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Research article

Effect of Kinesiotape Application on Knee Joint on Gait Kinematics in High Heels

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Abstract: Today, millions of women wear high-heeled shoes daily, and although it has been suggested that the use of high-heeled (HH) shoes leads to an increased incidence of osteoarthritis, back pain, and deterioration of posture. The study aimed to investigate the kinetic and kinematic analysis in the lower extremities while walking on high-heeled shoes and compared kinesiotape application on knee joints with HH shoes. Methods: A three-dimensional quantitative gait evaluation was performed without tape and with wear HH shoes, with kinesio taping application on the knee. Twenty-four healthy females (age, 21.6 ± 0.7 years; height, 1.64 ± 4.2 cm; body mass, 57 ± 3.9 kg) participated in the study. Spatiotemporal parameters cadence and walking speed were significantly different among the trials. Results: Knee and hip joint sagittal plane range of motion were different with kinesin taping applications While knee joint total excursion (ROM) was 57,5±8.7 degrees with HH shoes, it was decreased to 54.05±5.8 tape application walking HH shoes. Knee external flexion moment during the early stance phase decreased significantly in kinesin taping with HH shoes. Conclusion: These findings showed that Kinesio taping application on quadriceps femoris muscles affected the stance phase of the gait cycle and reduced knee joint flexion degree and knee flexion moments while walking with HH shoes. Tape application may be an option to reduce the negative effect of wearing high-heeled shoes on the knee while walking, or to reduce knee pain, to provide support for knee deformities.
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Keywords: High-Heel Shoes, Kinesiotape, Gait Analysis.

1. Introduction

Despite concerns about their harmful effects on gait and lower extremity function, social and fashion traditions encourage the continued use of high heels. Many studies have reported the possible harmful effects of wearing high-heeled shoes on the development of degenerative joint disease and posture [1-4]. Snow and Williams [4] found increases in the impact force, vertical, and anteroposterior GRF during high-heeled gait. Specifically, the impact force for 7.6 cm heels sharply increased compared with flat shoes. The high impact force would shock effect wave during heel strike, which is then transmitted up to joints and the musculoskeletal system, which may explain why leg and back pain complaints are common among high-heel wearers [5-7]. Higher heel heights increase slower self-selected walking speeds, shorter stride lengths [8-10], and greater knee flexion, plantar flexion, anterior pelvic tilt, and trunk extension [10-13]. Several studies found that the angle of knee flexion at the stance phase increased and the extensor moment with an increasing heel height [9,14-18]. Stefanyshyn et al. [17] indicated that increased muscle activation of the rectus femoris muscle to control this increased knee flexion, by increasing knee extensor moment. Simonsen et al. [16] found that knee extensor

moments in the stance phase were twice as high in the HH condition than without shoes. Ho& Blanchette [14] verified that the high-heeled shoes increase the stress of the patellofemoral joint due to the increased knee extensor moment. According to these authors, the changes would be related to the increased EMG activity of the extensor muscles of the knee, and the greater stress over the patellofemoral joint. Batista et al. [19] demonstrated the use of high-heeled shoes causing the increased VL activity in relation to VMO and decreased VMO: VL ratio suggests that the high heels are an aggravating factor for the muscular imbalance of the stabilizers of the patellofemoral joint in women with PFPS.

Previous studies reported that KT increases muscle activity, restricts the excessive movement of the joint and increases gait speed [20,21]. So, this study aimed to investigate, by using the gait analysis, the influence of kinesiotaping on the activity of the quadriceps femoris muscles during gait of high-heeled shoes in young women. Considering that high heels can cause changes in the kinetic and kinematics knee joint during gait, this study hypothesizes that this type of shoe can cause changes in the gait cycle, and kinesiotaping on rectus femoris muscles may affect knee joint kinetics and kinematics of gait.

2. Methods

Twenty-four young female adults volunteered for this study. They had not been affected by any major injury of the lower extremities, had no significant foot deformity or corns, never had any surgery, unreported neurologic conditions, pregnancy, knee joint injury or laxity, knee or hip joint muscle injuries, tendinitis, and overuse; patellofemoral pain syndrome; and pain on knee motion and willingly agreed to participate in this study. Average age, body weight, and height were 21.6 ± 0.7 years old, 57 ±3.9 kg, and 1.64 ± 4.2 cm, respectively. The subjects gave informed consent, and the study was approved by an institutional review board. This study was approved by the Ankara University Institutional Review Board and was conducted in accordance with the ethical principles of the Declaration of Helsinki.

