The effect of chronic ankle instability (CAI) on lower extremity mechanics and muscle function during gait and walking

Student Name

Institution

Course Code

1. Kinematics

1.1: Single/rear-foot segment model (CAI vs. Uninjured)

Monaghan, Delahunt, & Caulfield conducted a research in the year 2006 to try and find out the reasons leading to the development of instability of the chronic ankle in people. Previously this had not been investigated using 3D motion analysis and more so during walking. The hypothesis of their research was that the subjects would have different kinetic and kinematic patterns when walking normally then that of a control group. The research method applied was gait analysis on 5 subjects equally distributed among the genders. The researchers found that subjects with chronic ankle instability were significantly inverted when walking in a frontal plane. They came to a conclusion that the changes in kinetics and kinematics as a result of increased stress on the ankle joint structures ended up resulting in the repeated injuries.

The ankle joint of the body has been known to need precise neuromuscular control as it transitions from the terminal swing in the gait cycle stance phase. Delahunt, Monaghan, & Caulfield (2006) on this basis conducted a research to compare patterns experienced in the 3D joint of the lower limb when using the treadmill. The research was conducted in a controlled laboratory where data was collected from a group of participant who had practical instability. The displacements and speeds observed in the knee, ankle and hip joints together with those of the rectus femoris were collected when the subjects were walking on the treadmill at a controlled speed of 4 km/hr. From this study, it was observed that subjects who had practical instability had a reduction in the vertical foot-floor clearance before the heel strike and immediately after there was a heel strike. These same subjects were also witnessed to have an upsurge in the peroneus integral electromyography. The researchers came to a conclusion that altered kinematics were

the reason why subjects who had functional instability occasionally had ankle inversion injuries even in occasions where there is minimal or no external provocations.

Chronic ankle instability in relation to Kinematic patterns has not been extensively researched on. This led to Drewes et.al (2009) carrying out a research aimed at determining the people who had CAI would demonstrate altered ankle kinematics. The study was designed as a case-control and was carried out in a motion analysis laboratory. There were 7 subjects in this study and all had suffered from CAI. The subjects were made to walk and jog on the treadmill as 3-dimensional kinematics were captured concentrating on the lower extremities. They observed that the CAI cluster had extra rear-foot upturn together with shank exterior rotation when jogging and when walking. They concluded that altered ankle kinematics together with joint coupling predisposes a population that has CAI to more injuries due to ankle inversion.

Another research on this topic was conducted by Chinn, Dicharry & Hertel, (2013) evaluating frontal and sagittal plane of subjects who had a chronic ankle injury. Their research was designed as a cross-sectional study and carried out in a motion analysis laboratory. There were 15 subjects who had CAI and other 13 healthy subjects. In this research, the sagittal and the frontal plane kinematics would be calculated in the entire gait cycle (Chinn, Dicharry & Hertel, 2013). In all speeds, there was a 90% Confidence Interval (CI) with rapid increments in speeds. The results of their research were that CAI participants had more plantarflexed as compared to the others during increments in walking and jogging. The conclusion was that the alteration indicated that shod in CAI subjects adjusted their gait for them to successfully complete a task.

Terada et.al. (2015) conducted another study with the aim of evaluating the stride-to-stride erraticism as part of the lower limit in people while mobile. These persons needed to have chronic ankle instability (CAI). They did this with the use of nonlinear analysis. Their study involved 25 subjects who had self-reported CAI and other 27 healthy participants who had volunteered for this study. Their study involved having subjects walk on a treadmill at their own selected speeds for 3 minutes. The researchers would then record the kinematics of the lesser limit on sagittal together with frontal planes. A sample entropy was used to analyze the sequential structure of the walking erraticism. The results of the study were that the CAI cluster had lesser SampEn digits of the frontal plane when associated to those of the control group. There was also fewer stride-to-stride erraticism observed in the CAI participants which shows that having CAI could lead to a sensorimotor system that is less adaptable.

