International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:9, No:2, 2015

# The Effect of Fixing Kinesiology Tape onto the Plantar Surface during the Loading Phase of Gait

Albert K. Chong, Jasim Ahmed Ali Al-Baghdadi, Peter B. Milburn

***Abstract*—**Precise capture of plantar 3D surface of the foot at the loading gait phases on rigid substrates was found to be valuable for the assessment of the physiology, health and problems of the feet. Photogrammetry, a precision 3D spatial data capture technique is suitable for this type of dynamic application. In this research, the technique is utilised to study the plantar deformation as a result of having a strip of kinesiology tape on the plantar surface during the loading phase of gait. For this pilot study, one healthy adult male subject was recruited under the University's human research ethics guidelines for this preliminary study. The 3D plantar deformation data with and without applying the tape were analysed. The results and analyses are presented together with detailed findings.

***Keywords*—**Gait, human plantar, loading, Kinesiology Tape.

## I. Introduction

HUMAN walking (gait) comprises of loading and swing phases of the foot. In general, there are three distinct occurrences, namely: 1) heel-strike; 2) mid-stance; and 3) toe-off. These phases only occur when the foot is in contact with the walking surface (substrate) and body load is placed onto the foot. The plantar surface of the foot is the point of contact between the foot and the substrate during gait. Normal human gait requires a rapid movement of the foot as it goes through the phases. Thus, acquiring accurate dynamic spatial data relating to the interaction between the plantar surface and the substrate is difficult and often requires rapid data capture system such as photogrammetric techniques [1], [5], [6], [8]. For this investigation, we utilized video clips and photogrammetric 3D image processing techniques.

Therapeutic tape, athletic tape (AT) or Kinesiology tape (KT®) is often an elastic cotton strip with an adhesive strip for fastening onto the skin. These tapes have been used primarily to prevent and treat sports injuries. Bassett et al. [2] argued that their basic functions are to provide protection and support to the joints or muscles during sports and exercise. In [3] the authors examined the effect of taping on the functional performance in basketball players with chronic inversion ankle sprains. Fifteen subjects were assessed using Hopping test, Single Limb Hurdle test, Standing Heel Rise test, Vertical Jump test, the Star Excursion Balance test and Kinesthetic Ability Trainer test to quantify four common athletic attributes (agility, endurance, balance, and coordination). The tests were carried out four times at one week intervals using varied conditions, namely: placebo tape, without tape, standard athletic tape, and KT®. It was reported that only positive performance times were measured with AT and KT® in the single limb hurdle test when compared to the placebo and non-taped conditions (AT-placebo taping: $p = 0.03$; AT-non tape $p = 0.016$; KT®-Placebo taping $p = 0.042$; KT®-Non tape $p = 0.016$).The finding suggests that KT® and AT had no negative effects on a battery of functional performance tests and improvements were observed in some functional performance tests.

In [2] the authors presented a review of three investigations which examined the use and treatment efficacy of KT® for musculoskeletal conditions. The review shows that there was no significant clinical effect of KT®. Then, [11] investigated the effects of KT® using magnitude-based inferences to examine the clinical worth of reported positive (beneficial) outcomes via a meta-analysis. The authors' aim of the review was to evaluate the effectiveness of KT® in the treatment and prevention of sports injuries. The authors argued that KT® may have a small beneficial role in improving strength, range of motion in certain injured cohorts and further works are required to confirm these findings.

According to [4], KT® is hypothesized to facilitate small immediate increases in muscle strength by producing a concentric pull on the fascia, which may stimulate increased muscle contraction. Articles [7], [9], [11] provide additional hypotheses which suggest KT® facilitates muscle activity and improves muscle alignment which may contribute to marginal increases in muscle strength. Literature review shows that in the foot application, AT or KT® is commonly used to provide support of the heel and the plantar fascia, thus relieving pain caused by plantar fasciitis. The researchers in [10] conducted an investigation of applying KT® to the plantar fascia. The tapes were firmly adhered from the heel to the forefoot. In the research, the authors stretched the KT tapes so that their lengths were increased by approximately 133% of the original length. 52 subjects were recruited and they were assessed before and one week after treatment. Utilizing ultrasonographic data, the researchers determined that the fascia thickness at the insertion site may be reduced after KT® treatment. The fascia thinness at the inflamed site did not show any changes. However, KT® treatment reduced the pain significantly more than traditional physical therapy.

