Does Kinesio Taping Functional Correction Technique Affect Walking Plantar Pressures?

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Abstract: The use of the Kinesio Taping (KT) method is widespread in sports, but current research on the ability of KT to alter foot biomechanics is limited. The aim of this study was to examine the acute effects of KT on walking plantar pressures. Kinesio Taping Functional Correction Technique was applied on the transverse arch of the foot. Twenty-two young healthy male adults, aged between 19 and 33 voluntarily participated in this study. Plantar pressures for three functional segments (forefoot, midfoot and hindfoot) were recorded during walking (with and without KT) by pedobarographic measurement using FDM 1.5 pressure measuring device. The results show that KT Functional Correction Technique has an effect in reducing walking plantar pressures. It was shown that maximal plantar pressures at the forefoot and hindfoot significantly ($P < 0.05$) decreased by 1.51 N/cm^2 and 0.9 N/cm^2 respectively, when KT was applied to the foot during walking. KT has the potential for primary and secondary prevention of pathological manifestations in the mentioned area, but also in the holistic postural context. Further research is needed to investigate clinical significance of KT.

1 INTRODUCTION

There are various kinematic and kinetic tasks of the ankles and feet, from contact with the ground and adaptation to different surfaces, through deceleration, shock absorbing, to propulsion necessary for bipedal locomotion. High forces are transmitted through the most distal segments of the lower extremities. The arches of the foot frequently participate in the absorption and distribution of forces (Houglum and Bertoti, 2012). In a normal foot the segments of the lateral arch at full contact with the load of the foot (closed kinetic chain) are always in contact with the ground, while in a normally aligned foot the medial arch is rather high. The third arch of the foot is transverse, extending from medial to lateral through the cuneiform bones to the cuboid bone. Together with the longitudinal arches, it enables efficient load absorption from the superior direction (body weight), but also from the inferior one (ground reaction forces). Along with the joint congruence of the middle part of the foot, the transverse arch is maintained by the intrinsic muscles. Biomechanical integrity of the foot is achieved through the alignment of bone and joint segments, stabilization of plantar ligaments, support of plantar fascia and by intrinsic and extrinsic muscles. These structures act together to absorb the ground reaction forces (Oatis, 2009).

Foot is functionally divided into three parts: hindfoot, midfoot and forefoot. Hindfoot includes talus and the first segment of contact with the ground at the initial stance phase in the gait cycle - calcaneus. Main midfoot function in the relationship between stability and mobility is transfer of closed kinetic chain movements and related forces through tarsometatarsal joints to the forefoot, a segment crucial for terminal stance and pre-swing which is generally extremely adaptable to ground contact through various forms of closed kinetic chain (Houglum and Bertoti, 2012). Weight distribution in the foot can affect the bearing line of the ankle, knee, and hip (Guner and Alsancak, 2020).

Pedobarography is a modern technology enabling the assessment of the locomotor system based on the

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plantar pressure distribution. Also, this technique is useful in the rehabilitation of various types of dysfunctions of body movement (Lorkowski and Gawronska, 2021). Therefore, in assessment of data about feet structure and function kinetic and kinematic pressure measurement devices (PMDs) are used (Gruić et al., 2015). PMDs measure plantar pressure distribution beneath the foot to quantify pressure distribution, pressure magnitude and progression of the centre-of-pressure (CoP) as the participant walks barefoot over a force plate embedded in a walkway (Jameson et al., 2008). In contrast to motion capturing systems, pedobarography can usually be completed in shorter time and requires less specialized expertise to be performed. Anyway, pedobarography is ideally used with motion capture type analysis to provide complementary information on foot dynamics. However, when foot posture is the primary area of interest, pedobarography may provide sufficient information to answer clinical questions (Mudge et al., 2020). In addition to clinical examination of the patient, in this manner we get very useful information about the state of foot and the type of load in certain phases of walking. Data collection must be standardized so that they can be analysed and follow the results for each patient, as well as compare them with certain standards. In diagnosis pedobarography is used in case of walk disorders after surgery of the hip and knee, stroke, or other neurological problems. It is important to highlight the clinical application of pedobarography in diabetology, sports medicine and treatment of foot deformities and rehabilitation (Skopljak et al., 2014). It is known that the plantar surface of the foot is the most common place for occurrence of foot ulcerations. During ordinary or sport activities the foot is exposed to high static and dynamic loading forces, which can lead to disharmony of muscle strength and load which lead to appearance of overuse injuries. Accordingly, there are many strategies to reduce the maximal pressure during walking through relief of total contact with insoles or specifically prescribed foot and ankle exercises (Choi et al., 2014). Kinesio Taping (KT) has gained popularity in the treatment of musculoskeletal pathologies (Griebert et al., 2016). Regarding the prevention and rehabilitation of ankle and foot dysfunction, this method has been widely used in sports in recent years (Aguilar et al., 2016).

