EFFECT OF VIDEO-ASSISTED MINDFULNESS DEEP BREATHING AMONG COLLEGIATE ATHLETES WITH CHRONIC ANKLE INSTABILITY

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By

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ABSTRACT

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Vinodhkumar Ramalingam

Chronic ankle instability (CAI) is the most common injury in sportsmen, causing psychological stress from doubting their performance. Mindfulness intervention on pain management established in numerous studies, but intervention with video-assisted deep breathing during injury is still scarce. The present study aimed to investigate the effects of 3-min video-assisted mindfulness deep breathing (VAMDB) through neurophysiological changes on pain management in addition to conventional physiotherapy (CP) among CAI. The study recruited 23 collegiate athletes without CAI to the healthy control group, and 30 collegiate athletes with CAI randomly assigned to the experimental group (VAMDB+CP) and control group (CP only). The effectiveness of interventions assessed at three intervals using Cumberland ankle instability tool, functional ankle instability index, visual analogue score, brief pain inventory, mindful attention awareness scale, Oxford happiness questionnaire, Y-balance, and EEG. A 14-channel EEG employed as a novel bio-indicator of pain. Independent t-test and two-way repeated-measures ANOVA were applied to report the significant level ($p<0.05$). Pearson's correlation used to report the association of EEG with pain. CAI participants reported a significant increase ($p<0.001$) in pain intensity and interference, along with a significant decrease ($p = 0.001$) in dynamic balance and happiness scores compared with health control group. Further, the increase in pain among CAI participants showed a significant decrease ($p < 0.05$) in EEG response and a negative association with alpha, beta, and theta waves over occipital and left temporal regions. After exposed to 6-weeks of intervention and 6-weeks of follow-up, CAI participants in experimental and control groups reported a significant improvement ($p < 0.05$) over the time interval in pain, balance, and happiness. However, the mindful attention showed a significant difference in the time×group ($p = 0.001$), with an increased attention score in the experimental group. Further, the increase in mean occipital alpha found to be a sensitive indicator of improvement in male CAI participants.

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APPROVAL SHEET

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SUBMISSION OF THESIS

It is hereby certified that ***Vinodhkumar Ramalingam*** (ID No: ***17UED00895***) has completed this final year thesis entitled " *EFFECT OF VIDEO-ASSISTED MINDFULNESS DEEP BREATHING AMONG COLLEGIATE ATHLETES WITH CHRONIC ANKLE INSTABILITY*" under the supervision of Dr. Lee Poh Foong (Supervisor) from the Department of Mechatronics and Biomedical Engineering, Lee Kong Chian Faculty of Engineering and Science, and Emeritus Prof. Dr. Cheong Soon Keng (Co-Supervisor) from the Department of Medicine, Faculty of Medicine and Health Sciences.

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I Vinodhkumar Ramalingam hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

(VINODHKUMAR RAMALINGAM)

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TABLE OF CONTENTS

Page

CHAPTER

3.0 MATERIALS & METHODS 39

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BPI	Brief Pain Inventory
BL	Baseline
CAI	Chronic Ankle Instability
CAIT	Cumberland Ankle Instability Tool
CG	Control group
CP	Conventional Physiotherapy
EEG	Electroencephalogram
EG	Experimental group
FAI	Functional Ankle instability
FADI	Foot and Ankle Disability Index
FADI-S	Foot and Ankle Disability Index- Sports
FU	Follow-up
HCG	Healthy Control Group
ICC	Intraclass Correlation Coefficient
MAAS	Mindful Attention Awareness Scale
MBSR	Mindful Based Stress Reduction
MBCT	Mindfulness-Based Cognitive Therapy
MI	Mid-intervention
MM	Mindfulness Meditation
OHQ	Oxford Happiness Questionnaire
qEEG	Quantitative Electroencephalogram

PI	Post-intervention
SPSS	Statistical Package for the Social Sciences
VAMDB	Video Assisted Mindful Deep Breathing
VAS	Visual Analogue Scale
YBT	Y-Balance Test

CHAPTER 1

INTRODUCTION

1.1 Background

One of the most common injuries for athletes to endure is ankle sprains (Lynch, 2002; Moreira and Antunes, 2008). In that, three-quarters of ankle injuries involve the lateral ankle, which causes anterior talofibular ligament sprains in 73% individuals/cases (Fong et al., 2007; Roos et al., 2017) and 25% involve the medial ankle and or syndesmosis/high ankle injuries of the anterior-inferior or posterior-inferior tibiofibular ligament (Waterman et al., 2011). The annual incidence of acute ankle sprains was reported to be ranging from 2 to 7 per 1000 individuals. (Waterman et al., 2010; Gribble et al., 2016).

The ankle sprain injury is vexatious for athletes as it requires high sustainable functional activity of the lower extremity for different types of sports (Chinn and Hertel, 2010; Kaminski et al., 2013). According to systematic research, the ankle was perhaps the most frequently damaged body area, with a collected outcome of 24 out of 70 sportspeople suffering from this type of injury (Fong et al. 2007). The setback for ankle sprain injury causes athletes to frequently undergo repeated ankle sprains over the lateral ankle joint that cause constant ankle pain (Hertel, 2000, 2002). Ankle stability can be compromised if injured athletes are left untreated and lead to chronic ankle instability (CAI) (Coughlin et al. 2013). CAI is expected to occur among 40% of individuals who had an incidence of lateral ankle sprain (Doherty et al. 2016). Compared with healthy individuals, participants with CAI experience a higher level of physical and psychological barriers that in turn affect the quality of life (Houston et al. 2014), moreover the impact will be heightened for sportsmen. The epidemiological data from the professional and recreational Chinese athletes of Hong Kong highlighted that the occurrence of 59% severe ankle instability affected the sports performance of 73% of athletes who experienced recurrent ankle sprains over the lateral ankle joint (Yeung et al. 1994).

The hallmarks of chronic ankle instability (CAI) are repeated ankle sprains, giving way sense or functional ankle instability (FAI), and pain around the lateral ankle joint that may affect the individual's activities of daily life and sporting events (Hiller et al.2011; Melzack, 2001). The CAI produces an uncontrolled movement of the ankle to roll inwards with excessive plantar flexion and foot abduction (de Vries et al., 2002; Hertel, 2002) which results in repetitive injury to the lateral ankle. The repeated ankle injury was reported to initiate numerous impairments in the neurophysiological response like sensorimotor function (Burcal et al., 2019), disturbed central nervous system excitability, the plasticity of neural networks (Needle et al., 2017), and thus causing FAI during sports activities (Coughlan and Caulfield, 2007; Delahunt et al., 2010). In addition, CAI may also cause alteration in motor evoked potential and cortical activation that can result in deficits in motor thresholds of the brain (Rosen et al., 2019). These changes, in turn, disturb the normal balance and coordination due to the alterations in the mechanoreceptors of the peripheral joint to lose their position sense in CAI individuals (Dabadghav, 2016). On the other hand, the improvement in dynamic balance improves cortical function in the brain with a positive correlation of EEG alpha and beta waves (Burcal et al., 2017). According to the updated model of CAI (2019), persistent pain is the main reason for patients to seek a rehabilitation programme for CAI (Hertel and Corbett, 2019).

Further, CAI causes deficits in normal neurocognitive performance and balance (Rosen et al., 2019), and affects the physical and psychological quality of life and well-being of injured participants when compared with healthy individuals (Vela and Denegar, 2010). Researchers have found higher levels of life stress and depression in injured than non-injured collegiate athletes (Brewer, 1995) and predicted depression or worry may affect the happiness level (Lefebvre and Jensen, 2019) due to sports-related chronic pain (Owen, 2015). Further, the mental illness has a significant impact on day-to-day healthy living, which can lead to serious functional impairments such as anxiety and depression, both of which have been found to be predictors of poor athletic performance. According to a survey conducted by the American College Health Association, 30% of student-athletes experienced depression and anxiety at the same time, which could be attributed to pre-competition anxiety (Davoren & Hwang, 2014). Another study by Ferreira et al. (2007), found that anxiety is a major complaint and stressed the importance of therapeutic interventions to deal with distress. In addition, a study by (Charles E. Cox et al., 2017) reported that the existence of depressive symptoms is common among collegiate athletes, which is about 33.2%. This emphasised the importance of continuous improvement in mental health is vital to be addressed in healthy collegiate athletes (Charles E. Cox et al., 2017). Injured athletes experience depression 6 times comparing with healthy athletes (O´Connell and Manschreck, 2012) as the stress is an important predecessor during injury (Putukian, 2016) and that might cause anxiety and unhappiness in people with persistent foot and ankle pain (Shivarathre et al., 2014). Further, the participants with chronic pain found to have reduction in attention level (Dick and Rashiq, 2007). This initiates the worries in the collegiate athletes with CAI sufferers about their future performance or regain their original physical strength to do sport. Therefore, this unavoidably triggers worries among them, which affects the happiness level (Lefebvre and Jensen, 2019) and attention (Dick and Rashiq, 2007) of participants with chronic ankle pain. Hence, a simple non-invasive method to calm the CAI sufferer and reduce their negative thoughts is essential. Moreover, relaxation practices like deep breathing exercises (Scotland-Coogan and Davis, 2016) or muscle relaxation have been shown to be helpful in managing painful symptoms in people living with chronic pain (Kwekkeboom and Gretarsdottir, 2006). Chronic ankle pain due to repeated ankle sprains is common among collegiate and elite sports participants (Mattacola and Dwyer, 2002; Hertel, 2002; Doherty et al., 2016b).

Other than pain, injured athletes undergo emotional fluctuations characterized by feelings of loss, fear, pain, shock, decreased self-esteem, frustration, negative emotions, mood disturbance, isolation, and anger (Mittly and Nemeth, 2016; Santi and Pietrantoni, 2013; Tracey, 2003). Remarkably, collegiate athletes with recurrent ankle sprains are reported to have a higher level of fear compared with those with a single ankle sprain, indicating that repeated ankle sprains are more vulnerable (Houston et al., 2018). The study evidenced an association between stress and depression with back pain intensity and disability respectively among competitive athletes (Belz et al., 2018). A study by Nixdorf et al., (2013) reported a prevalence of 15% depression among elite athletes and demonstrated a positive correlation between high levels of depressive symptoms and negative coping strategies, and also between high levels of chronic stress and negative stress-recovery states.

Further, the existence of stress may affect the neurophysiology of the brain in young adults and result in lack of skills in pain coping, high risk of impairment towards emotion, social, and physical activities (Lee et al., 2018). The physically active male college students with CAI exhibited deficiencies in neurocognitive performance especially memory and attention, which affect postural stability and results in repeated ankle sprain (Rosen et al., 2020). A study by (Rosen et al., 2017) reported a significant linear relationship between the ankle stability and attention in university students with CAI. Besides, CAI involves both peripheral and central influence in controlling the ankle movements (Rosen et al., 2019). The peripheral alterations in FAI are being identified using the Cumberland Ankle Instability Tool (CAIT) with a point total of less than or equal to 27 is utilised in clinical settings (Claire E Hiller et al., 2006). Whereas the central cortical changes like dynamic balance and electrophysiological response of the brain are widely tested using the dynamic Y-Balance test (YBT) and electroencephalogram (EEG) respectively (Rosen et al., 2019). Clinically, pain is assessed subjectively by applying the visual analogue scale (VAS) (Alghadir et al., 2018) and brief pain inventory (BPI) (Williams et al., 2006; Keller et al., 2004), whereas objectively using the non-invasive tool electroencephalography (EEG) in recording the participants' brain waves (de Vries et al., 2013). Furthermore, EEG was used to record the brain wave response in order to determine the effects of deep breathing (Cheng et al., 2018).

The established treatment for participants with CAI is a nonsurgical rehabilitation programme (Ajis and Maffulli, 2006; Balduini et al., 1987; Rodriguez-Merchan, 2012) to reduce pain (Mattacola and Dwyer, 2002), improve ankle range of motion, neuromuscular control, and lateral stabilizer strength (Dabadghav, 2016; Beazell et al., 2012; Chinn and Hertel, 2010) by single-leg stance, hopping, and wobble board training to improve ankle stability (Hughes and Rochester, 2008). Further to protect against recurrent acute ankle sprains, ankle supportive devices, ankle tape, targeted neuromuscular training, and frequent sport-specific warm-up exercises are commonly used (Rodriguez-Merchan, 2012). Additionally, physical exercises are necessary to prepare the body for performance achievement, and mental relaxation exercises to gain the attention and well-being in athletes (Rooks et al., 2017).

As a holistic approach in rehabilitation of sports injury, the psychological needs of the athlete are required to be addressed in addition to the physical rehabilitation (Concannon and Pringle, 2012). Often, the psychological rehabilitation is managed by introducing the positive psychological skills such as goal setting (Ardern et al., 2013), imagery, motivational methods, relaxation techniques (Scotland-Coogan and Davis, 2016), self-talk, social support (Kamphoff et al., 2013), increased adherence, reduction in stress and anxiety (Wrisberg et al., 2006). Further, relaxation practises like deep breathing exercises (Scotland-Coogan and Davis, 2016) or muscle relaxation, shown to be helpful in managing painful symptoms in people living with chronic pain (Kwekkeboom and Gretarsdottir, 2006), anxiety (Manzoni et al., 2008) and depression (Jain et al., 2007).

Recently, mindfulness has indeed been widely introduced to the public and gained a good outcome from pain management with this practice (Forsyth and Hayes, 2014; Baer, 2003;Kabat-Zinn et al., 1985; Taylor and Taylor, 1998). Plews-Ogan et al., (2005) showed that formal mindfulness-based stress reduction (MBSR) practice, initially proposed by Jon Kabat Zinn in 1979 (Kabat-Zinn, 2012; ZINN, 2017) was more effective and longer-standing in mood improvement among participants with chronic musculoskeletal pain. In addition, the MBSR found to be effective in pain reduction and enhance mindfulness skills in tension headache (Omidi and Zargar, 2014). Interestingly, (Mohammed et al., 2018) demonstrated the advantage of combined interventions of physiotherapy and MBSR, where the combined interventions resulted in an increase in pain tolerance and mindfulness awareness among the injured athletes. The authors suggested that mindfulness practice can be a part of sports rehabilitation to increase pain tolerance and awareness to benefit injured athletes (Mohammed et al., 2018).

The integration of stress reduction interventions such as deep breathing and mindfulness are reported to influence positive health behaviours and enhance physical activities (Schultchen et al., 2019). Zeidan et al., (2010) reported a significant linear relationship between ankle stability and attention in university students with CAI. Josefsson et al., (2017) trait mindfulness can be useful for improving sports-related coping skills and thus enhance athletic performance by reducing rumination and improving negative emotions.

Notably, deep breathing techniques have been widely used to integrate the body and mind in order to train pain coping and well-being (Larsen et al., 2019; Ma et al., 2017). Evidence on deep slow breathing shows that it reduces pain (Ramalingam et al., 2019; Lee et al., 2018), improves sleep quality (González-Roldán et al., 2013), and improves mood among participants with depressive symptoms (Lerman and Haythornthwaite, 2018) and musculoskeletal pain (Larsen et al., 2019). Deep breathing stimulates the parasympathetic and inhibits the sympathetic activity patterns, which may reduce pain levels in injured participants and also improve the pain threshold level in healthy participants (Larsen et al., 2019). As a holistic multidisciplinary treatment, mindfulness has recently been shown to be beneficial in treating different chronic musculoskeletal pains (Scholten et al., 2018). Researchers have shown that the mindfulness intervention has resulted in a reduction of pain among back pain (Schmidt et al., 2012), fibromyalgia (González-Roldán et al., 2013), and rheumatoid arthritis patients (Pradhan et al., 2007).

The EEG has been majorly used to investigate the neurophysiological changes during deep breathing and mindfulness interventions. The alterations in alpha, beta and theta waves of the brain are generally used in reporting the influence of breathing and mindfulness on healthy participants (Cheng et al., 2018). Rijken et al., (2016) suggested trait mindfulness could be useful for improving sports-related coping skills and thus enhance athletic performance by reducing rumination and improving negative emotions. Further, a study by Dziembowska et al., (2016) on young male athletes illustrated significant changes in alpha and theta powers as a result of stress management tools that involved rhythmic breathing and actively self-generated positive emotions. The changes in brain waves were due to enhanced self-control and improved flexibility of the central and autonomic nervous system respectively (Dziembowska et al., 2016).

Numerous studies have investigated the outcomes of mindful breathing techniques for different durations. A study by Carmody and Baer, (2009) evidenced a decline in the willingness of participants on formal 8-week MBSR programs, which consisted of daily 45-min home mindfulness practice, and 150-min of mindfulness sessions during weekends. The authors suggested for minimizing the practice time for the better outcome of MBSR because longer time participation may be a barrier for willingness to participate. By considering the time duration of mindfulness, researchers have practiced mindfulness for various durations, such as brief mindfulness for a 20-min body scan to enhance learning in college students (Bonamo et al., 2015) , a 10-min mindful practice reported as a manageable duration among trainee clinical psychologists (Moore, 2008). Further, 5-min of relaxed breathing practice and 5-min of deep breathing training among collegiate athletes were reported as the best methods to manage stress, and also to prepare for training or competition (Hunt et al., 2018) and 6-min of brief mindfulness to reduce pre-sleep arousal among collegiate athletes (Li et al., 2018).

Cheng et al., (2018) found that 5-min of deep breathing methods was the optimal practise length, compared to 7 and 9-min of deep breathing over a 7-day period. Remarkably, a study by Szabo and Kocsis, (2017) reported that the short duration deep breathing for 3-min resulted in an improved physiological effect and psychological well-being on healthy participants (Williams et al., 2001). However, no studies explored the effects of 3-min deep breathing among participants with chronic ankle instability (CAI) on improvements in balance, happiness, attention, and brain waves that were affected due to pain.

In general, the physiological effects of deep breathing stimulate the wandering nerve "vagal tone" in accordance with polyvagal theory by increasing parasympathetic activity for well-being (Porges, 2011). As proposed, breathing techniques are contemplative activities that produce structural changes in cognitive neuroscience research and the well-being of practitioners (Gerritsen and Band, 2018). Deep breathing is a non-pharmacological pain management therapy (Taylor and Taylor, 1998a) that improves localised tissue circulation and shifts the focus away from the pain that the injured athletes experience (Catalano, 1989). Guided or focused deep breathing acts as a mindful mediation technique (Tomasino et al., 2014) engages the diaphragm (Bindu et al., 2013) by stimulating the vagal nerve (Porges, 2011) to control pain perception (Busch et al., 2012) and induces a change in sympathetic nervous system activity by lowering stress hormone levels (Paul et al., 2007). Besides that, deep breathing has been proven to be helpful as an effective self-management technique for patients with chronic musculoskeletal pain in terms of reducing disability and improving quality of life and subjective well-being (Anderson and Bliven, 2017)

The current study intended to explore neurophysiological changes on pain management by adopting a 3-min video-assisted mindful deep breathing (VAMDB) in addition to the common conventional physiotherapy (CP) in collegiate athletes with CAI. The effectiveness of the intervention was assessed using Cumberland Ankle Instability Tool (CAIT), Foot and Ankle Disability Index (FADI), visual analogue score (VAS), Brief Pain Inventory (BPI), Mindful Attention Awareness Scale (MAAS), Oxford Happiness Questionnaire (OHQ), Y- balance, and EEG. The research involved participants who have not attended mindfulness practices before and suffered from ankle sprain injury. The study findings might be useful to implement the combined interventions of VAMDB + CP in rehabilitating the participants with CAI.

1.2 Objectives of the study are:

1. To compare the ankle stability and electroencephalogram (EEG) response between the healthy participants and participants with chronic ankle instability (CAI).
2. To study the effectiveness of video-assisted mindfulness deep breathing (VAMDB) in managing CAI.

CHAPTER 2

LITERATURE REVIEW

2.1 Chronic Ankle Instability Background

Chronic ankle instability (CAI) is reported to occur in 23,000 ankle injuries in the United States (Kannus and Renström, 1991), 5000 ankle injuries in the United Kingdom (Lynch and Renström, 1999; Karlsson and Sancone, 2006) and 3000 cases of ankle injuries in Malaysia (Dey et al., 2016), approximately one sprain per 10,000 persons occurs every day, and roughly one in every five ankle injury individuals develops chronic symptoms (Wukich and Tuason, 2011). In sports, the incidence of ankle injuries are quit common as 85% of injuries are the lateral ankle sprain (Hertel, 2002) and 80% of injuries affect the ankle lateral ligaments that happen frequently in jumping and landing type of sport activities (Coughlan and Caulfield, 2007; McKeon and Mattacola, 2008). Perhaps, lateral ligament injuries are usual in sports and account for 25% of all sports-related injuries (Karlsson and Sancone, 2006).

The sport like volleyball, involves repeated jumps and landing movements in its sporting technique. Nearly 87% of league volleyball players between the age range of 18-37 years are reported to have at least one sport related injury during the game. Among the reported 362 sports injuries, 46 injuries were ankle sprains, which is higher comparing with the reported 30 injuries to the knee joint and lower leg muscles and 30 injuries affecting the interphalangeal of fingers as well as the shoulder joint. Remarkably, 50% of the reported ankle injuries occurred due to repeated ankle sprains for more than 2 occasions (Cieśla et al., 2015). On the other hand, 60 % of injuries are reported among the younger Malaysian badminton players who were below 20 years of age (Mohamad Shariff et al., 2013). The majority of sports injuries in Malaysian futsal players were reported to happen during the training or practice sessions as mild overuse injury involving the knee and ankle joints (Hamid et al., 2014). Further, a higher prevalence of lower limb injury (73.1%) was reported among 452 professional football, basketball, handball and volleyball male athletes in Kuwait. Overall, the frequency of lower limb injury were higher in volleyball players (79%) and low in football players (69%) with 73.8% injury rate for 12 months and 89.8% for lifetime (Marwan et al., 2012).

Likewise, a one-year observational study of 581 high school basketball players in Brazil revealed 167 injuries, with male players having a higher risk of injury than females. The ankle or foot have been the most injured anatomic areas in both genders (Bastos, 2014). Similarly, about 45% of ankle sprains were reported among recreational basketball players while landing and the incidence rate was 3.85 per 1000 participation. Moreover, the increased participation of collegiate athletes in sports raises the incidence of injuries, especially at the lower extremity, with 50% of injuries at the lateral ankle (Hootman et al., 2007). In addition, a report by Janssen et al., (2011) indicated a twofold increase on the risk of ankle injury recurrence for an injured person within a year.. If left untreated, up to 50% of cases with recurrent ankle sprains result in functional impairment, persistent discomfort in the ankle, or ankle instability, necessitating long-term medical treatment. As a result, preventing ankle sprain recurrence in collegiate athletes is critical.