All study participants reported wearing high-heeled shoes occasionally. To familiarize the subjects, they were asked to use high heel height type (HH) shoes one hour per day during the week before participating in the study. Women wore tight-fitting t-shirts and shorts for the data acquisition session and walked with high heel shoes and kinesiotaping with high heel shoes. HH shoes were 10 cm high, with a 1 x 2.5–2.5 x2.5-cm2-wide heel.

Y-shaped KT was applied the quadriceps of each subject, according to Kenso Kase's Kinesin taping manual, by the same physical therapist [22]. The tape was applied with no tension approximately 5 cm below the origin of the rectus femoris and with moderate tension (25%–50% of available tension) along the two tails. The remaining tape around the patella was unstretched (Figure 1).

A three-dimensional quantitative gait evaluation was performed in the Motion Analysis Laboratory at the Ankara University Department of Prosthetics and Orthotics using a Vicon Nexus system (Oxford Metrics, Oxford, UK) by the same experienced physiotherapist using six infrared JAI cameras at 250 Hz and one force plate (AMTI). The standard plug-in gait marker set was used to capture kinematic data: 16 reflective markers were placed on the anterior superior iliac spine, mid-lateral thigh, lateral knee joint, lateral shank, lateral malleolus, and the second metatarsal head, over the posterior calcaneus bilaterally, and on the posterior superior iliac spine. Force plates were embedded in the middle of a 10 m walkway. Cameras and force plates were calibrated before data collection. Subjects were walked two conditions, self-selected walking speed with HH shoes and then the application of KT with HH shoes.

Descriptive statistics were calculated for all data. Statistical analyses were performed using the SPSS version 23 software. The nonparametric Wilcoxon test was used to compare HH shoes measurements and measurements for the KT taping applications knee joint with HH shoes, respectively, within each subject. The statistical significance level was set at $p < 0.05$.

Figure 1. Application Kinesio tape

3. Results

Spatiotemporal parameters were significantly different among the trials (Table 1). Cadence and walking speed decreased with the KT application on the knee joint compared with the no tape condition only wear HH shoes ($p<0.05$). Kinematic data are displayed in Table 1. Sagittal plane knee joint kinematics were significantly different with KT applications, respectively, compared with the no tape condition (Figure 2). The degree of maximal knee flexion was significantly lower with the KT application than with no tape condition wearing only HH shoes. Knee joint sagittal plane total excursion (ROM) was significantly different with KT application with HH condition and decreased knee flexion/extension ROM with tape condition. While knee joint total excursion degree was 57,5±8.7 HH shoes, it was decreased to 54.05±5.8 tape application walking HH shoes. The degree of maximal knee extension was not different between the two conditions. Hip joint significantly increased the degree of maximal hip flexion and total excursion (ROM) in KT tape with HH condition, while not a significant degree of maximal hip extension between and two conditions. While hip joint total excursion degree was 45.9±4.7with HH shoes, it was increased to 47,3±5.07 tape application walking HH shoes. Sagittal plane Pelvic tilt total excursion was not significantly different between the two conditions. Kinetic data are displayed in Table 1. Knee external flexion moment during the early stance phase (KM1) decreased significantly with the tape HH condition ($p<0.05$) (Figure 3).