KT is an active, not a passive method; according to Aktas and Baltaci (2011), Kinesio tape does not act as an immobilizer, but through the improvement of proprioception (de Oliveira et al., 2019) provides active support to the musculoskeletal system. Therefore, KT is significantly different from Athlet Taping (AT) or orthoses. According to Yen et al. (2018), KT is significantly superior to AT in order to dynamically reduce foot inversion (or to increase foot eversion) during early stance phase. Self-adhesive, longitudinally elastic, cotton Kinesio tape is more porous and waterproof than standard bandage tapes, which allows it to be worn for 3 to 5 days after application (Kase et al., 2013). There are no medical substances on the Kinesio tape. The principle of its action is based on mechanical properties, primarily on elasticity (Kahanov, 2007) which is approximately 50% of the initial length, which is equivalent to the elasticity of the skin (Kase et al., 2013). The tendency towards active, mobilization, movement is contained in the name of the method, which is derived from the term "kinesiology", since the use of Kinesio tape seeks to enable normal movement of the body and body segments (Kase et al., 2013).

Optimization of muscle function and correction of malaligned joints are the effects of KT (Kase et al., 2013) which can be very useful for the purpose of improving posture and movement even among asymptomatic individuals. The neuromuscular basis of KT application implies the ability to improve proprioception (Kurt et al., 2016), a mechanism that Aarseth et al. (2015) describe as an increase in muscle pressure due to increased mechanoreceptor stimulation in the skin, which affects joint mechanics. According to Kase et al. (2013), the KT method can be applied at any stage of the rehabilitation process, but also in primary and/or secondary prevention where, as interpreted by Lemos et al. (2015), KT can be an input for solving a closed circle of pathological and compensatory patterns of posture and movement. Because the foot has a key function in absorbing and transmitting forces throughout the body, structural and functional postural deficiencies in the ankle and foot area can create repercussions on other segments of the kinetic chain, even those very distant. Thus, for example, collapsed arch of the foot could cause neck pain as a symptomatic manifestation of compensatory changes of the cervical spine and vertebral column and trunk, following the cause-and-effect relationship (Page et al., 2010) of human posture. The results of trial made by Aguilar et al. (2016) suggest that there is some benefit in applying KT before intense physical activity to change foot posture. According to Griebert et al. (2016) KT can correct biomechanical factors that may be associated with musculoskeletal pathology. Yen et al. (2018) state that KT can be a useful tool for correcting aberrant motion without restricting natural movement in sports. On the other hand, some researchers (Pérez-Soriano et al., 2014;

Cornwall et al., 2019; Guner and Alsancak, 2020) conclude that despite its widespread use, current research potential of KT to change foot posture and movement is limited.

In the available literature, we did not find any research on the effect of KT on walking plantar pressures after application of the KT Functional Correction Technique as a support on the transverse arch of the foot. In their prospective cohort study published in 2019, where the KT muscle facilitation technique was applied, Cornwall and colleagues emphasized that additional studies need to be conducted, with respect to other KT application methods, to change plantar pressures.

Therefore, the aim of this study was to examine whether KT Functional Correction Technique on the transverse arch of the foot can improve dynamic posture through the modification of walking plantar pressures. The hypothesis was that walking maximal plantar pressures would be significantly reduced after the intervention for all three parts of the foot (forefoot, midfoot and hindfoot), which we consider a positive effect of KT.