Our literature review did not produce evidence of previous investigation on the quantitative aspect of the effect of KT® or AT on fascia shape change during the dynamic loading phase of gait. In this project, we utilize the dynamic 3D plantar

Albert K. Chong is with the University of Southern Queensland, Australia; e-mail: chonga@usq.edu.au).
Jasim Ahmed Ali Al-Baghdadi is with Foundation of Technical Education, Baghdad, Iraq (e-mail: jasim76@gmail.com).
Peter B. Milburn is with Griffith University, Gold Coast, Australia (e-mail: peter.Milburn@Griffith.edu.au).

surface model to examine the shape change of the plantar surface as a result of applying AT. The objective is to determine the size of shape change and the effect on the plantar orientation during the loaded phase of gait.

## II. Methods

### *A. 3D Imaging System*

Eight JVC Everio GZ-HD500S camcorders were selected for the research (pixel count = 1920x1080; focal length = 3.0 mm; pixel size (video modes) = 0.0012mm). The camcorder setup arrangement is provided in Fig. 1. As shown in the figure, eight-camera mounting platform was fabricated to hold the camcorders in position directly underneath the force plate

In addition, a 3D imaging control frame was fabricated and installed under the force plate to provide object-space control for the camcorder stations' resection and 3D model scaling. The device which is made of 50 mm by 50 mm square composite tubing fit around the underside outer edge of the force plate. Retro-reflective targets were placed on the underside of the frame and coordinated.

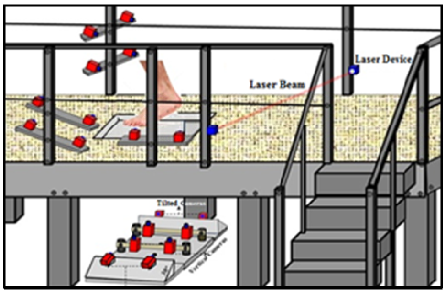



Fig. 1 The camcorder (red) and force plate position (under the foot)

### *B. AMTI OR6-GT-1K Force Plate*

The device was installed in the walking platform as shown in Fig. 1. The force measurement is correlated with the camcorder captured video using a "cut-off" laser system as shown in the figure. When the laser beam is cut by the foot crossing its path, a set of LED is activated and the LEDs' flash is captured by the camcorders while an electrical signal tagged the force plate recording simultaneously.

### *C. Camcorder Calibration*

Each camcorder was calibrated using a custom-made camera calibration test-field which consists of seven rows and 12 columns of targets at 30 mm spacing as shown in Fig. 2. In the calibration, ten convergent video clips of the test-field were captured at different view-points and different camera-orientations. A commercial software was used to calculate the lens calibration parameters and these parameters were used to calculate the amount of image distortion caused by the lens aberrations. These distortions were removed to produce precise 3D plantar surface model during the 3D image reconstruction.

### *D. Subject Recruitment and Trial Preparation*

One subject (age 35 years; height 179 cm; weight 89 kg) was recruited and volunteered for this project which was approved by the University Research Ethics Committee. After inspection by a podiatrist, the subject was prepared for the trial by marking selected anthropometric marks on the foot and the plantar surface with retro-reflective targets (Fig. 3). A midline of the foot and a number of cross sections were drawn on the plantar surface as described in [8]. It is important to note that the number of target assigned to each cross-section is not the same because of the width of the cross-sections are different.

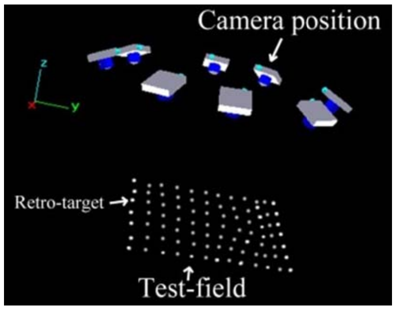



Fig. 2 Position of the camcorder relative to the test-field during system calibration

Then, the subject was shown a set of normal gait procedure and was given time to practise the walking over the force plate. After the initial bare-foot trial, AT was firmly adhered from the heel to the forefoot of the right foot. In this research, the tapes were stretched so that lengths were increased by approximately 133% of the original length as discussed in [10] (Fig. 4).

