Original Article

Physiotherapy and Occupational Therapy Journal
Volume 10 Number 1, January - March 2017
DOI: http://dx.doi.org/10.21088/potj.0974.5777.10117.1

The Effect of Strength Training and Strength-Agility Training on Knee Proprioception in Normal Collegiate Males

Md. Naim Akhtar*, Deepak Malhotra, Davinder Gaur*****

Abstract

The objective of this pre test post test experimental study design was to find out the effect of strength training and strength-agility training on knee joint proprioception in normal collegiate males. Fourty five study participants participated in the study. They were randomly allocated into 3 groups of 15 participants each on the basis of inclusion and exclusion criteria.i.e. group1- strength training, group2- strength-agility training and group3- control group. The training in the strength training group consisted of Leg press and Lunges exercises. In the strength-agility training group consisted of Leg press, Lunges and Change-of-direction sprints exercises. In the control group no exercise was given.The outcome measures were knee joint proprioception. The between-group comparisons at the end of the training showed that maximal proprioception gain was in group 2 (strength-agility training) specifically at an angle of 45^0. Although the gain at 15^0 was also statistically significant but it was comparatively less as compared to the gain at 45^0. The results of the study suggested that strength-agility training is more effective than strength training to improve proprioception in knee joint.

Keywords: Strength Training; Strength-Agility Training; Proprioception.

Introduction

The word proprioception is derived from Latin word "proprius" meaning "one's own", "individual" and "ception" meaning "perception", is the sense of the relative position of parts of the body and strength of effort being employed in movement [1].

Proprioception is any postural or movement information provided to central nervous system by sensoroy receptors in muscles, tendons, joints, skin which can potentially be used by the central nervous system to co-ordinate a wide range of natural movement in normal behaviours [2].

Proprioception is the sum of kinaesthesia and joint position sense. Kinaesthesia is defined as the awareness of joint movement and is dynamic. Joint position sense is restricted to the awareness of the position of a joint in space and is a static phenomenon (Grob *et al*., 2002; Lephart, 1992).

Knee joint proprioception is essential to neuro-motor control. Neuro-motor control of the knee involves the coordinated activity of surrounding muscles in particular, the quadriceps (Bennell *et al*., 2003). In recent years, increasing numbers of authors have recommended weight bearing tests of joint position or movement sense. Hsu *et al*. (2006) found that joint proprioceptive inputs play a major role in joint position sense [2].

Joint positioning and joint motion are two closely related proprioceptive sensations that are mediated by mechanoreceptors such as the Ruffini ending, the Golgi tendon organ, and the Pacinian corpuscle, which originate in the tendons, ligaments, and joint capsule. Sensory receptors in muscle and tendon are thought primarily to mediate subcortical reflexes, and as such, these receptors are not stimulated by changes in joint position. Dvir et al. concluded, however, that static position sense is the function likely to be controlled entirely by knee musculature. Barrack et al. reported that muscle and tendon receptors play a significant role in the sensation of joint motion and

Author Affiliation: *Post Graduate **Assisant Professor, Department of Rehabilitation Sciences, Hamdard University, New Delhi, India. ***Assisant Professor, Banarsidas Chandiwala Institute of Physiotherapy (BCIP), New Delhi, India.

Reprint Request: Davinder Kumar Gaur, Assisant Professor, Banarsidas Chandiwala Institute of Physiotherapy (BCIP), Maa Anandmai Marg, Kalkaji, New Delhi – 110019.
E-mail: physiodev2006@bcip.ac.in

Received on 10.01.2017, **Accepted on** 16.01.2017

position [3].

Proprioception an important component of balance and proper postural control, is perceiveing the position or movement of extremities and body segments in space. The sense of position of a joint depends on afferent signals from joint, muscle and skin receptors. Joint mechanoreceptors have the ability to detect the actual joint position and joint motion. Proprioception allows an individual to maintain joint stability during static and dynamic posture [4].

