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Influence of Hamstring Facilitatory Taping on Knee Muscle Activation and Dynamic Balance in Patients with Anterior Cruciate Ligament Deficient Knee

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SUMMARY

Background. Anterior cruciate ligament (ACL) deficiency affects proprioception, motor control, and dynamic balance. Stretch or Kinesio taping is one of the techniques hypothesized to address these deficits. However, there is limited objective evidence demonstrating the use of hamstring facilitatory taping in ACL deficient population.

Methods. This feasibility study with a pre/post experimental design was conducted on twenty patients with ACL deficient. The surface EMG activity was recorded from semitendinosus, biceps femoris, vastus medialis, vastus lateralis muscles during rest, walking, stair climbing and single leg hopping with and without taping. Dynamic balance was assessed using SEBT with and without taping.

Results. There was a statistically significant decrease in dynamic balance and EMG muscle activation with no additional improvement observed in biceps femoris and vastus lateralis muscles during the activities included in this study.

Conclusions. In this study no immediate improvement in muscle activation and dynamic balance was found with a single session of hamstring facilitatory taping.

Trial registration. Clinical trial registry of India. The number of registration is (CTRI/2018/07/014796).

KEY WORDS

ACL injury; ACL deficient knee; electromyography; knee ligament injury; taping.

ABBREVIATIONS

ACL: Anterior Cruciate Ligament
EMG: Electromyography
SEBT: Star Excursion Balance Test
IEC: Institutional Ethics Committee
MRI: Magnetic Resonance Imaging
ADI: Analog Devices, Inc
USA: United States of America
RMS: Root Mean Square
MVC: Maximum Voluntary Contraction
Lab: laboratory
SPSS: Statistical Package for Social Sciences
KT: Kinesio Tape
Cm: Centimeters
Kg: Kilograms
SD: Standard Deviation
P-value: used to denote level of significance

BACKGROUND

Anterior cruciate ligament (ACL) injury is one among the frequently occurring knee injuries having an incidence of approximately 68.6 per 100,000 person-years (1). ACL deficient knee is the term used for a knee with an injured anterior cruciate ligament. Chronic ACL deficiency presents with instability during daily activities or intense sports activities and on physical examination, Lachman, anterior drawer test and pivot shift tests are positive (2). Individuals with ACL rupture can be classified as copers (able to resume pre-injury levels of activity without dynamic instability) and non-copers (present with episodes of dynamic instability inspite of progressive ACL rehabilitation program) based on functional abilities (3).

ACL injury affects the "Ligamento muscular protective reflex"

This is when tibia displaces anteriorly beyond the limit of physiologic strain when high forces are subjected to ACL, proprioceptive

tors in the ligament activate a protective hamstring contraction which will exert a posterior pull on the tibia and prevent it from getting subluxated anteriorly (4). Muscle-tendon forces can influence the load on ACL (5). ACL injured ligament may get excessively loaded by isolated contraction of the quadriceps muscle as well as excessive anterior tibial translation and internal tibial rotation in the absence of adequate coactivation of hamstring thus rendering ACL as a sole stabilizer and leading to further ligament strain. When hamstring contraction is added to quadriceps muscle contraction it reduces anterior translation and internal rotation thus decreasing the strain on ACL (6). An ACL injury may lead to loss of ACL innervation, motor control, and proprioception, thus significantly reducing the necessary stabilization provided by the hamstring muscle group. As the proprioception and dynamic balance is affected while performing functional tasks it needs to be addressed during rehabilitation. Hamstring plays a major role in maintaining stability in ACL deficient knee, thus rehabilitation program should be emphasized on hamstring co-activation. ACL rehabilitation protocols mainly focus on hamstring strengthening exercises but the techniques for facilitation of muscle activity is not emphasized.