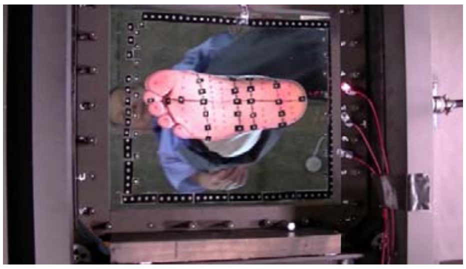


Fig. 3 Plantar marking and target fixing. Note the circular retro-reflective targets

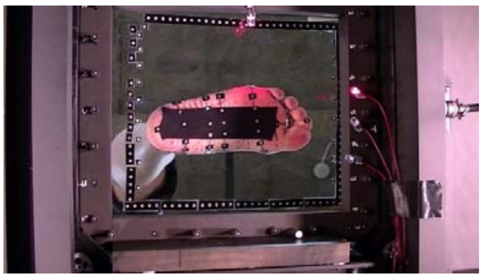


Fig. 4 AT adhered to the plantar surface

### *E. Trial I: Barefoot Gait*

Before switching on the force plate to record the ground reaction force, the subject was instructed to place his right foot horizontally at about 1.0 cm above the force plate and video clips were recorded. This set of eight camcorders' video clips was utilised to produce the 3D plantar surface when body-weight wasnot applied to the foot and this 3D model is called no-loaded (barefoot or BC-BRT) plantar surface. Next, the subject walked over the force plate with the right foot stepping on its surface. Video clips and GRF were recorded simultaneously.

### *F. Trial II: AT Gait*

Before switching on the force plate for recording the ground reaction force, the subject was instructed to place his right foot horizontally at about 1.0 cm above the force plate and video clips were recorded. This set of eight camcorders' video clips was used to produce the 3D plantar surface when body-weight was not applied to the foot and this 3D model was called no-loaded (BC-ART) plantar surface. Next, the subject walked over the force plate with the right foot stepping on its surface. Video clips and GRF were recorded simultaneously.

## III. Results and Analysis

### *A. 3D Image of the Loaded Gait Phase*

Fig. 5 show the 3D image captured during barefoot gait while Fig. 6 shows the AT gait over the same force plate. The brightly illuminated area of the plantar surface indicates the surface is in contact with force plate glass surface. The multi-colour LED flash synchronises the video clip of the eight camcorders.

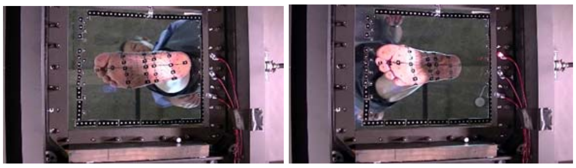


Fig. 5 Heel-strike and Toe-off phases of gait

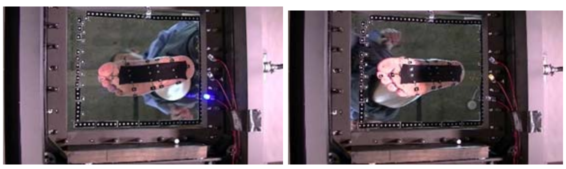


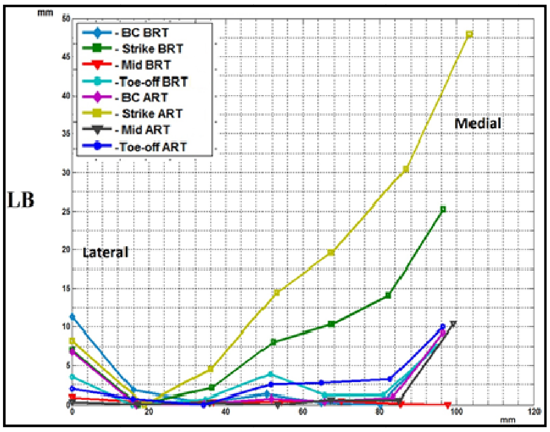
Fig. 6 Heel-strike and Toe-off phases of the AT gait