It was believed that for the most part, kinesthesia sensations are detected by Pacinian corpuscles and Ruffini endings. However, it is now clear that muscle spindles, once thought to encode exclusively individual muscle lengths, are also major contributors to the kinesthetic sense of position and movement (Clark et al. 1985) [5].

Agility is the ability to maintain or control body position while quickly changing direction during a series of movements (Twist and Benickly, 1995). Agility training is thought to be a re-enforcement of motor programming through neuromuscular conditioning and neural adaptation of muscle spindles, golgi-tendon organs, and joint proprioceptors (Barnes and Attaway, 1996; Craig, 2004, Potteiger et al., 1999) [6]. Agility is the ability to decelerate one's momentum, stop, overcome inertia and accelerate one's body mass in another direction. Clark (2001) sums it up by stating, "agility is the ability to decelerate, stabilize, accelerate and change direction quickly while maintaining proper posture and moving in the intended direction [7]. Looking at this from a physics perspective, momentum, impulse and inertia are the three critical components of agility. The ability to decelerate and stop one's momentum in a short distance/period of time requires great amounts of unilateral relative strength and power, particularly in the extensor mechanism musculature of the lower extremities. Impulse can be found in the period of time in which the switching from eccentric action (deceleration) to concentric action (acceleration) occurs.

"Any change of running direction is caused by an external impulse to the ground. The greater and quicker the direction change during desired high running speed, the greater force and shorter time of push off to the ground in the optimal direction is necessary [8]. The ability to then accelerate in a different direction also requires a great degree of unilateral relative strength and power. Often times in the beginning phases of agility training, these components are overlooked, and substituted for "drills", even if baseline strength and power levels are subpar.

According to Kurtz (2001), "agility is measured by the difficulty of coordination of assignments, precision of performance, the time between moment of change and the beginning of the response, and the time required for achieving a necessary level of precision'' [9].

With proper execution, agility skills can create various physical benefits. "Agility training enhances eccentric neuromuscular control, dynamic flexibility, dynamic postural control, functional core strength and proprioception [7] which can lead to overall increases in athletic performance. Agility can also "help to prevent injury by enhancing eccentric neuromuscular control and improving the structural integrity of the connective tissue [3]. These benefits can create an environment in which the development of other skills can be cultivated.

'Strength training' is performed with a variety of exercise machines, free weights, or even the use of gravity acting upon the athlete's body mass. Most resistance training (strength) programmes are based on a system of exercise to a repetition maximum (RM) as presented in the mid-1940s by T.L. De Lorme (De Lorme 1945) for use in physical medicine and rehabilitation [10].

Muscular strength is defined as the capacity of the muscles to exert force and is fundamental to the performance of many tasks that are encountered in daily living. Female athletes demonstrate less absolute strength than their male counterparts, suggesting a potential link between insufficient muscular strength and noncontact ACL injuries in female athletes [11].

Blackburn et al. (2000) reported that strength contributes to balance by producing muscle stiffness (resistance to muscle lengthening), which could enhance neuromuscular control by increasing proprioceptor sensitivity to stretch and reducing electromechanical delay from the muscle spindle stretch reflex [12].

There are many instances in daily life and sport where knee joint proprioception is essential for accurate modulation and activation of muscles, thus providing adequate neuromuscular control of knee joint position and joint movement, and ultimately the performance of physical tasks. Adequate proprioception is required for safe and capable movement of the body. Especially disturbed position sensation in lower limbs may lead to perturbation in daily activities such as walking, running, and may ultimately lead to injuries [4].