In the acute phase after injury, the muscle needs to be facilitated before initiating strengthening and selective hamstrings muscle activation exercises like eccentric hip extension along with other eccentric exercises (7), knee flexion-based exercises, and Nordic hamstring exercise. Taping is one of the techniques used in rehabilitation which is purported to produce facilitation and inhibition of muscle activity: it helps in joint repositioning, injury prevention, and improve proprioception (8). Dr. Kase proposed that muscle function is facilitated with a proximal-to-distal taping application. Hamstring facilitatory taping is a technique in which stretch tape applied along the line of muscle, from origin to insertion is used for the facilitation of muscle activity with minimal or no risks. The tape is applied to the patients' hamstring muscle group, in the standing position with trunk flexion to get initial flexion of the hip and stretch the hamstring muscle prior to application of tape (9). Taping is proposed to be used for the facilitation of muscle but there are no studies using objective measures like EMG recording, available in taping used for hamstring facilitation alone in ACL deficient knee. An athletic or rigid tape has been used till now for stabilizing ACL injured knee but the role of hamstring muscle facilitatory taping methods is not well established in ACL deficient knee.

ACL deficiency often results in dynamic balance deficits. Dynamic balance is evaluated clinically using Star excursion balance test (SEBT) which has an excellent inter-rater (0.88) and intra-rater (0.90) reliability for the anterior, posteromedial and posterolateral directions respectively. SEBT is widely used in literature for assessing proprioception and dynamic balance in lower extremity injuries like ACL injury or reconstruction (10, 11) and chronic ankle instability (12). Previous research demonstrates that dynamic stability can be improved early with neuromuscular and strength training program following an ACL rupture (3). However, there is a need to explore the influence of hamstring facilitatory taping in improving EMG muscle activation of quadriceps and hamstring and dynamic balance using Star Excursion Balance test in patients having an ACL deficient knee.

MATERIALS AND METHODS

Study design

The feasibility study with a pre/post-experimental study design sought approval by the Institutional Ethics Committee (IEC 97/2018) and Research committee, Manipal Academy of Higher Education, Manipal. University's guidelines and the amended Declaration of Helsinki on human experiments were followed for all the experimental procedures in this study (13). Purposive sampling was used for participant recruitment.

Participants

This feasibility study included 20 participants who were patients referred to physiotherapy department for rehabilitation with complete or partial ACL tear diagnosed on the basis of MRI with or without complaints of instability and Anterior drawer, Lachman or pivot shift test positive. Participants of either gender more than 18 years of age were included in the study during the period of conservative management, once the patients attained full weight bearing status at approximately 6 to 8 weeks after an ACL injury. The exclusion criteria were as follows: patients who had undergone ACL reconstruction, patients with bilateral ACL deficient knee, and the presence of other associated knee ligament injuries limiting the weight bearing status of the patient and complains of any other Neuromusculoskeletal disorders affecting the proprioception. The study procedure was explained and acquired a written informed consent from the participants. Participant recruitment was conducted in the clinical setting of Orthopedic Physiotherapy department in an academic hospital setting of Kasturba Hospital, Manipal.

Randomization

The experiment sequences were randomized using a chit method to minimize the learning effect of the test proce-

dure. In sequence A, outcome measures were assessed without taping condition first then with tape condition. In sequence B, outcome measures were assessed with taping condition first then without tape condition. The sequence was decided according to the chit picked by the participants.

Intervention

The subject was instructed to shave the thigh 24 hours prior to the tape application on the affected leg. The integrity of skin was assessed and skin was cleaned with alcohol rub just before taping. The patient was in standing position with initial complete trunk and hip flexion to stretch the hamstring muscle prior to tape application, then Mueller Kinesio tape was applied with 35- 50% tension from the ischial tuberosity till the insertion of lateral and medial hamstrings (Y pattern) along the line of the Biceps femoris and Semitendinosus muscles separately. A single session of hamstring facilitatory taping was performed and the tape was kept for approximately 30-40 mins. EMG muscle activation of biceps femoris, semitendinosus, vastus medialis, vastus lateralis muscles and dynamic balance using Star Excursion Balance test was assessed 30 mins before taping and immediately after taping. The tape was removed using the rollover skin method. The skin was assessed for any signs of allergic responses; none of the participants in this study reported any side effects after taping.