### *B. Plantar Shape Change*

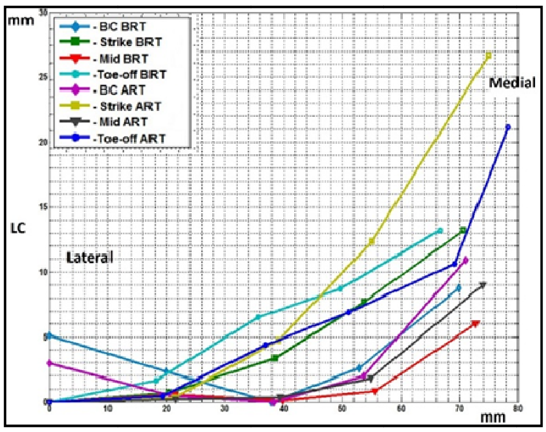
Fig. 7 shows the cross-sections characteristics for eight different scenarios. BC-BRT represented the shape of the barefoot plantar surface before it was in contact with the force plate while BC-ART represented the shape of the taped plantar surface before the plantar was in contact with force plate. The BC plots may reveal whether the plantar shape has changed simply by applying the Athletic tape to the plantar fascia. The figures should be evaluated individually as the number of targets for the cross-sections (LB, LC, LN and LH) was not similar.

Fig. 7 (a) shows the shape of the forefoot (cross-section LB) where the characteristic of toe-off phase can have significant effect on the shape. Both BC plots were similar, thus there was no apparent change in the shape of the cross-section when body-weight was not applied to the foot. At toe-off, the ART line was slightly above the BRT line at the medial while both lines were at level with the substrate at the lateral of the foot. The plot also reveals that during toe-off the plantar surface at the forefoot was slightly more flattened at ART than BRT. It was apparent that by reinforcing the forefoot with AT more surface was in contact with the substrate at the medial. At the time of the heel-strike the medial (ART) at the forefoot was further away from the substrate than the medial at BRT. There was no significant change of the forefoot during mid-stance for both trials as both surfaces were in contact with the substrate.

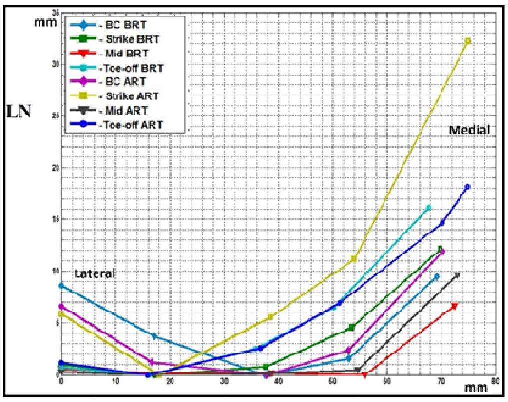
Fig. 7 (b) shows the characteristics of the plantar surface at mid-foot position (LC) for the eight scenarios. It was anticipated that the shape at LC for heel-strike and toe-off could reveal the change in the arch shape as a result of AT application. During the heel-strike, the medial arch was raised further above the substrate and the arch was slightly curved upward. There was no significant shape change at the moment of toe-off for both BRT and ART.



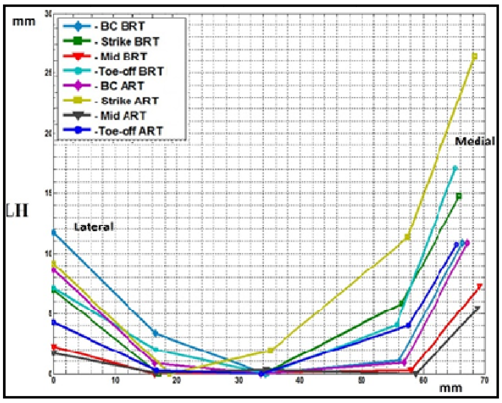

(a)




