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The Effect of Ankle Taping on the Centre of Pressure (Cop) At Heel Strike In Subjects with A History of Inversion Ankle Sprains; A Secondary Analysis of Existing Data

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Abstract:
Objective: *Prophylactic ankle taping is considered as one of the most effective treatment strategy following inversion ankle sprains. In the last few decades, several studies have established that centre of pressure (COP) of the ankle and foot complex plays an important role in estimating abnormal mechanics following inversion ankle sprains. The main purpose of this study was to evaluate the effect of ankle taping on the centre of pressure (COP) of the ankle and foot complex at heel strike in participants with a history of inversion ankle sprain.*
Methods: *In this study, secondary analysis of the data recorded from a well designed cohort study was conducted. The study participants were grouped as cases (n = 14) with a mean age of 26.9 (± 11.3) years and controls (n = 14) with a mean age of 34.9 (± 10.0) years. The cases represented the participants having functional ankle instability (FAI) following inversion ankle sprains and the controls represented non ankle sprain (NAS) participants. All the participants were instructed to walk barefooted over the Rs scan platform with untaped ankle. At heel strike of the stance phase, the participant's untaped foot print measurements were taken by the examiner followed by taped measurements. The participant's ankle and foot were taped using closed basket weave technique with figure of eight heel lock. All the participants were instructed to start and finish walking from the same starting point on the floor marked by the examiner with a tape. The variable measured was the X component (Medio-Lateral) of the centre of pressure (COP) at heel strike. Centre of pressure (COP) data was recorded at first foot contact (FFC) and first metatarsal contact (FMC) of the initial contact phase (ICP) of heel strike in stance phase. Microsoft windows excel and windows SPSS version 20.0 was used for the statistical analysis of the data collected from the participants in both the groups.*
Results: *Results obtained were not significant (p>0.05) while comparing the data between the taped and untaped participants in the functional ankle instability group (cases). The results comparing the untaped participants in between both the groups (cases and controls) and taped participants in between both the groups (cases and controls) recorded were also not significant (p>0.05). The non ankle sprain participants (controls) demonstrated significant results when compared between the taped and untaped participants at first foot contact (FFC) (p= 0.02) and first metatarsal contact (FMC) (p = 0.04). However the results comparing the initial contact phase (ICP) data between the taped and untapped participants of the non ankle sprain participants (controls) recorded were not significant (p>0.05).*
Conclusion: *The results obtained in this study states that ankle taping has no effect on centre of pressure (COP) of the ankle and foot complex at heel strike following a history inversion ankle sprain.*
Keywords: *Inversion ankle sprains, Prophylactic ankle taping, Centre of pressure, Functional ankle instability, Stance phase.*

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I. Introduction

This chapter will discuss briefly about inversion ankle sprain, functional ankle instability (FAI), centre of pressure (COP) of the ankle and foot complex and various effects of ankle taping followed by research aim. The ankle and the foot complex form a dynamic link between the human body and the ground (Abboud, 2002). The ankle joint also known as talocrural joint or mortise joint is formed by the articulation of the dome of the talus, the tibial plafond, and the medial and lateral maellolus (Hertel, 2002). The ankle joint is a synovial hinge joint and allows mainly plantarflexion and dorsiflexion movements (Abboud, 2002). Efficient functioning of the ankle joint is closely related to the performance of the subtalar joint formed by the articulation of talus and calcaneum and the distal tibiofibular syndesmosis formed by the distal part of tibia and fibula (Abboud, 2002). Subtalar joint permit inversion and eversion movements (Baumhauer et al, 1995). The ankle and foot complex sustains the greatest loading force per surface area than any other joint surfaces in the human body (Birrer et al, 1999). During normal walking, the joint reaction forces within the ankle joint is believed to be five times the total body weight which clearly establishes the fact that ankle joint is highly prone to injury than other joints in human body (Birrer et al, 1999).