Methodology

Subjects

A sample consisting total of 45 individuals was selected for the study using randomized sampling .It consisted of all male participants. All the subjects were randomly assigned (Lottery system) to three different groups. i.e, Strength training (Group1), Strength-Agility training (Group2) and Control group (Group3). Each subject was tested for knee proprioception on Biodex Multi Joint system-4 before the training protocol. Each subject of the respective group was done specific training for 6 weeks except control group. After the training protocol the subjects were again be tested for proprioception on Biodex Multi Joint system-4 machine. The Subjects were recruited according to inclusion and exclusion criteria and were assigned to group 1, 2, and 3 randomly after baseline testing. Inclusion Criteria: Gender : Normal collegiate males, Age : 18 to 28 year, BMI: Normal range WHO 18.5 - 24.9 kg/m^2, Knee joint ROM= 0-120^{0}to 135^0, Poor proprioception level (Absolute error >5^0). In case if we are not able to get subject with error of greater than 5^0 than a lower error would be included (Absolute error range = 3^0-5^0) Exclusion Criteria: Recent history (past six months) of any musculoskeletal or neurological impairment in lower extremities as reported by participants, Current or recent knee injuries as reported by participants in past 6 month, Limitation in knee ROM, Inflammation or pain in the lower extremities, Subjects who are involved in any form of structured physical training involving the lower extremities, Major surgery in lower extremity-acute and sub-acute period,Any apparent biomechanical deviation for the lower extremities –revealed after clinical inspection.

Procedure

All the selected subjects were informed in detail about the type and nature of the study. The subjects were requested to sign the consent form prior to the study. pre-testing evaluation was conducted in the lab prior to the testing session.

During the pre-testing evaluation demographic information and general assessment was obtained. Leg dominance was determined at that time by asking participant which foot they would kick a ball with. The leg indicated as the dominant leg was considered as the leg for testing sessions. The decision to use the dominant leg for all testing procedure wasm ade due to reference of previous research indicate that there is no difference in proprioception between the dominant and non-dominant leg [13].

All the subjects were randomly assigned (Lottery system) to three different groups. i.e, Strength training (Group1), Strength-Agility training (Group2) and Control group (Group3). Each subject was tested for knee proprioception on Biodex Multi Joint system-4 before the training protocol. Each subject of the respective group was done specific training for 6 weeks except control group. After the training protocol the subjects were again be tested for proprioception on Biodex Multi Joint system-4 machine.

Measurement of Proprioception

Active Angle Reproduction (Biodex Multi Joint System-4): In the seated positions, the subject's limb was passively moved to the target angles (i.e:15^0& 45^0). The leg was held there for 10sec. for the subject to memorize the position and then returned to 90^0 knee flexion. After a pause of 5sec, the subject moved the lower limb by active contraction at an angular velocity approximating 2^0/s and stopped when he perceived the target angle has been achieved. Once the angle was achieved, subjects were not be permitted to correct the angle. A total of three readings were taken for each respective angle and the difference between the perceived angle and each of the target angles noted for each trial [14,15].

Warm up

Warm up started at least 2-3 days before training.

Each subject was performed a warm-up consisting of 3 minutes of jogging and stretching of the muscles of the lower extremity [16].

Stretching Interventions [7]:

Before the static stretching interventions (either 15sec to the point of discomfort), participants undertook a 3minutes of seated recovery. Static stretching included three different stretching exercises: unilateral standing quadriceps stretch, unilateral standing hamstring stretch, unilateral standing calf stretch, executed for 15 sec for each leg and each exercise, to the point of discomfort.

For the unilateral standing quadriceps, the participants grabbed the ankle with the ipsilateral handmaking sure not to pull the leg into abduction while performing the stretch. For the unilateral standing hamstring stretch the heel of the foot is placed on an adjustable obstacle slightly below the hip level with the knee fully extended, while for the standing calf stretch the hands were placed against a wall and the foot is planted on the floor approximately 1 meter from the wall with the heel touching the ground (Alter, 1988). The subjects are then instructed to lean forward making sure that the stretched foot is flat on the floor. Participants are asked to maintain the stretching position where they felt discomfort throughout the required stretching time period. The participants are familiar with the stretching protocols, since they routinely performed these exercises in everyday training [17].