(b)




(c)




(d)

Fig. 7 Plantar surface characteristic between barefoot and AT applied gait. Note that BRT is bare right foot and ART designates AT is applied to right foot; Cross-sections: (a) LB; (b) LC; (c) LN and (d) LH

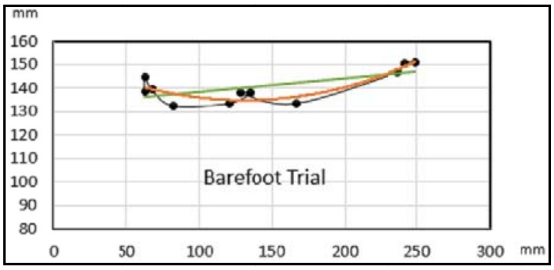
Fig. 7 (c) shows the shape of the heel (LH) of the eight scenarios. It was assumed that the shape at cross-section LH during heel-strike and toe-off could reveal the change in the plantar surface at a location close to the plantar fascia ligament where plantar fasciitis often occurs. At the moment of heel-strike the medial was raised further above the substrate and the arch was slightly curved for the barefoot. The effect of having the AT was more significant at the lateral arch and the effect was opposite to the change at heel-strike. Based on the discussion regarding the plots and the centroid of contact positional data it is certain that the plantar surface was experiencing geometrical and orientation change between barefoot and AT-applied situation.

*C. Plantar Shape Change*

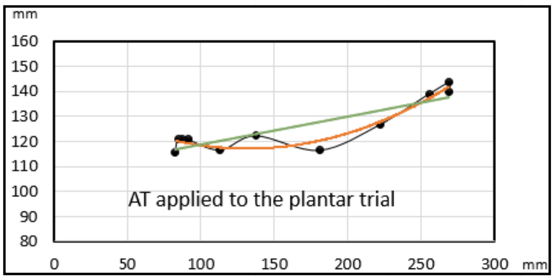
Table I shows 11 selected 3D plantar surface models for further analysis. The make-up consists of four samples from the heel-strike segment, three from the mid-stance segment and a further four from the toe-off segment. The centroid coordinates (Xc, Yc) of surface in contact with the force plate was calculated for each model. Fig. 8 shows the barefoot and AT-applied centroid plots which were based on the coordinates listed in Table I. In the figure, the linear regression line shows a steeper gradient between the heel-strike and the toe-off phase. The path connecting the centroids of the mid-stance varied more spatially along the y-axis for the ART, thus indicating that the plantar orientation changed more in size and direction for the three loading gait phases when AT was applied.

TABLE I
A SAMPLE OF THE COORDINATE OF THE CENTRE OF CENTRE OF CONTACT SURFACE DURING GAIT

| Situation | Gait phase | Xc | Yc |
|---|---|---|---|
| Barefoot | HS1 | 249.2 | 151.0 |
| | HS2 | 241.9 | 150.6 |
| | HS3 | 236.5 | 146.9 |
| | HS4 | 166.6 | 133.6 |
| | Mid1 | 128.3 | 137.9 |
| | Mid2 | 134.8 | 140.1 |
| | Mid3 | 120.3 | 133.6 |
| | TO1 | 82.4 | 132.6 |
| | TO2 | 67.7 | 139.6 |
| | TO3 | 63.4 | 144.7 |
| | TO4 | 62.8 | 138.6 |
| AT Applied | HS1 | 268.6 | 139.9 |
| | HS2 | 269.3 | 143.5 |
| | HS3 | 255.5 | 138.9 |
| | HS4 | 222.0 | 126.7 |
| | Mid1 | 180.9 | 116.5 |
| | Mid2 | 137.5 | 122.3 |
| | Mid3 | 113.2 | 116.6 |
| | TO1 | 91.4 | 120.8 |
| | TO2 | 86.4 | 120.7 |
| | TO3 | 86.7 | 121.1 |
| | TO4 | 82.7 | 115.7 |




(a)




(b)

Fig. 8 Plots of the centroid of plantar surface in contact with the substrate. Green line (linear regression line), orange (polynomial line) blue (line connecting adjacent points); (a) Barefoot gait; and b) AT-applied to plantar gait