Ankle sprains are considered as one of the most common musculoskeletal injury affecting the human body (Dong Je et al, 2009). Of all ankle injuries, inversion ankle sprains occurs most frequently (Shima et al., 2005). It is believed that inversion ankle sprains constitute almost 85% of all ankle injuries (Nelson et al., 2007). The prevalence of inversion ankle sprains is high in contact sports like football, hockey, and rugby however it also affects general population living sedentary lifestyle (Nelson et al., 2007). According to the epidemiological findings by Rogier et al (2008), about 5000 ankle injuries are treated per day in the United Kingdom and they are only due to acute inversion ankle sprains. An ankle sprain can be defined as a sudden injury which generally stretches fibers of the ligament (Benedetti et al, 1999). According to O'Donoghue (1976, Cited in Benedetti et al, 1999), ankle sprains can be classified as first degree, second degree and third degree sprains. The first degree sprains are mild sprains which causes slight tearing of the ligament fibers with minimal hemorrhage (O'Donoghue 1976, Cited in Benedetti et al, 1999). The second degree sprains results in an incomplete tear of the ligament with mild laxity, instability, slight reduction in function, strength and the potential for loss of proprioception in future (O'Donoghue 1976, Cited in Benedetti et al, 1999). The third degree ankle sprains are considered as severe ankle sprains resulting in complete disruption of the ligament fibers along with gross instability, laxity, and potentially a complete loss of full function, strength, proprioception (O'Donoghue, 1976, Cited in Benedetti et al, 1999). Most of the ankle injuries including inversion ankle sprains are generally perceived as benign and self limiting in nature and responds well to the conservative management (Barnsley and Anandacoomarasamy, 2005). Although in some cases residual symptoms may persists for few months to years depending on the immediate treatment interventions implemented and lifestyle followed after injury (Barnsley and Anandacoomarasamy, 2005). General symptoms following acute inversion ankle sprains mostly include pain, inflammation, and loss of motion etc (Olmsted et al, 2004).

Understanding the mechanism of inversion ankle sprains is crucial for planning its appropriate management and prevention (Karlsson and Andreasson, 1992). Inversion ankle sprains mostly results from the biomechanical abnormalities of the ankle and the foot complex during gait cycle (Wright et al, 2000). The inadequate positioning of the ankle and foot while impacting the ground during walking or landing from a jump causes forced plantar flexion and inversion of the ankle and foot complex causing direct damage to the lateral ankle and foot structures (Willems et al, 2004). The anterior talofibular ligaments (ATFL) most frequently get injured following inversion ankle sprains as this ligament has the lowest ultimate load 138.9N as compared to posterior talofibular ligament (PTFL) i.e. 261.2N and calcanofibular ligament (CFL) i.e. 345.7N as per data obtained from the mechanical tests on normal ankles (Bozkurt and Doral, 2006). Other lateral ankle complex structures constituting of posterior talofibular ligament (PTFL), calcanofibular ligament (CFL), peroneal muscles, and tendons also remain at high risk for damage following inversion ankle sprains depending on the severity of the injury (Karlsson and Andreasson, 1992). Williems et al (2004) reported that injury to the ankle and foot structures following inversion ankle sprains can often lead to biomechanical instability of the ankle and the foot complex. According to Pijnenburg (2000), 40% inversion ankle sprain injuries can potentially progress to cause chronic ankle instability (CAI) if not managed effectively. Pijnenburg (2000) further reported that acute inversion sprains can even result in functional instability of the ankle and foot complex long after the apparent signs and symptoms of the original injury have resolved owing to the pathologic laxity of lateral ankle and foot ligaments. Functional ankle instability (FAI) is a late complication of acute inversion ankle sprain and can be best described as ‘a tendency of the ankle and foot complex to repeatedly give way’ during functional activities like walking (Freeman et al, 1965). Functional ankle instability (FAI) affects about 10% to 30 % of the people suffering acute inversion sprains and is mostly associated with problems related to ankle musculature, decreased proprioception, loss of balance and ligamentous laxity (Caulfield and Garrett, 2000).

Estimation of ground reaction forces (GRF) using plantar force plate platforms is considered as one of the most valid and reliable instrument in investigating ankle and foot pathology following lower limb injuries (Morley et al, 2010). Ground reaction forces (GRF) are generally the forces exerted by the ground on the foot during foot contact (De Wit et al, 2000). The centre of pressure (COP) of the ankle and foot is the place where all the ground reaction forces (GRF) acts on the foot (Rocchi et al, 2004). Centre of pressure (COP) of the ankle and foot complex is considered as a critical measure of gait and balance in lower limb injuries including inversion ankle sprains (Cornwall et al, 2003). Several studies have reported variation in the centre of pressure (COP) of the ankle and foot complex following inversion ankle sprains. Nyska et al (2003) stated that more forces concentrated under the mid foot and lateral forefoot during the stance phase of gait in patients with recurrent ankle sprains (RAS). Williems et al (2004), while evaluating gait related risk factors for subjects with inversion ankle sprains reported that subjects who are at risk of sustaining an inversion sprain has a laterally situated centre of pressure (COP) at first foot contact (FFC). Likewise Monaghan et al (2006) also noticed a more inverted position of the foot before and after initial contact during gait in participants with functional ankle instability (FAI). Examination of centre of pressure (COP) of the ankle and foot complex following inversion ankle sprains provides vital information regarding the existing foot pathology which can play an important role in its prevention and rehabilitation (Williems et al (2004).