2.2 Mechanism of Injury in Chronic Ankle Instability

The bony articulation in the talocrural joint controls ankle joint stability in the foot. During functional motions, the anterior talofibular ligament, calcaneofibular ligament, and posterior talofibular ligament all work together to maintain the lateral ankle joint stability. The anterior talofibular ligament is the ankle's weakest lateral ligament structure. The plantar flexed position of the ankle does not cause much strain because this ligament aligned horizontally when the foot is in its anatomical position. On the other hand, the ankle plantar flexion and foot inversion motions put more strain on the anterior talofibular ligament, which is highly susceptible to injury (Marder, 1994). In sports about 40% of ankle injuries are found to cause repeated ankle sprains (Yeung et al., 1994) with the mechanism of uncontrolled inversion movement of the ankle with excessive plantar flexion and foot inversion. The lateral ligaments of the ankle joint are the most commonly injured structures that cause chronic ankle instability (CAI) as a result of recurrent ankle sprains (Hertel, 2002; de Vries et al., 2002). CAI is characterized by recurrent ankle sprains that result in a reduced level of functional activity even in collegiate and recreational active individuals. The most frequent symptoms of CAI include ankle sprain, pain and swelling around the ankle, loss of muscle strength, repetitive sprain, and functional ankle instability (FAI) (Hiller et al., 2011). Despite the fact that muscle weakness was not found to be a factor contributing to causing chronic ankle instability (CAI) (Lentell et al., 1990), the muscular imbalance in the ankle joint was found to be a predictor of CAI (Baumhauer et al., 1995). Nearly 50% of patients with ankle injuries suffer from a common and dangerous residual condition known as functional ankle instability (FAI) (Karlsson and Lansinger, 1992) which is described by (Freeman et al., 1965). Besides, the participants with CAI are reported to have mechanical ankle instability that manifests as ligamentous laxity. CAI causes frequent ankle sprains, which can reduce wellbeing and delay up to 72 percent of individuals from resuming their prior level of sporting activity (Hiller et al., 2011). Primarily the chronic ankle instability (CAI) produces the physiological dysfunctions like poor neuromuscular control and repeated ankle sprains or giving way sensation in the ankle, which result in causing ankle pain and swelling. Likewise, functional ankle instability (FAI) may be found to occur in approximately 10% to 20% of patients suffering from acute ankle lateral ligament injury (Mitchell et al., 2008).

2.3 Psychological Influence in Chronic Ankle Instability

Athletes who sustain an injury physically are at risk of developing major psychological problems such as anxiety and depression (Williams and Andersen, 1998; Johnson, 2007; Maddison and Prapavessis, 2005). According to O´Connell and Manschreck, (2012), athletes with injuries are six times more likely than non-injured athletes to experience depression. As such, injured athletes have more anxiety, a reduced level of self-esteem, and are more prone to developing depression in the case of chronic injuries. Preparing for elite level sporting events presents a new set of circumstances, like a high-pressure professional model with pressures and constraints which induce injury to the players (Schaal et al., 2011). Likewise, the psychological factors that influence the negative effects in a stressful athletic events raise the chance of injury. (Williams and Andersen, 1998). A study by Maddison and Prapavessis, (2005) among rugby players (n=470), found that coping abilities as well as repeated sports injuries, all connected with stress reactions and injuries. In early of 1990s, a preliminary work on the pre-season psychological reactions of injured players among the 343 male collegiate athletes those who played various sports exhibited a greater depression, anxiety and lower self-esteem than the control group (Leddy et al., 1994). A research by Li et al., (2017) reported 28.8% preseason anxiety and 21.7% depression from 389 collegiate athletes those who sustained 597 injuries. Additionally, players with pre-season symptoms of anxiety had a greater injury prevalence rates than players without symptoms of anxiety. Further, a study by Shivarathre et al., (2014) showed a strong relationship between stress and negative emotions in individuals with severe pain in their feet and ankles. This means that athletes who experienced pre-season anxiety symptoms had a higher injury incidence rate than athletes who did not experience anxiety symptoms. On the other hand, the presence of chronic pain and disability induce worries and thus decrease the happiness level among the participants (Lefebvre and Jensen, 2019). The improvement in happiness level and decrease in depression were shown to have been accomplished for chronic musculoskeletal pain patients with 8-week psychological-based therapies (Peters et al., 2017). Among CAI individuals, chronic physical and psychological problems in relation with chronic pain will affect their willingness in physical or sporting activities. This implies that therapists must understand the impact of these distinct psychological problems in terms of planning a holistic approach to CAI rehabilitation.

2.4 Assessment tools for Chronic Ankle Instability

2.4.1 Cumberland Ankle Instability Tool

The Cumberland Ankle Instability Tool (CAIT) is a 9-item, 30-point brief, reliable, and valid list of questions used to determine the severity of CAI. On the other hand, CAIT is used to monitor and assess treatment progress in improving CAI (Claire E Hiller et al., 2006). CAIT was extensively applied among healthy and ankle-injured college players with an average age of 23±6.1 years and was reported to have higher reliability with a test-retest reliability Intra-class Correlation Coefficient (ICC) score of 0.96. Besides, the participants with a CAIT score of less than or equal to 27 were considered to have functional ankle stability(Claire E Hiller et al., 2006). Further, a study by (Vuurberg et al., 2018) applied a Dutch version of the CAIT tool to evaluate the validity and reliability of CAIT. Among 130 participants with foot and ankle complaints, the results of the study illustrated an excellent ICC score of 0.94 and confirmed the CAIT questionnaire was a valid and reliable tool to distinguish stable and unstable ankles based on functional activities (Vuurberg et al., 2018). Whereas, a study by O'Driscoll et al., (2011) employed CAIT to study the effectiveness of a 6-week training programme for neuromuscular functions on ankle instability and found significant improvement in CAIT score from 23 to 27 points as an indication of progress in ankle stability. According to the literature, the CAIT is the better tool for assessing and monitoring the participants' chronic ankle instability.

2.4.2 Y - Balance test & Foot and Ankle Disability Index

In clinical settings, the stability of the ankle is usually assessed using the Y – balance test kit (Shaffer et al., 2013), Foot and Ankle Disability Index (FADI), and FADI-sports (Martin et al., 1999; Hale and Hertel, 2005). The Y-balance test was originated from star excursion balance test (SEBT) in measuring dynamic balance of the ankle during single leg stance in different directions (Olmsted et al., 2002). The Y-balance test is an objective dynamic balance test, as used by Shaffer et al., (2013) among 64 healthy service members in a military training camp, demonstrated strong interrater test-retest reliability with ICC scores ranging from 0.85 to 0.93 on two occasions. Another study by Plisky et al., (2009) among male collegiate soccer players demonstrated that the Y-balance test reported to have an intrarater reliability score of ICC = 0.85 to 0.91 and interrater reliability score of ICC = 0.99 to 1.00). However, research conducted among athletes with CAI by Doherty et al., (2016) found that they performed poorly during the test performance in reaching anterior, posteromedial, and posterolateral directions. This initiates the additional support to be safe to assess the participants' dynamic balance using FADI, which is a subjective response by the participants. Hale and Hertel, (2005) revealed that FADI and FADI-S are valid instruments in measuring ankle stability, with

ICC values of 0.89 and 0.84, respectively, and reported that both the tolls (FADI and FADI-S) are sensitive for testing the progression of CAI.

2.4.3 Pain intensity Visual Analogue Scale and Brief Pain Inventory

Visual Analogue Scale (VAS) has now been widely utilised for pain assessment in clinical settings by the various health professionals including physiotherapist, doctors, and nurses (Jensen and Karoly, 2001; MacKichan et al., 2008; Franck and Bruce, 2009). A study by Boonstra, Schiphorst, et al., (2008) validated the reliability of VAS score obtained from chronic low back pain participants aged above 18 years at a university rehabilitation centre and reported a moderate to good reliability with ICC score ranging from 0.7 to 0.84. Besides that, BPI is a multimodal pain evaluation method that was originally created to measure pain in cancer patients (Majedi et al., 2017; Aisyaturridha et al., 2006). However, now has been widely used to measure the amount of functional interference caused by pain, such as movement, mood, walking ability, regular work, relationships with others, sleep, and life satisfaction (Williams and Arnold, 2011). The BPI has been applied for pain assessment in patients suffered from musculoskeletal pain disorders (Jumbo et al., 2020; Keller et al., 2004) such as arthritis pain (Keller et al., 2004; Mendoza et al., 2006; Majedi et al., 2017), temporomandibular joint pain (Thie et al., 2001), low back pain (Lin et al., 2015; Song et al., 2016; Keller et al., 2004; Gammaitoni et al., 2003), fibromyalgia (Williams and Arnold, 2011), hamstring grade 2 injury (A Hamid et al., 2012), and chronic Achilles tendon pain (Mkumbuzi et al., 2020). In addition, the osteoarthritis patients (n = 133) demonstrated excellent reliability of the 7-item

BPI interference subscale with an ICC score of 0.89 on their psychometric properties (Williams et al., 2006). On the contrary, VAS and BPI are the subjective assessment tools for pain assessment as their scores depend on the patients' own pain perception and resiliency (MacKichan et al., 2008; Sherman and Ohrbach, 2006). In order to enhance the accuracy of the pain assessment, the recent studies have utilized a non-invasive electroencephalographic (EEG) technique that records the changes in the electrical activity of brain that are related to the pain response of an individual (Hauck et al., 2008; Kumar et al., 2015)as the pain can cause short- and long-term alterations in the brain's structures and functions (Lazaridou et al., 2017).

2.4.4 Electroencephalogram as a Diagnostic Tool for Chronic pain

According to the Melzack neuromatrix theory of pain (Melzack, 2001), the chronic pain is usually not generated from the local tissue injury response and inflammation, instead the pain response is produced by the neural network of the brain (Hertel and Corbett, 2019). Since the participants with chronic ankle instability (CAI) experience chronic pain, that affects the neural networks of the brain. The chronic pain in musculoskeletal conditions interferes with the normal process of central nervous system activities, which are reflected in musculoskeletal functions (Schabrun and Hodges, 2012; Schabrun et al., 2013). Moreover, pain is linked to patterns of brain activity that are either spatial or temporal, which is ultimately determined by the integration of neuronal activity across brain regions. The prior studies on pain related to the structural and metabolic changes in the brain regions shown by dynamic oscillations indicated the role of brain neurobiology in pain assessment (Baliki and Apkarian, 2015; Rauschecker et al., 2015). The spontaneous neural network functions of the brain recorded by scalp EEG with high temporal resolution have been used recently to detect the alterations in brain response during pain (Jobert et al., 2012). Numerous studies show that the frequencies of pain-related neuronal fluctuations by using electroencephalographic (EEG) ranging from theta (4–7 Hz), alpha (8–13 Hz), and beta (14–29 Hz) (Ploner et al., 2017; Moran et al., 2010). Previously EEG applied immensely over the induced pain conditions. A study by (Ploner et al., 2006) studied the response of the brain among 12 right-handed male participants with an age range of 22-41 years by stimulating the dorsum of the hand with a painful cutaneous laser stimulus. The participants were positioned in comfortable sitting with closed eyes during the EEG recording. The study findings showed that the laser pain stimulation suppressed the alpha and beta band due to the laser-stimulated pain. Another study by Nir et al., (2010) recorded a 5 min continuous EEG among 18 healthy participants in resting, innocuous temperature and psychophysically-anchored noxious temperature. In the trial, the peak alpha frequency was correlated with the bilateral temporal region during their resting state and noxious stimulus, which advanced the objective pain findings. Further, the alpha 1-power showed a negative correlation between the alpha power of bilateral temporal regions and the pain score in noxious conditions and resting state (Nir et al., 2012).

In recent years, a few studies explored the EEG to assess the clinical pain conditions. A study by Boord et al., (2008) among participants with spinal cord injury with neurogenic pain and without neurogenic pain by recording the brain waves with eyes closed and eyes open for 20 s intervals showed a consistent decrease in brain waves over all the 14 electrodes among the participants with pain. In addition, a higher frequency of brain waves was reported in the eyes closed condition compared with the eyes open state. The study by de Vries et al., (2013) reported a decrease in peak alpha frequency among chronic abdominal pain patients over the parietal and occipital regions with a significant correlation between pain duration and peak alpha frequency. The EEG recordings by Meneses et al., (2016) on 21 rheumatoid arthritis patients with chronic pain in a resting eyes closed position revealed an increase in absolute alpha power over the frontal, central, parietal, temporal, and occipital regions. Similarly, an increase in relative alpha power was reported over all the regions of the brain except the frontal region. Likewise, a study by Schmidt et al., (2012) demonstrated an increase in absolute theta power over the frontal, central and parietal regions in back pain patients (n=37) underwent 5 min of eyes closed and eyes open in a seated position. However, no difference in mean peak power and frequency of theta, alpha and beta power bands were observed between the back pain patients and the healthy controls. Remarkably, the topographic distribution of EEG was maximum in the parieto-occipital regions of the brain. A study by Kumar et al., (2015) observed the EEG responses of 31 patients from various parts of the brain and discovered that the parietal region mirrored the pain experienced by the patient throughout the post-operative pain recovery period. González-Roldán et al., (2016) analysed the resting 5 min eyes closed EEG patterns of fibromyalgia patients (n=20) showed increased beta waves in the right frontal lobe compared with pain-free controls (n = 18). A quantitative study applied 2-min EEG recordings to identify the neurophysiological changes among 100 young adults under depression and euthymic. However, experimental study among patients with hip osteoarthritis reported the challenges in acquiring the evoked brain potentials on clinical pain conditions (Malinen et al., 2010). An experimental study on tonic heat stimulated pain intensity revealed a negative relationship between the alpha, beta, and theta waves indicating that an increase in subjective pain sense causes decrease in the EEG activity of the alpha, beta, and theta waves (Gram et al., 2017). In the experiments with cold induced pain, alpha waves were found to have increased in response over the posterior region and decreased over the contralateral temporal region (Li et al., 2016). The study results demonstrated decreased theta and alpha power over the brain regions, and high alpha power specifically over the central regions among the participants with depression (Lee et al., 2018). Further the study by Kemp et al., (2010) studied the alpha symmetry response during 2 min eyes closed condition among 15 major depressive, 14 posttraumatic disorder participants and 14 healthy controls. The study findings showed the high alpha power over the left frontal regions in major depressive participants and low alpha power was reported among posttraumatic disorder participants. Furthermore, with prolonged pain exposure, the alpha wave EEG increases transiently by up to 50% over the non-dominant right hemisphere (Dowman et al., 2008; Teplan, 2002). In contrast, exploratory studies in EEG activity on induced pain revealed an increase in beta waves and a decrease in theta and alpha waves response (Sarnthein et al., 2006), whereas clinical pain conditions revealed a decrease in beta waves response due to an increase in cortical excitability of the brain (Schutter and Hortensius, 2011). According to previous research, EEG could potentially form a trend on changes in brain waves that are important in characterising the pain (Mu et al., 2008) that may be useful in a clinical setting for assessing the pain and its improvement among CAI participants.

2.5 Gender

The alpha and beta brainwaves have been reported to be an indicator of specific gender (Ghani et al., 2017). Pain perception may differ between genders because the sex hormone is important in controlling pain between genders (Cairns and Gazerani, 2009). According to Corsi-Cabrera et al., (1993), the relative beta and theta waves are dominant in males. On the other hand, the brain signals differs between the genders due to the anatomical differences (Mourtazaev et al., 1995). There is also an evidence suggesting that the sex-related cortical differences during the processing of pain response result in differential brain activation (Bartley and Fillingim, 2016). A study by Gary B. Rollman and Lautenbacher, (2001) demonstrated a lower pain threshold of musculoskeletal pain among females than males as the females rated a pain as severe, while males tared as a mild pain for the same condition. This difference in the perception of may be due to the male sex hormone testosterone which promotes musculoskeletal pain tolerance (Stutts et al., 2009). Additionally, the studies have demonstrated that female patients with musculoskeletal pain had associated with negative mood (Hirsh et al., 2006; Thibodeau et al., 2013) and negative apprehension about their pain situation compared with male participants (Bränström and Fahlström, 2008). Psychosocially, females experience greater stress than males, which may be due to different inferences on reporting musculoskeletal pain and accepting the situation (Gary B. Rollman and Lautenbacher, 2001). Furthermore, the neurocognitive deficits in male participants with CAI, notably loss of attention, was found to be one of the factor responsible to induce CAI (Rosen et al., 2020). Due to the differences in the neurophysiological response among the genders, the current study focussed only male participants.

2.6 Chronic Ankle Instability Rehabilitation

Ankle sprains are a prominent concern among medical professionals, particularly for youngsters involved in sports. The majority of ankle sprains are inversion types of injuries to the lateral part, which affect the ligaments supporting the lateral ankle stability, whereas high ankle sprains result from tibiofibular syndesmosis. Individuals with ankle sprains are recommended to undergo evaluation and advised to rest for the first three to seven days to reduce pain and speed up the healing process. In order to decrease swelling and discomfort, improve the recovery time process, and protect damaged ligaments, using lace-up ankle support or an air stirrup brace coupled with an elastic compression wrap. Early mobilisation promotes faster healing and pain relief than extended rest. Nonsteroidal anti-inflammatory drugs, acetaminophen, and mild opioids are among the pain-relieving choices for individuals with ankle sprains. Because a preceding ankle sprain is the most common cause of repeated acute ankle sprains, it's vital to counsel recovering patients here about how to prevent recurrent ankle sprains. Ankle bracing and splints, ankle tapes, a targeted training programme for neuromuscular components, and routine sport-specific warm-up movements have all been shown to reduce the incidence of ankle sprains, thus they are recommended for participants returning to sport and perhaps other high-risk activities (Tiemstra, 2012; Hale et al., 2007; Webster and Gribble, 2010). Further, CAI participants undergo conservative treatment using taping and bracing to reduce the repeated ankle sprains, and proper strength training to support them back to normal life and sports activities (McCriskin, 2015; Rodriguez-Merchan, 2012). According to a systematic review by Webster and Gribble, (2010) on CAI interventions, holistic assessment methods and the specific functional rehabilitation are important for better management of ankle instability.

A randomized controlled trail by Beazell et al., (2012) reported that the proximal and distal tibiofibular joint mobilisation among 43 CAI participants was reported with no significant dorsiflexion movement improvement across the time between the study groups. Rooks et al., (2017) used a short-term mindfulness and relaxation program to enhance the athletes' well-being, and found that both training programs increased involvement, as well as decreased anxiety level with increase in overall mood throughout the sports. Previous findings have recommended to engage the athletes in mindfulness and relaxation techniques in addition to physical activities to gain the benefits of cognitive and emotional control. Similarly a study by Mohammed et al., (2018) instigated mindfulness technique on 20 collegiate athletes with severe injuries and reported an improvement in pain tolerance as the awareness of mindfulness increased among the participants. Further, the study findings reported a favourable change in positive mood with a considerable reduction in stress and anxiety. The authors recommended the incorporation of mindfulness techniques as part of the rehabilitation process in treating injured athletes to increase their awareness and pain tolerance.

2.7 Mindfulness

The principle of mindfulness and its benefits for clinical practice have received a lot of attention recently in healthcare studies. Mindfulness is a non-judgmental approach to paying attention to one's experiences in the present moment (Kabat-Zinn, 1994). Mindfulness training necessitates frequent practice of attentive breathing and various forms of relaxation (White, 2013), which has been shown to enhance a wide range of cognitive and healthcare outcomes. In addition, mindfulness training reduces anxiety, depression, and stress, and these advantages have been linked to improvements in cognitive control, emotion management, positive mood, and acceptance towards pain reduction (Crowe et al., 2016). As a result, it appears logical to assume that mindfulness, in and of itself, might reduce pain through some of these pathways. Mindfulness for eight weeks was found to enhance pain acceptance in individuals with lower back pain (Zeidan et al., 2012). Previous research has shown that fibromyalgia patients who participate in the formal MBSR programme are less likely to avoid pain-related threat phrases than those who do not (Grossman et al., 2004; Grossman et al., 2007; Garland et al., 2014). Another study found that even after three months, the presence of irritable bowel syndrome symptoms improved significantly following a formal 8-week MBSR (Garland et al., 2014). Previous mindfulness studies, on the other hand, have raised concerns about the 8-week standard MBSR with regular three-hour weekly sessions that resulted in poor attendance of the participants due to time constraints (Parswani et al., 2013; Davis et al., 2014), which may affect its acceptance among the general public. The fundamental mechanisms of mindfulness intervention driving sensory and motor outcomes, psychological features, and subjective changes associated with chronic musculoskeletal diseases are consistent with a bio-psycho-social paradigm, which alters the neurophysiology of the brain. Consequently, these changes have a big impact on the clinical symptoms, aetiology, and rehabilitation treatment of chronic musculoskeletal disorders. Mindfulness therapies, such as deep breathing and physical interventions, which may generate neuro-plastic changes and influence outcomes in people with persistent musculoskeletal pain. These were used to address the alterations by stimulating the central nervous system functions among participants with chronic pain (Pelletier et al., 2015). Further, the physiological effects of deep breathing or mindful deep breathing may stimulate the vagal tone in accordance with polyvagal theory by increasing parasympathetic activity for well-being (Porges, 2011). Furthermore, among collegiate athletes, deep breathing was found to be the most effective approach to produce relaxation for stress management and competition preparation (Hunt et al., 2018).

Further, mindful exercise is paying close attention to breathing and proprioceptive awareness of muscles and motions while exercising in a non-judgmental manner (La Forge, 2005). It has been proposed recently that combining mind-body activities with bodily motions is very effective. A randomised controlled trial by Lutkenhouse, (2007) involved 118 participants from various sports activities in formal mindfulness exhibited greater coach ratings compared to standard psychological skills training. This signifies the notion that mindfulness is made up of five key elements: being present, awareness, acceptance, and attention, as well as the transformational process of being mindful and working toward a more holistic way of living (Ludwig and Kabat-Zinn, 2008). Mindfulness training necessitates frequent practise of attentive breathing and various forms of relaxation (Brown et al., 2013). such as MBSR, mindfulness-based cognitive therapy (MBCT) (Segal et al., 2002; Williams et al., 2008) and acceptance & commitment therapy (ACT) (Forsyth and Hayes, 2014). Perhaps, the MBSR and MBCT interventions were the series of meditation practices which consisted of 4 to 8 sessions that included body scan, seated meditation, mindful breathing, movement and walking (Day et al., 2014). According to researchers, MBSR is the most frequently used meditation intervention in terms of pain results (Holzel, et al 2007) and inflammation (Rosenkranz et al., 2013). MBSR formal methods are usually 8 weeks long, involving regular documentation, a trained professional, and a quiet retreat day (ZINN, 2017; Ludwig DS and Kabat-Zinn J, 2008; Kabat-Zinn, 2012; Kakigi et al., 2005). Although, mindfulness has different approaches, all of them teach individuals how to sustain concentration on a dynamic and automatic stimulus while acknowledging their thoughts and feelings. Researchers found that consistent meditation practise for a short period of time 20 min for 3 days in an experimental pain was effective at increasing mindfulness skills that was associated with better health outcomes (Zeidan et al., 2010). The Mindfulness-Oriented Recovery Enhancement (MORE) included as part of MBSR and

MBCT in a non-pharmacological chronic pain intervention among participants to reduce the medical cost, showed greater reductions in emotional part of pain than supporting all other domains, which include general activity, mood, walking ability, normal work, relationships, sleep, and enjoyment of life (Garland et al., 2014).

