتين بشكل عشوائي وبمتوسط أعمار بين 17-35. المجموعة الضابطة خضعوا لبرنامج العلاج الطبيع ي التقليدي ومجموعة الاتزان خضعوا لبرنامج العلاج الطبيعي التقليدي بالإضافة إلى تمرينات الاتزان المبكرة . المرضى تم تقييمهم قبل وبعد الفترة التأهيلية (4 أسابيع) لقياس عزم وقوة العضلات الباسطة والضامة للركبة عند سرعة 60 و 180، درجة في الثانية بالإضافة إلى مؤشر الاتزان . **النتائج :** قياسات الأيزوكينتك ومؤشر الاتزان ، كلهم قد ارتفعوا بين التقييم الأولي و النهائي . ولكن ، لم يكن هناك اختلافات في النتائج ما بين المجموعتين.
الاستنتاج : لا يوجد فروق بين النتائج الخاصة بالمرضى عند إضافة التمارين الاتزان المبكرة لبرنامج إعادة التأهيل بعد الاستئصال الجزئي للغضروف عند الرياضين .

الكلمات الرئيسية : استئصال غضروف الهلالي ، تقوية العضلة ، التمارين الاتزان ، الرياضين .