Management of inversion ankle sprains draws significant argument in the present time despite having diverse treatment measures (Hertel, 2002). Researchers have evaluated several treatment measures concerning the management of inversion ankle sprains i.e. immobilization by cast, functional treatment by tape or brace, surgical treatment etc but treatment selection still remains controversial which can be attributed mostly to the complexity of the ankle and foot injuries and ineffectiveness of the applied management strategies (Wolfe et al, 2001). Ankle taping is considered as the treatment of choice by most of the clinicians following acute inversion sprains due to its lower cost and greater functional independence when compared to braces and cast immobilization (Olmstead et al, 2004). There have been many clinical and experimental studies that have attempted to identify the mechanism by which ankle taping prevent inversion ankle sprains or functional ankle instability (FAI). Robbins et al. (1998) reported that ankle taping plays an important role in modifying impaired proprioception following inversion ankle sprains. Robbins et al (1998) stated that prophylactic ankle taping provides essential cutaneus cues to the injured part by uniting the skin of the foot with the leg by the traction of the tape which in turn increases the afferent feedback from the injured site enhancing ankle joint position sense. Likewise Karlsson and Andreasson (1992) reported that ankle taping improves peroneal muscle response following inversion ankle sprains which plays an important role in counteracting potentially injurious inversion force after landing during injury. The knowledge gained by these studies is of great clinical value but the effects of ankle taping on ankle joint mechanics or gait parameters following inversion ankle sprains have not been established by any of these studies. Studies over the years have mostly discussed regarding the clinical effects of ankle taping following ankle and foot pathologies with very little research done regarding the potential effects of ankle taping on biomechanical parameters including centre of pressure (COP) of the ankle and foot complex following inversion ankle sprains.

The specific research aim in this study was to examine the effect of ankle taping on the centre of pressure (COP) of the ankle and foot complex at heel strike in the participants with a history of inversion ankle sprain. In this study, secondary analysis of the data recorded from a cohort study was examined.

II. Methodology

2.1Study participants

The participants were recruited from students and staff at the University of East London. Fourteen adults (mean age: 37 years; mean height: 171 cm and mean body mass: 75 kgs) with a self reported history of inversion ankle sprain having functional ankle instability (FAI) were matched to a control group of another fourteen adults with no previous history of any inversion ankle sprain (Non ankle sprain participants) (Mean age: 35 years; Mean height: 169 cm; Mean body mass: 71 kg). Exclusion criteria of the participants constituted of any history of a surgical procedure involving the lower leg, ankle or foot or any neurological deficits or gait abnormalities. The study was approved by the ethical committee of the School of Health and Biosciences, University of East London. The participants were briefed about the aim of the study and the informed consent was given by all the participants prior to the testing. All the participants were recruited and tested by the same examiner.

2.3Study design

In this study, secondary analysis of the data recorded from a well designed cohort study was conducted. Sample size estimation was done in the main study however no sample size calculations were conducted. Participants were tested individually at prearranged time in the biomechanics laboratory of the University of East London. Prior to testing all participants completed a questionnaire (Hubbard and Kaminski, 2002) to determine if functional ankle instability (FAI) was present. The reliability of the study questionnaire was not evaluated in the main study as no standard protocol exists to estimate functional ankle instability (FAS) following inversion ankle sprains (Donahue et al, 2011). Participants who did not meet the criteria for having functional ankle instability (FAI) were assigned to the control group. The dominant ankle of the control group participants determined by kicking a ball against a wall was used for all testing (Right ankle = 12 and Left ankle = 2). For the cases the affected ankle was chosen for examination (Right ankle = 14). Prior to testing all participants height and weight was measured by the examiner. Height was measured using Harpenden stadiometer. The stadiometer was mounted on a straight wall at 90° angle to the floor. The heel plate mounted on the floor was in the same vertical plane as the backboard of the stadiometer. The floor was level and free of carpeting to prevent any measurement errors. The participants were asked to stand straight with their heels touching the upright of the stadiometer and look straight ahead. The level was brought down to touch the top of their head. The height recorded was taken to the nearest 0.5 cm. Weight was measured in kilograms by using a weight machine. The participants were instructed to wear loose clothing during weight measurements and remove any jewellery items from the body along with shoes and socks to record correct data. The ankle was examined clinically for the evidence of any swelling or ecchymosis by the examiner. Anterior drawer test and talar tilt test was performed by the examiner to confirm functional ankle instability (FAI) following inversion ankle sprains. The examiner performed the anterior drawer test by stabilizing the tibia and fibula (lower leg) with one hand and drawing the talus forward with the other hand with the patient in sitting position with knee bending down from the edge of the bench and ankle in plantar flexion (Magee, 2002). The test was indicated as positive when the patient complained of pain during or after the testing procedure confirming ligamentous injury of the anterior talofibular ligament (ATFL) (Magee, 2002). For the talar tilt test, the examiner again stabilised the tibia and fibula and pushed the ankle joint into inversion stressing the lateral complex (Magee, 2002). The test was implicated as positive when the patient complained of pain indicating injury to the lateral ligaments of the ankle and foot complex (Magee, 2002)

