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Does KinesioTape application to thigh muscles affect muscle strength, proprioception and jumping on the following days?

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Abstract. The purpose of this study was to examine the effect of KinesioTape (KT) application to quadriceps and hamstring muscle on healthy subjects. Range of motion, muscle strength of the lower limbs, jumping distances and heights, and proprioception were evaluated. *Material and Method*. 20 subjects were enrolled in this study. Subject were older than 18 years of age and none of the subjects have a known prior lower extremity injuries. Measurements were done without KT application, immediately after KT application, 24 hours after the KT application and 5 days after the KT application. Isokinetic testing results, proprioceptive measurement results, balance testing results, jumping results and range of motion results were evaluated. *Results*. In this study 5 days after the KT application results' of initial peak torque and total work done by flexors were statistically significantly better than measurements without KT application, immediately after KT application and 24 hours after the KT application results. Active and passive flexion range of motion results also have shown improvements. There were no differences between jumping height, jumping distance, balance and proprioceptive measurements. *Conclusions*. KT application in different techniques can have positive or negative effects on muscle performance. According to current literature and result of our study those affects are negligible.
Key words**:** *KinesioTape, isokinetic dynamometer, jumping tests, proprioception, range of motion.*

Introduction

Physically active individuals, whether they are professional or amateur, engage in sports are constantly looking for ways to improve their muscular performances. KinesioTape (KT) application is one of the way. KT application is quite popular nowadays. It is advocated that KT application have therapeutic effects like relieving pain, increasing the muscle strength and improving the functional outcomes (1).

KinesioTape and KinesioTape application methods were introduced by Kase at 1973 (1,2). KinesioTape can lengthen up 75% more to its original length. Tension and application direction of the KinesioTape affects the KinesioTape's effects. KinesioTape can be used for both muscle facilitation and inhibition (2).

To assess the effects of the KinesioTape application, functional tests were need to be done. Functional evaluations can be done by muscle strength tests, jump tests, agility tests, balance-coordination tests and proprioception tests (3,4).

In literature, there were studies that evaluated the KinesioTape applications' functional effects. However those results are contradictory (4). And at the same time, there was not enough test for evaluation of the balance.

In this study, we want to evaluate the effects of KT application at range of motion of the knee, muscle strength, jumping distances' and heights', and proprioception in healthy subjects' dominant lower limb.

Material and Method

The study was approved by Süleyman Demirel University Faculty of Medicine's Ethics Committee by decision No. 83, dated 06.04.2014.

20 subjects who were over 18 years old and with no exclusion criteria were enrolled into the study. Exclusion criteria were; severe pain, acute injury of the muscles-tendons, incompatible subjects to tests, major effusions, range of motion limitations, orthopedic injuries of the lower extremities, known allergic reactions to KT application and systemic diseases that were not allowing to test at isokinetic systems.

Demographical data were recorded, body weights were measured with a balance beam scale and heights were measured with stadiometer (SECA 700, Germany). Body mass index is measured by dividing the body mass by the square of the body height (5). Body composition were determined by bioelectrical impedance method (Tanita Body Composition Analyser; TBF 300,Tokyo, Japan). Tegner activity level was recorded to determine the activity levels of the subjects (6).
Measurements were done without KinesioTape application, immediately after KT application, 24 hours after the KT application and 5 days after the KT application. Isokinetic testing measurements results, proprioceptive measurement results, balance testing results, jumping results and range of motion results were evaluated. A draw was made to eliminate the positive effect of adaptation to the measurements and KT applications were randomized.
For measurements that were done 24 hours later, KT applied for 24 hours and then test were done; and measurements that were done 5 days later, KT applied for 5days and then tests were done. 7 day rest were given for each test sessions.
Taping Methods
Quadriceps Femoris Taping. Subjects were lying in supine position. Starting point for KT application was spina iliaca anterior inferior. KT applied to starting point with no tension. Then KT applied with tension toward patella. After reaching the upper corner of the patella KT divided in shape to 'y'. Then tail of ther KT's were applied around the patella towards the end point, tibial tuberosity (Image 1).
Hamstring Application. KT application for hamstrings were done when patients were at prone position. Starting point for hamstring application was ischial tuberosity.
KT applied to starting point with no tension. Then patients lean forward to lenghten the hamstring muscles. Then KT was applied with tension through hamstring to the medial tibial condyle with no tension. For lateral hamstring application same taping method applied but this time ending point was through the head of fibulae (Image 2). KT applications were done by a Medical Doctor who has the KT application certificate.

