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Comparative effect of isotonic and isokinetic exercises on strengthening of injured knee ligament

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Abstract
The purpose of the study was to compare the effects of Isokinetic and isotonic exercises on strengthening of injured knee ligaments. For the study, 20 female athletes were purposively selected, who had suffered knee ligament injury and are in the rehabilitation phase, from Lakshmibai National Institute of Physical Education, Gwalior. Two equal groups were made out of the total 20 subjects – Group A (Isotonic Exercise Group) and Group B (Isokinetic Exercise Group). Both the groups were given training three days a week for 6 weeks on CSMI HUMAC NORM Isokinetic Machine. Using Pre-post design, data was collected on CSMI HUMAC NORM Isokinetic Machine as peak torque. Data was analyzed using IBM SPSS (version 20.0.0). Analysis of Co-variance (ANCOVA) was used as the statistical technique by taking pre-test as the covariate. The results of the study showed that there was significant improvement in peak torque values of injured knee ligaments in both experimental groups. But based on the mean difference, isokinetic exercise group performed better in post-test than isokinetic exercise group. So it is concluded that Isokinetic exercises are better for strengthening than isotonic exercises.

Keywords: Isokinetic, isotonic, ligament, injury, strengthening, rehabilitation

Introduction
Injuries are virtually the sole drawback of exercise, but maybe a common consequence of physical activity and have been shown to pose substantial problems [1-3]. Athletic participation often results in musculoskeletal injury [4]. According to NEISS, in 2012, among adults between the ages of 25 and 40 years, the most common injuries in basketball and soccer were fractured or sprained ankles and knees, followed by facial injuries and broken or dislocated fingers. Knee injuries occur commonly in sports, limiting field and practice time and performance level. Although injury etiology relates primarily to sports specific activity, female athletes are at higher risk of knee injury than their male counterparts in jumping and cutting sports. Particular pain syndromes such as anterior knee pain and injuries such as noncontact anterior cruciate ligament (ACL) injuries occur at a higher rate in female than male athletes at a similar level of competition [5]. There are various studies which shows the injury rate of males and females in multi exposure of games. Data was taken by The National Collegiate Athletic Association Injury Surveillance System from 1989-1993, 1989-1997, 1989-2002, and 1989-2004. The basketball and soccer data are dominated by the large exposure studies of Mihata *et al*., Agel *et al*., and Arendt and Dick. The female injury rates for basketball were 0.28, 0.29, and 0.30 from 3 different studies, respectively. For soccer the rates were 0.32, 0.33, and 0.31, respectively. For male subjects, the corresponding rates were 0.08, 0.08, and 0.07 for basketball and 0.12, 0.12, and 0.13 for soccer [6-8].
Muscle strength is dependent on pennation angle, fascicle length and muscle cross-sectional area [9]. There are various muscle strengthening exercises which helps in strengthening as well as rehabilitation of knee ligament injuries such as isotonic and isokinetic exercises. Further we go in detail about these exercises.
During isotonic exercise, resistance to the body segment remains constant throughout the entire ROM. The tension demand placed on a muscle is maximal only during a small portion of its ROM, causing the total work done to be less than maximum capacity. The clinical value of isotonic exercise, therefore, is limited by its inability to impose maximal tension and work demands on a muscle throughout its full range of action [10].
Isokinetic exercise is different from the other modes. If maximal muscular force is applied to the lever arm throughout the ROM and the speed of movement of the lever arm remains constant, the muscle contraction is termed isokinetic.

An isokinetic exercise machine provides resistance at a fixed speed in direct proportion to the amount of muscle force exerted by the subject. Resistance accommodates the varying force at the skeletal lever, and the muscle is able to maintain a state of maximal contraction through its full ROM [11].

Isotonic exercises also have been widely used in sports and clinical settings. They are suggested to prevent sarcopenia and loss of muscle strength (Taaffe *et al*., 2014), and to be incorporated in early rehabilitation programs (Okoro *et al*., 2016) [17] (Jørgensen *et al*., 2017) [18].

Isokinetic muscle strengthening has been used with great success in rehabilitation of: anterior cruciate ligament reconstruction (Dauty *et al*., 2014) [12], jumping capacity in athletes (Rouis *et al*., 2015) [13], osteoarthritis (Coudeyre *et al*., 2016) [14], and muscle weakness caused by Parkinson's disease (Kakinuma *et al*., 1998) [15].

As these exercises (isotonic and isokinetic) independently strengthen the muscles but there are very few studies which compare between these exercises. In this study we wish to fill the research gap that which kind of exercise (Isotonic or isokinetic) will be more effective for strengthening and rehabilitation of injured knee ligaments.