2.4Equipment Setup

A foot scan pressure plate (Rs Scan International) was used to record plantar pressure. The pressure plate was 578mm x 418mm in size, having 4096 Sensors with a capacity of 300Hz. The pressure plates were mounted onto a hard levelled floor with a two meter walkway either side of the plate. The half meter Rs Scan foot scan USB system was connected to a compatible Toshiba computer where the data was recorded. The force data were digitally converted and stored in the computer for subsequent analysis.

2.5Experimental procedure

Before the actual testing the participants were instructed to practice walking barefooted along the walkway, striking the correct foot on the pressure plate to become familiar with the procedure. After familiarization, three valid footprints of the participants were measured. Untaped foot print measurements were taken by the examiner initially followed by taped measurements. The trial was considered to be valid when the following criteria were meet i.e., a heel strike pattern observed by the examiner, walking speed within the outlined boundaries, no adjustment in step length or step frequency to aim on the pressure plate. All the participants were instructed to start and finish walking from the same starting point within a specific boundary marked by the examiner with a tape. The participants were instructed to walk in their normal gait pattern and the walking speed of the participants was not recorded. The participant's ankles were taped by closed basket weave technique with figure of eight heel lock by the examiner. The examiner also attached foam under wrap to protect the leukotape sticking to the skin. New under wrap was used to minimize cross infection. The participants were advised to refrain from the testing procedure in case of any discomfort and inform the examiner. The foot width and length were measured from the imprint captured by the system and reported in millimetres. Centre of pressure of the ankle and foot complex was measured for all participants in both the groups (cases and controls) in untaped and taped circumstances following which the data was recorded. X coordinate of the centre of pressure (COP) was recorded in this study which corresponds to the centre of pressure (COP) displacement of the ankle and foot in the medial-lateral direction (Figure 1). For the *X*-axis examination of the centre of pressure (COP), lateral direction was signed as negative (-) degree and the medial side direction signed as positive (+) degrees when calculated from the midline of the plantar surface of the foot (Figure 1) (Wiliems et al, 2004).

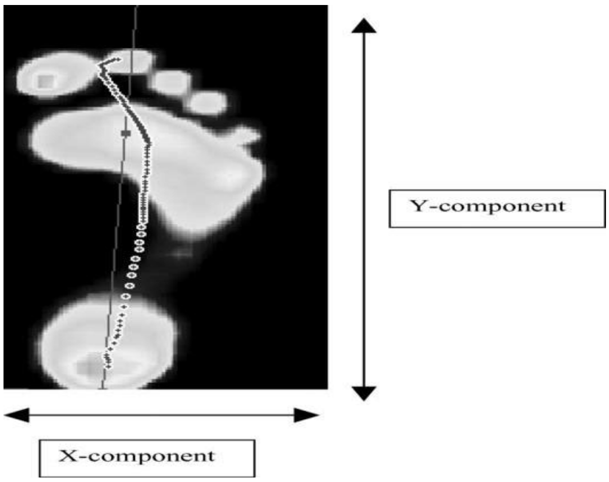

Figure 1: The X component (Medial-Lateral) and Y component (Anterior-Posterior) of Centre of pressure (COP) Source: Wiliems et al (2004)

The Cop X- component was identified at each of the two instants, first foot contact (FFC) and first metatarsal contact (FMC). First foot contact (FFC) can be defined as the instant the foot make its first contact with the pressure plate (Figure 2) (Willems et al, 2005). First metatarsal contact (FMC) can be defined as the instant when one of the metatarsal heads contacts the pressure plate (Figure 3) (Willems et al, 2005). The First foot contact (FFC) and First metatarsal contact (FMC) instants were identified and centre of pressure for initial foot contact (ICP ΔCOP) was calculated by subtracting the centre of pressure of first foot contact (FFC CoP) from centre of pressure of first metatarsal contact (FMC CoP). (Williems et al, 2005).