Leg press[18]:

Session	Set	Repetitions	% Of 1 Rm	Rest Time
1ST Three	4	8	30	60sec
2nd three	4	8	45	60sec
3rd three	4	6	60	50sec
4th three	3	6	75	40sec

Lunges (19,20):

Week	Forward lunge	Lateral lunge	Backward lunge
wk1	3 set x 8 rep	3 set x 8 rep	3 set x 8 rep
wk2	3 set x 10 rep	3 set x 10 rep	3 set x 10 rep
wk3	3 set x 12 rep	3 set x 12 rep	3 set x 12rep
wk4	4 set x 8rep	4set x 8rep	4 set x 8rep
wk5	4set x 10 rep	4 set x 10 rep	4set x 10 rep
wk6	4set x 12 rep	4 set x 12 rep	4set x 12 rep

Strength Training (Leg press and Lunges):

Two Session in Each Week

Lunges were performed in the forward lunge, lateral lunge, and backward lunge. All 3 lunges started with the Subjects standing with their feet near each other and hands on their hips. All lunges were performed with the dominant limb taking the step and lowering into 90^0 of hip and knee flexion while the trunk was maintained in an upright position. This prevented the knee from moving anterior to the foot, and the knee of the non-dominant limb did not touch the ground. Subjects were instructed to keep their knees over the toes for all lunges. They lunged forward, lateral and backward (toward the dominant side).

Week	Repetition number x Distance (m)	Rest between Repetitions (3minutes)	Angle of directional change $(0)^0$	No. of change direction
1	6x40	Complete	100	3
2	8x30	Complete	100	3
3	8x20	Complete	100	4
4	5x40	Complete	100	4
5	6x30	Complete	100	5
6	5x30	Complete	100	5

Agility training [21]:

Change-of-Direction Sprints

Two Session in Each Week.

Data Analysis

A pre-test post-test experimental group design was used for the study. The baseline values for dependent variable Knee joint Proprioception was taken on day 1 (pre intervention score) by using Biodex Multi joint System 4. The final reading was taken after six weeks. The data was analyzed using SPSS 16, Illinois Inc. Chicago, USA software. One way ANOVA test was applied for comparison of pre test and post test readings between all the groups. Paired t test was applied to compare the pre test and post test readings within all the groups. Post hoc test was applied for comparison of pre test and post test readings of the multiple groups. The test were applied at 95% confidence interval and p values set at 0.05.The result were taken to be significant if $p<0.05$.

Results

A total number of 45 subjects participated in the study out of which 15 participated in Strength training Group (group 1), another 15 subjects participated in Strength-Agility training (group 2) Another 15 participated in Control group (group 3). The demographic data was analyzed by comparing means of descriptive. They have their mean age to be 23.53 ± 2.06 years, 22.13 ± 2.77 years and 24.67 ± 2.52 years respectively. They have their mean height to be 169.73 ± 6.73 cm, 169.60 ± 5.30 cm and 171.40 ± 7.53 cm respectively and mean weight to be 66.20 ± 8.05 kg, 64.00 ± 8.00 kg and 63.13 ± 9.34 kg respectively. They have their mean BMI 22.73± 1.62, 22.13 ± 2.16 and 21.47± 2.16 respectively.

Table 5.1: Demographic data for three groups

	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD	P value
Age	23.53 ± 2.06	22.13 ± 2.77	24.67 ± 2.52	0.027
Height	169.73 ± 6.73	169.60 ± 5.30	171.40 ± 7.53	0.709
Weight	66.20 ± 8.05	64.00 ± 8.00	63.13 ± 9.34	0.599
BMI	22.73± 1.62	22.13 ± 2.16	21.47± 2.16	0.234

There was insignificant difference between these groups on baseline demographic characteristics including age (p value = 0.027),height(p value = 0.709),weight(p value = 0.599) and BMI (P value = 0.234). The data showed that three groups were homogeneous.

There was no statistically significant difference present in pre test baseline of Proprioception among all the three groups with the p values for mean ± SD of Proprioception pre 15p was p= 0.497. There was statistically significant difference present in pre test baseline of Proprioception among all the three groups with the p values for mean ± SD of Proprioception pre 45p was p= 0.012.