## IV. Conclusion

We carried out a literature review of the physical and clinical effects of applying AT onto the skin of chronic and newly injured area of the human body such as joint and fascia which exhibit pain and swelling. The review reveals that there were no previous investigation on the quantitative aspect of the effect of AT on fascia shape change during the dynamic loading phase of gait. The investigation utilises a multi-camcorder imaging system, gait platform and photogrammetric techniques to capture 3D plantar surface to evaluate the shape change between barefoot and AT-taped plantar fascia. The second purpose of the investigation was to determine whether AT alters the centre of surface in contact with the substrate and orientation of the plantar.

The results show that the plantar surface did not exhibit any changes between barefoot and AT-applied setting when the foot was not in contact with the substrate. However, for AT, during the toe-off phase, the medial side of the plantar surface was positioned slightly further away from the substrate. This means that the plantar rotation was slightly larger in the sagittal plane for ART than BRT at toe-off. During heel-strike, the effect of AT was significantly more at the lateral where the plantar surface was further away from the substrate and the spatial difference in the vertical axis was roughly 1.0 cm.

As an extension of this research, the next investigation will involve the testing of a cohort of 15 middle-aged adults. The statistical significance of the plantar surface deformation and the changes in plantar orientation between BRT and ART will be determined to compare with the results obtained from this preliminary study.

## Acknowledgment

The authors thank the University of Southern Queensland and Griffith University for the funding of this project.

## References


[1] AL-Baghdadi, J.A.A, Chong, A.K., McDougall, K., Alshadli, D, An investigation of the 3-dimensional surface capture of the human foot. Proceedings of the 2012 International Workshop on Geoinformation Advances. Johor Baharu, Malaysia, 2012, 7-8 November, pp.26-46.

[2] Bassett K, Lingman S, Ellis R, The use and treatment efficacy of kinaesthetic taping for musculoskeletal conditions: A systematic review. New Zealand Journal of Physiotherapy. 2010;38(2):56-62.

[3] Bicici S, Karatas N, Baltaci G, Effect of athletic taping and kinesiotaping® on measurements of functional performance in basketball players with chronic inversion ankle sprains. Int J Sports PhysTher,2012, 7(2): 154–66.

[4] Bonacci J, Green D, Saunders PU, Change in running kinematics after cycling are related to alterations in running economy in triathletes. J Sci Med Sport, 2010; 13:460-4.

[5] Chong, A. K Low-cost compact camera for CMT disorder application. The Photogrammetric Record. 2011, 26(134): 263-273.

[6] CoudertT., Vacher P., Smits, C., Van Der Zande, M, A method to obtain 3D foot shape deformation during the gait cycle. Ninth International Symposium on the 3D Analysis of Human Movement, 2008, June 28-30. Valenciennes, Frances, 4 pages. http://www.univvalenciennes.fr/ congres/3D2006/Abstracts/117-Coudert.pdf, accessed 27/09/2014. (accessed on the 17th January 2015).

[7] Hsu YH, Chen WY, Lin HC, The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. J ElectromyogrKinesiol 2009; 19 (6): 1092-9

[8] Kimura, M., Mochimaru, M. &Kanade, T, Measurement of 3D foot shape deformation in motion. Proceedings of the 5th ACM/IEEE International Workshop on Projector camera systems, New York, USA, 2008, August 20th, 8 pages.

[9] Thelen MD, Dauber JA, Stoneman PD. The clinical efficacy of kinesio tape for shoulder pain: a randomized, doubleblinded, clinical trial. J Orthop Sports PhysTher, 2008; 38(7): 389-95

[10] Chien-Tsung Tsai, Wen-Dien Chang, Jen-Pei Lee. Effects of Short-term Treatment with Kinesiotapingfor Plantar Fasciitis.Journal of Musculoskeletal Pain, 2010;18(1): 71-80.

[11] Williams S, Whatman C, Hume PA, Sheerin K, Kinesio taping in treatment and prevention of sports injuries: a meta-analysis of the evidence for its effectiveness. Sports Med,2012;42(2): 153–64.