2.7.1 Mindfulness and Physiological Response of Brain

Mindfulness training prepares the prefrontal cortex of the brain to be calm and attentive, allowing us to remain focused, away from distractions, and function at our best (Christine Yu, 2014). Practicing mindfulness alters two stress-processing paths in the brain by increasing the activation of prefrontal regulatory areas and inhibiting stress-processing activity. Perhaps the research finding by Rosenkranz et al., (2013) showed that mindful meditation led to lower stress hormones (resting cortisol levels). Though mindfulness brings our attention inward, it also activates the insular cortex of the brain. Furthermore, mindfulness has a positive impact on the activity of the hypothalamus, pituitary, and adrenocortical systems as well as sleep (Rosenkranz et al., 2013). Brand et al., (2012) implemented a 8-week MBSR program for 20 participants, 9 of whom had long history of practising meditation (an average of 264 months) and 11 of whom were novices, and found that both the long-term experience and novice groups had significantly lower cortisol levels, as well as better sleep and self-attribution of mindfulness.

2.7.2 Mindfulness and Pain

Pain behavioural control is influenced by a variety of factors, including attention, beliefs, training, expectancies, mood, and the management of emotional reactions to painful sensory experiences. Mindfulness has been shown to reduce pain through a variety of processes, including improved physiological and behavioural control, as well as a modification in the sense of sensory evaluation. Several cognitive techniques, generally requiring enhanced selective attention and decreased sensory processing, may be able to reduce pain (Zeidan et al., 2012). It has recently been proven that mindfulness can help to reduce discomfort. The study by Gard et al., (2012) investigated the brain responses of participants who were involved in mindfulness and those who were not. They found less pain among mindful practitioners compared with non-practitioners when exposed to unpleasant electric stimuli. These findings showed a novel pain modulation mechanism involving enhanced sensory processing and decreased cognitive control, which contrasts sharply with previously known pain modulation processes. The function of trait mindfulness in pain among youths was investigated in198 adolescents and shown to have an indirect link with experimental pain severity and threshold. The findings show that trait mindfulness is linked to both real world and experimental pain. They also provide insight into how mindfulness may reduce pain in children and adolescents (Petter et al., 2013).

Another study assessed the quality of life and pain intensity outcomes of formal MBSR among female patients with nonspecific persistent low back pain.

Patients who received 8 sessions of MBSR reported considerably less pain compared to those who got only normal medical care. The authors found that MBSR, which included a body scan, sitting and walking meditation, was an effective intervention approach for reducing pain severity and improving physical and mental quality of life in female patients with nonspecific chronic low back pain (Banth and Ardebil, 2015).

A randomized, waitlist-controlled pilot study by (Pradhan et al., 2007) examined the impact of MBSR on depressive symptoms and psychological state in chronic pain patients. The participants in the MBSR group (n=31) following a 2-month follow-up showed no effect on depressed symptoms or other outcomes as like waitlist control group (n=32). However, after MBSR and a 4-month reinforcement programme, substantial improvements in psychological distress and well-being were found in individuals with chronic pain. Mindfulness may supplement medical disease treatment by reducing psychological distress and increasing well-being. Further, a systematic review by Bawa et al., (2015) reported 6 months of MBSR training in chronic musculoskeletal pain and various pain conditions reported that an 8-week session resulted in a substantial reduction in pain, depression, sleep quality, mindfulness attention, as well as the individuals' mental and physical function with a smaller effect size while compared with inactive and control group participants. According to the meta-analysis, relaxation training such as meditation and progressive relaxation benefit both patients with psychological symptoms and healthy volunteers with a larger effect size than other relaxation techniques. It specifically controls anxiety and reduces stress levels in participants with pain and psychological issues (Manzoni et al., 2008). Besides that, a systematic review in patients with arthritic pain found that progressive relaxation training, such as deep breathing, reduces post-operative pain symptoms, indicating that interventions with relaxed training reduce stress and pain levels while improving quality of life (Kwekkeboom and Gretarsdottir, 2006). A longitudinal study on chronic pain patients using MBSR and mediation practise found that mindful practise improved pain intensity, quality of life, and psychological well-being more than mediation (Rosenzweig et al., 2010). Furthermore, a feasibility study proposed by Howarth et al., (2016) among 90 participants with a 15 min brief self-help mindfulness intervention for pain coping management necessitates the importance of short-duration mindfulness practises.

2.7.3 Assessment of Mindfulness Approach:

The mindful attention of the participants involved in sports and clinical studies was assessed using the 15-item Mindful Attention Awareness Scale (MAAS) questionnaire (Day et al., 2014; Mothes et al., 2014). MAAS was used to measure the self-reported dispositional mindfulness attention of male sports participants (Mothes et al., 2014) and headache sufferers (Day et al., 2014). From the literature, a 3-week programme for seven days with 30-min mindfulness sessions for secondary school students resulted in an increase in attention score (Dorothy A. Sisk, 2017). Whereas, the 8-week MBSR program in addition to physiotherapy intervention among 20 injured collegiate athletes between the age range of 21-36 years showed an increase in VAS and MAAS compared with participants who underwent physiotherapy only (Mohammed et al., 2018). It is evident from the previous studies that the mindfulness and happiness levels are positively associated. According to the responses of 302 college students, mindfulness increased coping abilities and self-esteem while also lowering worries (Bajaj et al., 2019). Further, a study among 120 healthy participants with noxious stimulation of pain showed that the participants with happy mood rated reported lesser pain intensity compared to participants with worry (Lefebvre and Jensen, 2019). The happiness level of an individuals is assessed using the 29-item Oxford Happiness Questionnaire (OHQ)(Medvedev et al., 2017; Parswani and Argyle, 2002; Liaghatdar et al., 2008). The validity of OHQ demonstrated a stronger association with the wellbeing of the participants compared with the Oxford happiness inventory (Hills and Argyle, 2002). Therefore, the present study applied OHQ as the outcome measure to find the participant happiness level at the time of chronic ankle instability and also during the rehabilitation.

A study by Sanger and Dorjee, (2015) emphasized that mindfulness training could elucidate developmentally salient shifts in the neural plasticity of the brain. Barnhofer et al., (2010) evaluated the prefrontal asymmetry directly before and after the 15-min mindfulness breathing meditation, loving kindness, and rest, with a 2 min resting EEG. The findings indicated that brief meditation benefits the pre-frontal alpha asymmetry state of depressive participants. The EEG was used as a tool to measure the efficacy of an 8-week MBSR programme in 22 chronic pain patients in a pilot study. On the other hand, indicated no changes between the pre-and post-intervention periods in the EEG. However, psychological functioning, pain intensity, and quality of life all indicated a medium-sized influence (Schmidt et al., 2015). The neurophysiological changes in the brain during deep breathing and mindfulness interventions are extensively studied using EEG. A study conducted among healthy participants for 7 days duration with various short durations of mindful deep breathing reported alterations in theta, alpha, and beta waves of the brain (Cheng et al., 2018). Further, a randomized controlled trial among 41 young male athletes under the age range of 16 to 21 years with 3 min eyes closed EEG measurements showed significant changes in alpha and theta brain waves following biofeedback training that included rhythmic breathing and positive emotions activities (Dziembowska et al., 2016).

The time limitations and personal obligations were the main issues raised from preceding mindfulness studies concerning participants engagement (Parswani et al., 2013; Davis et al., 2014). The significant demand for time and the standard requirement for the presence of an instructor might deter people from participating in these activities (Carmody and Baer, 2009). Individual participation in a normal MBSR course usually lasts for eight weeks, with weekly sessions lasting around three hours and daily practice of about an hour (Jon Kabat-Zinn, 1979). By considering the difficult of acceptance among young individuals in the current fast-paced lifestyle, the study among healthy participants by Cheng et al., (2018) modified the mindfulness intervention durations to 5-min VAMDB. Moreover, participants' individual practises were tracked using a smartphone app that had the ability to send text message alerts to fill up practise diary to track the frequency of home practise (Crane et al.

2014). Furthermore, a 5 min deep breathing was rated as the ideal practise length, indicating that it may be used instead of long duration mindfulness activities (Cheng et al., 2017). A study by Prasad et al., (2011) investigated the effects of 5, 15, and 30 min of paced breathing meditation on anxiety and quality of life among health care workers and found that the duration of practise had no effect on anxiety and quality of life . Remarkably, a study by (Szabo and Kocsis, 2017) found that 3 minutes of short-term deep breathing enhanced physiological effects and psychological well-being. Since the duration of practise has no effect on the participants' quality of life or anxiety (Prasad et al., 2011), the current study introduced a 3 min video assisted deep breathing in CAI participants, which had already demonstrated positive physiological effects in healthy participants. Meanwhile, based on the literature findings, the pain, balance and loss of attention are found to affect the participants' EEG responses. Hence, the present study aimed to understand the EEG response among collegiate athletes with and without CAI.

Finally, the study hypothesised that the use of a 3-min VAMDB will reduce the occurrence of ankle instability and improve the level of mindful attention in collegiate athletes with chronic ankle instability. In addition, the present study findings on the differences in EEG response between healthy and chronic ankle instability participants could be used as biomarkers to assess pain improvement among the CAI individuals to monitor the progression of the rehabilitation.

2.8 Mindfulness for Chronic Ankle Instability

The present study aimed to report the combined effects of 3 min video-aided mindful deep breathing (VAMDB) along with conventional physiotherapy (CP) in collegiate athletes with chronic ankle instability (CAI). Thus far, no study have been reported on the effectiveness of VAMDB in ankle sprains. Hence, the present study was designed to demonstrate the novel findings of the combined effects of VAMDB and CP in Male CAI collegiate athletes.

CHAPTER 3

MATERIALS & METHODS

3.1 Study Participants

In this study, collegiate athletes who participate in organised and competitive sports with repeated inversion ankle sprains and without musculoskeletal injuries or pain in an age range of 18 – 25 years were recruited as the participants. The study was carried out in the physiotherapy centre of INTI International University, Malaysia for a period of 13 months from January 2018 until February 2019. The estimated sample size for testing objective 1 "to compare the ankle stability and electroencephalogram (EEG) response between the healthy participants and participants with chronic ankle instability (CAI)" was 52, and for objective 2 "to study the effectiveness of video-aided mindful deep breathing (VAMDB) in managing CAI" was 24. By considering that the objective 1 required a higher sample size, the estimated study sample size was determined as 58 by considering 10% dropout rate of participants, which consisted of 29 participants for each group, namely healthy control group and CAI participants group. The recruited participants were given unique identification numbers, the participants without CAI were assigned to healthy control group and the participants with CAI were assigned to the CAI group (Figure 3.1). The participants in the CAI group were randomly assigned to Control group and Experimental group as blinded by the physiotherapy centre maintenance officer using the computer randomization process (Figure 3.2).

The clinical physiotherapist who specialised in musculoskeletal conditions conducted the preliminary assessment and physiotherapy management for the study participants.

3.2 Healthy Control group

A total of 24 collegiate athletes who participate regularly in competitive and recreational sports activities were enrolled in healthy control group (HCG). They were recruited through flyers and sending an invitation to University sports club. The participants with musculoskeletal pain, recent sports injuries, psychological problems and presently practicing in any type of mindfulness

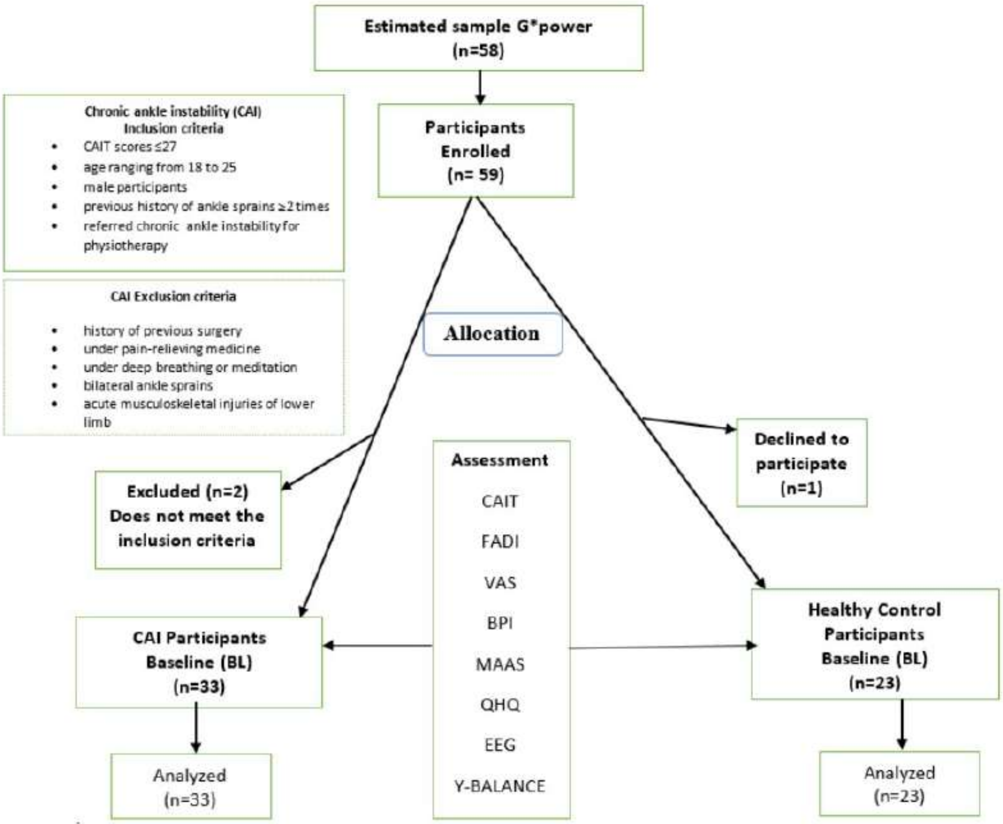


Figure.3.1 Study flow chart

were excluded. After signing inform consent, one participant withdraw during the group allocation process. Finally, 23 participants in HCG were involved in assessment process and analysed.

3.3 CAI Participants- Experimental and Control group

Total of 35 male participants who diagnosed with repeated ankle sprains with clinical signs of giving way sense, multiple ankle sprains greater than 2 times, lateral ankle pain, swelling, and ankle instability were recruited. These injured participants were diagnosed by the sports medicine and orthopaedic specialists as CAI and referred to the physiotherapy centre. The participants with CAI were randomized with the support of online randomizer after the baseline assessment into the control group (CG) (n=17) and experimental group (EG) (n=16). The control group received conventional physiotherapy (CP), while the experimental group received the combinations of video-aided mindful deep breathing (VAMDB) and CP. The CAI participants who met the inclusion criteria of CAIT scores of ≤ 27, age ranging from 18 to 25, male participants (Bastos, 2014), previous history of ankle sprain in last 6 months, and repeated ankle sprains more than 2 times were included (Delahunt et al., 2010). Whereas, the participants with any history of previous surgeries in the lower extremity, presently under pain-relieving medicine, previous participation in deep breathing or mindfulness, both ankle instability, acute injuries to the musculoskeletal structures such as bones, joint structures, and nerves in the lower extremity were excluded (Fu and Hui-Chan, 2005; Gribble et al., 2013). The participants were thoroughly investigated for meeting the inclusion criteria.

The two participants who were practicing yoga and meditation were excluded while doing the allocation for baseline assessment. The demographic information of 33 CAI participants who assigned as patient to the study groups are shown in Table 4.1. After randomization, three participants who failed to attend the follow-up sessions after baseline assessment from the both groups were excluded and hence only 30 participants from the patient group who completed the intervention were included for analysis (Figure 3.2).

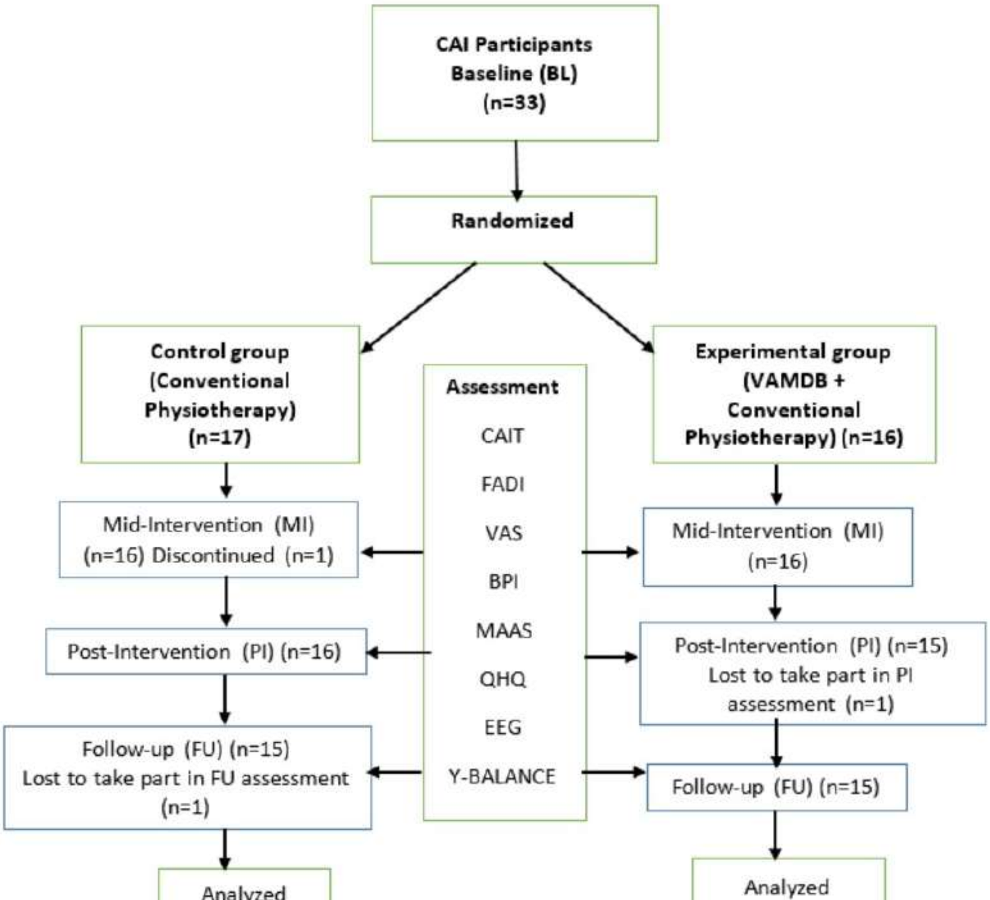


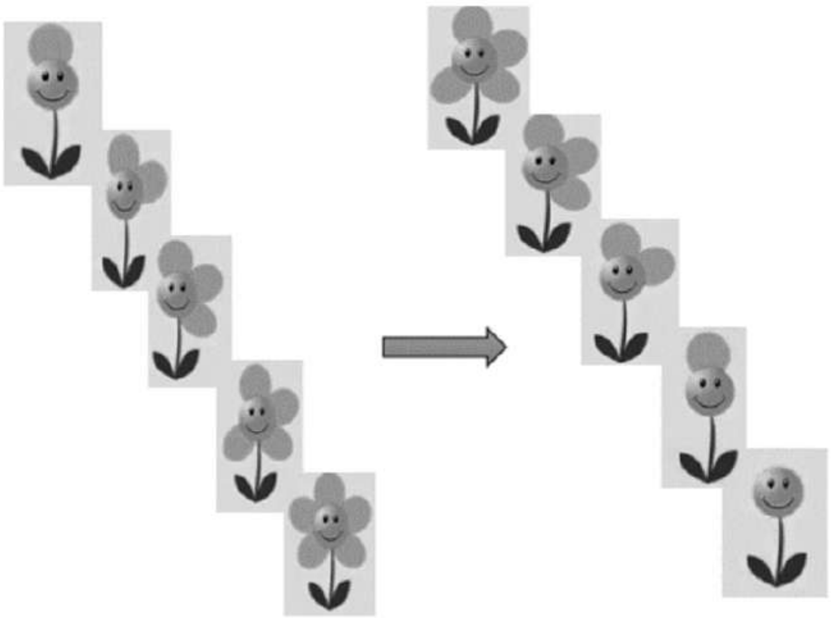
Figure.3.2 Consort flow diagram

3.4 Ethical Concern

The local university scientific and ethical review panel accepted the research protocols in order to comply with the Helsinki Declaration. Before the evaluation and intervention, all of the participants gave their informed consent. The study protocol was registered under clinical trial registry (ClinicalTrials.gov Identifier: NCT04812158). The participants in CAI group and healthy control group were informed of the study assessment procedures and risks involved. The equipment's used in this experiment were calibrated and subjected for risk assessment prior to utilizing for assessments on the study participants.

3.5 Experiment Procedure: Video-Assisted Mindfulness Deep Breathing

The participants in the experimental group (EG) were managed with 3-min VAMDB along with conventional physiotherapy (CP) (Mattacola and Dwyer, 2002), while the control group (CG) received CP. The chronic ankle instability participants in the both the groups were underwent CP for 5-times in a week (Matsusaka et al., 2001; Gauffin et al., 1988) for 6-weeks in physiotherapy centre under the guidance of clinical physiotherapist (Appendix 11). Whereas the participants in the experimental group (EG) were assisted to access Google Play store (https:/play.google.com/store/apps/details?id =com. vamdb.asus.happyproject) to install VAMDB in their hand phones after randomised into EG. Following each session of conventional physiotherapy intervention at the physiotherapy centre, the participants in the experimental group were demonstrated to perform VAMDB for 3-min in the physiotherapy centre 5-times in a week for 6-weeks. Further, the participants in the experimental group were instructed to continue the same practice as a home exercise 2-times a day along with physiotherapy home exercise. Besides, the participants were reminded to practice VAMDB by the text messages from the researchers and their practice schedule was monitored with a reply message from the participants daily.



Breath-in Breath-out

Figure 3.3: Illustration of Breathing Pattern in 3-min VAMDB

As shown in Figure 3.3, VAMDB technique involves a video demonstration, which shows a flower with a smiley face in the center and surrounded by the petals. The petals appear and disappear in a timely manner, where the participants were instructed to focus on the smiley face of the flower and asked to breathe in during the appearance of the petals and then breath out during the disappearance of the petals to standardize the participants breathing pattern (Cheng et al., 2018). At the same time, the control group participants were never informed about the 3-minute VAMDB, but they were reminded to do the CP exercises at home via text messages and monitored with a reply message.