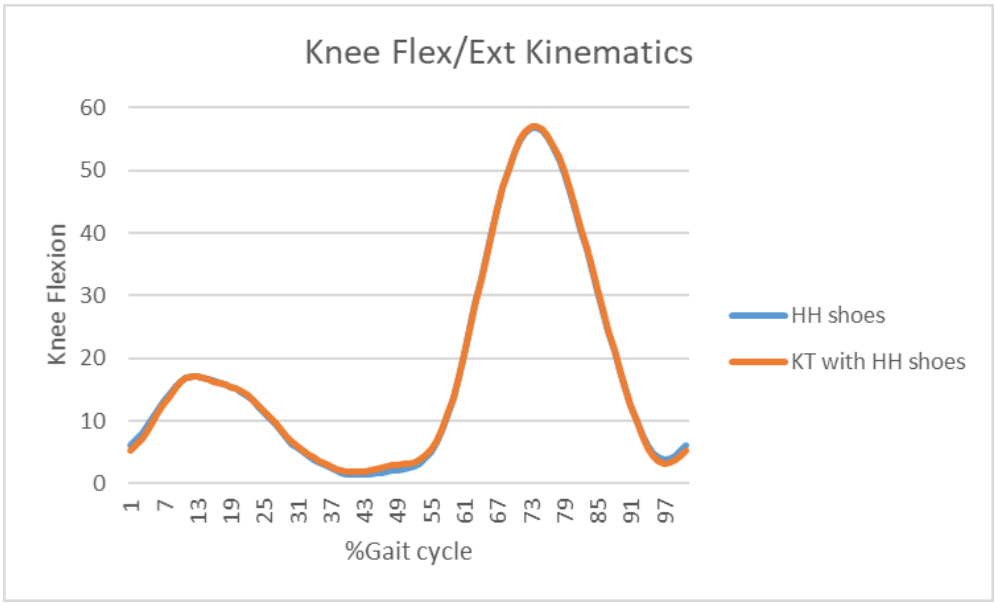

Figure 2.

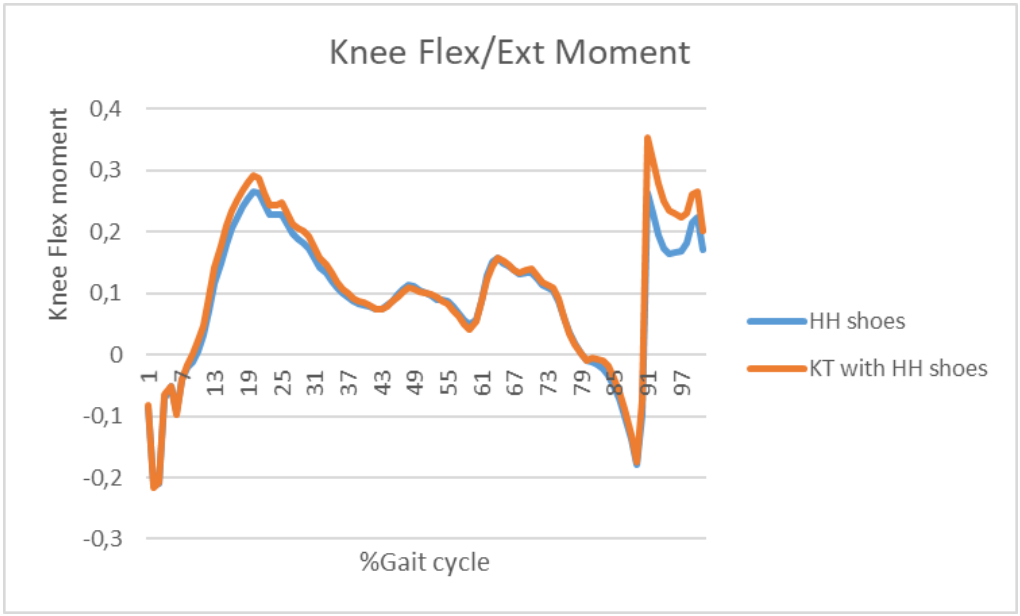

Figure 3.

Table 1. Comparison of the high heel-height and kinesiotape with high heel-height shoes spatiotemporal parameters, sagittal plane kinematic and kinetic parameters in young women.

Spatiotemporal Parameters	**High Heel Height Shoes**	**Kinesiotape with High Heel Height Shoes**	p
Cadence (steps/min)	103.2±7	99.37±7.3	.001*
Stride length (m)	1.12±0.16	1.12±0.12	0.32
Walking Speed (m/s)	0.97±0.2	0.93±0.14	.009*
Kinematic parameters Sagittal Plane			
Knee flexion/extension ROM (°)	57,5±8.7	54.05±5.8	.000*
Max knee flexion (°)	57.04±7.8	54.1±7.5	.000*
Max knee extension (°)	-0.42±7.7	0.13±8.2	.059
Hip flexion/extension ROM (°)	45.9±4.7	47,3±5.07	.039
Max hip flexion (°)	35.3±5.4	37.3±6.1	.002*
Max hip extension (°)	-10.5±5.2	-9.8±7.1	.252
Pelvic ROM(°)	4.7±1.09	4.5±1.5	.33
Kinetic Parameters			
KM1 (Knee flexion/ extension moment max stance phase) Nm/kg	0.315±0.33	0.168±0.32	.000*

*p<0.05

Cadence: The number of steps per minute, Step length: The distance along the line of progression from opposite foot contact to current foot contact, Walking speed: The speed of the current foot based on the stride time and stride length.