2 METHODS

2.1 Participants

The convenience sample comprised of 22 healthy male university students, with a mean age of 23.2 ± 3.6 years (ranging from 19 to 33 years), body height 178.5 ± 5.4 cm (ranging from 169.5 to 188.5 cm), and a mean body weight 80.6 ± 11.7 kg (ranging from 60.2 to 101.6 kg). Inclusion criteria were no pain and no history of lower limb injuries in the last 12 months. All subjects participated in the study voluntarily. Before enrollment, everyone was given informed consent, which they had to sign as a prerequisite for participating in the research. The study was approved by the ethics committee of the Faculty of Kinesiology, University of Zagreb, and was carried out in accordance with the Declaration of Helsinki.

2.2 Procedure

The research was performed in the Biomechanics Laboratory of Faculty of Kinesiology, University of Zagreb. Measurement protocol started from initial standing position with participants being barefoot. Each participant walked over the trackway 9.5 m long to the end of the trackway, turned around and went back for 6 times. During the gait, subject should be instructed to develop and reach velocity normal for aiming himself towards ordinary activity when there are no disturbing aspects.

The initial measurement was performed without KT, and the final with KT (within-group design). After the initial measurements, KT was applied according to the protocol of Kase et al. (2013), and after 60 min the acute effects of the intervention were examined. The 60-min interval between intervention and final testing (as in Donec et al., 2012 and Voglar and Sarabon, 2014) increased the potential that the material would be successfully applied, as discussed by Aktas and Baltaci (2011) and Ruggiero et al. (2016).

2.2.1 Instrument

The instrument used in this study was Zebris FDM 1.5 (Germany) gait analysis system which was centrally positioned on a 158 cm long and 60.5 cm wide trackway platform. Measurements on platform are supported by 11264 capacitive sensors with density of 1.4 sensors/cm² with measuring range 1-120 N and accuracy ± 5%. Sensor area is 149 x 54.2 cm (L x W) with sampling rate 100 Hz.

2.2.2 Pedobarographic Measurement

Measurement and evaluation was done on the personal computer using the intuitive Zebris FDM Software Suite. It synchronously evaluates the measuring data of the ground reaction forces and the video camera. After defining the left and right ground contacts, an analysis of the measuring cycles is automatically performed in the subsequent report that displays the measured results. Reports offer 63 quantitative variables and graphics within participants like pressure plots, gait parameters (geometry, phases, timing), CoP analysis, force and pressure parameters, and curves, and three foot zone analysis.

Maximal plantar pressures within each foot region (forefoot, midfoot, hindfoot) were recorded bilaterally for further data analysis. Walking speed (velocity) was also measured.

2.2.3 Kinesio Taping Application

KT interventions were conducted by one researcher, the author of this paper (master physiotherapist with 14 years of experience, also a certified Kinesio Taping practitioner (CKTP) and instructor (CKTI) with 11 years of experience with the KT method), always through the same, standardized procedure recommended by Kase et al. (2013). The application of Kinesio tape was preceded by cleaning the skin with alcohol and placing the subjects in the prone, with ankle in neutral position. The same material Kinesio Tex Gold FingerPrint Tape, Kinesio Holding Company, Albuquerque NM, 5 cm wide, black, was used for all participants in the study. The KT application is shown in Figure 1.

Figure 1: Kinesio Taping Functional Correction Technique applied to the transverse arch of the foot.

Functional Correction Technique was chosen, starting on lateral foot with no tension, then 75+ % tension was applied across the arch (symbol + means that tension is applied through movement). Finally, end with no tension was applied on the medial aspect of the foot. The adhesive on the tape was heat activated by gently rubbing from the ends towards the middle of the tape. KT Functional Correction Technique is characterized by a "Spring-Assist or Limit" mechanism that provides sensory stimulation to either assist transverse arch and limit a motion (arch collapse) by increasing stimulation to joint receptors and mechanoreceptors.

2.3 Statistical Analysis

Data were analysed using the software package STATISTICA v.13.5 (StatSoft, Inc., Tulsa, OK, USA). Descriptive parameters were calculated, while the main analysis comparing the condition without KT (-) and the condition with KT (+) was performed using the nonparametric Wilcoxon Matched Pairs Test, with the timepoint as a dependent factor. The level of statistical significance was set at $P \leq 0.05$.