3.6 Assessment Procedures

The participants ankle stability was assessed using following measures such as pain intensity (VAS, BPI), dynamic balance (CAIT, FADI, and YBT), mindfulness attention (MAAS), happiness level (OHQ) and neurophysiology of brain waves (EEG). The primary outcome assessed in the present study was the pain intensity, whereas the secondary outcomes assessed were the dynamic balance, mindful attention, happiness, and EEG. A clinical physiotherapist who is specialized in musculoskeletal conditions conducted the preliminary assessment and conventional physiotherapy management. The study was carried out in a physiotherapy centre with sufficient lighting and a quiet environment. On arrival at the physiotherapy centre, the participants were asked to fill in the demographic information, CAIT, FADI, VAS, BPI, MAAS, and OHQ questionnaires, and then subjected to EEG and YBT (Appendix 4-10). The 15 participants from the CG group and 15 from the EG were managed to complete the study protocol and follow-up assessments. The parameters of the measurement in this work were assessed at baseline, mid-intervention, post-intervention, and follow-up sessions. The participant baseline assessment was conducted before the participants were exposed to the intervention. Whereas the mid-intervention assessment was conducted at the end of week 3 following the early functional CAI rehabilitation in the initial phase. The post-intervention assessment was conducted at the end of week 6 following intermediate functional and advanced rehabilitation before the participants returned to the game, and follow-up assessments were carried out at the end of week 12 to monitor the participants' post-intervention effects.

3.6.1 Primary outcome

3.6.1.1 Visual Analogue scale

VAS was used to record the participants self-reported pain intensity on a 10 cm line to point out the pain level. The point at 0 cm represents "no pain" and 10 cm represents "worst pain". The same scale was used from baseline until follow-up sessions to monitor the progress of the pain. VAS pain score is a reliable scale with Cronbach's alpha 0.76 to 0.84 to assess chronic musculoskeletal pain (Alghadir et al., 2018; Boonstra, Preuper, et al., 2008).

3.6.1.2 Brief pain inventory

Besides VAS, a short form BPI was used (Jumbo et al., 2020; Keller et al., 2004) which contained 4- items (worst pain, least pain, average pain, and pain right now) to measure the pain intensity, and 7 –items (general activity, mood, walking, normal work, relations, sleep, enjoyment of life) to assess the pain interference (Keller et al., 2004; Lin et al., 2015; Mkumbuzi et al., 2020). The participants were instructed to report the pain intensity from 0 (no pain) to 10 (as pain bad as you can imagine). Similarly, the pain interference was recorded from 0 (does not interfere) to 10 (completely interferes). The BPI interference 7- item subscale was reliable with Cronbach's alpha 0.89 and 0.82 (Williams et al., 2006).

3.6.2 Secondary outcomes

3.6.2.1 Cumberland Ankle Instability Tool

CAIT, which has a 9-item questionnaire, was used to find the chronic ankle disability among participants and to recruit in the study if the score was ≤27 in the CAIT tool over 30 (Gribble et al., 2013; Claire E Hiller et al., 2006). The scores ≤27 represent "poor" ankle stability and >27 represent "better" ankle stability. The same tool was used to monitor the participants' progress until the follow-up session. CAIT has been reported to be a reliable and valid tool with Cronbach's alpha 0.83 (Claire E Hiller et al., 2006).

3.6.2.2 Foot and Ankle Disability Index

FADI consists of 34-item which has activity related 22-item, pain related 4-item and sport specific functions related 8-item (FADI sport) used in the baseline to check the CAI of the participants. The lower scores represent "poor" ankle stability and higher scores represent "better" ankle stability. The same tool was used to test the participants' progress from mid-intervention until the follow-up session. FADI and FADI sports have been reported to be valid and reliable tool with Cronbach's alpha 0.89 and 0.84 (Hale and Hertel, 2005). Further, a systematic review by Eechaute et al., (2007) confirmed that FADI as an appropriate tool for measuring CAI.

3.6.2.3 Y-balance test

The dynamic balance status of the participants from the baseline until follow-up sessions were assessed using Y- balance test (YBT) by measuring the foot reaching distance in following directions anterior, posteromedial and posterolateral. The lower scores represent "poor" dynamic ankle stability whereas the higher scores represent "better" dynamic ankle stability. The YBT has found to be a reliable and valid dynamic balance assessment with Cronbach's alpha 0.80 to 0.85 among doctoral physical therapy students (Shaffer et al., 2013; Shaffer et al., 2015).

3.6.2.4 Mindful Attention Awareness Scale

MAAS involving 15-item questionnaire was applied to identify the mindfulness state participants during the baseline, mid- intervention, post-intervention and follow-up assessments. The changes in the mind adaptation of participants before and after the intervention were evaluated based on the MAAS score which was obtained from the Likert scale rating from 1(almost always) to 6 (almost never). The reliability of MAAS among adults has been reported with Cronbach's alpha 0.81to 0.86 (Mohsenabadi et al., 2018).

3.6.2.5 Oxford Happiness Questionnaire

The happiness level of the participants were assessed using the OHQ, which consists of 29-item questionnaire. The OHQ score was recorded on 6 points Likert scale from 1 (strongly disagree) to 6 (strongly agree) and OHQ among human participants has established to be a reliable tool with Cronbach's alpha of 0.87–0.92 (Hills and Argyle, 2002; Liaghatdar et al., 2008).

3.6.2.6 Brainwave acquisition

The brain waves were recorded at 14 different places utilising the 14-channel, non-invasive wireless Electroencephalogram (EEG) Emotiv EPOC headset (EMOTIV Inc., San Francisco, USA): AF3, AF4, F3, F4, F7, F8, FC5, FC6, P7, P8, T7, T8, O1, and O2 (Figure 3.3). In accordance with the International 10–20 System nomenclature, the channel electrodes were set at a sampling rate of 128 Hz during the EEG recording. Upon arrival, the participants were advised to wait for 15 min before recording the EEG. Spontaneous EEG was recorded in a comfortable sitting position for 2 min, with eyes closed (Barnhofer et al., 2010; Kemp et al., 2010; Lee et al., 2018; Ramalingam et al., 2019).

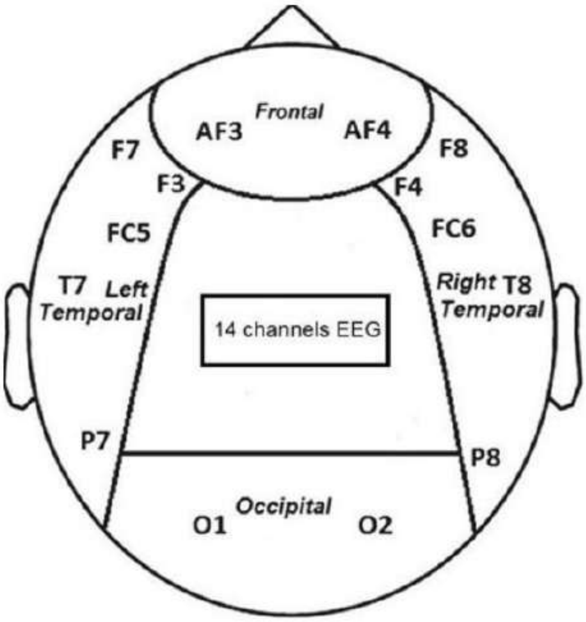


Figure 3.4: Grouping of Electroencephalogram 14 Channel Electrodes

The EEG recordings of the participants were collected between 9 and 12 hours in the morning to reduce participants sleeping artefacts and to exclude the EEG from the influence of circadian variables. The recorded raw EEG signals were processed with the support of MATLAB by using the EEGLAB plug-in. The recorded brain signals were filtered with a low band of 1Hz to smoothen and a high band of 45Hz to sharpen the brain waves. The EEG processed data were categorised into four regions for signal analysis: frontal (AF3, AF4), right temporal (F4, F8, FC6, P8, T8), left temporal (F3, F7, FC5, T7, P7), and occipital (O1, O2).The EEG data of the present study were log-transformed to report the most sensitivity with highest statistical power (Smulders et al., 2018). Following the brain signal recording, the dynamic balance was tested by using YBT tool in anterior, posterolateral and posteromedial directions before starting the intervention.

3.7 Statistical analysis

The data analyses were carried out by using SPSS version 22.0 (SPSS, Inc). The descriptive statistics, Independent sample T-test and Repeated measures analysis of variance (ANOVA) were used to compare the analysis. The Shapiro-Wilk test was applied to test the normal distribution of the data. Independent sample *t*-test was used to confirm the significant ($p<0.05$) difference between the healthy control group (HCG) and overall CAI participants. Besides, it was used for randomization of the participants between the groups as there were no significant ($p>0.05$) difference between the groups (CG and EG) on demographic data and baseline variables such as VAS, BPI, CAIT, FADI, YBT, MAAS, OHQ and EEG. Repeated measures ANOVA was performed to test the significant difference in the intervention effects between the time intervals (baseline, mid-intervention, post-intervention, and follow-up) and also between the groups (CG and EG). Post–hoc analysis Bonferroni conducted if significant effects within the group*time interaction and between the group intervals were identified. The *p* value for time interaction was set as 0.0125 (0.05/4). Condition on if the sphericity violated (p-value < 0.05), the Greenhouse- Geisser estimated epsilon less than 0.75 or Huynh-Feldt estimated epsilon greater than 0.75 correction was applied. The Cohen's *d* was used to report the effect size of the outcome measures within and between the groups (0.20 = small, 0.50 = medium, and 0.80 = large) (Cohen, 1992). Pearson's correlation was used to report the association of EEG with pain intensity and pain interference. The results are presented as mean ± standard deviation (Table 4.1 & Table 4.2).

CHAPTER 4

RESULTS

4.1 Participants Demographics Data

Fifty-nine (59) male collegiate athletes with age ranged between 18-25 years were enrolled as the study participants. Table 4.1 shows the overall group-wise demographic information of participants such as age, body mass index (BMI), educational level, race, sports involved, dominant leg, injured leg, and repetition of injuries. Among the 59 enrolled participants, only 56 participants met the eligibility assessment. A 23 participants with an age range of 21.95± 1.84 years without CAI and musculoskeletal injuries were allocated to healthy control group (HCG). Similarly, 33 participants with an age range of 21.70 ± 1.99 years with chronic ankle instability (CAI) were grouped into CAI group before randomization. An average BMI of 23.64±2.66kg/m^2 and 24.25±2.21kg/m^2 was reported for HCG and CAI group participants respectively.

Among the 23 healthy participants in healthy control group (HCG), 17.4% were Malaysian Malay, 21.7% were Malaysian Indians, 47.8% were Malaysian Chinese, 4.3% were Indo-Aryan, and 3% were Indo-Mauritians. They were involved in collegiate sports, 34.8% from football, 13% from basketball, 26.1% from badminton, 8.7% from martial arts, 4.3% from squash and 13% from futsal. The majority of participants (69.6%) responded as being right-side leg dominant, and 30.4% responded as having left-side leg dominant during the sports and functional activities.

Table 4.1: Demographic Details of the Participants

	Over all CAI participants [n= 33]	**Healthy Control Group (HCG) [n=23]**
	Mean (^SD)	Mean (^SD)
Age (years)	21.70 (1.99)	21.95 (1.84)
BMI	23.64 (2.66)	24.25 (2.21)
Race		
Malaysian Chinese	51.5%	47.8%
Malaysian Malay	24.2%	17.4%
Malaysian Indian	21.2%	21.7%
Indo-Mauritians	3%	8.7%
Indo -Aryan	^NA	4.3%
Collegiate Sports		
Basket ball	24.2%	13%
Foot ball	24.2%	34.8%
Badminton	18.2%	26.1%
Squash	3%	4.3%
Futsal	12.1%	13%
Frisbee	6.1%	NA
Martial arts	12.1%	8.7%
Dominant side leg		
Right	84.8%	69.6%
Left	15.2%	30.4%
Injured side leg		
Right	66.7%	NA
Left	33.3%	NA
Repetition of ankle sprain		
2 times	30.3%	NA
3 times	45.5%	NA
4 times	18.2%	NA
5 times	6.1%	NA

^SD: Standard Deviation, NA – Not applicable.

Whereas among 33 CAI participants, 24.2% Malaysian Malay, 21.2% Malaysian Indians, 51.5% Malaysian Chinese, and 3% Indo-Mauritians. The CAI participants included the collegiate athletes from various sports activities, 24.2% from football, 24.2% from basketball, 18.2% from badminton, 6.1% from frisbee, 12.1% from martial arts, 3% from squash and 12.1% from futsal.

Table 4.2: Base Line Data of Study Participants

	Over all CAI participants [n= 33]		**Healthy Control Group (HCG) [n=23]**			**Control Group (CG) [n= 17]**		**Experimental Group (EG) [n= 16]**		
	M	*SD*	*M*	*SD*	*p*	*M*	*SD*	*M*	*SD*	*p*
Age	21.70	1.99	21.96	1.85	0.623	21.65	1.84	21.75	2.21	0.886
BMI	23.64	2.66	24.25	2.21	0.374	24.95	2.72	22.25	1.79	0.002
CAIT	19.97	3.19	29.43	0.84	**<0.001**	20.18	2.24	19.75	4.02	0.713
FADI	120.45	6.73	135.39	0.99	**<0.001**	120.76	6.62	120.13	7.05	0.790
MAAS	61.55	11.58	65.87	11.74	0.177	61.47	11.46	61.63	12.09	0.970
OHQ	4.17	0.54	4.66	0.50	**0.001**	4.05	0.51	4.29	0.57	0.200
VAS(pain intensity)	4.33	1.34	0	0	**<0.001**	4.35	1.32	4.31	1.40	0.933
BPI(pain intensity)	4.31	0.96	0	0	**<0.001**	4.26	1.01	4.37	0.93	0.748
BPI(pain Interference)	2.46	0.63	0	0	**<0.001**	2.47	0.69	2.44	0.58	0.913
Y-Balance	74.78	6.49	82.53	5.75	**<0.001**	73.79	7.06	75.83	5.87	0.373
Right Temporal										
Alpha	1.54	0.49	1.55	0.95	0.949	1.56	0.48	1.52	0.52	0.810
Beta	1.68	0.54	1.50	0.78	0.317	1.67	0.54	1.69	0.57	0.914
Theta	1.66	0.66	1.77	1.13	0.646	1.70	0.64	1.61	0.70	0.678
Left Temporal										
Alpha	1.33	0.67	2.21	0.87	**<0.001**	1.38	0.58	1.28	0.77	0.681
Beta	1.44	0.58	2.03	0.73	**0.002**	1.50	0.48	1.37	0.68	0.529
Theta	1.40	0.79	2.24	0.97	**0.001**	1.38	0.74	1.41	0.86	0.918
Frontal										
Alpha	1.35	0.68	1.40	0.74	0.765	1.33	0.53	1.36	0.83	0.884
Beta	1.28	0.61	1.56	0.89	0.210	1.31	0.57	1.26	0.66	0.791
Theta	1.56	0.73	1.71	1.17	0.583	1.56	0.58	1.55	0.88	0.979
Occipital										
Alpha	1.32	0.64	1.98	0.80	**0.001**	1.38	0.66	1.26	0.62	0.587
Beta	1.10	0.57	1.46	0.66	**0.032**	1.17	0.62	1.02	0.52	0.482
Theta	1.29	0.89	2.22	0.77	**<0.001**	1.35	0.70	1.22	1.08	0.689

Data are given as M: Mean & SD: Standard Deviation.
CAI: Chronic Ankle Instability
CAIT: Cumberland Ankle instability Tool, FADI: Foot and ankle disability index, VAS: Visual Analogue Scale, BPI: Brief Pain Inventory MAAS: Mindful Attention Awareness Scale, QHQ: Oxford Happiness Questionnaire
p: < 0.05 : Significant difference between the Chronic Ankle Instability and Healthy control group participants.

Comparing the healthy control group (HCG), around 87.9% of the CAI participants were right leg dominant and only 12.1% were left leg dominant during the sports and functional activities. In that, 66.7 % of the injured were right leg dominant compared with 33% of the injury from left leg dominant individuals Around 45.5% of the participants experienced at least 3 repetitions of ankle sprains, followed by 30.3% who experienced 2 repetitions, 18.2% who experienced 4 times, and only 6.1% who experienced 5 times. There were no significant difference over the demographic variables between the HCG and CAI participants as shown in Table 4.2. However, post randomization the CAI participants BMI showed a significant difference with $p=0.002$ between the control group (CG) and experimental group (EG). Whereas, the other outcome variables between the CG and EG participants were not significant at the baseline assessment as shown in Table 4.2.

4.2 Comparison of Ankle Stability between healthy control group (HCG) and CAI Participants

4.2.1 Findings on primary outcome measures

The primary outcome measures were used to compare the status of ankle pain between healthy control group (HCG) and chronic ankle instability (CAI). The participants with CAI reported an average pain intensity of 4.33±1.34 in VAS and 4.32±0.96 in BPI. Similarly, the pain interference also was found to be moderate with the reported value of 2.46 ± 0.63. Whereas the pain intensity and the interference among CAI was significantly increased ($p < 0.001$) compared with HCG (Table 4.2).

Table 4.3: Primary Outcome Measures

Variables	Over all CAI participants [n= 33]		Healthy Control Group (HCG) [n=23]		Independent sample T-test			Effect size
	M	*SD*	*M*	*SD*	*t*	*df*	*p*	*d*
VAS(pain intensity)	4.33	1.34	0	0	15.483	54	**<0.001**	NA
BPI(pain intensity)	4.31	0.96	0	0	21.406	54	**<0.001**	NA
BPI(pain Interference)	2.46	0.63	0	0	18.692	54	**<0.001**	NA

Data are given as M: Mean & SD: Standard Deviation.
NA – not applicable
VAS: Visual Analogue Scale, BPI: Brief Pain Inventory
***p* < 0.05**: Significant difference between the Chronic Ankle Instability and Healthy control group participants,.
d: Cohen's d response mean effect size between time effect

4.2.2 Findings of secondary outcome measures

Secondary outcome measures compared the status of ankle stability and psychological measures of participants, which included dynamic balance, mindful attention, happiness, and EEG data with alpha, beta, and theta brain waves, between the healthy control group (HCG) and chronic ankle instability (CAI) groups. Since the alpha, beta and theta waves are the bio-indicator of pain response, the present study compared the brain signal responses of alpha, beta and theta waves of baseline EEG data from CAI participants with HCG by applying an independent *t*-test (Table 4.4). In addition, an association of the brain wave response with pain intensity, and pain interference level were carried out by Pearson's correlation test.

The dynamic balance of CAI participants using CAIT, FADI and YBT was reported to show a significant (p <0.001) decrease in balance score compared to healthy control group (HCG) with large effect size (d>1.26). Relating to the

Table 4.4: Secondary Outcome Measures

Variables	Over all CAI participants [n= 33]		Healthy Control Group (HCG) [n=23]		Independent sample T-test			Effect size
	M	*SD*	*M*	*SD*	*t*	*df*	*p*	*d*
CAIT	19.97	3.19	29.43	0.84	-13.874	54	**<0.001**	4.05
FADI	120.45	6.73	135.39	0.99	-10.534	54	**<0.001**	3.10
Y-Balance	74.78	6.49	82.53	5.75	-4.603	54	**<0.001**	1.26
MAAS	61.55	11.58	65.87	11.74	-1.366	54	0.177	0.37
OHQ	4.17	0.54	4.66	0.50	-3.432	54	**0.001**	0.94
Right Temporal								
Alpha	1.54	0.49	1.55	0.95	-0.064	54	0.949	0.01
Beta	1.68	0.54	1.50	0.78	1.009	54	0.317	0.27
Theta	1.66	0.66	1.77	1.13	-0.461	54	0.646	0.12
Left Temporal								
Alpha	1.33	0.67	2.21	0.87	-4.272	54	**<0.001**	1.13
Beta	1.44	0.58	2.03	0.73	-3.369	54	**0.002**	0.90
Theta	1.40	0.79	2.24	0.97	-3.579	54	**0.001**	0.95
Frontal								
Alpha	1.35	0.68	1.40	0.74	-0.305	54	0.765	0.07
Beta	1.28	0.61	1.56	0.89	-1.364	54	0.210	0.37
Theta	1.56	0.73	1.71	1.17	-0.601	54	0.583	0.15
Occipital								
Alpha	1.32	0.64	1.98	0.80	-3.410	54	**0.001**	0.91
Beta	1.10	0.57	1.46	0.66	-2.206	54	**0.032**	0.58
Theta	1.29	0.89	2.22	0.77	-4.065	54	**<0.001**	1.12

Data are given as mean & SD: standard deviation.
CAI: Chronic Ankle Instability, HCG: Healthy control group
CAIT: Cumberland Ankle instability Tool, FADI: Foot and ankle disability index MAAS: Mindful Attention Awareness Scale, OHQ: Oxford Happiness Questionnaire
d: cohen's d response mean effect size between time effect
$p < 0.05$.Significant difference between the Chronic Ankle Instability and Healthy control group participants

increased pain intensity and decreased balance score, the happiness score and mindful attention was found to be decreased in chronic ankle instability (CAI). The results reported a significant ($p = 0.001$) decrease in happiness score with large effect size (d= 0.94) among the participants with CAI indicating the negative influence of pain and disturbance in balance on happiness level.

Similarly, MAAS score also reported to be decreased in CAI indicating lower attention level among CAI participants, however the difference in MAAS score was not significant ($p = 0.177$) with healthy control group (HCG) (Table 4.4). The present findings confirm the presence of pain and disruption in dynamic balance as the result of an ankle injury. Furthermore, ankle injuries also affect the happiness and attention level of CAI participants.