$$ICP\Delta CoP = FMC\ CoP - FFC\ CoP$$

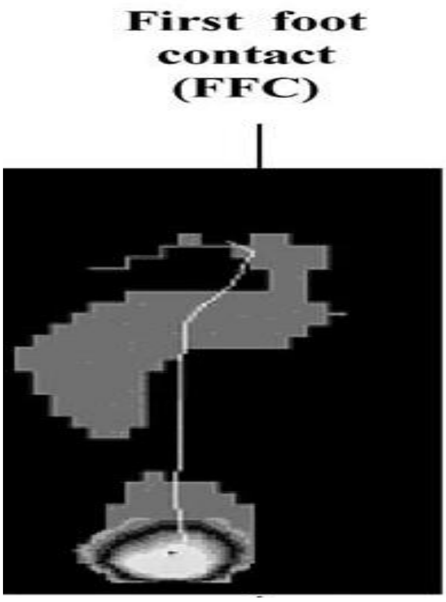

Figure 2: First foot contact (FMC) of initial contact phase (ICP) Source: Wiliems et al (2004)

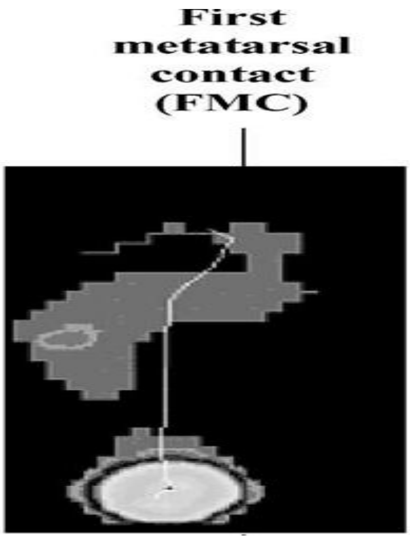

Figure 3: First metatarsal contact (FMC) of initial contact phase (ICP) Source: Wiliems et al (2004)

2.6Statistical methods

Statistical analysis was performed using Microsoft windows excel and windows SPSS version 20.0. The distribution of the data was explored by Kolmogorov-Smirnov test and found to be normally distributed. The statistical significance was estimated by calculating p values ($p < 0.05$). Age, height, weight, foot width, foot length values of the participants from both the groups (cases and controls) were recorded and mean, standard deviations were calculated. Mean and standard deviation values of the participants from both the groups (cases and controls) were compared for age, height, weight, foot width, foot length to evaluate any statistically significance results. Following evaluation of the anthropometric data comprising height, weight, age along with foot length and foot width, centre of pressure (COP) values of the participants from both the groups were analysed. Mean and standard deviations were calculated for the centre of pressure (COP) values recorded from the participants of both the groups (cases and controls) in taped and untapped conditions. Comparison of centre of pressure (COP) values were done both within the individual study groups i.e. cases with ankle taping and without ankle taping, controls with ankle taping and without ankle taping and in between the two study groups i.e. cases and controls with ankle taping, cases and controls without ankle taping. Differences between the control and the cases in between the groups were examined using independent t-tests. Paired *t*-tests were undertaken to evaluate the difference in centre of pressure between the taped and untapped ankles within the individual study groups. Following all comparisons, the statistical significance of the differences was estimated and study results were summarised. In the next chapter study results will be discussed.

III. Results

3.1Introduction

This chapter will provide a detailed summary about the present study results. Mean, standard deviation and p values calculated during data analysis were compared between the different study groups to inspect any significant results ($p < 0.05$). The study results analysed were summarised in five separate tables in this chapter. Table 1 represented the figures comparing age, height, weight, foot width and foot length between the cases (Functional ankle instability) and controls (Non ankle sprains). Table 2, 3, 4 and 5 represented the X component values for the centre of pressure (COP) at heel strike comparing cases and controls without ankle taping, cases and controls with ankle taping, cases with and without ankle taping, controls with and without ankle taping.

Table 1: Comparison of Age, height, weight and foot width and foot length between cases (Functional ankle instability) and controls (Non ankle sprain)

	Functional Ankle Instability (FAI)/ Non Ankle Sprain (NAS)	**Mean**	**SD**	**P- Value**
AGE (YEARS)	FAI NAS	36.9 34.9	11.3 10.0	0.62
WEIGHT (KG)	FAI NAS	75.6 70.9	14.7 14.5	0.40
HEIGHT (CM)	FAI NAS	170.6 169.3	10.0 8.6	0.71
FOOT WIDTH (CM)	FAI NAS	9.4 8.9	0.7 0.7	0.09
FOOT LENGTH (CM)	FAI NAS	26.3 26.7	2.2 2.0	0.67

In Table 1, age (Yrs), weight (Kg), height (Cm), foot width (Cm) and foot length (Cm) of all participants in cases (functional ankle instability) were compared with controls (non ankle sprain). Study results demonstrated no significant findings when study parameters were compared between the participants of both the groups ($p > 0.05$) establishing the fact that participants were evenly distributed between the study groups.