Table 5.2: Base line measurement

	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD	p value
Prop. Pre 15^0	4.91 ± 3.37	5.29 ± 3.19	4.07 ± 1.75	0.497
Prop. Pre 45^0	7.68 ± 3.72	11.73 ± 4.67	8.02 ± 3.25	0.012

The comparison of within group significance was done using Paired sample 't' test for group 1 group 2, and group 3 respectively. Pre- post measurement were compared for each outcome measures of dependent variable of subjects.

Table 5.3: Proprioception gain in group 1

	Pre test value Mean ± SD	Post. Test value Mean ± SD	Pair t test	
			t value	p value
Prop.15^0	4.91 ± 3.37	1.93 ± 1.04	2.95	0.011
Prop.45^0	7.68 ± 3.72	2.99 ± 1.24	5.41	0.000

In within group analysis, on comparing Proprioception pre 15^0 and Proprioception post 15^0, Proprioception pre 45^0 and Proprioception post 45^0. Proprioception was improved significantly in group1 with p value = 0.011 and p value = 0.000 respectively.

In within group analysis, on comparing Proprioception pre 15^0 and Proprioception post 15^0, Proprioception pre 45^0 and Proprioception post 45^0. Proprioception was improved significantly in group

Table 5.4: Proprioception gain in group 2

	Pre test value Mean ± SD	Post test value Mean ± SD	Pair t test	
			't' Value	'p' value
Prop.15	5.29 ± 3.19	1.91 ± 0.94	4	0.001
Prop.45	11.73 ± 4.67	2.01 ± 1.38	8.13	0.000

Table 5.5: Proprioception gain in group 3

	Pre test value Mean ± SD	Post test value Mean ± SD	Pair t test	
			't' Value	'p' value
Prop.15	4.07 ± 1.75	3.73 ± 1.47	1.20	0.247
Prop.45	8.02 ± 3.25	6.95 ± 3.17	2.17	0.048

2 with p value = 0.001 and p value = 0.000 respectively.

In within group analysis, on comparing Proprioception pre 15^0 and Proprioception post 15^0 was not improved significantly in group 3 with p value = 0.247. Proprioception pre 45^0 and Proprioception post 45^0. Proprioception was improved significantly in group 3 with p value = 0.048.

The comparison of between group significance was done using one way ANOVA for group 1, group 2, and group 3 respectively.

Proprioception Gain in Between Groups

In between group analysis, on comparing the mean value ± SD of Proprioception pre 15^0 and Proprioception post 15^0, Proprioception pre 45^0 and Proprioception post 45^0 for all three groups. There was no statistically significant difference present in Proprioception pre 15^0 among the three groups for mean ± SD with p value = 0.490 .There was statistically significant difference present in Proprioception post 15^0, Proprioception pre 45^0 and Proprioception post 45^0 among the three groups for mean ± SD with p value = 0.000, p value = 0.012 and p value = 0.000 respectively.

Table 5.6: Proprioception gain in between groups

	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD	'f' value	' P' value
Prop.pre 15	4.91 ± 3.37	5.29 ± 3.19	4.07 ± 1.75	0.71	0.490
Prop.post 15	1.93 ± 1.04	1.91 ± 0.94	3.73 ± 1.47	11.87	0.000
Prop.pre 45	7.68 ± 3.72	11.73 ± 4.67	8.02 ± 3.25	4.91	0.012
Prop.post 45	2.99 ± 1.24	2.01 ± 1.38	6.95 ± 3.17	22.75	0.000

Multiple Group Comparisons Result

ANOVA followed by post hoc test (tukey) was performed to do multiple comparisons between three groups to analyze the post training effect on all three groups. When multiple comparisons done in different groups, group 1 is compared to group 2, group 1 is compared to group 3 and group 2 is compared to group 3.

Proprioception Gain Difference between Group 1 and Group 2

In multiple group analysis, on comparing the mean value ± SD of Prop.pre 15p - prop.post 15p and Prop.pre 45p - prop.post 45p for group1 and group 2. There was no statistically significant difference present in Prop.pre 15p - prop. post 15p among the two groups for mean ± SD with p value = 0.930. There was statistically significant difference present in Prop. pre 45-prop.post 45 among the two groups for mean ± SD with p value = 0.001.