Methodology

Study design

Pre-test and post-test group design was used in the study. This study compared the two experimental groups over a period of 6-weeks. Two experimental groups were made of the total 20 subjects, each comprising of 10 subjects. The two experimental groups were:

Treatment Group A: Isotonic exercises

Treatment Group B: Isokinetic exercises

Subjects

20 female athletes were purposively selected from Lakshmibai National Institute of Physical Education, Gwalior with age ranging from 18-24 years. The inclusion criteria for the subjects were:

a. Subjects suffering from knee ligament injury
b. Absence of any other injury or neuromuscular disorder which will affect them in performing exercises.

All the subjects were informed about the complete procedure of the study as well as the risks involved. After this, the subjects signed the informed consent form, stating their voluntary participation in the study. The study was conducted by following the Declaration of Helsinki after approval from the Departmental Research Committee.

Treatment procedure

The training was given on CSMI HUMAC NORM Isokinetic Machine. The treatment procedure begin by entering the details of subjects such as name, age, gender, height and weight after which the selection of joint and motion was specified. After this, the subject sat on the Chair where the different aspects of the machine were set as per the anthropometry of the subject like- Rotation scale, Back angle, Fore/Aft Position of Chair and Dyna Tilt, Dyna Height, Dynarotation & Monorail of Dynamometer. Then the anatomical zero position was set after which ROM Limits were locked by locking the limb at zero position for weighing it. After this, automatically exercises started from trial rep to termination set with rest periods between sets.

For the purpose of this study, the training program consists of two Groups:

Experimental Group-A (Isotonic Group) was given training 3 days a week i.e. on Monday, Wednesday and Friday, mostly in the evening time. 10 subjects of knee ligament injury, 6 of them have injury in left knee and 4 of them have injury in right knee were a part of this group. Isotonic exercise training was given one by one after setting the isotonic mode protocol i.e., Con (EXTS)/Ecc (EXTS). The exercise protocol given was - 3 trial repetitions with rest of 5 sec followed by 3 sets of termination of 5 exercises with repetition rest of 5 sec.

Experimental Group-B (Isokinetic Group) was given treatment 3 days a week i.e. on Tuesday, Thursday and Saturday, mostly in the evening time. 10 subjects of knee ligament injury, 1 of them have injury in left knee and 9 of them have injury in right knee were part of this group. Isokinetic exercise training was given one by one after setting the isokinetic mode protocol i.e., Con (EXTS)/Ecc (EXTS). The exercise protocol given was - 3 trial repetitions with rest of 5 sec followed by 3 sets of termination of 5 exercises with repetition rest of 5 sec.

Data collection

All the subjects included in the study completed the whole treatment process without reporting any sort of injury. The data for injured knee strength was collected twice i.e. before the start of the treatment procedure (pre-test) and after the completion of 6-weeks training (post-test). The subjects were asked to be relaxed in the sitting position on the chair of the CSMI HUMAC NORM Isokinetic Machine, then with the help of Con (EXTS)/Ecc (EXTS) mode, data was collected for injured knee strength as peak torque.

Fig 1: CSMI HUMAC NORM isokinetic machine

Statistical technique

The data was analyzed using IBM SPSS (version 20.0.0). Since, the sample was purposively selected; Analysis of Co-variance (ANCOVA) was used as the statistical test, by taking pre-test as covariate, for comparing the effectiveness of both treatment programs as well as for the pairwise comparison of the means of the experimental groups. The level of significance was set at 0.05.

Results

Table 1: Descriptive statistics

Dependent variable: Post-test			
Treatment	**Mean**	**Std. deviation**	**N**
Isotonic	188.2000	53.54624	10
Isokinetic	261.0000	126.11304	10
Total	224.6000	99.07147	20

Table 2: Tests of between-subjects effects

Dependent variable: Post-test					
Source	**Type I Sum of squares**	**Df**	**Mean square**	**F**	**Sig.**
Corrected Model	79479.193[a]	2	39739.596	31.407	.000
Intercept	504451.600	1	504451.600	398.677	.000
Pretest	67977.525	1	67977.525	53.724	.000
Treatment	11501.668	2	11501.668	9.090	.020
Error	8857.207	16	1265.315		
Total	592788.000	20			
Corrected Total	88336.400	19			

a. R squared = .900 (Adjusted R squared = .871)

Table-2 shows that *p*-value (0.020) for Treatment is significant as it is less than 0.05. Its significance shows that there was an overall statistically significant difference in post training of isotonic and isokinetic exercises once their means had been adjusted. Also, *p*-value (0.000) for Pre-test is also significant, which means that the two experimental groups differ in the beginning of the treatment, hence their post-test is adjusted by taking pre-test as covariate.