Table 2: X component values for the centre of pressure (COP) at heel strike comparing cases (Functional ankle instability) and controls (Non ankle sprain) without ankle taping

	Untaped Ankle	**Mean**	**SD**	**P- Value**
FFC (MM)	FAI NAS	-4.24 -1.52	4.31 5.33	0.15
FMC (MM)	FAI NAS	-4.36 -3.07	3.28 4.51	0.39
ICP (MM)	FAI NAS	-0.12 -1.54	2.66 2.21	0.13

In Table 2, X component values for the centre of pressure (COP) at heel strike i.e. first foot contact (FFC), first metatarsal contact (FMC) and initial contact phase (ICP) was compared between cases (Functional ankle instability) and controls (Non ankle sprain) without ankle taping. The X-component value of the COP for FFC is situated more laterally for the cases (- 4.24) than the controls (-1.52) without ankle taping. Quite similar to FFC findings, FMC values also demonstrated more lateral deviation of COP for cases (- 4.36) than controls (-3.07) without ankle taping. However while comparing the initial contact phase (ICP) data between the cases and controls without ankle taping, COP findings of the control group (-1.54) demonstrated more lateral deviation than the cases (-0.12). No significant differences were noted when FFC, FMC and ICP values were compared between cases and controls without ankle taping ($p > 0.05$). Standard deviation values recorded were quite high when FFC, FMC and ICP values were compared between the groups (cases and controls) without ankle taping signifying greater variance of the data recorded from the mean reducing the internal validity of the depicted results.

Table 3: X component values for the centre of pressure (COP) at heel strike comparing cases (functional ankle instability) with controls (non ankle s

	Taped ankle	Mean	SD	P- Value
FFC (MM)	FAI NAS	-5.01 -5.51	4.45 4.98	0.78
FMC (MM)	FAI NAS	-4.96 -5.37	5.20 4.82	0.83
ICP (MM)	FAI NAS	0.05 0.14	2.56 2.95	0.93

prain) with ankle taping

In Table 3, X component values for the centre of pressure (COP) at heel strike i.e. first foot contact (FFC), first metatarsal contact (FMC) and initial contact phase (ICP) were compared between cases (Functional ankle instability) and controls (Non ankle sprain) with ankle taping. FFC values of the cases (-5.01) with ankle taping depicted less lateral deviation of the COP than the controls (-5.51) with ankle taping. Likewise FMC values also demonstrated less lateral deviation of the COP for the cases (- 4.96) with ankle taping than the controls (-5.37) with ankle taping. Contrast to the findings of FFC and FMC, the ICP values demonstrated medial displacement of the COP both in cases (0.05) and in controls (0.14) with ankle taping. However all the comparisons between FFC, FMC and ICP between the groups (cases and controls) depicted insignificant results ($p > 0.05$). Standard deviations were again noted high while comparing FFC, FMC and ICP between the groups with taping reducing validity of the study results.

Table 4: X component value for the centre of pressure (COP) at heel strike comparing cases (functional ankle instability group) with and without ankle taping

	Functional ankle Instability (FAI)	Mean	SD	P- Value
FFC (MM)	TAPED ANKLE UNTAPED ANKLE	-5.01 -4.24	4.45 4.31	0.18
FMC (MM)	TAPED ANKLE UNTAPED ANKLE	-4.96 -4.36	5.20 3.28	0.48
ICP (MM)	TAPED ANKLE UNTAPED ANKLE	0.20 -1.20	2.44 2.66	0.63

In Table 4, X component values for the centre of pressure (COP) at heel strike i.e. first foot contact (FFC), first metatarsal contact (FMC) and initial contact phase (ICP) were compared between the participants of the functional instability group (cases) in ankle taped and untaped conditions. The X-component value of the COP at FFC deviated more laterally for the taped participants (-5.01) than the untaped participants (-4.24) in the cases. FMC values recorded also depicted more lateral deviation of COP for the taped participants (-4.96) than the untaped participants (-4.36). However when overall ICP values were compares, contrasting findings were observed between taped and untaped participants of the cases i.e. taped participants depicted medial displacement of COP (0.20) whereas untaped participants depicted lateral deviation of COP (-1.20). No significant results were noted in any of the comparisons ($p > 0.05$).