Table 5.7: Proprioception gain difference between Group 1 and Group 2

	Group 1 Mean ± SD	Group 2 Mean ± SD	'P' value
Prop.pre 15-prop.post 15	2.98 ± 3.92	3.38 ± 3.27	0.930
Prop.pre 45-prop.post 45	4.69 ± 3.35	9.72 ± 4.62	0.001

However, improvement in mean difference in group 1 for Prop.pre 15-prop.post 15 (2.98 ± 3.92) and Prop.pre 45p - prop.post 45p (4.69 ± 3.35) was less than improvement in mean difference for Prop.pre 15p - prop.post 15p (3.38 ± 3.27) and Prop. pre 45p -prop.post 45p (9.72 ± 4.62) of group 2. Thus Strength-Agility training improved more Proprioception than the Strength training.

Proprioception Gain Difference between Group 1 and Group 3

In multiple group analysis, on comparing the mean value ± SD of Prop.pre 15- prop.post 15 and Prop.pre 45p - prop.post 45p for group1 and group 3. There was no statistically significant difference present in Prop.pre 15p - prop.post 15p among the two groups for mean ± SD with p value = 0.053. There was statistically significant difference present in Prop.pre 45p -prop.post 45p among the two groups for mean ± SD with p value = 0.018.

Table 5.8: Proprioception gain difference between Group 1 and Group 3

	Group 1 Mean ± SD	Group 3 Mean ± SD	'P' value
Prop.pre 15-prop.post 15	2.98 ± 3.92	0.34 ± 1.09	0.053
Prop.pre 45-prop.post 45	4.69 ± 3.35	1.06 ± 1.90	0.018

However, improvement in mean difference in group 1 for Prop.pre 15p - prop.post 15p (2.98 ± 3.92) and Prop.pre 45p - prop.post 45p (4.69 ± 3.35) was more than improvement in mean difference for Prop.pre 15p - prop.post 15p(0.34 ± 1.09) and Prop.pre 45p - prop.post 45p (1.06 ± 1.90) of group 3. Thus Strength training improved more Proprioception than the control group.

Proprioception gain difference between Group 2 and Group 3

In multiple group analysis, on comparing the mean value ± SD of Prop.pre 15p - prop.post 15p and Prop.pre 45p - prop.post 45p for group 2 and group 3. There was statistically significant difference present in Prop.pre 15p - prop.post 15p and Prop.pre 45p -prop.post 45p among the two groups for mean ± SD with p value = 0.022 and p value = 0.000 .

Table 5.9: Proprioception gain difference between Group 2 and Group 3

	Group 2 Mean ± SD	Group 3 Mean ± SD	'P' value
Prop.pre 15-prop.post 15	3.38 ± 3.27	0.34 ± 1.09	0.022
Prop.pre 45-prop.post 45	9.27 ± 4.62	1.06 ± 1.90	0.000

However, improvement in mean difference for Prop.pre 15p - prop.post 15p (3.38 ± 3.27) and Prop.pre 45p - prop.post 45p (9.72 ± 4.62) of group 2 was more than Prop.pre 15p - prop.post 15p (0.34 ± 1.09) and Prop.pre 45p - prop.post 45p (1.06 ± 1.90) of group 3. Thus Strength-Agility training improved more Proprioception than the control group .

Discussion

The objective of present study was to find out the effect of strength training and strength-agility training on knee proprioception in normal collegiate males.

After providing six weeks of training it was observed that, there is a significant improvement in proprioception in group 1 (strength training) and group 2 (strength-agility training) on comparison with control group.

The result of the present study showed that maximal proprioception gain was in group 2 (strength-agility training) specifically at an angle of 45^0.Although the gain at 15^0 was also statistically significant but it was comparatively less as compared to the gain at 45^0.

Improvement in proprioception is more with Strength-agility training than with strength training alone: The reason may be strength-agility training group received both the trainings including agility (Change-of-direction sprints) and strength training (Leg press and Lunges) in comparison to strength training group which received only strength training (Leg press and Lunges).