Doherty et.al (2016) another researcher on the topic noticed a research gap in the prediction of chronic ankles instability injuries and to those that have occurred due to ankle sprain injury. The researchers then used 69 ankle sprain damage patients who had the condition for more than six months. They used these participants in a research aimed at defining whether there existed a correlation between CAI and ankle sprain injuries. The researchers collected data from their lower extremity kinetic and kinematic. The group which had CAI was observed to have an amplified knee flexion during period 1. During the second period, this same group was observed to have more extensor dominance in their knee, and their ankle joint had a total displacement. They concluded that there existed a correlation between acute deficits and long term outcomes.

One of the recent researches on the single/rear-foot segment model was conducted by Tavakoli, Forghany, & Nester in the year 2016. They had observed that some of the repetitive ankle sprains were being termed as functional ankle instability for them having neurological basis. They therefore decided to carry out a research that investigated effects of cognitive demand on foot kinematics on people that are physically active and have functional ankle instability. They did this with the use of 21 physically active participants who had FAI and 19 healthy controls. They had to complete tasks of normal walking and other tasks of walking while performing cognitive tasks. They discovered that in normal walking the ankle joint was significantly inverted for the FAI group than the control group. They then came to a conclusion that participants suffering from FAI had different ankle movement patterns which increased their movement variability. Cognitive task loads increased the risk of ankle instability amongst these people.

1.2: Single/rearfoot segment model (CAI vs coper)

There exists a research gap on the difference in movement patterns after CAI develops from a lateral ankle sprain. This led to Brown et.al (2008) to hypothesize that functionally and mechanically unstable subjects would have different kinetics and kinematics when compared to another groups `copers` who has an ankle sprain injury. They then conducted a study with 63 subjects comprising of recreational athletes to try and proof their hypothesis. They then measured the peak ground forces and frontal plane motion of the subjects as they conducted 5 tasks. They observed that the mechanically unstable cluster had a minimum of a difference in the sagittal and frontal plane ankle motion, especially in the early contact. The greatest differences were observed when conducting stop jump and drop jumps. They interpreted this to mean that

the mechanically unstable cluster had a rehabilitated ankle motion pattern as likened to the other subgroups.

Chronic ankle instability is a condition that has been attributed to the foot positioning before a heel strike occurs. It is also thought to be the cause of the perpetuating and developing CAI. Brown (2011) conducted a study to determine whether people who mechanical instability had denoted as MI or those who had Functional Instability denoted as FI have a lower foot-floor clearance or a more of a plantar flexed and inverted position. He conducted the research in a controlled laboratory study. He performed 3 dimensional motion analysis on the 11 male subjects who were athletes. In his results, he found that the MI cluster had a superior foot external rotation when likened to the FI cluster and the coper group as well. He also found that the FI group had more plantarflexion as compared to the MI cluster. He then concluded that the differences in the leg and foot position when taking periodic swing were found in MI, FI and coper clusters. It was therefore correct to say that greater plantar flexion coupled with a decrease in the minimum metatarsal height could lead to an increased risk of inadvertent contact which leads to episodes of instability.

Doherty et.al (2016b) also conducted another study with the aim of comparing locomotive biomechanics between people with CAI and those with a lateral ankle sprain (LAS) as copers. This was to be done as a cross-sectional study. Their study involved 28 participants who had CAI and 42 others who had LAS copers and each was required to do a five self-selected gait trials. The minor kinematic and kinetic data that is extremely temporal would then be collected using 3D technology. The results were such that the CAI group was observed to have increased hip flexion in period 1 while in period 2 the same group was observed to have

decreased hip extension. They concluded that there was a potential link between the features if these subjects and the outcome in the long run.