3 RESULTS

The main descriptive results of the assessment of walking plantar pressure according to foot segments and timepoints are presented in Table 1. Among the results we can notice a decrease in walking maximal plantar pressure after the intervention in all parts of the foot.

The results of the Wilcoxon Matched Pairs Test for the plantar pressure measured in this trial are presented in Table 2. Statistically significant differences ($P < 0.05$) were found for forefoot and hindfoot walking maximal plantar pressures.

In order to check whether the walking speeds were balanced according to the observed conditions (with and without the KT), we applied Student's t-test for independent samples. The average walking speed of the subjects in the condition with KT it was 4.5 ± 0.52 km/h, while in the condition without KT it was 4.57 $\pm$ 0.42 km/h. No statistically significant differences in walking speed ($P = 0.592$) were found between the two conditions.

4 DISCUSSION

The aim of this study was to examine the acute effects of KT on walking plantar pressures. The research hypothesis was tested by checking the significance of the dependent factor. It was shown that maximal plantar pressures at the forefoot and hindfoot significantly ($P < 0.05$) decreased by 1.51 N/cm^2 and 0.9 N/cm^2 respectively, when KT Functional Correction Technique was applied to the foot during walking.

Table 1: Descriptive forefoot, midfoot and hindfoot walking maximal plantar pressure (N/cm^2) parameters, without (-) and with (+) KT.

Variable	N	M	SD	Min	Max
forefoot -	44	46.90	9.34	21.50	64.30
forefoot +	44	45.39	9.10	22.80	66.00
midfoot -	44	14.45	6.99	5.50	37.30
midfoot +	44	14.41	6.96	6.10	32.50
hindfoot -	44	35.77	7.41	22.10	49.30
hindfoot +	44	34.87	7.22	22.20	48.30

Table 2: Wilcoxon Matched Pairs Test for forefoot, midfoot and hindfoot walking maximal plantar pressure, for condition without (-) and with (+) KT.

Pair of Variables	N	T	Z	P
- and + (forefoot)	44	234.50	2.87	0.003979
- and + (midfoot)	44	483.00	0.14	0.888627
- and + (hindfoot)	44	326.50	1.96	0.049250

The post-intervention manifestation of the "Spring-Assist or Limit" mechanism may be associated with the activation of the central generator of segmental posture and movement pattern via proprioceptors, through a stimulus that acts on the principle of pre-stressing (Kase et al., 2013).

As a result of its proposed therapeutic effect (Kase et al., 2013), KT can be useful to people with excessive foot pronation to improve function. Several studies (Luque-Suarez et al., 2014; Pérez-Soriano et al., 2014; Aguilar et al., 2016; Griebert et al. 2016; Yen et al., 2018; Cornwall et al., 2019; Guner and Alsancak, 2020) investigated the effects of KT in the ankle and foot dysfunctions prevention and/or rehabilitation. Among the mentioned studies, our results are most consistent with the findings of Griebert et al. (2016) who found that KT significantly decreases plantar pressures. They analysed subjects with Medial Tibial Stress Syndrome, an overuse injury typical for physically active. We also find an association with our results in a study by Yen et al. (2018) which included a kinematic assessment of the gait of individuals with chronic ankle instability. Researchers found less foot inversion when walking with KT compared to walking without KT during the loading response phase.