Table 5: X component value for the centre of pressure (COP) at heel strike comparing controls (non ankle sprain participants) with and without ankle taping

	Non Ankle Sprain	Mean	SD	P- Value
FFC (MM)	TAPED ANKLE UNTAPED ANKLE	-5.51 -1.53	4.98 5.33	0.02
FMC (MM)	TAPED ANKLE UNTAPED ANKLE	-5.37 -3.07	4.82 4.52	0.04
ICP (MM)	TAPED ANKLE UNTAPED ANKLE	0.14 -1.5	2.95 2.21	0.10

In Table 5, comparisons were made for the X component value for the centre of pressure (COP) between the taped and untaped participants of the control group. The X-component value of the COP for FFC is situated more laterally for the taped participants than the untaped participants in the control group. The findings suggest statistical significant result with P = 0.02. FMC values when compared between the taped and untapped participants of the control groups also depicted more lateral deviation for the taped participants than the untapped participants. The findings again suggested statistical significant finding with p = 0.04. However when ICP were compared, it was seen that taped participants (0.14) demonstrated medial deviation but the untaped participants (-1.5) demonstrated lateral deviation of COP. Results suggested insignificant findings (p>0.05).

III. Discussion

Over the years numerous researches were conducted to evaluate the clinical benefits of ankle taping following inversion ankle sprains. The knowledge gained by these studies is of great clinical value but the effects that ankle taping has on biomechanical gait parameters have not been determined by any of these studies. In the present study, individuals with a history of inversion ankle sprains and having functional ankle instability (n=14) were compared with controls (n=14) without any ankle sprains to evaluate the effects of ankle taping on centre of pressure of the ankle and foot at heel strike of gait cycle. The clinical findings of the present study states that ankle taping does not have any effects on centre of pressure (COP) of the ankle and foot complex at heel strike following a history of inversion ankle sprains. The study findings are discussed below as per analysis:

Comparison of Age, height, weight with foot width and foot length between cases (Functional ankle instability) and controls (Non ankle sprain)

Risk factor estimation following inversion ankle sprains plays an important role in the diagnosis, management and future prevention of similar injuries (Hertel, 2002). Age, height and weight, foot width and foot length are considered as prospective risk factors for inversion ankle sprains by many researchers (Murphy et al, 2003). Although there is much controversy regarding the actual effect of the following risk factors on the injury mechanism of inversion ankle sprains, none of the risk factors can be neglected during diagnosis (Murphy et al, 2003). In this study, prospective risk factors for ankle inversion sprain i.e. age, height, weight, foot width and foot length were evaluated and matched between cases (functional ankle instability) and controls (non ankle sprains) to eliminate presence of any compounding factor (Bland and Altman, 1994). Unevenly distributed risk factors between the cases and controls have the capability to influence the study results (Bland and Altman, 1994). Comparison all the risk factors between the participants of both the groups demonstrated insignificant results (p >0.05) supporting the fact the participants in both the study groups have similar traits. This comparison not directly answers the research question but it plays an important role in establishing the fact the participants in both the study groups have similar features.

X component values for the centre of pressure (COP) at heel strike comparing cases (Functional ankle instability) and controls (Non ankle sprain) without ankle taping

While comparing X component value of COP between cases and controls without any ankle taping, FFC values depicted more lateral deviation of COP for the cases (-4.24) than the controls (-1.52). X component value of COP at FMC also demonstrated similar results with more lateral deviation for cases (-4.36) than the controls (-3.07). More lateral deviation of COP at FFC and FMC demonstrated less lateral ankle stability for the cases (functional ankle instability) following inversion ankle sprains than the healthy controls group with no ankle sprains while ankles were not taped (Nyska et al, 2003; Williems et al, 2004; Monaghan et al, 2006). The exact cause of lateral deviation of COP for the cases was not known in this study but it may be due to less strength of the lateral ankle ligaments and peroneal muscle tendons (ankle evertors) to counteract the strong invertor force during gait (Sawkins et al, 2005; Karlsson and Andreasson, 1992). The present study results can be correlated to the findings of Williems et al (2004), who also noted more laterally deviated X component of COP at FFC (cases = -2.75, controls = -1.95) and FMC (cases = -2.00, controls = -1.14) for the cases than the controls without any taping while evaluating gait related risk factors for inversion sprains in a physically active population. The case group in the study by Williems et al (2004) constituted of participants having inversion ankle sprain and the control group constituted of healthy adults without any ankle sprain. Williems et al (2004) documented unstable lateral ankle complex following inversion ankle sprain as the possible reason for the lateral deviation for the COP in the cases. Although the present study results depicted similar features as Williems et al (2004), an important fact to note is that williems et al (2004) conducted the study on the participants while running other than normal walking procedure implemented for the testing in the present study. Ground reactive force in running is believed to be three times more than that of walking with more pressure generation under the plantar surface of the foot (Nishikawa, et al, 2002). Apart from FFC and FMC values, when X component value of COP at ICP was compared between the cases and controls without taping it was noted that controls (-1.54) deviated more laterally than the cases (-0.12) i.e. a fact which was not hypothesised. Williems et al (2004) while comparing the ICP values between the cases (0.75) and controls (0.81) noted medial deviation of COP for both cases and controls. Williems et al (2004) didn't explain any possible reason for the study findings. All the comparisons between FFC, FMC and ICP between the groups (cases and controls) depicted insignificant results ($p > 0.05$) in this study. Standard deviation values recorded were quite high when FFC, FMC and ICP values were compared between the groups (cases and controls) without ankle taping reducing the internal validity of the depicted results.