4.2.2.1 Alpha wave response

The alpha wave has already been highlighted as a major marker of pain in musculoskeletal condition and is commonly dominant during closing the eyes in a wakeful state. Hence, the present study investigated the alpha wave response of the participants in wakeful state by placing them in closed eyes and reported a significant ($p < 0.001$) decrease in alpha wave mean value among CAI participants (1.33±0.67) compared to healthy control group (HCG) (2.21± 0.87) with a large effect size ($d= 1.13$) over the left temporal region. Accordingly, as illustrated in Figure. 4.1(a), the alpha wave response showed a negative association ($r = -0.438$, $p=0.011$) with the pain interference only but not with pain intensity. Next to the left temporal region, the activity of alpha wave on the occipital region is found to be dominant with a significant ($p = 0.001$) decrease in alpha wave response among CAI (1.32±0.64) comparing with HCG (1.98±0.80) with a larger effect size (d=0.91). However, no association was observed for pain intensity and interference. Further, the alpha wave responses over frontal and right temporal regions were analysed. The results reported a slight and non-significant (p=0.765) decrease in alpha wave

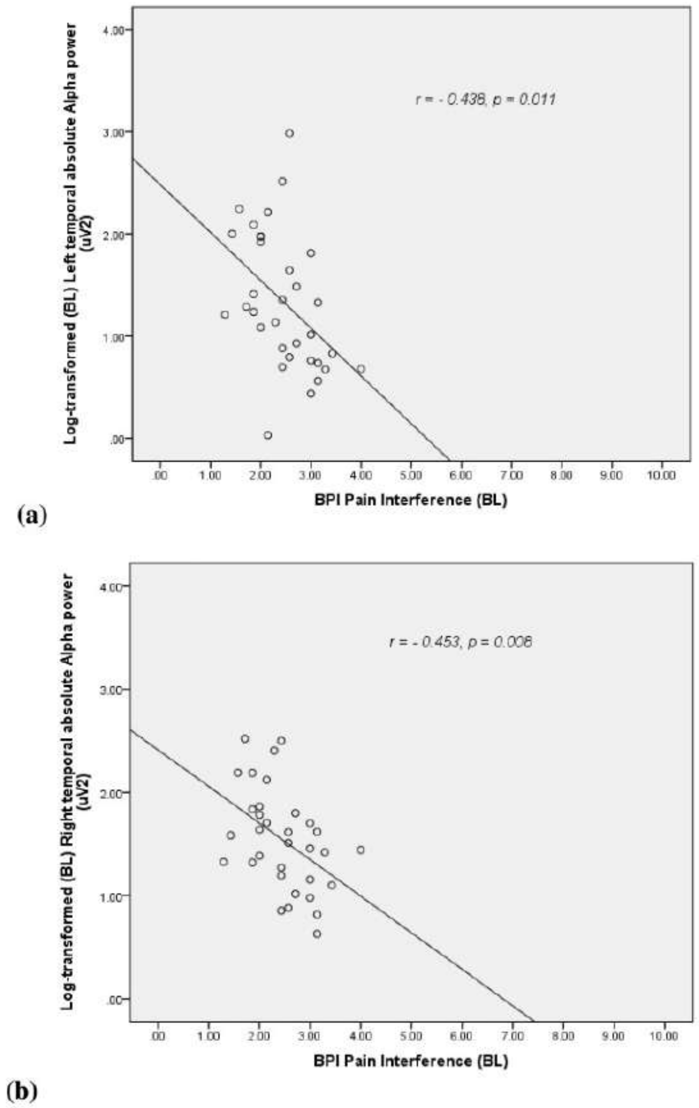


Figure 4.1 (a), (b): Ilustrates the Association between Pain Interference and Alpha wave in CAI

mean score on frontal region (1.35±0.68) among chronic ankle instability (CAI) participants over healthy control group (HCG) (1.40 ± 0.74). Nevertheless, there is no significant (*p*=0.949) changes in alpha wave was observed over the right temporal region as the reported values of alpha mean scores were (1.55±0.95) and (1.54±0.49) for CAI and HCG respectively (Table 4.4), with a negative association (*r* = -0.453, *p*=0.008) to pain interference only with left temporal region (Figure. 4.1(b)). The present findings showed a remarkable difference in alpha wave over the occipital and left temporal regions among CAI participants with pain compared to healthy control group (HCG).

4.2.2.2 Beta wave response

Similar to alpha wave, the beta wave is also reported to be a reflector of alert or wakeful state, which undergoes change during pain or stressful conditions. As the chronic ankle instability (CAI) participants experience pain due to ankle injury, the beta wave response was recorded in the present study. Table 4.4 presents the significant (p =0.002) decrease in beta wave mean value of CAI (1.44±0.58) over healthy control group (HCG) (2.03±0.73) on left temporal region with a larger effect size (d=0.90). However, the pain intensity and interference showed no association. In line with the results of alpha wave, the beta wave mean score also exhibited a significant (p = 0.032) decrease over occipital region by the reported mean score of 1.10±0.57 and 1.46±0.66 for CAI and HCG respectively with a moderate effect size (d=0.58). Accordingly, the association between beta wave and pain intensity (VAS only) was found to be negative (r = - 0.354, p=0.043) as shown in Figure 4.2(a). This shows the sensitivity of beta wave in response to pain over the occipital region. Similar with alpha wave, the beta wave of frontal region in CAI showed non-significant (p = 0.210) slight decrease in mean score (1.28±0.61) comparing with HCG (1.56±0.89). In contrast, the right temporal region showed a slight and non-significant (p = 0.317) increase in beta wave CAI (1.68±0.54) over HCG (1.50±0.78) as shown in Table 4.4. However, a negative (r = - 0.387, p = 0.026)

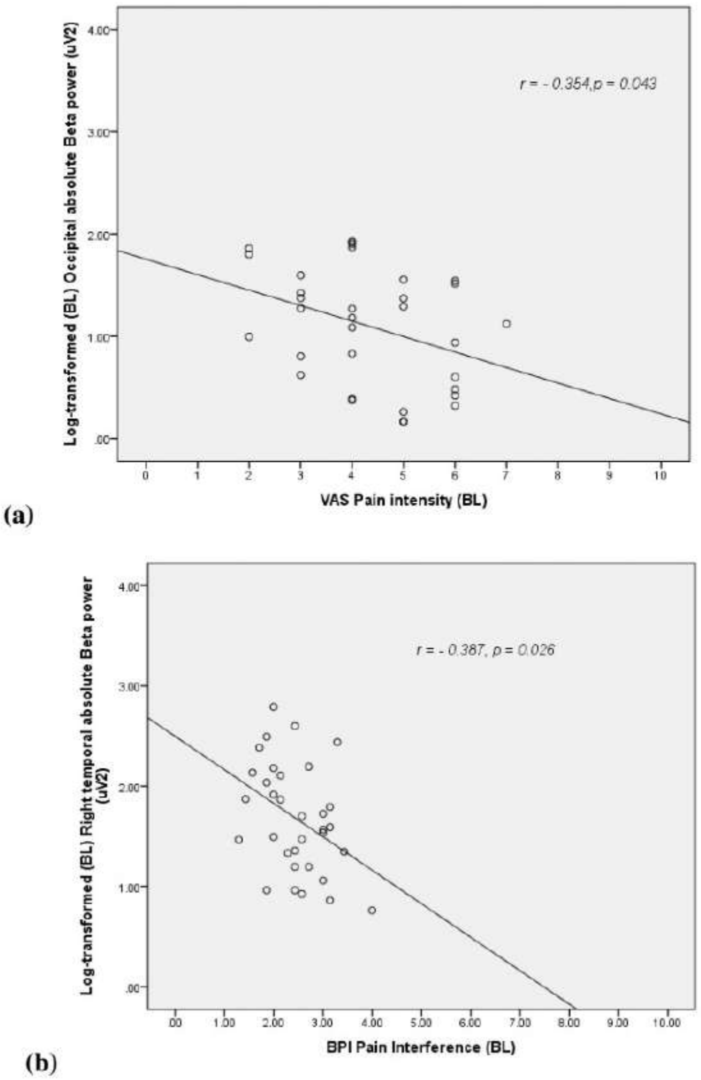


Figure 4.2 (a), (b): Illustrates the Association between Pain Interference (BPI), Pain Intensity (VAS) and Beta Wave in CAI

association was reported with pain interference while no association with pain intensity (Figure 4.2(b)). The findings suggest that, like the alpha wave, the mean beta wave score for CAI was found to be decreased over the left temporal and occipital regions.

4.2.2.3 Theta wave response

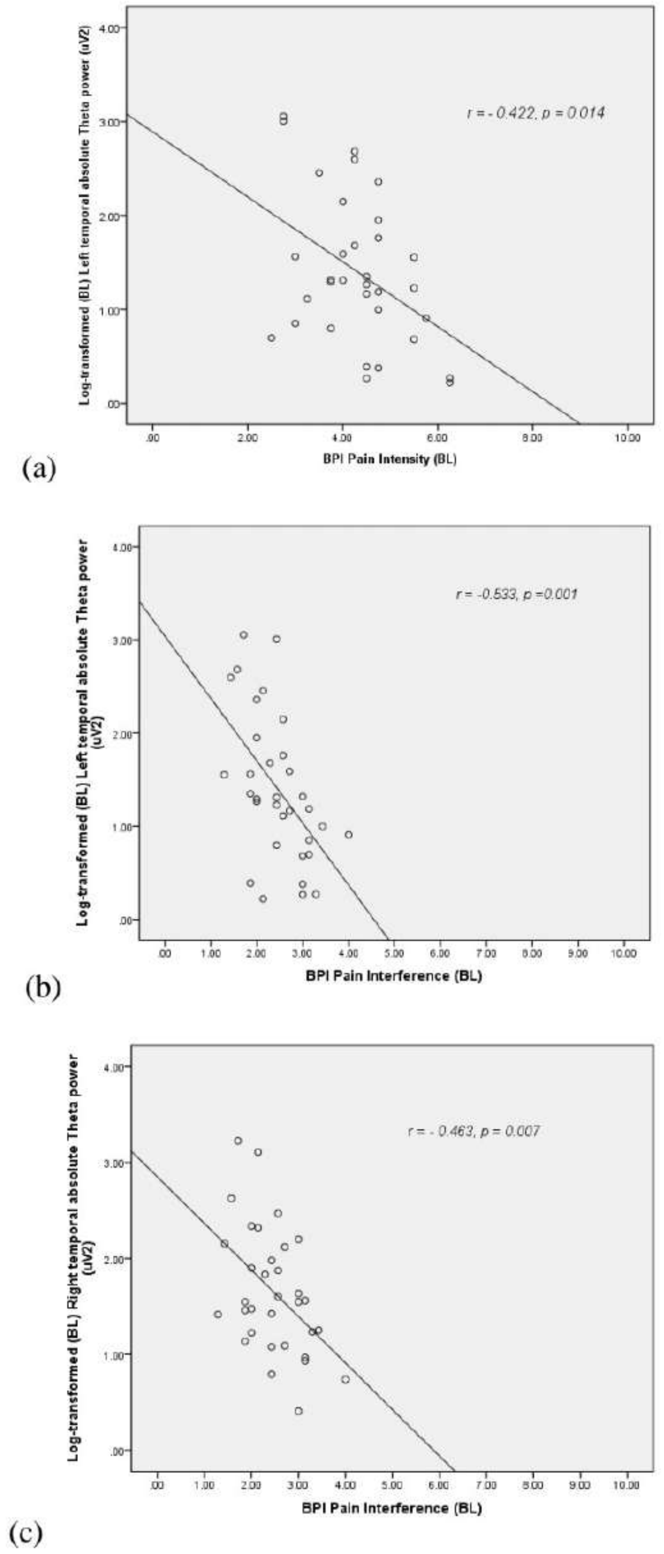


Figure 4.3 (a), (b), (c): Illustrates the **Association between Pain Interference (BPI), Pain Intensity (BPI) and Theta Wave in CAI**

Following the alpha and beta wave, the third prominent brain wave indicating the pain response is the theta wave. In line with the alpha and beta waves, the present study reported a significant ($p = 0.001$) decrease in theta wave mean scores among chronic ankle instability (CAI) participants (1.40±0.79) compared to healthy control group (HCG) (2.24±0.97) with larger effect size (d=0.95) on left temporal region (Table 4.4). Correspondingly, as shown in Figure 4.3(a), (b), a negative association was found with pain intensity ($r = -0.422$, p=0.014) (BPI only) and pain interference ($r = -0.533$, p=0.001) among CAI participants. Further, theta wave mean score over occipital region was found to be significantly ($p < 0.001$) decreased in CAI (1.29±0.89) compared to HCG (2.22±0.77) with larger effect size (d=1.12) as shown in Table 4.4. Similar to alpha wave, the decrease in theta wave response was not correlated with pain intensity. Further, theta wave over the frontal region showed a non-significant ($p = 0.583$) decrease in theta wave mean score of CAI (1.56±0.73) comparing with HCG (1.71±1.17). Also, the right temporal region showed a non-significant ($p = 0.646$) decrease in theta mean score (1.66±0.66) comparing with HCG (1.77±1.13) as shown in Table 4.4. In addition, negative association (r= -0.463, p=0.007) was reported with pain interference only, but not with pain intensity (Figure 4.3(c)). The results strongly emphasize that theta wave activity response was shown to be decreased over both the right and left temporal regions. In summary, regardless of the brain regions studied, the present study reported a remarkable alteration in alpha, beta and theta waves reflecting the changes in the brain response during pain among CAI participants.

4.3 Findings on Effectiveness of Video-Assisted Mindfulness Deep Breathing in Managing Chronic Ankle Instability

The present study was conducted in order to determine the combined effects of VAMDB+CP (video-assisted mindfulness deep breathing+ conventional physiotherapy) over CP (conventional physiotherapy) on improving ankle stability among chronic ankle instability (CAI) participants. The effectiveness of the intervention was assessed with primary outcome measures such as pain intensity and interference using VAS and BPI, and also by secondary outcome measures such as dynamic balance by CAIT, FADI, and YBT, mindful attention with MAAS, and happiness using OHQ for four time intervals as presented in Appendix 12. In addition, participants EEG signals were recorded as a secondary outcome measure to study the changes in alpha, beta and theta waves (Appendix 12). Before commencing the interventions in experimental group (EG) and control group (CG), the baseline (BL) assessment was conducted, and then the mid-intervention (MI) assessment at the end of the third week, the post-intervention (PI) assessment at the end of the sixth week, and the follow-up (FU) assessment at the end of the twelfth week were carried out following the interventions to report the beneficial effects on improving CAI. The significant effects were reported using Greenhouse-Geisser for the following outcomes measures: VAS, BPI, CAIT, FADI, YBT, MAAS, OHQ, frontal alpha, and beta since their sphericity was violated with $p<0.05$. Whereas the frontal theta, occipital alpha, beta, and theta, left and right temporal alpha, beta, and theta frequency values were not violated with $p > 0.05$.

4.3.1 Improvement on Pain Intensity and Pain Interference

Since the pain is the one of the major symptoms of chronic ankle instability (CAI), the reduction in pain level was reported using VAS and BPI to assess the beneficial effects of treatments on improving the pain among the participants. ANOVA results of VAS pain score showed an improvement in pain intensity level over time *F* (2.264, 63.380) =105.607, p <0.001, η^2 =0.790 after exposure to 6-weeks of intervention in both experimental and control group participants. On the other side, no significant change in pain level was observed between the experimental and control groups F (1, 28) = 0.470, p = 0.498 and the time×group interaction F (2.264, 63.380) = 0.403, p = 696 among the participants.

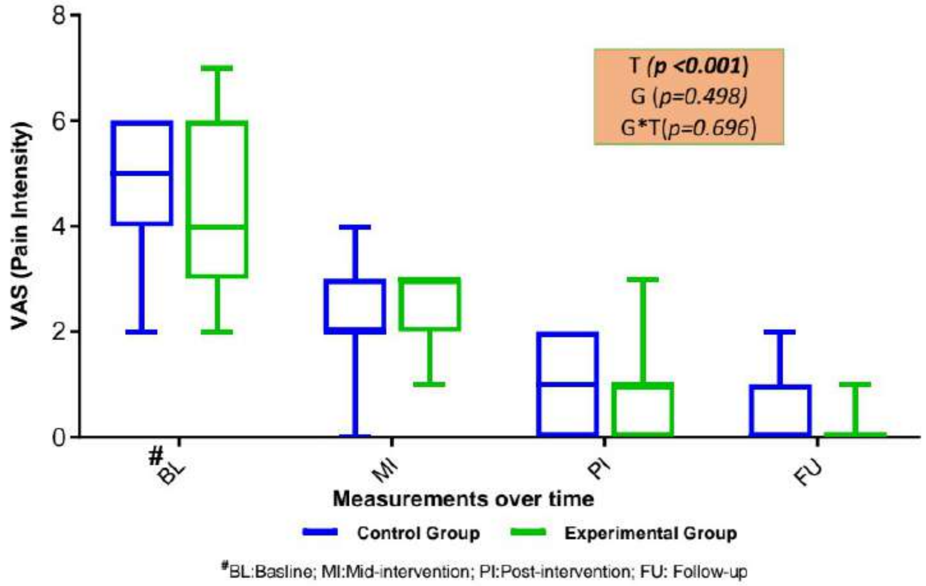
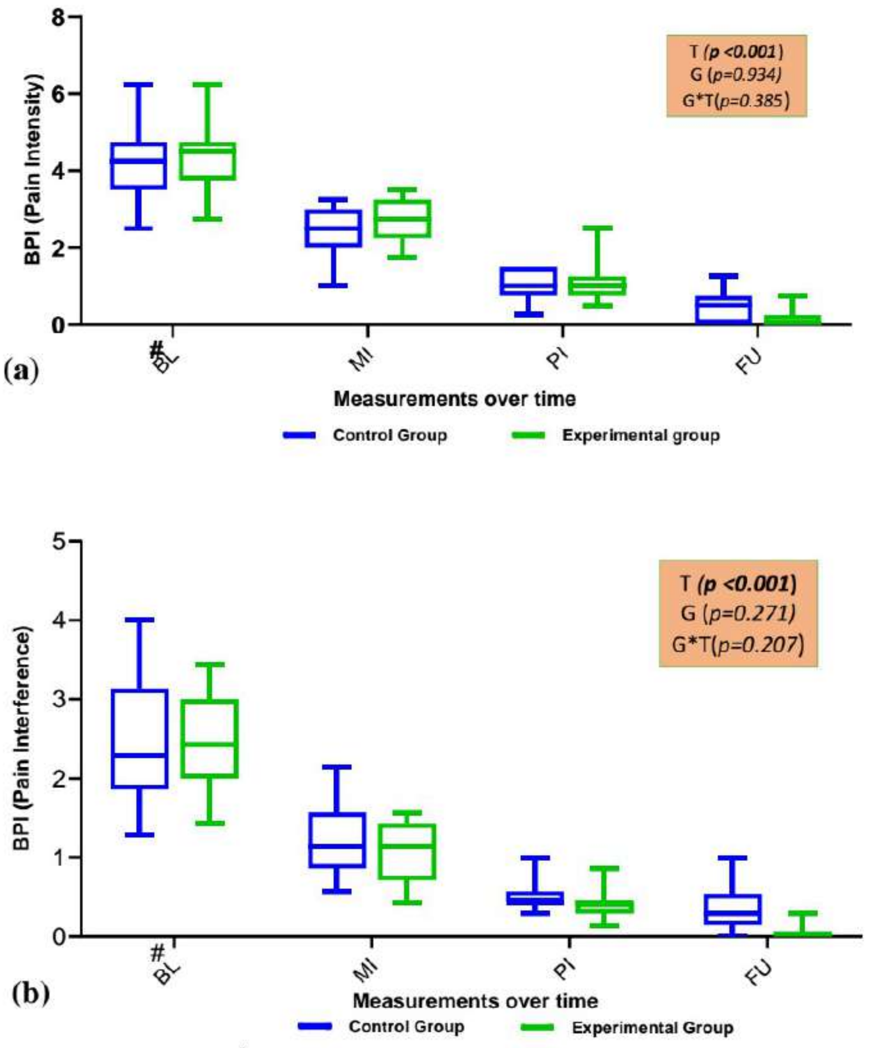


Figure 4.4: Adjusted Mean of Pain Intensity (VAS) for Groups

In the experimental and control groups, mean VAS scores demonstrated a reduction in pain from baseline to mid-intervention, baseline to post-intervention, and baseline to follow-up. In the follow-up sessions, participants in the experimental group who exposed to VAMDB were observed to have better pain reduction and copping than those in the control group (Figure 4.4).In addition to VAS pain score, the BPI pain score was also used to report the improvement on the pain level and pain interference among CAI participants. The ANOVA results showed an improvement in participants BPI pain intensity and pain interference over time F (1.659, 46.462) =248.935, p <0.001, η2 =0.899 and F (1.436, 40.217) =286.785, p <0.001, η2 =0.911 respectively, following 6-weeks of intervention in both experimental group and control group. Furthermore, as shown in Figure 4.5 (a), (b), the mean scores of BPI pain intensity and interference showed reductions in pain score and pain interference score from baseline to mid-intervention, baseline to post-intervention, and baseline to follow-up in the experimental and control groups.

In line with the improvement in VAS pain score, the follow-up testing on BPI pain intensity and interference scores showed improvement among participants in the experimental group compared with the control group (Figure 4.5). On the other side, no significant change in BPI pain intensity and pain interference were observed between groups F (1, 28) = 0.007, p = 0.934 and F (1, 28) = 0.464, *p* = 0.271. Similarly, the time × group interaction for pain intensity F (1.659, 46.462) = 0.932, *p* =0.385 and pain interference F (1.436, 40.217) = 1.658, *p* =0.207 showed a similar results, which is in line with VAS pain score intensity findings. In accordance with the participants VAS score, the BPI pain intensity mean score in EG showed improvement in pain from baseline to mid-intervention, baseline to post-intervention and baseline to follow-up consistently (Figure 4.5 (a)).



#BL:Basline; MI:Mid-intervention; PI:Post-intervention; FU: Follow-up

Figure 4.5 (a), (b): Adjusted Mean of Pain Intensity and Interference (BPI) for Groups

Likewise, the BPI pain interference mean score was reported to be reduced from baseline to mid-intervention, mid-intervention to post-intervention and mid-intervention to follow-up compared with control group (CG) as shown in Figure 4.5 (b). In general, the improvement in pain mean scores show that the combined interventions (VAMDB+CP) among the participants in EG resulted in better reduction of pain intensity and pain interference comparing with CG, which underwent conventional physiotherapy (CP) only.

4.3.2 Improvement on Dynamic Balance

The progressive healing in pain often improves an individual's balance by providing stable support for functional activities, which is commonly threatened in CAI from repeated ankle sprains. As the CAI affects the dynamic balance of the athletes, an improvement in dynamic balance due to the interventions was assessed by Cumberland ankle instability tool (CAIT), foot and ankle disability index (FADI), and Y-balance test (YBT). Two-way repeated measures analysis of variance (ANOVA) showed a significant improvement in CAIT scores (F (2.137, 59.833) =169.981, p <0.001, η2 =0.741), FADI scores (F (1.889, 52.901) =86.511, p <0.001, η2 =0.755 and YBT scores (F (2.185, 61.167) =46.122, p <0.001, η2 =0.652) over time within the groups from baseline to follow-up sessions in both experimental group (EG) and control group (CG). However, no significant improvement in CAIT scores (F (1, 28) = 0.004, p = 0.953), FADI scores (F (1, 28) = 0.278, p = 0.602) and YBT score (F (1, 28) = 1.352, p = 0.223) between the experimental group (EG) and control group (CG) was reported.