4. Discussion

Given the aforementioned importance of high heels for female gender identity and their widespread use as a fashion accessory, it seems difficult to imagine that many women have given up on these shoes altogether [23]. The lack of information about the impact of elastic therapeutic tape during walking with high heel height shoes in young women led us to conduct this research. Our objective was to determine whether the application of KT on quadriceps muscle affects walking with high-heeled shoes. Despite the problems described, insoles offer the opportunity to increase the wearing comfort of women who decide to wear high heels [24]. Alternative solutions can be worked on to prevent these problems from occurring, apart from the use of insoles, the effect of using elastic tape was investigated in this study. In our study results, while there was no statistically significant change in sagittal plane pelvic tilt movement, significant changes were found in the knee and hip kinematic values. While the total excursion value of the knee joint decreased, the total excursion value of the hip joint increased. Generally, the amount of knee flexion appears to increase with increasing heel height [25] and the duration of knee extensor moments has been found to increase [16,26]

In their review, Wiedemeijer and Otten [27] supposed that an increase in plantar flexion increases knee flexion. The knee must compensate for the loss of power production in the ankle joint by increasing power production. Simultaneously, increased knee flexion increases shock absorption, which is partially lost in the ankle joint. Increased knee flexion allows forefoot loading early, which improves balance and causes an anterior pelvic tilt, which in turn increases the lordosis and lumbar muscle activity. According to the results in our study, the application of kinesiotape to the knee joint during walking with high-heeled shoes may affect the knee flexion positively by reducing it, and it may create a reducing factor in the occurrence of deformity and pain, especially in the knee joint. With the application of facilitating tape on the quadriceps muscle, reduction in external knee flexion moment and knee flexion can be protective against injury and pain that may occur in this region. Our results, the increase in the angular value of hip joint flexion did not cause any change in the pelvic tilt movements. Cadence and walking speed decreased with KT application, this may have occurred because of decreased knee flexion degree.

Choi and Lee indicated that the application of kinesiology tape application to the rectus femoris, vastus medialis, and vastus lateralis of the quadriceps increased the muscle torque, regardless of the tape application direction [28]. Additionally, Lins et al. [29] evaluated the effects of KT on the activity of the vastus lateral, rectus femoris, and vastus medialis muscles in healthy women who exercise and found no significant effect. The difference between these results may be due to the different forms and tensions of the Kinesin tape application. Different Kinesio tape techniques can provide different tactile stimulation intensities [22]. In particular, KT applied to overstretched skin stimulates the cutaneous afferent nerve, engaging α-motor neurons that improve the performance of the quadriceps after muscle fatigued induction [30].

This study has several limitations. First, limitation in this study was the sample size, with a greater sample size we could get better results. Second, only the immediate effect of the kinesiology tape application was assessed, and a long-term effect was not evaluated. Thirdly, the study sample excluded those with weakened quadriceps muscles or muscle fatigue. Future research should improve on these limitations. In particular, additional research is needed in subjects with quadriceps muscle fatigue or weak muscle strength. The aims of the researchers were to, in addition to alternative solutions that will minimize the known negative effects of shoes on body posture in women who prefer to wear high-heeled shoes, shoe modification, use of insoles and tape use can be supportive during walking in women with knee pain, knee muscle weakness, and knee injury.

5. Conclusion

The application of kinesiology tape application to the quadriceps femoris decreased sagittal plane knee flexion degree and knee external flexion moment during gait with HH shoes. We believe that increasing quadriceps muscle strength can reduce gait and posture disorders that may be encountered with the use of high heels, and with this, use of kinesiotape may be a recommendation for women with knee injuries.

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