Proprioception improve more at the angle of 45^0 in the comparison of 15^0:

The reason may be because in the middle range of knee motion (45p), the capsule, ACL, and PCL are relatively relaxed and thus the poorest proprioceptive sensory feedback should be noted [29]. Therefore there is more scope for improvement in proprioception.

Another reason may be when the knee is in relative extention position (15p), it is stable and also there is not much pressure on posterior horn of menisci. Thus other inner' structures may take the responsibility of the proprioceptive sense other than menisci. When the knee is in flexion (45^0) there would be more pressure on the posterior horn of menisci because of the relative instability. Therefore knee flexion results in a higher firing frequency of the mechanoreceptors on meniscus, pressure stimulates the slowly adapting Ruffini and Golgi receptors, which boost proprioceptive awareness [30].

The result of the study is in agreement conducted by Pincivero et al (2001), who studied the effects of joint angle and reliability on knee proprioception, in their study they examined the reliability and effects of knee angle on the detection and subsequent response to passive knee movement. The results of their study demonstrated that at a more extended knee joint position (15p) significantly less knee movement response than in a more flexed position (30p -60p) [31].

So, during strength training and strength-agility training there is increased and repetitive flexion of the knee joint in weight bearing position. Therefore there would be more stimulation of the mechanoreceptors in the menisci which may have led to more increase in proprioception specifically at 45^0 of knee flexion

Conclusion

The result of present study showed, there is a statistically significant improvement in knee joint proprioception after six weeks of strength training and strength-agility training programs. But the strength-agility training group showed more improvement when compared to strength training alone. Therefore for maximum proprioception gain it would be advisable to add an agility component in the strength training program.

So, it may be concluded from the present study that strength-agility training is more beneficial in improvement of knee joint proprioception than strength training alone.

Acknowledgment

We express our sincere thanks to Dr. Shibili Nuhmani and Dr. Kalpana Zutshi for helping in the study process.

Conflict of interest: None

References

1. Mosby's Medical, Nursing and Allied Health Dictionary, Fourth Edition, Mosby-1994.p.1285.
2. Andersen SB, Terwilliger DM and Denegar CR. Comparisn of open versus closed kinetic chain test positions for measuring joint position sense. Journal of sport Rehabilitation. 1995; 4:165-171.
3. Michael J. Higgins and David H. Perrin, Comparison of Weight-Bearing and Non-Weight-Bearing Conditions on Knee Joint Reposition Sense, Journal of Sport Rehabilitation, 1997; 6:327-334.
4. Nursen Özdemer, Sevgi Sevi Subasi, Nihal Gelecek, Sükrü Sari, Pðlates Egzersðz Eððtðmðnðn Dðz Proprðosepsðyonu Üzerðne Etkðlerð – Randomðze Kontrollü Çalisma: The Effects of Pilates Exercise Training on Knee Proprioception – A Randomized Controlled Trial.
5. Elizabeth O. Johnson, PhD. International Encyclopedia of Rehabilitation: Copyright © 2010 by the Center for International Rehabilitation Researc Information and Exchange (CIRRIE).
6. Michael G. Miller et al. The Effects Of A 6-Week Plyometric Training Program On Agility: 21 June 2006 / Accepted: 07 August 2006 / Published (online): 01 September 2006.
7. Clark M. National Academy of Sports Medicine: Performance Enhancement Specialist Manual. Integrated Speed Training: Section Ib. NASM, Az. 2001.
8. Kraemer w., Hakkinen K. Strength Training for Sport. Blackwell Science Ltd. 2002.p.79-84.
9. Kurz T. Science of Sports Training. Island Pond, Vt. 1991.p.137-138.
10. Paavo V. Komi, Strength and power in sports,Vol-3. Second Edition Chapter15,page no 281-287.
11. Takashi et al, Knee Proprioception and Strength and Landing Kinematics During a Single-Leg Stop-Jump Task, Journal of Athletic Training. 2013; 48(1):31–38.
12. Kevin McCurdy and George Langford, The Relationship Between Maximum Unilateral Squat Strength And Balance In Young Adult Men And Women, Journal of Sports Science and Medicine. 2006; 5:282-288.
13. Barrack RL, Skinner HB, Brunet ME, Cook SD, Joint kinaesthesia in the highly trained knee. Journal of Sports Medicine.1984; 24:18-20.
14. Michael J. Callaghana, James Selfeb, Alec McHenryc, Jacqueline A. Oldhama, Effects of patellar taping on knee joint proprioception in patients with patellofemoral pain syndrome,page-3.
15. Giselle Cross, Patrick A. Costigan and Scott K. Lynn Is Lower Limb Joint Proprioception Systemic, Email: 3PAC13@post.queensu.ca,page- 485.
16. Warren B. Young, Mark H. Mcdowell, And Bentley J. Scarlett, Specificity of Sprint and Agility Training Methods. Journal of Strength and Conditioning Research, 2001; 15(3):315–319.
17. Charilaos Tsolakis and Gregory C. Bogdanis; Acute effects of two different warm-up protocols on flexibility and lower limb explosive performance in male and female high level athletes: Journal of Sports Science and Medicine. 2012; 11:669-675.
18. Rahman Rahimi, Naser Behpur: The Effects Of Plyometric, Weight And Plyometric-Weight Training On Anaerobic Power And Muscular