Image 2. Hamstring application.

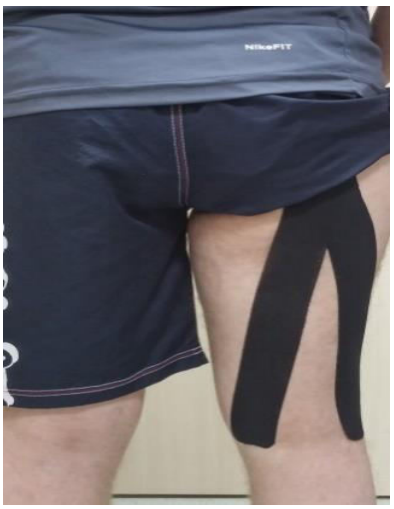

Image 1. Quadriceps femoris application.

Functional Tests
Functional tests were started with range of motion (ROM) measurements. Active and passive knee extension and flexion measurements were done with a goniometer (Baseline Stainless Steel Goniometer,USA).
Then multiaxial proprioceptive evaluations were done (Prokin PK252, Tecnobody, Bergamo, Italy) (Image 3). Protocol consists of two phases; training and testing. Trainig phase were done to teach participants to multiaxial proprioceptive system. At this phase vertical, horizontal and oblique lines followed by participants at computer screen while moving the mobile foot board for 120 seconds for each line. Between each exercises subjects were allowed to rest for 5 minutes. At evaluation phase, subjects were asked to follow a circular path on computer. It was told to subject that tract must be routed for 5 times and with minimals errors, as fast as possible.

To follow the tract perfectly subject must tilt the foot board at 7.5 degree at all ways. Resistance applied to subjects were 20% of the subjects' weight (7). Subjects' dominant foot was on the mobile board during the test. Subjects non-dominant foot was allowed to touch the ground and both hands of the subjects were allowed to grisps the supports.

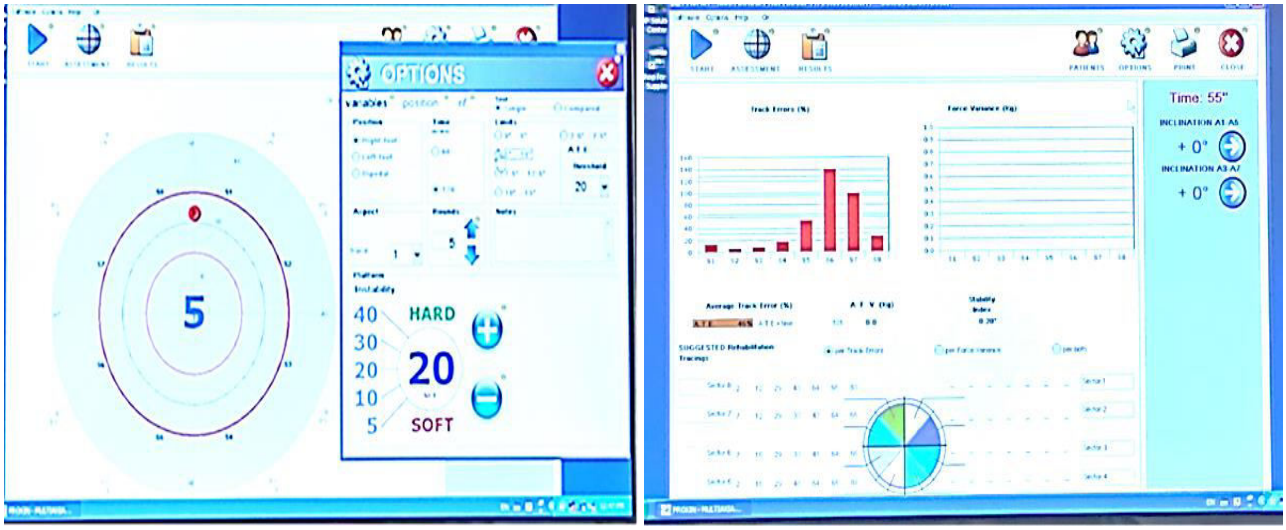

Image 3. Multiaxial proprioceptive evaluation, path and a result.