It is crucial to draw a line as whether there is a correlation between Chronic Ankle Injuries and those that are inflicted as a result of deficits caused by ankle sprain injury. Doherty et.al. (2016) used 69 participants to try and draw this relationship by comparing the results to those of copers. The participants would be grouped into two as either the CAI subgroup or the coper one. Data on the lower extremity kinetic and kinematic was collected for correlation analysis. The subgroup with the greatest disability `chronic ankle instability` was observed to have amplified knee flexion in period 1. In the second period the same subgroup was observed to have more extensor dominance of their knee and a total displacement in the ankle joint. Due to this, they concluded that there is a link between long-term outcomes and acute deficits.

As reported by Donovan & Feger (2017) there are no biomechanical assessment tools that are readily available to examine excessive inversion following and prior to lateral ankle injuries. Before such a tool is established its crucial to determine whether there exists a relationship between the ankle frontal plane motions. This will help in determining whether one task or a combination of the same would be appropriate for the evaluation of patients. Donovan & Feger (2017) would then proceed to conduct a research to try and analyze the relationship that exists between frontal ankle kinematics when stepping down, walking and jump landing. They used 56 subjects for this study who were volunteers. The measures taken included those of ankle frontal plane motions during peak inversions and initial contact. Pearson correlation coefficient would then be used to analyze the relationship between the kinematics of the ankle frontal plane. The results showed strong correlations in the peak inversions when walking and stepping down.

These strong relationships were concluded to suggest that one evaluation test was adequate in the identification of the abnormal ankle biomechanics.

1.3 Single/rearfoot segment model (CAI vs coper and uninjured)

Doherty et.al (2016a) noted that there existed no research that predicted the link between chronic ankles Instability Injured patients and those that had been inflicted due to deficits as a result of the ankle sprain injury. They, therefore, proceeded to so an analysis of 69 participants who had a six month history with an ankle sprain damage to try and uphold whether this connection existed by comparing them with an uninjured control group. Their self-reported disability status was used to ascertain whether they were in the chronic ankle instability group or in the uninjured subgroup. Data on the lower extremity kinetic and kinematic was collected and correlation analyzed. The subgroup with the chronic ankle instability was observed to have amplified knee flexion in period 1. In the second period the same subgroup was observed to have more extensor dominance of their knee and a total displacement in the ankle joint. Due to this, they concluded that there is a link between long-term outcomes and acute deficits

1.4: Multi-segment foot model (CAI vs. Uninjured)

Instability in an individual has been attributed to many factors including altered gait kinematics amongst individual suffering from functional ankle instability (FAI). This is despite the fact that research findings are not consistent on this matter. Wright, Arnold, Ross, & Pidcoe, in the year 2013 decided to clarify the findings through the use of 69 participants. 23 of the participants had FAI, 23 copers and 23 as the control group. During gait the researchers calculated forefoot and hind foot sagittal and frontal plane angles during the initial contact. They found out that the FAI group had more inverted ankles than the controls while the copers had no significant difference from the controls or FAI group. They concluded that this lack of difference

means that increased inversion error in FAI does not necessarily explain the symptoms of instability.

De et.al (2013) would then use a multi-segmented foot on gait kinematics of subjects who had ankle flux. Rehabilitated ankle kinematics were recounted to play a part in the underlying mechanics of Chronic Ankle Injury. They noted that in previous researches the foot had been exhibited as a rigid section totally disregarding how complex the ankle and the foot anatomies were. They conducted a study meant to evaluate the stance phase of the kinematics. They would then proceed to use 77 subjects where 29 had CAI, 24 were copers and 24 were controls. A rigid foot model measured the subjects when walking and running barefoot. A 20m long run was used in the collection of the data. They observed that the CAI and the coper groups had similar differences in the last stance and mid stance than the control group. Their study revealed that there were a significant last stance and mid stance difference in the rigid, rear and medial forefoot. They recommended that there be more research on the foot kinematics so as to expand the knowledge on the subject.