Outcome measures

Surface EMG amplitude of hamstring and quadriceps muscle activity and Star Excursion Balance Test (SEBT) were the outcome measures which the investigator measured with and without taping, on the same day before and after a washout period of 30 minutes given between the two conditions.

Surface Electromyography (EMG) recording

After preparing the skin, surface (Trigno wireless EMG sensors (made up of 99% Silver, rectangular shaped, sized 27 × 37 × 17 mm with inter-electrode distance 10 mm)) sensors were placed over muscle bellies of semitendinosis, biceps femoris, vastus medialis and vastus lateral muscles following the Seniam guidelines (14). The sensors were placed on the skin and attached using Delsys adhesive sensor interface. Wireless EMG signals at 0-500Hz, pre-amplified (0-1.5 mV) were captured using a Delsys, Trigno wireless EMG system (8 channel) ADI instruments, USA. EMG activity of hamstring (biceps femoris and semitendinosus) and quadriceps (vastus lateralis and medialis) was recorded on affected leg using surface electromyography (EMG) in terms of amplitude at rest, during walking, stair climbing up and down, single leg hopping front and back with a rest period of 1 minute between the activities. After this, a washout period of 30 mins was given for all the participants. EMG raw data was imported to "EMG lab chart version 8.1.13 software (2018) and data extraction was done, mean RMS values were retrieved and this data was transferred to excel worksheet for data analysis. Surface EMG measurement from single site muscle is moderate to high (0.66 -0.89) measured in terms of MVC.

Star Excursion Balance Test (SEBT)

Dynamic balance was assessed on the affected and unaffected leg using the Star excursion balance test wherein the participant assumes a single limb standing position and tries to reach as far as possible along each reaching line and touching only with the toes of the reaching limb lightly, without placing complete foot or shifting weight onto the reaching limb, and then he or she returns the reaching limb back to the center of the grid which is the starting position and resumes a bilateral stance. Three trials were taken to minimize errors and the average of 3 trials was taken as the final reach distance measured in centimeters (15). Dynamic balance was reassessed using the Star excursion balance test on the affected and unaffected leg with and without taping. SEBT is a valid tool to measure dynamic balance with moderate to high intratester reliability (0.78-0.96) and intertester reliability (0.81-0.93) after 1 day of practice. However, these test results are influenced by practice effect hence it is recommended to perform 3-7 practice trials in each direction before recording the actual reach distance. Interrater reliability is 0.94-0.99 (16).

Data analysis

Statistical Package for Social Sciences (SPSS) version 16 was used for data analysis. Descriptive statistics used for demographic characteristics. Shapiro-Wilk test was done to check for normality distribution of the data. Data were not normally distributed thus Wilcoxon Signed Rank test (Non-parametric) was used to compare the outcomes on affected as well as the normal leg. Level of significance set as, P-value ≤ 0.05

RESULTS

Totally 85 participants screening was conducted based on the inclusion and exclusion criteria; out of which 20 partic-