After multiaxial proprioceptive evaluation, subjects were allowed to rest for 5 minutes to evaluate the explosive power, jump tests were done. One leg hop test and vertical jump tests (hands free, squat jump and counter-movement jump) were performed. One leg hop tests were done at dominant lower extremity. Vertical hands free jump tests were done when hands were allowed to move freely. Weight-beared equally at both lower extremities and foots are width open. The participant placed the highest mark on the board during the jump. Distances between the highest marked point on starting position and the highest point during jumps were evaluated with a tape measure and recorded. For squat jump and counter movement jump measurements, vertical jumpmeter is used (TKK 5406, Takei, Japan) (8). All jump tests were done 3 times and best jump results were noted for evaluation. For each jumping, 2 minutes breaks were given to rest.
After the jump tests were over, knee proprioception tests were done via isokinetic dynamometer (HUMAC® NORM™ Testing & Rehabilitation System Model 770, USA). Both active and passive joint position sensation tests were done while eyes of the subjects were closed. For active reposition, subjects were asked to move the bar of the dynamometer actively to reach the point given just earlier the testing. For passive sense of joint position isokinetic dynamometer was moving continous passive movement (CPM) at 1˚/s angular velociy. 30º, 45º and 75º were selected and patients were asked to find these points. Tests were done for 5 times and mean of the absolute error values were evaluated. (9,10).
After the proprioception evaluations were done, isokinetic testings were done for muscle strength evaluation. Submaximal warm-up excercises at cycle ergometer done for 10 minutes and 5 minutes dynamic strechting exercises were done. All tests were done at the dominant lower extremity of the subjects. Range of motion for the tests were 0º extension and 90º flexion**.** Isokinetic tests were done at concentric/concentric mode at 60°/s and 240°/s angular velocities. For 60° angular velocity, 2 submaximal repetition were done for adaptation to dynamometer and 5 maximal repetitions were done for testing. After 60 seconds rest, at 240° angular velocity, 4 submaximal repetitions for adaption to dynamometer and 15 maximal repetitions for testing were done. All results were evaluated as Newton.meter. Subjects were motivated verbally during the tests. (11)
Statistical Evaluation. Statistical datas were evlautaed by NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) package programme. $p<0.05$ was statistical significancy. In the evaluation of the data, descriptive statistical methods (mean, standard deviation) as well as one way ANOVA tests that were compared in the comparison of normal distrubiton variables were used. Newman Keuls multiple comparison test was used for subgroup comparisons and Friedman test was used for comparison of variables not showing normal distrubition.

Results

20 subjects (10 male, 10 female) were enrolled into this study. Mean age of the subjects were 22.8±2.8 year, mean height was 169.7 ± 9.1 cm; mean body weight was 62.9 ± 16.1 kg; mean BMI was 21.6 ± 3.9 kg/m^2 and mean fat percentage was 18.1%± 8.7. Tegner activity level of the subjects was 5.1 ± 0.8.

Results of the ROM evaluations were statistically significant better at passive and active flexion only ($p<0.05$).

Passive flexion at 5 days after the KT application results were statistically significant better than without KT application and 24 hours after the KT application ($p<0.05$). Immediately after KT application results were statistically significant better than without KT application results ($p<0.05$). There were no differences between other ROM results at passive flexion ($p>0.05$) (Table 1-2).

Active flexion without KT application results were statistically significant lower than immediately after KT application results and 5 days after the KT application results ($p<0.05$). There were no differences between other ROM results at active flexion ($p>0.05$) (Table 1-2).

Table 1. Evaluation of the ROM results

	Without KT	Immediately KT	1st day	5th day	p
Passive Flex (°)	144.9±7.3	146.3±7.6	145±5.9	146.6±6.6	**0.035***
Active Flex (°)	133.5±7.6	134.7±7.6	134.6±7.2	135.3±7.1	**0.044***
Passive Ext (°)	-2.1±2.4	-2±1.4	-1.9±2.6	-2±2.8	0.986
Active Ext (°)	0±0	0±0	0±0	0±0	

ROM: Range of Motion, KT: KinesioTape, Flex: Flexion, Ext: Extension. Paired one-way ANOVA.
* $p < 0.05$

Table 2. Evaluation of the active and passive flexion ROM results

	Passive Flex	Active Flex
Without KT / Immediately KT	**0.023***	**0.022***
Without KT / 1st day	0.950	0.210
Without KT/ 5th day	**0.037***	**0.011***
Immediately KT/ 1st day	0.097	0.847
Immediately KT / 5th day	0.671	0.494
1st day / 5th day	**0.048***	0.430

ROM: Range of Motion, KT: KinesioTape, Flex: Flexion Newman Keuls Multiple Comparisons Test.
* $p < 0.05$

There were no statistically significant differences shown at multiaxial proprioceptive evaluation, jumping height and distance's results (Table 3) and active and passive proprioception results (Table 4).