Table 3: Estimates

Dependent variable: Post-test				
Treatment	**Mean**	**Std. error**	**95% Confidence interval**	
			Lower bound	**Upper bound**
Isotonic	190.670[a]	15.912	153.045	228.295
Isokinetic	258.530[a]	15.912	220.905	296.155

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 142.5000.

Since, the *p*-value for pre-test was significant in Table – 2, Table – 3 shows the adjusted means and standard error for post-test.

Table 4: Pairwise comparisons

Dependent variable: Post-test						
(I) Treatment	**(J) Treatment**	**Mean difference (I-J)**	**Std. error**	**Sig.[b]**	**95% Confidence interval for difference[b]**	
					Lower bound	**Upper bound**
Isotonic	Isokinetic	-67.859*	22.508	.020	-121.081	-14.637
Isokinetic	Isotonic	67.859*	22.508	.020	14.637	121.081

Based on estimated marginal means, *. The mean difference is significant at the .05 level, b. Adjustment for multiple comparisons: Least significant difference (Equivalent to no adjustments)

Based on the results shown in Table - 4,we can say that both the groups had a significant difference as $p<0.05$ i.e. 0.02 but based on the mean difference between the two groups, we can depict that isokinetic exercises have more effect on the subjects when we compared to isotonic exercises as the mean difference for isokinetic is positive.

Discussion

The results of the study indicate that there is a significant effect of isotonic and isokinetic training on the strengthening of the injured knee ligaments since, our p value was less than 0.05.

The group statistics also revealed that the mean for isokinetic training was greater than the mean of isotonic training. So the researcher concluded that isokinetic training had a better effect than isotonic training as similar results are produced in study conducted by Dragana Golik-Peric *et al.* (2011) [19] who studied the effects of two specific training protocols i.e., isokinetic training and isotonic training were introduced in order to restore desired values of the concentric ratio and muscle strength and to evaluate the effects they induced in the trained muscle groups. After the protocols were implemented, the initial strength imbalances improved significantly in both groups. However, in the isokinetic group these imbalances improved more than in the isotonic group which supported the results of this study. [19].

Isotonic and isokinetic exercises were used to increase the strength and performance in various studies in which one study was taken and results were compared with our study and it was found that when we are talking about the strength isokinetic exercises produce more strength as compared to isotonic exercises which suggests that isokinetic exercise concept can be used in training as well as in rehabilitation program [20].

Another study was found which was conducted to examine how the balance of the lower limbs and the muscle activities of the tibialis anterior, the medial gastrocnemius and the peroneus longus are influenced by isotonic and isokinetic exercise of the ankle joint. A main effect was shown by in the non-dominant tibialis anterior, the dominant tibialis anterior, the dominant gastrocnemius muscle and the

dominant peroneus longus. A main effect of time was shown by both the isotonic and isokinetic exercise groups for the sway area when support was provided by the non-dominant side. The two exercise groups showed significant differences in muscle activities, and the group performing isokinetic exercise showed higher muscle activities. In terms of balance, there was no difference between the groups, but there was a significant difference between the pre-test and the post-test results [21].

There are various studies which shows almost same results as our study in which one study shows association between isotonic and isokinetic knee strength with knee function and activity level after anterior cruciate ligament reconstruction. It was found that quadriceps strength was generally more strongly associated than hamstring strength with future knee function and activity levels. In this study as with the quadriceps strength results, isokinetic hamstrings strength did not seem to be more strongly associated with the various outcomes; but both isokinetic and isotonic hamstring strength were significantly associated with Lysholm scores. The results is slightly differ from our study due to the reason that they assessed isokinetic hamstring strength in a seated position whereas isotonic strength was assessed using a prone leg curl machine which is used as training machine in clinical rehabilitation [22].

The reasons behind the difference occurred may be because of Isokinetic exercise allows muscles to gain strength consistently all through the range of movement but with isotonic exercise, the muscle shortens at a constant rate throughout the motion, but the muscle tension varies.

Conclusion

The present study concluded that isokinetic exercises are better at strengthening of injured knee ligaments than isotonic exercises for collegiate females. Though isokinetic exercises can only be performed with the help of an isokinetic dynamometer, it is expensive and its operation requires more technical effort and knowledge. For this reason, isotonic exercises are preferred by many therapists. Although the isokinetic exercises are better than isotonic exercises, the study also concluded that isotonic exercises are effective in strengthening the injured knee ligament. Therefore, based on the above mentioned circumstances, a therapist or an injured person can use both the type of exercises for strengthening of the injured part.

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