Our results contrast with those of Aguilar et al. (2016) who concluded that the application of KT on the arch of the foot in healthy individuals has no short-term effect on the change of walking plantar pressures. Contrary to us, Aguilar et al. (2016) used the KT Mechanical Correction Technique with 75% tape stretch. The same KT technique and principles of application were used by Guner and Alsancak (2020), although they assessed the static load and concluded that immediately after the application KT does not alter weight bearing on the foot. Just the load-bearing line of the ankle joint changed. Researchers conclude that KT may be of some benefit in short-term correction of foot pronation, although their practical suggestion is to combine KT with orthotic footwear. Luque-Suarez et al. (2014) applied tape with 100% stretch, but their static kinematic assessment did not show any postural improvement 24 hours after KT application, compared to sham KT (applied without tension). Contrary to our findings, according to research by Cornwall et al. (2019) and Pérez-Soriano et al. (2014), application of KT did not result in a change in plantar pressure in healthy individuals. Cornwall et al. (2019) applied the KT Muscle Facilitation Technique for posterior tibialis muscle. However, they made a big mistake by repeated measurements only 5-10 min post-interventional, since it takes a minimum of 30 min (Kase et al., 2013) for KT to be effective with respect to adhesive activation and adaptation. Regardless of this oversight, the fact is that the arch of the foot is maintained by the shape of the bones and their interrelationships, furthermore by non-contractile soft tissues (e.g. plantar ligaments and fascia) and contractile soft tissues (i.e. muscles), where non-contractile tissues make a greater contribution to arch maintenance than contractile (Oatis, 2009). Therefore, the KT Functional Correction Technique, in our opinion, was a better choice for reducing walking plantar pressures than the KT Muscle Facilitation Technique. Pérez-Soriano et al. (2014) applied KT on peroneus and triceps surae muscles, examining changes in walking plantar pressures (unlike Cornwall et al. (2019) who examined static plantar pressures). Pérez-Soriano et al. (2014) discuss that the walking pattern in terms of plantar pressure distribution is not affected by KT Muscle Facilitation Technique. Given the great forces required to maintain the arch of the foot, in which non-contractile structures predominate (Oatis, 2009), the KT Muscle Facilitation Technique indeed seems too weak to change plantar pressures. This goal requires a technique that will not rely on the recoil mechanism (in which the elasticity of the tape causes tissue decompression (Tu et al., 2016)), but on the spring mechanism in the function of limiting unwanted movement or unwanted changes in segmental foot posture - and that is characteristic of KT Functional Correction Technique.

Our findings could be clinically relevant because KT is a common method that is widely used by various practitioners (e.g. physiotherapists, medical doctors and athletic trainers), to prevent and/or rehabilitate neuro-musculoskeletal disorders. Following the premise of Luque-Suarez et al. (2014) on KT as a simple alternative to traditional taping in people with overpronated feet, we also see the practical implications in the perspective of alternatives to orthopaedic insoles that provide passive support, while KT Functional Correction Technique with its “Spring-Assist or Limit” mechanism is active. To the best of our knowledge, this is the first study on the use of KT Functional Correction Technique in plantar pressures analysis.

One strength of this study is that it was conducted by an experienced physiotherapist and Certified Kinesio Taping Instructor. Guided by the idea that KT research should focus on the impact of the KT method, and not on testing the effect of Kinesio tape placed on the subject’s skin, with an emphasis on who, how and for what purpose applies the tape, we fully agree with Stockheimer et al. (2016) commentary *“Research requires deep knowledge of the modality to be tested”*, with universal repercussions, emphasizing the need for adequate theoretical and practical education (i.e. with certificates, licenses) of researchers who, in this case, apply Kinesio tape, or rather apply the KT method. We used a within-group design since differences between groups in subject characteristics could potentially negatively influence the results. Nonetheless, the absence of a sham-tape group can be considered a lack of the research as the role of placebo effect regarding the use of KT is not investigated. Furthermore, limitations of the current study are that only acute effects of KT were assessed, and longitudinal arches were not supported, considering that the medial longitudinal arch is crucial (Oatis, 2009) for a normally aligned foot. A key limitation of pedobarography is its inability to detect a patient’s habit of avoiding pressure in the area of pain that leads to an antalgic gait. An altered gait pattern can affect pressure scores and provide contradictory information on areas of pain (Choi et al., 2014).

Therefore, in future research, kinematic assessment could be included as well as to evaluate the impact of KT on foot biomechanics in a clinical sample. Jumps or some sport-specific movements that are subject to perturbations (Briem et al., 2011) and require good proprioception as a risk zone for ankle and foot injuries, could also be studied. Regarding the clinical significance of the research, we agree with Yen et al. (2018) that due to the small magnitude of acute positive change, the clinical significance of our results in terms of reducing the risk of injury is unclear and should be investigated in the future, through randomized clinical trials including a larger sample size.

5 CONCLUSION

This study showed that Kinesio Taping method has a positive effect on walking plantar pressures of healthy individuals. Application of the Functional Correction Technique significantly reduced walking maximal plantar pressures in forefoot and hindfoot.

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