Table 3. Evaluation of multiaxial proprioceptive test results and jump tests results

	Without KT	Immediately KT	1st day	5th day	p
ATE	82.1±34	80.6±38.5	82.3±38.4	78.5±37.2	0.831
TTE (s)	51.1±26.7	49.2±25.6	52.8±24.1	47.4±17.9	0.752
SJ (cm)	29.4±6.5	30.5±6.8	30.4±7.3	30.2±7.2	0.116
CMJ (cm)	34.5±6.7	35.4±7,3	35.1±7.6	34.9±8.1	0.262
FJ (cm)	38.2±9.2	38,1±9.6	38.4±9.5	38.8±10.2	0.620
OLHT (cm)	123.8±27.7	127.7±27.1	128.1±28.4	128.3±29.1	0.103

KT: KinesioTape, ATE: Average Tracking Error, TTE: Time to execute test, s: second. SJ: Squat Jump, CMJ: Counter Movement Jump, FJ: Free Jump, OLHT: One legged hop test, cm: centimeter. Paired one-way ANOVA

Table 4. Evaluation of the active and passive proprioception results

	Without KT	Immediately KT	1st day	5th day	p
Active Prop 30º	3.3±2.1	2.3±1.1	2.3±1.3	2.2±1.5	0.088
Active Prop45º	3.7±2.9	3.3±3	2.7±1.9	2.6±1.8	0.163
Active Prop 75º	2.7±1.5	2.3±1.2	2.2±0.8	1.9±0.9	0.319
Passive Prop 30º	2.7±2.2	2.1±1.3	2.1±1.2	1.7±0.7	0.903
Passive Prop45º	2.1±1.3	1.8±1.2	1.9±1	1.9±1.1	0.766
Passive Prop75º	2.1±1.5	1.7±0.9	1.7±0.9	1.2±0.8	0.143

KT: KinesioTape, Prop: Proprioception. Friedman Test

Isokinetic testing results showed that flexor peak torque and total work done at high angular velocity results showed statistically significant differences ($p<0.05$). 5 days after the KT application results were statistically significant better than without KT application, immediately after KT application and 24 hours after the KT application results for flexor peak torque values at high angular velocity ($p<0.05$). No differences were found between other groups ($p>0.05$) (table 6).
Flexor total work done 5 days after the KT application results were statistically significant better than without KT application, immediately after KT application and 24 hours after the KT application results ($p<0.05$). No differences were found between other groups ($p>0.05$). All isokinetic data were shown at table 5 and 6.

Table 5. Extension and flexion PT values, fatigue index and work done results

	Without KT	Immediately KT	1st day	5th day	p
Ext PT(Nm) @60°/s	156,4±58	150,2±53,2	151,6±52,1	154,3±56,9	0,235
Ext PT (Nm)@240°/s	85,6±30,2	87,2±31,7	87±30,6	90,4±33,9	0,159
Flex PT (Nm)@60°/s	91,8±35,5	91,8±37,8	92,2±34,03	93,6±29,3	0,917
Flex PT (Nm) @240°/s	58,2±18	55,3±18,7	58,1±18,7	61,5±17,7	**0,003***
Ext FI @240°/s	21,9±8,6	21,8±8,5	21,9±9,7	23,7±9,7	0,851
Flex FI @240°/s	24,3±14,2	21,5±11,6	25±10,9	24,6±12,2	0,631
Ext WD (Nm) @240°/s	1179,2±400,2	1217,3±394,2	1208,2±419,1	1256,1±472,2	0,184
Flex WD (Nm) @240°/s	711,8±220,1	705,7±254,5	718,7±249,8	783,4±203,3	**0,007***

KT: KinesioTape, Flex: Flexion, Ext: Extension, PT: Peak Torque, FI: Fatigue index, WD: Work Done, Nm: Newton meter. Paired one-way ANOVA. * $p < 0.05$

Table 6. Evaluation of the isokinetic flexor peak torque and work done at high angular velocity results

	Peak Torque	Work Done
Without KT / Immediately KT	0.102	0.807
Without KT / 1st day	0.943	0.733
Without KT/ 5th day	**0.015***	**0.01***
Immediately KT/ 1st day	0,099	0.539
Immediately KT / 5th day	**0.003***	**0.011***
1st day / 5th day	**0.047***	**0.019***

KT: KinesioTape, Newman K Multiple Comparisons Test. * $p < 0.05$

Discussion and Conclusion

The purpose of this study was to examine the effects of KinesioTape (KT) application to quadriceps and hamstrings muscles on healthy subjects. Range of motion limits, muscle strength of the lower limbs, jumping distances and heights and proprioception were evaluated.