Similarly, no significant improvement was evidenced between the groups for both time×group in CAIT score (F (2.137, 59.833) = 2.141, p =0.123), FADI scores (F (1.889, 52.901) = 1.465, p = 0.240, and YBT score (F (2.185, 61.167) = 1.704, p = 0.188) (Appendix 12). However, the mean CAIT balance score of the participants in the experimental group showed improvement from

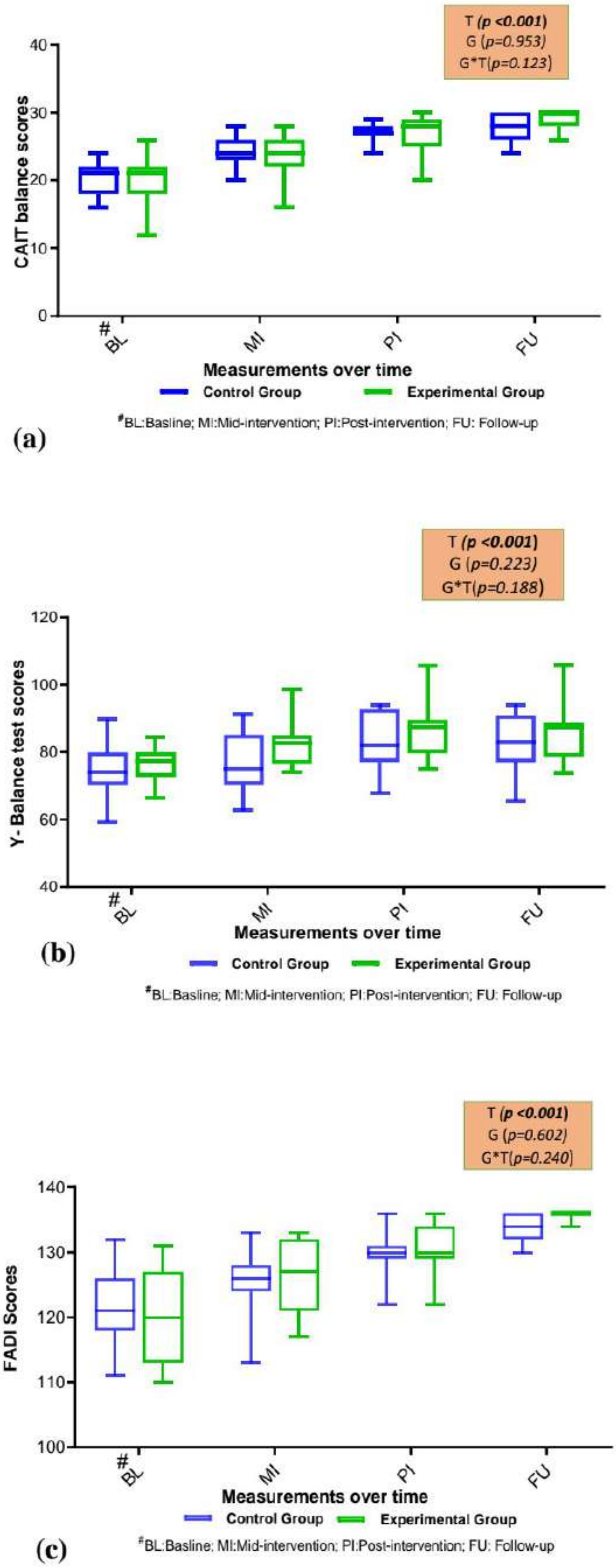


Figure 4.6 (a), (b)& (c): Adjusted Mean of Dynamic Balance for Groups

baseline to mid-intervention, baseline to post-intervention and baseline to follow-up. Likewise, YBT score also improved from baseline to mid-intervention, baseline to post-intervention and baseline to follow-up. In addition, FADI score also showed an improvement from baseline to mid-intervention, baseline to post-intervention and baseline to follow-up (Appendix 12). Notably, the FADI scores in follow-up showed an improvement in balance of experimental group (EG) compared to control group (CG) as the reported values of FADI scores were 135.66±0.72 and 133.66±2.22 for EG and CG respectively (Figure 4.6 (c). Similarly, CAIT and YBT scores were also increased in EG with the reported score of 29.07 ± 1.49 and 85.94±8.28 respectively compared to CG score of 27.87 ± 1.20 and 82.92±9.03 for CAIT and YBT respectively (Figure 4.6 (a),(b)). However, the improvement in CAIT, FADI and YBT were not significant between the groups. The study results evidently indicate the advantage of combined effects of VAMDB+CP over the conventional physiotherapy (CP) on improving the ankle stability of the collegiate athletes.

4.3.3 Improvement on Mindful attention and Happiness level

In accordance with the better outcomes on pain and balance of the participants with chronic ankle instability (CAI) due to the combined interventions (VAMDP+CP) in experimental group (EG), the mindful attention and happiness scores also were found to have improved remarkably from baseline to follow-up in EG. The mindfulness attention awareness scale (MAAS) questionnaire used in this study reflects the mental adaptation of the participants towards the attention on the interventions. In addition, Oxford happiness questionnaire

(OHQ) was used to report the participants psychological improvement resulted from the interventions.

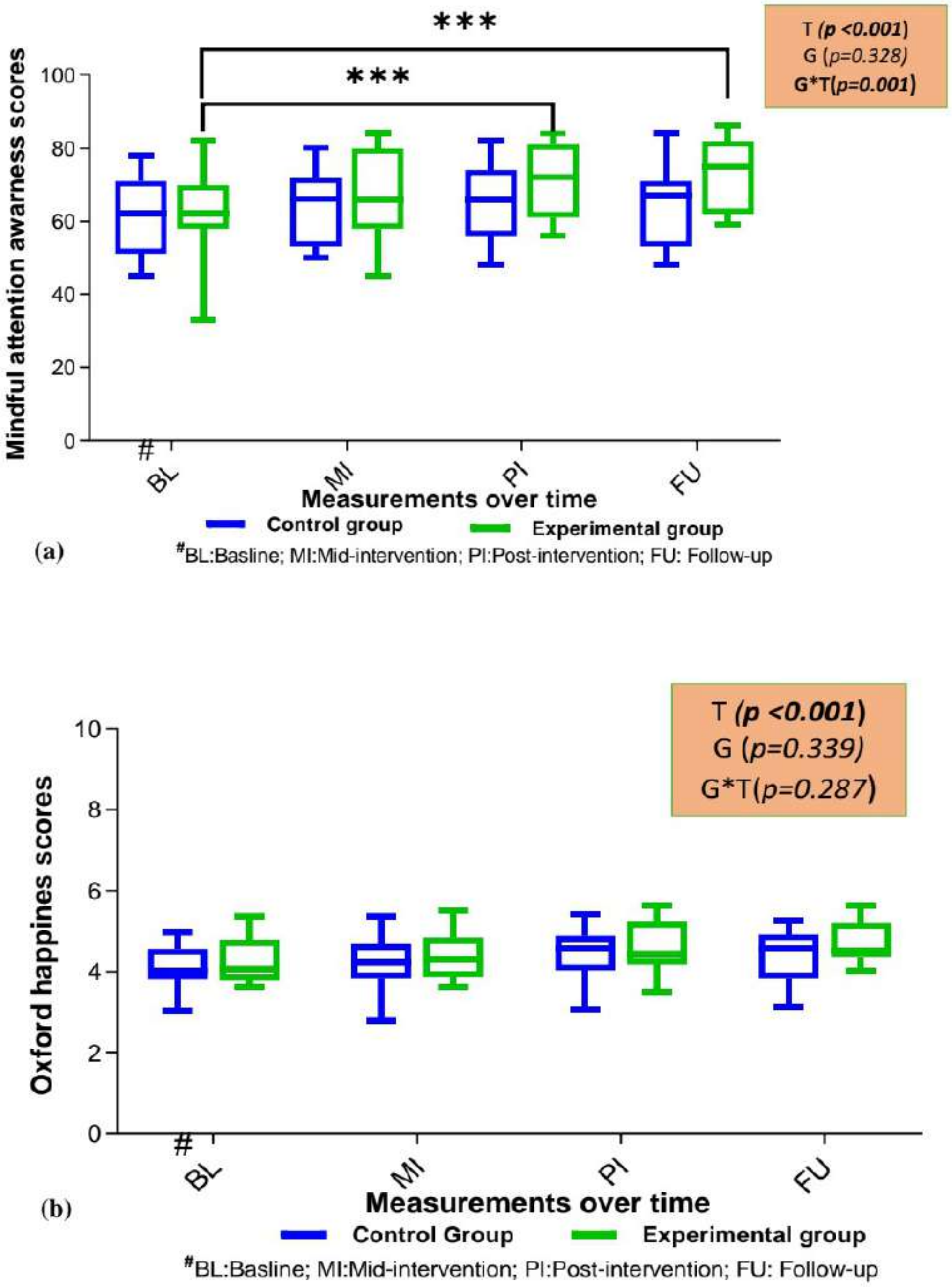
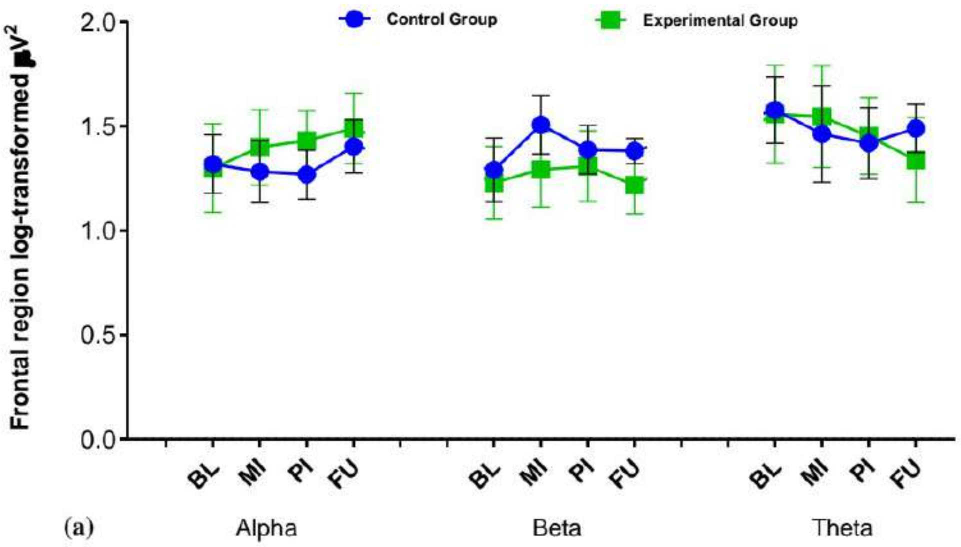


Figure 4.7(a) &(b): Adjusted Mean of Mindful Attention and Happiness for Groups

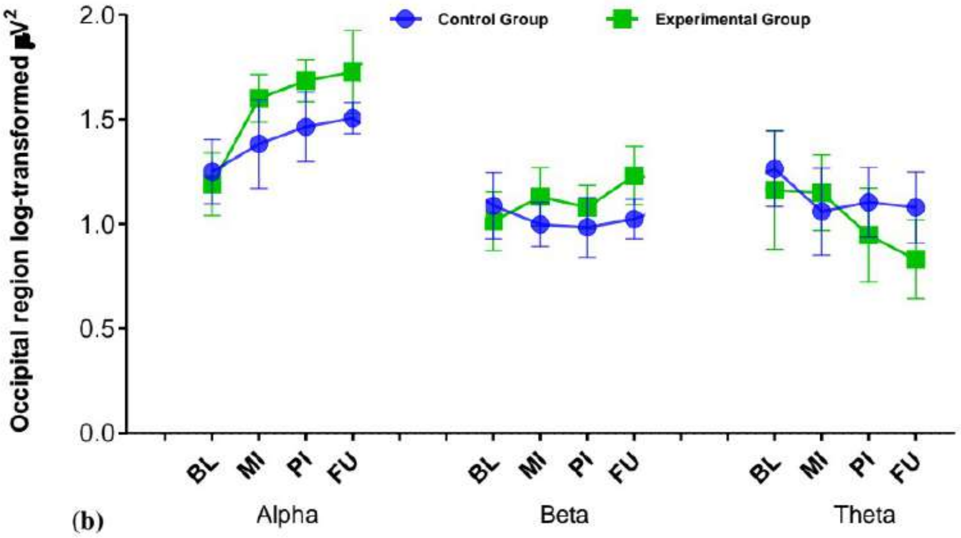
The mindful attention level of chronic ankle instability (CAI) participants demonstrated a significant improvement between time interaction F (2.107, 59.008) =18.298, p <0.001, η^2 =0.417, and time × group F (2.107, 59.008) = 9.054, p = 0.001, η^2 =0.222, and no significant improvement between the groups (F (1, 28) = 0.993, p = 0.328). Likewise, there was a significant improvement in participants happiness level over time F (1.792, 2.870) =26.714, p <0.001, η^2 =0.488. But, no significant improvement between the time×group interaction F (1.792, 2.870) = 0.679, p = 0.496 and groups (F (1, 28) = 0.390, p = 0.537) (Appendix 12). Further, a significant (p < 0.001) improvement on mindful attention in experimental group (EG) with larger effect from baseline to post-intervention (d = 1.33), and baseline to follow-up (d = 1.64), but not at mid-intervention as shown in Figure 4.7(a). Nevertheless, no significant (p > 0.05) improvement in MAAS score was reported from mid-intervention to follow-up session in the control group (CG). In particular, the mean score at follow-up revealed a higher MAAS score of 73.06 ± 9.54 in the experimental group compared with a MAAS score of 64.93 ± 10.73 in the control group. The results clearly indicate that the experimental group participants exposed to 3-min video-assisted mindfulness deep breathing consistently from the baseline gained better attention compared to control group participants who were not exposed to the new intervention. In addition to improvement in attention, the mean score of happiness in experimental group from baseline to follow-up, and baseline to post-intervention was higher (Appendix 12). Further, an increase in happiness score from mid-intervention until follow-up as shown in Figure 4.7(b) indicates an improvement in the psychological state of the individuals from the experimental group (EG) compared with control group (CG).

4.3.4 Intervention Effects on EEG - Brain Waves

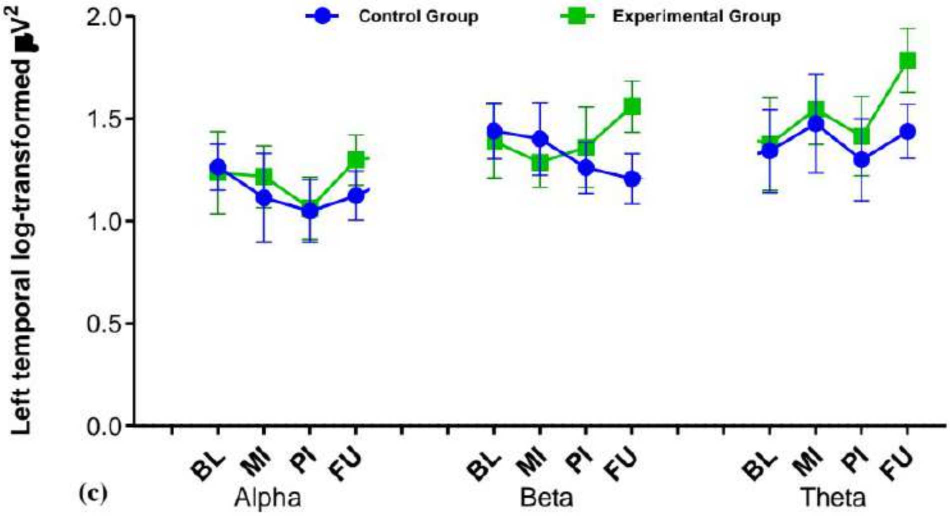
The present study implemented EEG tool as one of the secondary outcome measure to evaluate the progress in pain and balance of the collegiate athletes with CAI since the researchers recommended EEG as the biomarker of pain. Among the brain waves recorded in EEG, the alpha wave was identified as the indicator of improvement in pain due to the interventions. Accordingly, the present study findings reported an increase in alpha mean score over occipital region from baseline to follow-up in both the experimental (EG) and control groups (CG) with a significant increase between the time interaction F (3, 84) =3.557, $p < 0.018$, $\eta 2 = 0.113$. Remarkably, an increase in alpha mean score was observed in EG from baseline to post-intervention compared to CG as shown in Figure.4.8 (b), whereas, the p value was greater ($p > 0.0125$) which showed a non-significant improvement in occipital alpha scores (Appendix 12). However, the mean alpha score showed an increase in trend from the baseline to follow-up among the experimental group compared with control group participants (Figure.4.8 (b)). In addition, the topoplots were employed in the present study to observe the changes in the intensity of brain waves due to the beneficial effects of interventions. In line with increase in alpha mean score over occipital region, the topography of alpha was coherent, which consistently showed an increase in alpha wave intensity on the same region from baseline to follow-up in experimental group (EG) compared to control group (CG) (Figure 4.9). Similarly, an slight increase in alpha mean score and topography were observed over the frontal region from baseline until follow-up, whereas the left and right temporal regions were found to have a decrease in alpha mean score and


Frontal region log-transformed µV^2
2.0
1.5
1.0
0.5
0.0
Control Group
Experimental Group
BL
MI
PI
FU
Alpha
Beta
Theta

(a)


Occipital region log-transformed µV^2
2.0
1.5
1.0
0.5
0.0
Control Group
Experimental Group
BL
MI
PI
FU
Alpha
Beta
Theta

(b)


Left temporal log-transformed µV^2
2.0
1.5
1.0
0.5
0.0
Control Group
Experimental Group
BL
MI
PI
FU
Alpha
Beta
Theta

(c)

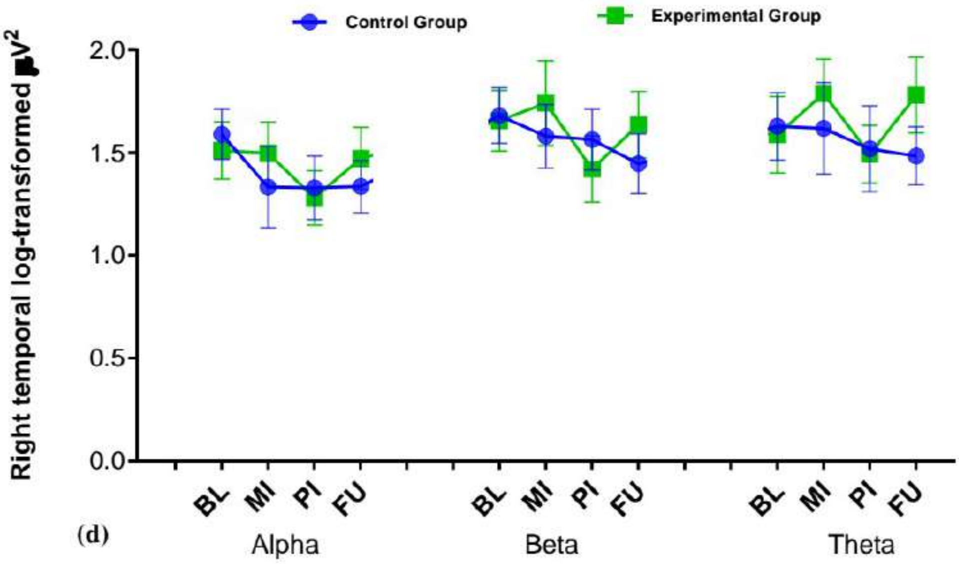


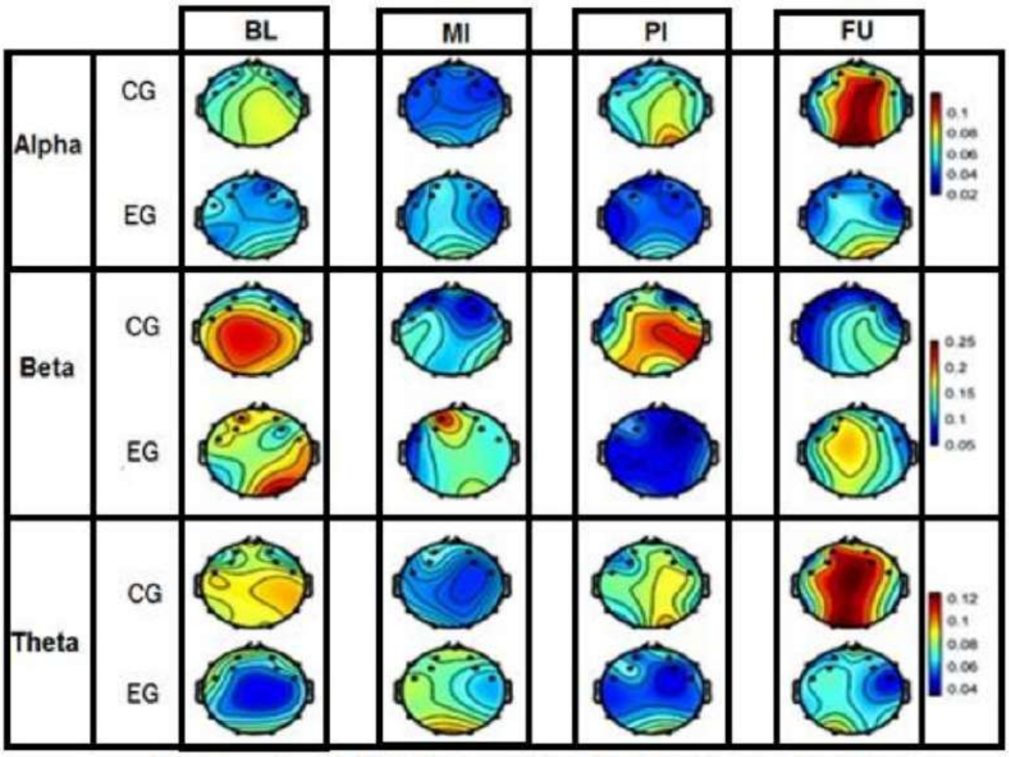
Figure 4.8 (a), (b), (c), (d): Adjusted Mean of EEG Scores for Groups

topography from baseline to post-intervention in both experimental group (EG) and control group (CG) (Figure 4.8 (c), (d)).

On the other hand, an increase in trend was observed over left and right temporal for alpha intensity from post-intervention to follow-up in EG and CG as well. However, no statistical difference was observed between EG and CG on alpha mean score over occipital (F (1, 28) = 1.143, $p = 0.294$), frontal (F (1, 28) = 0.476, $p = 0.496$), left temporal (F (1, 28) = 0.234, $p = 0.633$) and right temporal regions (F (1, 28) = 0.132, $p = 0.719$). Similarly, no significant change between the time × group interaction was reported in occipital (F (3, 84) = 0.543, p = 0.654), frontal (F (2.269, 63.529) = 0.130, p = 0.901), left temporal (F (3, 84) = 0.195, p = 0.899) and right temporal (F (3, 84) = 0.401, p = 0.753) regions of CAI participants.