Strength. Facta Universitatis Series: Physical Education and Sport 2005; 3(1):81–91.

19. James Burk, CSCS. Lunge Progressions. Varner, M., et al. The lunge. Strength and Conditioning Journal. 1990; 12(4):77-81.

20. Rebecca L. Begalle, Lindsay J. DiStefano: Quadriceps and Hamstrings Coactivation During Common Therapeutic Exercises. Journal of Athletic Training 2012; 47(4):396–405.

21. Warren B. Young, Mark H. Mcdowell, And Bentley J. Scarlett: Specificity of Sprint and Agility Training Methods. Journal of Strength and Conditioning Research, 2001; 15(3):315–319.

22. Glenna Batson, P.T., D.Sc., M.A. Update on Proprioception Considerations for Dance Education.

23. Dietz V: Proprioception and locomotor disorders. Nat Rev. 2002; 3:781-9.

24. Schaffer SW, Harrison AL. Aging of the somatosensory system: a translational perspective. Phys !er. 2007; 87(2):193-207.

25. Paavo V.Komi, Strength and power in sports, Blackwell Science publication,2nd edition, 2003; 3: 229-251.

26. William E. Prentice,Rehabilitation Techniques for Sports Medicine and Athletic Training, Fourth Edition, Mc Graw-Hill Publication, 2004.p.225-238.

27. K.R.Thompson,A.E. Mikesky,R.E. Bahamonde, D.B. Burr; Effects of physical training on proprioception in older women: J Musculoskel Neuron Interact 2003; 3(3):223-231.

28. Michael G. Miller, Jeremy J. Herniman, Mark D. Ricard, Christopher C. Cheatham and Timothy J. Michael; The effects of a 6-week plyometric training program on agility: Journal of Sports Science and Medicine. 2006; 5:459-465.

29. M.R. Safran, A.A. Allen, S.M. Lephart, P.A. Borsa F.H. Fu, C.D. Harner: Proprioception in the posterior cruciate ligament deficient knee; Knee Surg, Sports Traumatol, Arthrosc. 999; 7:310–317.

30. Mustafa Karahan , Baris Kocaoglu , Cengiz Cabukoglu , Umut Akgun , Rustu Nuran: Effect of partial medial meniscectomy on the proprioceptive function of the knee; Arch Orthop Trauma Surg. 2010; 130:427–431.

31. Danny M. Pincivero, Brad Bachmeier, And Alan J. Coelho : The effects of joint angle and reliability on knee proprioception ; Med. Sci. Sports Exerc., Vol. 2001; 33(10):1708-1712.