There were statistically significant differences found at active and passive knee flexion ROM, and isokinetic testing results were showed flexor peak torque and total work done statistically significant improved at high angular velocity.

KT has improved its popularity last years. It is believed that it improves to muscle strength and lymphatic circulation, pain relieving effect with neurologic suppression and improves the proprioception via mechanoreceptors. (12-14). However studies show controversial results for those effects (4).

In this study KT application has shown beneficial effects at 5 days after the KT application at knee flexion ROM limits. At Hutcheon's study KT has been applied for 24 hours and there was no beneficial effect on knee ROM was shown (15). Williams et. all's meta-analysis shows there may be minimal effects to injury site ROM and strength. However there were no improvements shown for pain relief, ankle proprioception. At this meta-analysis 2 of 8 study show improvement for pain relief, 16 of 72 study shows improvement at ROM, 6 of 16 studies show improvement at strength and 2 of 4 study show improvement at proprioception (4).

Varcelli et all's one leg hop test and 3 hop jump test result (16) and De Almeida et all's one leg hop test and 3 hop jump test result (17), Kümmel et.all's CMJ test result (18), Hoyo et.all's CMJ test results and Arhab et all's SJ and CMJ test results shows neither a positive nor a negative effect on jumping distances with KT applications. The literature we investigated, there was only Aktaş and Baltaci's study's show beneficial effect on jumps. For male participants dominant lower extremity and for female participants non-dominant lower extremity one leg hop test results were improved but those improvement was not shown for vertical jump (3).

There was no effectiveness of KT application were shown at 30°, 45° and 75° target angles active and passive proprioception at isokinetic testing systems. Like our results, Hutcheon test results which were done at 17 healthy subjects KT applied to quadriceps muscle, without KT application, just after KT application and 24 hours later the application results' (15) and De Almeida et all's 45° active reposition results show no differences (10).

In our study, multiaxial proprioceptive measurements were done too (ProKin System). In the literature there was no study to evaluate effects of KT application to hamstring and quadriceps muscle for multiaxial proprioceptive measurement.

Isokinetic testing results in our study showed statistically significant differences at some parameters. KT application 5 days later results' showed differences between without KT application, just after KT application results and 24 hours later the KT application results for flexion peak torque and total work done by flexors.

Fu et al's study with 14 healthy participants showed no differences at isokinetic testing (CON/ECC @ 60°/s-@180°/s) between without KT, just after KT application and 12 hours after KT application to quadriceps muscle (1). Varcelli et all's study with 36 healthy subjects showed no differences at KT muscle activation application, muscle inhibition and pseudo tape application at quadriceps muscle (16). De Almeida et all's study with 60 healthy subjects showed no differences neither concentric peak torque nor eccentric peak torque just after KT application (17). Arhab et all's study with 52 healthy subject's showed no differences between KT activation, KT inhibition and non-elastic tape application (20).

Aktas and Baltaci's study with 20 healthy subjects at high angular velocity (@180°/s)'s results for just after KT application showed significant results for quadriceps application However for slow angular velocity results does not show improvement like our study. (3). Kim and Lee's study for riders without KT and just after KT application results showed improvement at peak torque results and total work done results at both flexion and extension at both high and low angular velocity results(21). Vithoulka et all's study at 20 healthy women results at concentric/eccentric mode at both high and low angular velocity results showed no differences at both hamstring and quadriceps peak torque results. However at concentric/eccentric mode for quadriceps muscle at low angular velocity results at eccentric mode shows statistically significant improvement (22).

Csapa and Alegre's meta-analysis for KT application to healthy subjects' skeletal muscles shows there were no or negligible results (23).

It is believed that KT application is effective in two ways theoretically. KT application increases the blood flow to application area and this blood flow improves myofascia's functions. The other theory is the activation of cutaneous mechanoreceptors via KT application (3).

Results of our study shows ROM and muscle strength improvement at flexion which supports the theories. However none of the theories explain why there was no improvement at extension.

As a result of this study, KT application to thigh muscles has no effects on dynamic balance, jumping distances and active and passive proprioception. However there were ROM improvement at flexion and high angular velocity isokinetic testing results with application time. Different techniques and application to thigh muscles may have some positive or negative effects. However our results and literature investigated shows those results are negligible.

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