Following the alpha wave, an increase in the beta wave implies an improvement in the pain and attention. The present study findings, showed an increase in the beta mean score response over the frontal and occipital regions from baseline to follow-up in both experimental group (EG) and control group (CG). Like the alpha wave, the topography of beta wave in EG and CG displayed an increase in intensity over the frontal and occipital regions. In contrast, the beta mean score was reported to be decreased from post-intervention to follow-up in EG, which is in line with the reduced topography of beta wave over the frontal region. However, the beta wave in CG maintains decrease in the mean score, which is coherent with beta topography. Further, a decrease in beta mean score and topography was observed from baseline to post-intervention over the left temporal and right temporal region, whereas it increased from post-intervention to follow-up following the similar trend of beta wave observed on frontal region. Conversely, the frontal beta showed no significant improvement between time F (2.394, 67.034) =0.446, p =0.677, time × group interaction F (2.394, 67.034) = 0.156, p = 0.890, and groups (F (1, 28) = 0.918, p = 0.346). Likewise, occipital beta showed no significant improvement between time F (3, 84) =0.217, p=0.884, time × group interaction F (3, 84) = 0.450, p = 0.718, and groups (F (1, 28) = 0.764, p = 0.389). Similarly, no significant improvement was reported in the left temporal region between time F (3, 84) =0.402, p = 0.752, time × group F (3, 84) = 1.409, p = 0.246 and groups F (1, 28) = 0.166, p = 0.687, and right temporal region between time F (3, 84) = 0.720, p = 0.543, time × group F (3, 84) = 0.580, p = 0.630, and groups F (1, 28) = 0.114, p = 0.738. (Appendix 12).

Further, a decrease in theta wave was observed along with improvement in pain. The mean theta score over the frontal and occipital regions were found to be decreased from baseline until follow-up by the effects of interventions in both experimental (EG) and control groups (CG). But, an increase in theta mean



#BL: Baseline; **MI**;Mid-intervention; **PI**:Post-intervention; **FU**:Follow-up

Figure 4.9: Topography of EEG Signals

(CG: Control Group and EG: Experimental group)

score and topography was observed in left and right temporal regions after the interventions in EG and CG. Likewise, the topography of theta wave in EG and CG displayed a decrease in intensity over the frontal and occipital, and an increase in intensity over the left and right temporal regions after undergoing pain management as shown in Figure 4.9. However, no significant difference in theta wave mean score was found between EG and CG across the occipital (F

(1, 28) = 0.477, $p = 0.496$), frontal (F (1, 28) = 0.006, $p = 0.941$), left temporal (F (1, 28) = 0.582, $p = 0.452$), and right temporal regions (F (1, 28) = 0.464, $p = 0.501$). Likewise, no significant improvement in theta waves was reported between time and time × group interaction in occipital region (F (3, 84) =0.615, p=0.607 and F (3, 84) = 0.252, $p = 0.860$), frontal region (F (3, 84) =0.354, p=0.786 and F (3, 84) = 0.188, $p = 0.904$), left temporal region (F (3, 84) =0.669, p=0.573 and F (3, 84) = 0.195, p = 0.899), and right temporal region (F (3, 84) =0.470, p=0.704 and F (3, 84) = 0.454, p = 0.715), respectively (Appendix 12).

Notably, based on the study findings, the alpha wave response over the occipital regions is identified to be an ideal indicator of improvement in ankle stability resulting from the novel intervention VAMDB used in this present study because of its enhanced response on occipital region.

CHAPTER 5

DISCUSSION

The present research aimed to compare ankle stability and electroencephalogram (EEG) response between healthy and chronic ankle instability (CAI) participants. In addition, it explored the effectiveness of video-assisted mindfulness deep breathing (VAMDB) in the treatment of CAI with primary (VAS and BPI) and secondary outcome measures (CAIT, FADI, Y-balance, MAAS, OHQ, and EEG). From the study findings, it is evident that presence of pain in CAI affects the participants' well-being by decreasing the dynamic balance, mindful attention, happiness and EEG signals of the brain. The intervention results showed that the 3-min VAMDB, along with conventional physiotherapy (CP) was able to deliver a substantial improvement in CAI. Further, the combined interventions (VAMDB+CP) demonstrated an improved mindfulness attention and a remarkable increase in alpha mean scores of EEG signal on occipital region of the brain in the experimental group (EG). Similarly, 6-week conventional physiotherapy employed in the control group (CG) resulted in an improvement in pain intensity, dynamic balance, and happiness.

Raising participation in collegiate sports increases the incidence of lower limb injury, especially the ankle that produces repetition of uncontrolled inversion ankle movements leading to chronic ankle instability (CAI) (Hootman et al., 2007; Faizullin and Faizullina, 2015; Hertel, 2002; de Vries et al., 2002). CAI results in pain, swelling over the ankle and limit the functional activity in sports (Hiller et al., 2011; Mitchell et al., 2008). The presence of ankle pain and functional activity limitation compromise CAI participants' dynamic balance which is the common problem reported from previous research (van Middelkoop et al., 2012). Further, the participants' pain interference and psychological feelings towards pain and functional activity limitations were concerned in this present study. So, the present study incorporated VAS and BPI as the primary outcome measures and CAIT, FADI, Y-balance, MAAS, OHQ and brain waves as secondary outcomes measures to assess both the functional and psychological disturbances in CAI following the injury (Mkumbuzi et al., 2020; Williams and Arnold, 2011; Mothes et al., 2014; Medvedev et al., 2017).

Studies reported that athletes with CAI had presented with mild to moderate ankle pain (Ramalingam et al., 2020; Hiller et al., 2012; Cruz-Diaz et al., 2015). Similarly, the CAI participants in this present study also presented with moderate pain at baseline. In line with VAS, the CAI participants' BPI pain intensity and pain interference were reported to be mild to moderate among participants. Whereas, BPI pain intensity and interference in low back pain participants showed moderate to severe in baseline (BL) among females (Gammaitoni et al., 2003). A study by Rollman and Lautenbacher, (2001);Bartley and Fillingim, (2013) reported that level of stress and experience of musculoskeletal pain among females were different and higher compared to male as evidenced in the present study which involved only the male participants.

On the other hand, moderate pain in CAI participants affects the functional activities such as walking, running, and specific movements in sports, and further the psychological components as reported by Al Adal et al., (2019). Since pain affects the balance, the participants CAI was confirmed using CAIT tool (Claire E. Hiller et al., 2006; Vuurberg et al., 2018). The dynamic balance was further assessed using self-reported FADI and YBT objective measurements to check the functional stability (Hale and Hertel, 2005; Shaffer et al., 2015; Shaffer et al., 2013). The ankle pain among CAI athletes reported to have reduced in CAIT score with the average range of 22.47 ± 1.69 at baseline (Cruz-Diaz et al., 2014). Whereas, the another study among CAI with ankle pain reported lower CAIT score of 16.1±3.7 (Zhang et al., 2020) compared to the results of present study CAIT score of 19.97± 3.19 at baseline. A study by Ferrer-Peña et al., (2019) reported a negative association of VAS with YBT by indicating an increase in pain intensity can cause decrease in YBT due to hip pain. Also, another study on athletes with ankle pain reported a decrease in YBT (72.79±11.40) and FADI (109.54± 18.49) scores compared to an established normal range for balance owing to increase in pain (Ramalingam et al., 2020). Likewise, CAI participants showed reduction in YBT (74.78±6.49) and FADI (120.45±6.73) scores at the baseline compared to participants without CAI with the reported scores of (82.5±5.75) and (135.39±0.99) for YBT and FADI respectively, inferring that the moderate ankle pain due to CAI can affect the dynamic balance. Whereas the study by Hale et al., (2014) reported comparatively lower FADI score (87.92±10.49) in participants with CAI. An increase in pain and the subsequent decrease in balance in CAI can reduce the mindful attention and happiness level of the individuals (de Vries et al., 2002; Hiller et al., 2011; Bajaj et al., 2019; Nithyanandan, 2020). Since the pain can affect the attention of the individuals, the present study used the MAAS score to report the attention status of the participants before and after the interventions. The results showed a lower MAAS score of 61.55 among CAI participants with moderate pain, compared to the MAAS score of 65.87 among the HCG participants. Similarly, a study by Omidi and Zargar, (2014) on tension headache with severe pain reported a big drop in MAAS score of 37.8 and an another study by Mohammed et al., (2018) on injured athletes reported a MAAS score of 57.90 which is closer to the MAAS score reported in the present study among CAI participants. Following the attention, the influence of pain on happiness level was investigated using OHQ. A study by Golmakani et al., (2012) evidenced that the happiness favours reduction in pain during labour. Similarly, our study reported a reduction in happiness score during pain in CAI, for an example, the mean happiness score of CAI participants was 4.17, which is lower than the happiness score reported from the HCG (4.66). indicating the negative influence of pain on happiness level in CAI.

In line with the pain and pain interference, the secondary outcome measures of EEG showed a decrease in alpha, beta and theta waves over left temporal, frontal and occipital regions due to pain in CAI. The mean values of alpha, beta and theta wave from CAI participants showed a remarkable decrease over left temporal and occipital regions compared to HCG participants. Similar to the present study findings, there were a few reports on decrease in alpha and beta wave in response to painful conditions (Nickel et al., 2017; Peng et al., 2014;

Schulz et al., 2015). Another research on pain conditions reported a decrease in alpha wave over the posterior parieto-occipital and peripheral tempo-occipital regions, as well as a decrease in theta wave over the central regions, which is similar to the current study findings (Chang et al., 2001). In line with CAI participants response to alpha wave, a study on cold-induced pain findings revealed a decrease in alpha wave but an increase in beta wave reported over the central region of the brain, which was not recorded in this present study (Chen and Rappelsberger, 1994). Furthermore, the study applied transcutaneous electrical nerve stimulation among young healthy individuals with induction pain revealed an increase in alpha wave over the occipital and parietal regions (Yıldırım, Güntekin, Hanoğlu, et al., 2020). This indicates that alpha wave is observed to be increased in healthy individuals when compared to participants who are in pain. Similarly, HCG participants who underwent EEG baseline recording in this present study showed an increase in alpha wave response as compared to CAI participants. For clinical pain, similar studies in musculoskeletal pain conditions among participants with evoked clinical hip and elbow pain had reported a decrease in alpha and beta wave responses (Kisler et al., 2020; Gervasio et al., 2018). On the other hand, a study demonstrated a lower beta wave response over frontal, central, and posterior areas among the participants with chronic pain conditions such as complex regional pain syndrome (Lee et al., 2019). Besides, a study proposed that alpha wave activity seemed to be essential for processing pain signals since it is thought to coordinate brain communication. Consequently, the alpha waves were reported to be decreased in the somatosensory and premotor areas of the brain in pain conditions. The same authors demonstrated that the increase in alpha wave response was associated with a decrease in pain response (Kim et al., 2019). Accordingly, CAI participants' baseline alpha wave was reported to be decreased and associated with an increase in pain intensity in the present study. Indeed, a study among chronic back pain patients showed a reduction in beta wave over the pre-frontal region (May et al., 2019). Similar to the alpha wave, CAI participants' beta and theta waves revealed a decrease in EEG response in baseline. Meanwhile, research found an association between a decrease in theta waves and pain intensity in participants having orthodontic pain and cold-induced pain (Wang et al., 2015). Apart from the statistical analysis, the visual observation of the topoplot images of baseline in experimental group (EG) and control group (CG) displayed a decrease in the alpha, and beta waves over the frontal and occipital regions and an increase in theta wave over the temporal regions (Figure 4.9). However, topoplots of chronic neuropathic pain patients revealed an increase in EEG amplitudes over the central part of the brain (Garland and Howard, 2018; Prichep et al., 2011).

Furthermore, a negative correlation between the pain intensity and the pain interference score reported in our study elucidates the involvement of pain in disturbing the functional activities of the participants with CAI. A negative correlation between the pain interference and brain wave response over the right temporal (alpha, beta and theta) and left temporal (alpha and theta) regions demonstrated in the present study implies that the suppression of brain waves occur as the pain interference operates. Further, a negative weak association between beta wave and pain intensity was found among the CAI participants in this study. Kim et al., (2019) illustrated a significant negative correlation between the pain interference and beta power of left posterior insula among chronic multiple sclerosis patients. Similarly, Garland and Howard, (2018) revealed a negative association between pain interference and event-related potential response of the brain during a 3-month follow up among chronic pain patients treated with opioids. In contrast, a study by Jacobs et al., (2016) demonstrated a significant positive correlation of pain interference with P2 potentials at the CPz and Cz electrodes of the brain in chronic low back pain. A study reported that a painful stimulus might result in evoked fewer changes in EEG activity that might be due to the increased brain activity by motor and proprioceptive brain activation in the pain conditions (Shao et al., 2012). Furthermore, the source analysis reports suggested that most of the brain regions show increased cortical excitability in pain conditions, as compared to the no-pain condition, hence an increase in EEG amplitudes might reflect an idling state of the brain (Dowman et al., 2008). Besides, the study demonstrated a significant difference in cortical activities between the pain and no pain conditions (Legrain et al., 2011).

In this present study, video assisted mindfulness deep breathing (VAMDB) with the aid of a smartphone application was used as a novel intervention along with the existing conventional physiotherapy for rehabilitating CAI individuals for the better outcome. The application of video-based deep breathing has brought the advantage of enabling the participants with the uniform breathing rhythms in a given time to enhance the accuracy in deep breathing for better outcomes. Previous studies have evidenced that the mindfulness techniques such as focused deep breathing help to relieve the strain and thus prevents the progression of pain and disability (Kowal and Wilson, 2011; Ussher et al., 2014; Baker, 2016). Besides, the focused deep breathing training involves participants' attention focused towards the timing and movement of respiration. The deep breathing training induces a change in the activity of the sympathetic nervous system by decreasing the levels of stress hormones which has been proven to be helpful as an effective self-management training among the people with chronic pain to reduce the level of disability and improve the quality of life (Carlson, 2012; Kowal and Wilson, 2011; Ussher et al., 2014). A study by Gabriely et al., (2020) reported that the breathing exercise for a period of 3 weeks had a beneficial effect only on physiological stress but not on the attention. Whereas, the mindfulness practice had improved both the attention level and the physiological stress (Gabriely et al., 2020; Metz et al., 2013). Further, Chandla et al., (2013) demonstrated that a 6-weeks deep breathing training resulted in significant improvement on both anxiety and attention levels as the diaphragmatic breathing modulates cognitive performance through its influence on the autonomic nervous system to regulate the information processing related to attention. Therefore, we inferred that it is an ideal approach to incorporate a 6 weeks mindfulness technique along with the breathing exercise for the better outcomes (Yoshida et al., 2020). Hence, the present study applied a 3- min video-assisted mindfulness deep breathing (VAMDB) along with conventional physiotherapy (CP) among chronic ankle instability (CAI) participants in the EG for a period of 6-weeks. The effectiveness of the combined interventions (VAMDB+CP) was evaluated by assessing improvements in pain intensity, dynamic balance, mindfulness attention, happiness level and brain waves.

The previous research evidence shows that the exercises reduce nociceptor activity through an increase in endogenous analgesic neutrophils and the anti-inflammatory cytokines in the exercising muscle. Thus, exercise restores the normal tissue function and joint movements, which could be due to the reduction in mechanical pain (Chimenti et al., 2018). In addition, the exercises produce analgesia by increasing the endogenous opioids and altered serotonin function also reduce central excitability and glial cell activation. Regular exercise can alter central nociceptive processing and increase central inhibition, which results in a reduction of pain sensitivity in chronic pain (Chimenti et al., 2018). Further, a study by McBeth and Jones, (2007) exhibited a strong relationship between poor mental health and chronic musculoskeletal pain in adults. Researchers have postulated that deep breathing and mindfulness improve pain relief through attentional re-allocation, relaxation, stress reduction, and positive mood (Jafari et al., 2020; Zeidan et al., 2019). As predicted from the literature, the study participants in both the experimental group (EG) and control group (CG) groups were reported with a significant reduction in pain intensity. Notably, based on the mean scores, the current study found that the participants in the experimental group (EG) experienced better pain relief. This could be due to the combined effects of mindful deep breathing and conventional physiotherapy (CP). Hence, the study findings indicate the benefit of combining VAMDB along with CP. Further, similar to the findings of Chevidikunnan et al., (2016) that demonstrated the benefit of the physiotherapy intervention in pain reduction and dynamic balance, our results also demonstrated a significant improvement in dynamic balance (Y-balance, FADI and CAIT) over time in both experimental and control groups. Besides, the experimental group showed a better improvement in balance score compared with the control group. Henceforth, the study results specify that the combination of VAMDB with conventional physiotherapy (CP) potentially brings better outcomes in balance improvement comparing with CP only.

Recent investigations have reported that chronic ankle instability (CAI) commonly results in the poor balance because of the alterations in somatosensory function and corticomotor excitability that occur during inversion ankle sprains (Needle et al., 2017; Rosen et al., 2019). The rehabilitation of ankle instability with pain-free ankle movements, stretching, strengthening, and balance exercises in conventional physiotherapy (CP) have proven to improve the ankle muscle strength and ankle joint proprioception (Mattacola and Dwyer, 2002). Also, conventional physiotherapy influences the functions of the sensorimotor system to enhance balance and proprioception (Sefton et al., 2011). This improvement in neural adaptations in turn controls the cortical excitability of participants (Taube et al., 2008).. Mindfulness elicits participants relaxed attentional focus that benefits the balance (Kee et al., 2012; Pantano and Genovese, 2016). Additionally, deep breathing may improve the strength of diaphragmatic deep core muscles, which increases the strength and proprioception of participants that benefits the balance (Stephens et al., 2017). In accordance with the findings of the earlier studies, the incorporation of 3 min VAMDB exercise along with conventional physiotherapy (CP) in the present demonstrated an enhanced improvement in the dynamic balance of CAI participants

An increase in the dynamic balance among the participants of both VAMDB+CP and CP groups in the present study indicates the beneficial effects of ankle rehabilitation. The progress in participants' ankle stability may be due to an improvement in alterations in cortical activation to restore the dynamic balance by the neurophysiological effects of VAMDB and conventional physiotherapy (CP). As stated by Black et al., (2017), the 15-item MAAS questionnaire has been a valid measure of mindfulness attention. The participants who underwent VAMDB reported a significant improvement in mindful attention level over time from mid-intervention to follow-up compared to the participants in the control group (CG). Similarly, a study by Gabriely et al., (2020) compared the MAAS score between mindfulness and device-guided slow breathing and reported a significant increase in mindful attention among the participants in the mindfulness group only. Similarly, the present study showed an increase in mean mindful attention score of the experimental group participants compared with control group. Hence, the study findings convey that the mindfulness deep breathing exercise induced an attention focus overtime on the given task as the mindfulness training modifies the neural activity of the brain (Yoshida et al., 2020) and encourages the attention level (Tang et al., 2016; Yoshida et al., 2020) only in the experimental group (EG) participants those who introduced with VAMDB+CP.

Consistently, our study reported a significant increase in the happiness level of the participants in experimental group as well as the control group, which maybe because of the improvement in pain due to the beneficial effects of the combined (VAMDB+CP), and conventional physiotherapy (CP) interventions.

Researchers have supported our findings by demonstrating an association of mindfulness with happiness, coping efficacy, and decreased level of stress (Carruthers and Hood, 2011; Nithyanandan, 2020). Further, Siegel, (2014) specified that the mindfulness plays a major role in building awareness on emotional states such as pain condition to get the tolerance.

It is postulated that chronic musculoskeletal pain affects both the brain's morphology and function (Dos Santos Pinheiro et al., 2016; Ervilha et al., 2004). In spite of numerous techniques available to study the central pain mechanisms (Apkarian et al., 2005), quantitative Electroencephalography (qEEG) has been proven to be a valuable and non-invasive tool for pain response because of its relevancy and reliability of providing information on the alterations in brain response during the resting condition and cognitive tasks (de Vries et al., 2013). Previous studies have applied EEG to investigate the changes in brain waves by the effects of manual therapy technique in chronic pain (Martins et al., 2015) and the effects of proprioceptive exercise and cognitive therapy in stroke patients (Kim et al., 2013). In addition, Cheng et al., (2018) utilized EEG for assessing the neurophysiological changes of brain waves following deep breathing. Henceforth, we used EEG as a tool to reflect the changes in brain waves following the physiotherapy and mindfulness deep breathing exercises.

The present study reported changes in brain waves among the participants in experimental group as well as the control group following the respective interventions. This may be due to an improvement in pain by the beneficial effects of conventional physiotherapy (CP) and VAMDB. Remarkably, the study findings suggest the prevailing of the occipital region in reflecting the EEG changes following with the treatments. Similarly, the topoplots of the occipital region also showed an increase in alpha power. Further, the participants who underwent VAMDB+CP showed a higher score of alpha wave over the occipital region from baseline to post-intervention (Figure 4.8 (b)) indicating the better improvement in pain by the beneficial effects of VAMDB in the experimental group over the control group participants. Similar to our findings, the previous studies advocated the increase in alpha waves in posterior cortical areas in healthy individuals and confirmed that the alpha activity was especially dominant in the occipital region (Egsgaard et al., 2009; Meneses et al., 2016; Yıldırım, Güntekin, Hanoğlu, et al., 2020). In eyes closed EEG recording, the domination of alpha activities in the posterior region of the brain may be due to its increased activity on cognitive processing and attention (Dos Santos Pinheiro et al., 2016). In addition, alpha activity in the frontal region also found to be increased in response to the treatment among our study participants. Supporting our study findings, (Lagopoulos et al., 2009) reported a significant increase in alpha wave in meditation , specifically over the occipital and frontal regions.