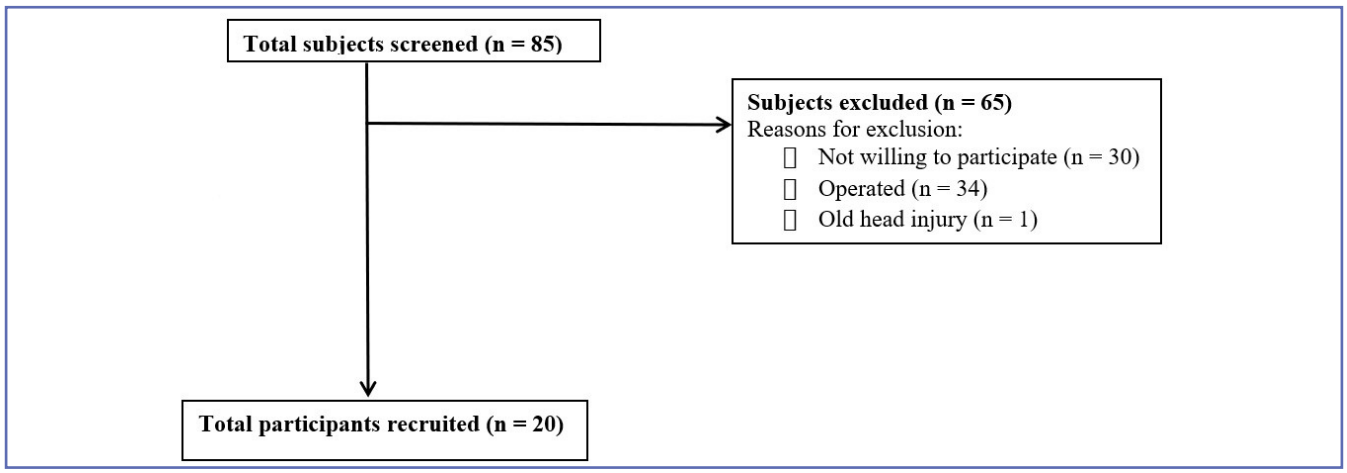

Figure 1. Flow diagram of study.

Table I. Participants' demographic characteristics.

Characteristics	Mean ± SD
Age in years	31.1 ± 13.7 years
Gender	Males: 18 (80%) Females: 2 (20%)
Height in centimeters	172.5 ± 8.04 cm
Weight in kilograms	76.6 ± 10.8 kg
Limb length in centimeters	93.10 ± 6.7 cm
Side of injury	Right ACL tear = 11 Left ACL tear = 9
Diagnosis	Complete ACL tear = 13 Partial ACL tear = 7
Duration from the time of injury	8.5 ± 13.2 months
Rehabilitation status	Receiving rehabilitation: 16 Not started rehabilitation: 4

SD: Standard Deviation; cm: centimeters; kg: kilograms.

ipants fulfilled the requirements of the inclusion criteria and were recruited for this study. The study flowchart is shown in **figure 1**. Participants' baseline demographic characteristics are shown in **table I**.

Results for comparison of quadriceps and hamstring muscle amplitude with and without taping are demonstrated in **figures 2-5**. An evident change from baseline is observed in outcomes and there was a statistically significant decrease in muscle amplitude of Biceps femoris and vastus lateralis muscles during walking, stair climbing and hopping back with taping. The comparison between SEBT scores with and without taping is shown in **figure 6**. There was no statistically significant improvement in SEBT reach distance scores with taping.

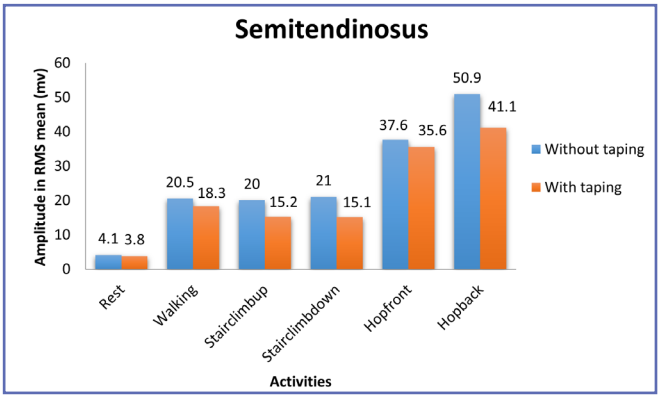

Figure 2. Comparison of Amplitude of Semitendinosus muscle with and without taping during different activities.

There was no significant difference in Semitendinosus muscle activation with taping during all the activities.

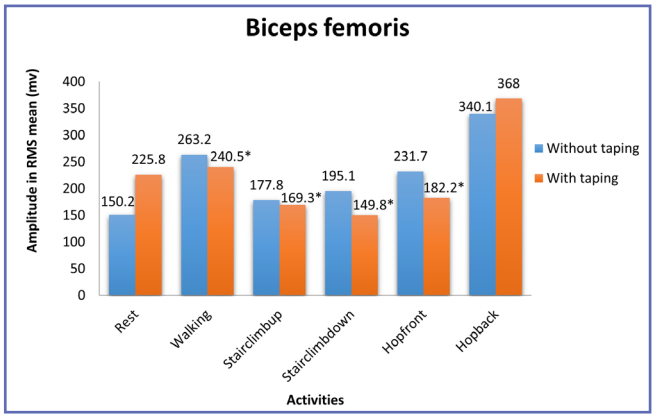

Figure 3. Comparison of Amplitude of Biceps femoris muscle with and without taping during different activities.