A study was conducted by Dingenen et.al. (2017) with the aim of evaluating the multi-segmental kinematic patterns as observed in CAI participants. The conducted a cross-sectional study. They collected kinematic data from 12 non injured controls and from 15 CAI victims. A three-dimensional analysis would then be used during walking barefoot. The participants were also required to walk in low and high dye taping. Two model was then used to analyze the results, these are the Rizzoli 3D multi segment foot model and the rigid plug-in gait model (Dingenen et.al. 2017). The CAI participants would then be observed to have decreased ankle dorsiflexion especially in loading response. There was no significance difference in the high dye

taping. There was a conclusion that there exists significant differences in the kinematic patterns of the ankle joint and the rear foot.

.

References

Brown, C. (2011). Foot clearance in walking and running in individuals with ankle instability. *The American journal of sports medicine*, *39*(8), 1769-1777.

Brown, C., Padua, D., Marshall, S. W., & Guskiewicz, K. (2008). Individuals with mechanical ankle instability exhibit different motion patterns than those with functional ankle instability and ankle sprain copers. *Clinical biomechanics*, *23*(6), 822-831.

Chinn, L., Dicharry, J., & Hertel, J. (2013). Ankle kinematics of individuals with chronic ankle instability while walking and jogging on a treadmill in shoes. *Physical Therapy in Sport*, *14*(4), 232-239.

Ridder R., Willems, T., Vanrenterghem, J., Robinson, M., Pataky, T., & Roosen, P. (2016). Gait kinematics of subjects with ankle instability using a multisegmented foot model. *Medicine and science in sports and exercise*, *45*(11), 2129-2136.

Delahunt, E., Monaghan, K., & Caulfield, B. (2006). Altered neuromuscular control and ankle joint kinematics during walking in subjects with functional instability of the ankle joint. *The American Journal of Sports Medicine*, *34*(12), 1970-1976.

Dingenen, B., Deschamps, K., Delchambre, F., Van Peer, E., Staes, F. F., & Matricali, G. A. (2017). Effect of taping on multi-segmental foot kinematic patterns during walking in persons with chronic ankle instability. *Journal of science and medicine in sport*, *20*(9), 835-840.

Doherty, C., Bleakley, C. J., Herte, J., Caulfield, B., Ryan, J., & Delahunt, E. (2016a). Gait biomechanics in participants, six months after first-time lateral ankle sprain.

Doherty, C., Bleakley, C., Hertel, J., Caulfield, B., Ryan, J., & Delahunt, E. (2016b). Locomotive biomechanics in persons with chronic ankle instability and lateral ankle sprain copers. *Journal of science and medicine in sport*, *19*(7), 524-530.

Donovan, L., & Feger, M. A. (2017). Relationship between ankle frontal plane kinematics during different functional tasks. *Gait & posture*, *54*, 214-220.

Drewes, L. K., McKeon, P. O., Paolini, G., Riley, P., Kerrigan, D. C., Ingersoll, C. D., & Hertel, J. (2009). Altered ankle kinematics and shank-rear-foot coupling in those with chronic ankle instability. *Journal of sport rehabilitation*, *18*(3), 375-388.

Monaghan, K., Delahunt, E., & Caulfield, B. (2006). Ankle function during gait in patients with chronic ankle instability compared to controls. *Clinical Biomechanics*, *21*(2), 168-174.

Tavakoli, S., Forghany, S., & Nester, C. (2016). The effect of dual tasking on foot kinematics in people with functional ankle instability. *Gait & posture*, *49*, 364-370.

Terada, M., Bowker, S., Thomas, A. C., Pietrosimone, B., Hiller, C. E., Rice, M. S., & Gribble, P. A. (2015). Alterations in stride-to-stride variability during walking in individuals with chronic ankle instability. *Human movement science*, *40*, 154-162.

Wright, C. J., Arnold, B. L., Ross, S. E., & Pidcoe, P. E. (2013). Individuals with functional ankle instability, but not copers, have increased forefoot inversion during walking gait. *Athletic Training and Sports Health Care*, *5*(5), 201-209.