X component values for the centre of pressure (COP) at heel strike comparing cases (functional ankle instability) with controls (non ankle sprain) with ankle taping

No previous study was conducted before comparing X component of COP values between the participants having functional ankle instability (FAI) following inversion ankle sprains and the healthy controls having no ankle sprains with ankle taping. While comparing the X component value for COP between cases (functional ankle instability) and controls (non ankle sprain) with ankle taping it was noted that FFC values of both cases and controls were deviated laterally however the cases (-5.01) were less deviated than the controls (-5.51). In FMC also the cases (-4.96) depicted less lateral deviation of COP than the controls (-5.37). We have seen that the COP value of cases at FFC and FMC deviated more laterally than the controls when ankles were not taped for both the groups (Table = 2). In the present comparison also with ankle taping, X component value of COP deviated laterally for both cases and controls at FFC and FMC questioning the effect of ankle taping on ankle and foot mechanics following inversion ankle sprains. However when the overall ICP values were calculated, medial deviation of the COP was noticed both in cases (0.05) and in controls (0.14) with ankle taping. Although exact cause of medial deviation of the X component of COP at ICP for cases and controls was not determined in the present study but it may be due to the fact that ankle and foot was not able to accommodate to the changes initially with ankle taped (Williems et al, 2004). All the comparisons between FFC, FMC and ICP between the groups (cases and controls) depicted in this study insignificant results ($p > 0.05$). Standard deviations were again noted high while comparing FFC, FMC and ICP between the groups with taping.

X component value for the centre of pressure (COP) at heel strike comparing cases (functional ankle instability group) with and without ankle taping

While comparing X component value of COP within the functional ankle instability group (cases) with and without ankle taping it was noted that the COP at FFC is situated more laterally for the taped participants (-5.01) than the untaped participants (-4.24). FMC values recorded also depicted more lateral deviation of COP for the taped participants (-4.96) than the untaped participants (-4.36). In both the cases i.e. FFC and FMC, ankle taping was not able to counteract the force of the ankle invertors and neutralize the ankle and foot complex in the taped participants of the cases (Abboud, 2002). However when the X component value for the ICP was compared for the taped and untapped participants in the cases, medial displacement of the COP was noted for the taped participants (0.20) signifying foot pronation whereas the untaped participants (-1.2) demonstrated lateral deviation of COP (foot supination). The present study result states the fact that ankle taping has got some effects on the X component of COP at ICP but not on FFC and FMC when compared between the taped and untapped participants in the functional ankle instability participants (cases). All the comparisons between FFC, FMC and ICP between the groups (cases and controls) depicted in this study insignificant results ($p > 0.05$).

X component value for the centre of pressure (COP) at heel strike comparing controls (non ankle sprain participants) with and without ankle taping

X component value for COP compared between the taped and untaped participants of the control group demonstrated more laterally deviated COP at FFC for the cases (-5.51) than the controls (-1.53). The results were significant with $p = 0.02$. FMC values compared between the taped and untaped participants of the control group also depicted more lateral deviation for the cases (-5.37) than the controls (-3.07). The results were again significant with $p = 0.024$. In the control group without any ankle sprains, it was assumed that the participants of both the groups (taped and untaped) will depict neutral COP measurements, but the present study estimating X component value of COP demonstrates great variation of COP for the taped participants when compared with the untapped participants at FFC and FMC. This study however was not able to answer the actual cause of the lateral deviation of COP for the participants with taped ankle. When the ICP values were compared between the taped and untapped participants of the control group, it was noted that taped participants demonstrated medial deviation (0.14) and untaped participants demonstrated lateral deviaton (-1.5). No significant differences were noted ($p>0.05$). The ICP values supports the fact that taping have some effect on the normal healthy adults without any ankle sprains but future studies are much required to evaluate the role of ankle taping on FFC and FMC components of COP.

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