*P-value < 0.05; there was a significant decrease in Biceps femoris muscle activation with tape during walking, stair climbing up and down and Hopping front.

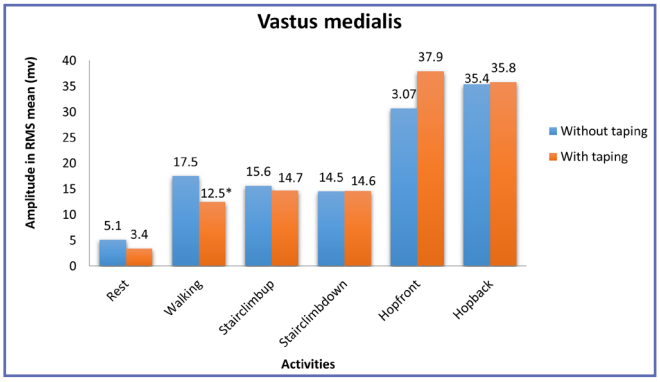

Figure 4. Comparison of Amplitude of Vastus medialis muscle with and without taping during different activities.

*P-value < 0.05; there was a significant decrease in vastus medialis muscle activation during walking. There is an increase in muscle activation while hopping front which is not statistically significant.

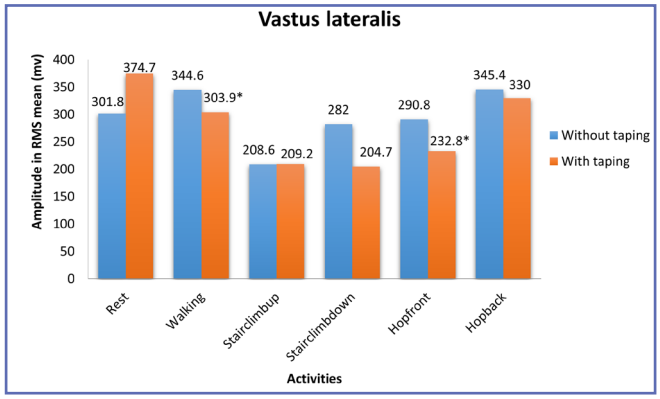

Figure 5. Comparison of Amplitude of Vastus lateralis muscle with and without taping during different activities.

*P-value < 0.05; there was a statistically significant decrease in vastus lateralis muscle activation during walking and hopping front.

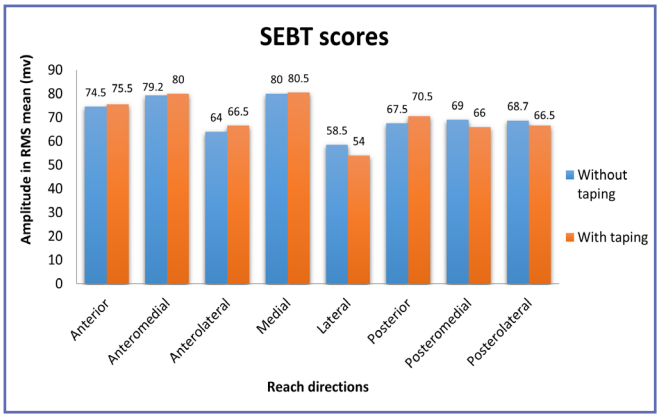

Figure 6. Comparison of Star excursion balance test scores (SEBT) with and without taping.

There was no statistically significant difference in SEBT scores with taping.

DISCUSSION

This study aimed to determine the influence of hamstring facilitatory taping on hamstring and quadriceps muscle activity and dynamic balance in functional tasks.

Statement of principal finding

Results of this study were contrary to the hypothesis, it was found that there was a decrease in amplitude of muscle activation observed rather than increase and no additional improvement of muscle activation was found with hamstring facilitatory taping. This is in line with the studies which used Kase's proximal to a distal application of KT and did not any find strength gains, however these studies did not evaluate the EMG muscle activation. A similar study also found no improvement in neuromuscular performance with quadriceps taping after reconstruction of ACL (17). However, in the present study, it was also observed that biceps femoris and vastus lateralis muscle activity was increased at rest and while hopping back whereas vastus medialis activity had increased during the hopping front and back activity with taping but there was no statistically significant difference.

Strengths and weaknesses

The possible reasons for the study results could be the technique of taping used in this study was applied with muscle stretch and 35-50% stretch according to Kase's technique (18) the tension in the tape which could have been insufficient to produce greater muscle activation. According to the International Association of taping, 2011 it was stated that 50-75% tension resulted in muscle facilitation, which needs to be

confirmed with further studies (19). Previous studies revealed that KT would not be strong enough to shorten the muscle spindle and thus stated that the mechanism of muscle activation by kinesiology taping is due to the stimulation of the cutaneous receptor. Taping activated deep (type IV) cutaneous receptors which reduced the Ia presynaptic inhibition and postsynaptic inhibition of cutaneous and fascial receptors (20). There could be a possibility that the individuals might have used certain compensatory strategies like reduced gait speed or altered gait pattern while walking, increased hip and trunk flexion as well as knee flexion during stair climbing by activating other groups of muscle like gastrocnemius instead of the hamstring. However, it cannot be confirmed by this study as the kinematic analysis was not done for the participants during the procedure.

Another factor to consider is the duration of muscle taping. In this study, taping intervention was done for an average duration of 30 minutes for all participants. A similar preliminary study states that there is a maximal increase in motor units participation of a muscle after Kinesio taping intervention of twenty-four hours (21).

Also, the participants with ACL deficient knee in this study were already receiving physiotherapy rehabilitation exercises, as a result of this the amplitude of muscle activation at the time of recruitment in this study or before taping intervention would have been higher than expected. Taping being a passive intervention might have been insufficient in producing greater activation as compared to active exercises.

The present study found that there was no significant difference in dynamic balance with hamstring facilitatory taping. A study by Kase (18) hypothesized that KT could improve balance by improving muscle function as well as motor control. However, there is no evidence supporting the hypothesis that KT affects balance. The possible reason for no improvement in dynamic balance in this study could be because of no improvement seen in muscle activation with KT.

Limitations

There was heterogeneity among the participants in terms of duration of ACL deficiency which ranged from 2 months up to 3 years, duration for which the participants were involved in active rehabilitation which ranged from less than 1 week to a few months, the type of ACL injury (complete and partial) among participants was different and period between taping intervention and initiation of active rehabilitation could not be standardized. Although the participants of the study comprised of individuals with both partial and complete ACL tear who fulfilled the criteria for ACL deficiency, this would have indirectly influenced the effect of taping as a result of the different rate of recovery and individual compensatory mechanisms in both groups respectively. However the aim of the current study was to observe the immediate pre/post effect of hamstring facilitatory taping on ACL deficient knee alone irrespective of the other types of rehabilitation thus reducing the source of bias.

Implications for future research

As hamstring facilitatory taping was not found to be beneficial in improving muscle activation as opposed to our hypothesis, other forms of active interventions like exercises could be used to improve muscle facilitation rather than Kinesio taping. Different taping technique and duration of application may be considered in future studies.

CONCLUSIONS

This study has shown that a single session of hamstring facilitatory taping did not cause an immediate improvement in muscle activation and dynamic balance.

FUNDINGS

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DATA AVAILABILITY

Data will be available with corresponding author and will be provided on request.

CONTRIBUTIONS

BK, PS, GB: conceptualization, design, implementation of the study, and manuscript preparation. BK: data collection. PS: data analysis and interpretation of data. GB: revision of the manuscript and guarantor of the study.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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