Further, a decline in alpha mean score in both right and left temporal regions observed in this study during CAI is similar to the findings of Meneses et al., (2016) who reported the lowest alpha wave density at the temporal region in chronic pain conditions. Studies have also reported a decline in alpha wave over frontal, temporal and occipital regions (Kan and Lee, 2015) and also a high alpha power over the central region (Lee et al., 2018) of brain on depressive participants. Cheng et al., (2018) opined that the cortical activation of brain during attention engagement activities might result in decreasing alpha activity at temporal regions. Similar to alpha wave, the beta wave also showed an increased power in the frontal and occipital regions following the conventional physiotherapy (CP) and video assisted mindfulness deep breathing (VAMDB). In line with baseline temporal alpha response in both experimental and control groups with CAI participants, the participants with chronic rheumatic pain reported a decrease in alpha wave over the temporal region (Meneses et al., 2016). It is an accepted fact that the activity of alpha and beta waves are responsible for the sensorimotor rhythm of movement preparation and planning (Burcal et al., 2019). In contrast, the previous studies have demonstrated an increase in beta and theta waves on the frontal area in chronic musculoskeletal pain conditions (Dos Santos Pinheiro et al., 2016; Xu and Huang, 2020). Further, the alpha, beta and theta waves over the temporal region in experimental group (EG) and control group (CG) did not show significant changes from the baseline to different time intervals in the present study. Whereas, the recent results from chronic back pain patients reported with decrease in left frontal alpha and theta waves, and temporal beta waves following with longer duration mindfulness interventions such as mindfulness-meditation, cognitive therapy, and mindfulness-based cognitive therapy (Day et al., 2021). Whereas, a trend of decline in theta wave power was observed at frontal and occipital regions following the treatments in both experimental and control groups of our study. Sarnthein et al., (2006) reported over activity of theta wave in neurogenic pain patients and it was demonstrated that the neuro-feedback training for neuropathic pain resulted in decreased theta wave power due to a reduction in pain (Krupina et al., 2020). The present study results showed an increase in absolute mean theta wave over the temporal and alpha wave over the occipital region by the effects of conventional physiotherapy (CP) and VAMDB. Similar results were reported in the following studies (Jerath, 2016; Kisler et al., 2020; Lagopoulos et al., 2009) on meditation and deep breathing. A study reported an increase in alpha, beta, and theta waves at frontal, occipital, and temporal regions following 6 weeks of meditation (Ahani et al., 2014). In line with our findings, enhanced EEG activities were reported at frontal and occipital regions (Dos Santos Pinheiro et al., 2016).

The EEG response recorded in the present study illustrated the potential of EEG to be an ideal tool to reflect the beneficial changes caused by the intervention. Surprisingly, the alpha wave response over the occipital region reported in this study implies the credibility of the alpha wave to be a bio-indicator for assessing the improvement in pain management as VAMDB+CP intervention caused a substantial increase in mean score of alpha wave at the occipital region from baseline to follow-up compared with control group. Besides, the topography of alpha wave on the occipital region also displayed an increased alpha activity following VAMDB+CP over control group. It is obvious from the present study that demonstrated an increment in alpha wave frequency over frontal and occipital regions following the treatments through an improvement in ankle stability. Studies have evidenced that the increase in alpha wave frequency can result from an improvement in pain (Martins et al., 2015) and the balance (Burcal et al., 2019). Further, the study findings suggest that both conventional physiotherapy (CP) and the combined interventions (CP+VAMDB) played a substantial role in improving pain and dynamic balance, which eventually reflected on alpha frequency. As proposed by Egsgaard et al., (2009), the present study reported the prominent change in the activity of alpha wave over the occipital region by the effects of interventions as the alpha EEG rhythm is modulated by the attention process, speed of information processing, motor functions, and pain.

Studies have proven the beneficial effects of deep breathing in enhancing the psychological and physiological status of humans through increased blood flow by capillary expansion, stress reduction, and decrease in pain perception (Cj, 2013; Mattacola and Dwyer, 2002). Focused deep breathing has been proven to improve the autonomic nervous system and also induce relaxation and wellbeing due to the increased production of feel-good hormones such as dopamine, serotonin, endomorphins and melatonin which result in alterations in brain waves (Cj, 2013; Mattacola and Dwyer, 2002). The relaxation of muscle by deep breathing sends signals to the brain indicating no danger, which results in reduced release of stress hormones such as cortisol and adrenalin. Further, the activation of the digestive system by deep breathing improves nutrients absorption, escalates muscle endurance, and thus reduces pain (Cj, 2013). Accordingly, the incorporation of focused video assisted mindful deep breathing in the present study resulted in an enhanced outcome for rehabilitating CAI.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The primary outcome measures of the present study demonstrated an increase in pain intensity and pain interference resulting from chronic ankle instability (CAI) among collegiate athletes. Whereas, the secondary outcome measures demonstrated a decrease in balance, mindful attention and happiness level. In addition, EEG signals revealed a decreased response of alpha, theta and beta waves over the occipital and left temporal regions among CAI participants compared with healthy control group. Further, the primary and secondary outcome measures of the present study demonstrated an enhanced effect of the combined interventions of 3-min video-assisted mindfulness deep breathing (VAMDB) along with conventional physiotherapy to restore the ankle stability among collegiate athletes with CAI over the conventional physiotherapy. An increase in EEG alpha wave frequency over the occipital region among the experimental group participants reported in this study reflects the neurophysiological changes of the brain due to the beneficial effects of interventions. The progressive effects of 3-min video-assisted mindfulness deep breathing in pain management among the collegiate athletes with CAI recommends VAMDB as an additional beneficial intervention to improve the well-being of injured athletes during rehabilitation.

6.2 Limitations and Future Research

The present study reported the EEG responses of the frontal, occipital, and temporal regions, but on the central and parietal regions due to the limitations in the availability of the channels in the EEG recording device. Since the study was conducted in a single location, it did not meet the estimated sample size. Further, the psychological parameters such as salivary cortisol levels, memory tests, and anxiety, stress, and depression inventories, require further investigation to assess the improvement in the psychological states of the participants by the benefits of interventions. Moreover, the psychological parameters need to be reported distinctly for team and individual sports individuals since the anxiety and depression levels are reported to be different among the participants involved in team and individual sports (Pluhar et al., 2019). Additionally, the CAI participants were a heterogeneous sample of people participating at varying activity levels and athletic backgrounds in their specific sports, which needs to be considered in future work. Furthermore, the majority of Chinese participants involved in this present study may have influenced the study results towards the Chinese race. Hence, the future studies are required with balanced number of participants from different races. There is an evidence suggesting that the sex-related cortical differences during the processing of pain responses result in differential brain activation (Bartley and Fillingim, 2013) and as reported psychosocially, females experience greater stress than males, which may be due to different inferences on musculoskeletal pain and accepting the situation (Gary B Rollman and Lautenbacher, 2001). Therefore, this study finding cannot be applicable to female participants. Hence, future research is required on female participants with CAI using VAMDB. Since, the present study did not have adequate sample size, no solid inference was reported from the statistical analysis of the obtained data. Hence, future studies are recommended on large population to report statistically significant difference in the primary and secondary outcome measures between the groups. The present research can serve as a foundation for larger-scale projects of randomized controlled trails on CAI and video-assisted mindfulness deep breathing (VAMDB) in future.

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Appendix 1

Participant Information Sheet

PROJECT TITLE

"Effect of Video-Assisted Mindfulness Deep Breathing among Collegiate Athletes with Chronic Ankle Instability".

INVITATION

I would like to invite you to participate in this research study, which is concerned with the things you do to stay healthy following acute and chronic sports pain

This study is aimed to find the effectiveness of video assisted mindfulness deep breathing (VAMDB) in recovery of chronic ankle instability among collegiate athletes by correlating the pain intensity between Visual Analogue scale (VAS), Brief Pain Inventory (BPI), electroencephalographic (EEG) response. In addition, the participants progress from chronic ankle disability by using Foot and ankle disability index (FADI), Cumberland ankle instability tool (CAIT), Y-balance, Mindfulness attention awareness scale (MAAS) and Oxford happiness scale

This research study is conducted by Vinodhkumar Ramalingam and his team, Senior Lecturer in physiotherapy from INTI International University as a part of his PhD programme. This project has been approved by ethical committee of INTI International University.

INSTRUCTIONS

While taking part in this study, you will be asked to do the following:

Phase 1: Fill up a demographic Information questionnaire about your personal data, CAIT, FADI, VAS and BPI, MAAS, and Oxford happiness scale

Then participate in (i) physical examination for brain response by using electroencephalograph EEG following pain, (ii). Dynamic balance assessment to correlate with the intensity of pain among Malaysian collegiate athletes.

Phase 2: Following the pre-intervention measurement, conventional physiotherapy management in a week during alternative days for 6 weeks.

Phase 3: Participate in post intervention measurement of all the parameters at the end of 3rd week, 6th week and follow-up at 12th week.

TIME COMMITMENT

Phase 1: Filling up of Demographic and pre analytical measurements will take around 30 minutes.

Phase 2: Intervention for 35-45 minutes, 5 times a week (not on Saturday and Sunday) for 6 weeks continuously. The participants have to come to INTI physiotherapy centre for the first 6 weeks.

Phase 3: Post intervention measurement of all the parameters at the end of 3rd week, 6th week of intervention and follow-up at 12th week will take around 30 minutes for each measurement.

PARTICIPANTS' RIGHTS

You may decide to stop being a part of this research study at any time without explanation.
You have the right to omit or refuse to answer or respond to any question that is asked to you. In addition, you have the right to ask your questions about the procedures practised (unless answering these questions would interfere with the study outcome). If you have any questions on this information sheet/test/training, you may ask the researcher before the study begins or during the course of training.

BENEFITS AND RISK

Researcher does not anticipate any risk from this research study. However, researchers have to touch at the head, injured joint and neighbouring muscles during the measurement and intervention procedures. Also will have to wipe the skin with non- alcoholic sterile cotton swab on the lateral aspect of the leg to fix the surface electrodes for EEG measurement.
The intervention may reduce the occurrence of chronic ankle pain and provide an insight about the risk factors associate with injuries among collegiate athletes.

COST, REIMBURSEMENT AND COMPENSATION

Your participation in this study is voluntary and it does not carry any remuneration or reimbursement.

CONFIDENTIALITY/ANONYMITY

The data collected will be confidential and only for the research. It will be kept under confidentiality.

FOR FURTHER INFORMATION

Vinodh Kumar will be glad to answer your questions about this study at any time. You may contact him at faculty of health and life science Phone No. 0102928163
Email: vinodh.ramalingam@newinti.edu.my

Appendix 2

Informed Consent Form

PROJECT TITLE:

"Effect of Video-Assisted Mindfulness Deep Breathing among Collegiate Athletes with Chronic Ankle Instability".

PROJECT SUMMARY:

This study is aimed to find the effectiveness of video assisted mindfulness deep breathing (VAMDB) in recovery of chronic ankle instability among collegiate athletes by correlating the pain intensity between Visual Analogue scale (VAS), Brief Pain Inventory (BPI), electroencephalographic (EEG) response. In addition, the participants progress from chronic ankle disability by using foot and ankle disability index (FADI), Cumberland ankle instability tool (CAIT), Y-balance, Mindfulness attention awareness scale (MAAS) and Oxford happiness scale

This research study is conducted by Vinodhkumar Ramalingam and his team, Senior Lecturer in physiotherapy from INTI International University as a part of his PhD programme. This project has been approved by ethical committee of INTI -IU.

By signing below, you are agreeing that: (1) you have read and understood the Participant Information Sheet, (2) questions about your participation in this study have been answered satisfactorily, (3) you are taking part in this research study voluntarily.

____

Participant's Name

______________________ ______________________

Participant's signature Date

______________________ ______________________

Name of person obtaining consent Signature of person obtaining consent

Appendix 3

Demographic Information

Date: _________

Instruction: Please fill in the details and mark (x) in the boxes provided.

1. Name:
2. Age:
3. Gender: ☐Male ☐ Female
4. Sports playing: ☐ Badminton ☐ Football ☐ Futsal ☐ Squash
   ☐ Basketball ☐ Hockey☐Others specify:________
5. Limb dominance: ☐ Right ☐ Left
6. Duration of playing weekly (Hours/Week):
   ____
7. Any injury during playing in the past 1 year:
   ☐ 9-12 months ☐5-8 months ☐1-4 months ☐less than 1 months
8. Mention the involved side ______________ (right or left)
9. Any injury occurs during other than sporting activities in the past 1 year: specify the activity ___________and side________(right or left) for the period of:
   ☐ 9-12 months ☐ 5-8 months ☐ 1-4 months ☐ less than 1 months
10. Suffered from any other medical conditions such as ankle fracture, back pain, knee pain or muscle strain, please specify ______________ (if none state **"No"**).
11. Underwent surgery for your injury. "yes" or "No"
12. Are you having neurological problem (pain travels down towards leg or hand). "yes" or "No"
13. Are you undergoing physiotherapy management? "yes" or "No"

-------------------------------------END---

Thanks for your time and information.

Appendix 4

Data recording sheet

Participant Code No:

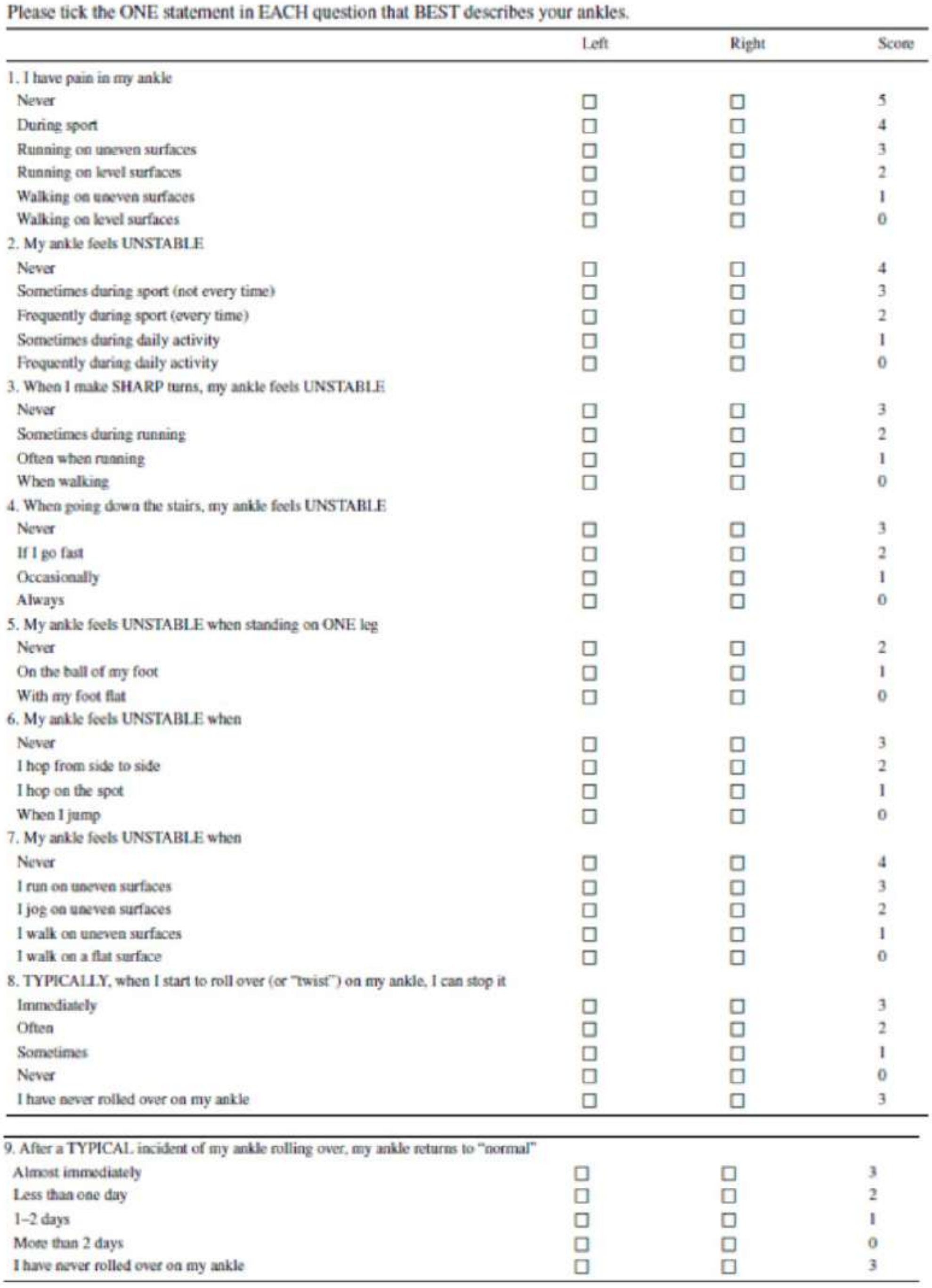
Anthropometric data:

Height: in cm Weight: in kg

Outcome measures	Baseline (week 1)		Mid-intervention (end of week3)		Post – intervention (end of week 6)		Follow up intervention (end of week 12)	
CAIT								
Y- Balance	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Anterior								
Posteromedial								
Posterolateral								
Limb Length								
FADI								
Pain score NRS (0-10)								
BPI (pain Intensity)								
BPI (pain Interference)								
MAAS								
OHQ								
Researcher Signature								
Researcher Name								

Appendix 5

Cumberland ankle instability tool (CAIT)



Please tick the ONE statement in EACH question that BEST describes your ankles.

	Left	Right	Score
1. I have pain in my ankle			
Never	☐	☐	5
During sport	☐	☐	4
Running on uneven surfaces	☐	☐	3
Running on level surfaces	☐	☐	2
Walking on uneven surfaces	☐	☐	1
Walking on level surfaces	☐	☐	0
2. My ankle feels UNSTABLE			
Never	☐	☐	4
Sometimes during sport (not every time)	☐	☐	3
Frequently during sport (every time)	☐	☐	2
Sometimes during daily activity	☐	☐	1
Frequently during daily activity	☐	☐	0
3. When I make SHARP turns, my ankle feels UNSTABLE			
Never	☐	☐	3
Sometimes during running	☐	☐	2
Often when running	☐	☐	1
When walking	☐	☐	0
4. When going down the stairs, my ankle feels UNSTABLE			
Never	☐	☐	3
If I go fast	☐	☐	2
Occasionally	☐	☐	1
Always	☐	☐	0
5. My ankle feels UNSTABLE when standing on ONE leg			
Never	☐	☐	2
On the ball of my foot	☐	☐	1
With my foot flat	☐	☐	0
6. My ankle feels UNSTABLE when			
Never	☐	☐	3
I hop from side to side	☐	☐	2
I hop on the spot	☐	☐	1
When I jump	☐	☐	0
7. My ankle feels UNSTABLE when			
Never	☐	☐	4
I run on uneven surfaces	☐	☐	3
I jog on uneven surfaces	☐	☐	2
I walk on uneven surfaces	☐	☐	1
I walk on a flat surface	☐	☐	0
8. TYPICALLY, when I start to roll over (or "twist") on my ankle, I can stop it			
Immediately	☐	☐	3
Often	☐	☐	2
Sometimes	☐	☐	1
Never	☐	☐	0
I have never rolled over on my ankle	☐	☐	3
9. After a TYPICAL incident of my ankle rolling over, my ankle returns to "normal"			
Almost immediately	☐	☐	3
Less than one day	☐	☐	2
1–2 days	☐	☐	1
More than 2 days	☐	☐	0
I have never rolled over on my ankle	☐	☐	3

Appendix 6

The Foot & Ankle Disability Index (FADI) Score and Sports module

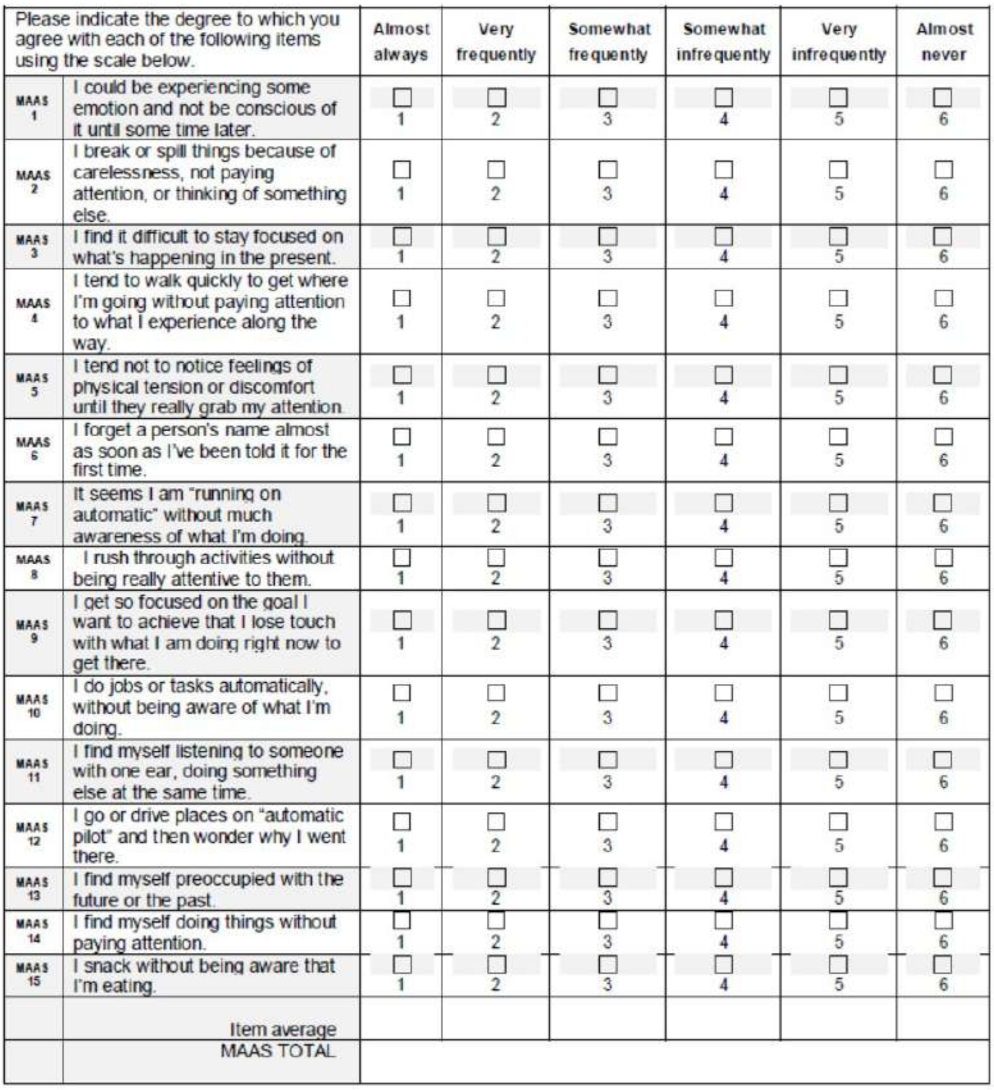
Participant Code No:______________________ **Date:** ___________

Please answer (√) every question with one response that most closely describes your condition in the past weeks. If the activity in question is limited by something other than your foot or ankle, write N/A.

	No difficulty at all(4)	**Slight difficulty(3)**	**Moderate difficulty(2)**	**Extreme difficulty(1)**	**Unable to do(0)**
1. Standing	○	○	○	○	○
2. Walking on even ground	○	○	○	○	○
3. Walking on even ground without shoes	○	○	○	○	○
4. Walking up hills	○	○	○	○	○
5. Walking down hills	○	○	○	○	○
6. Going up stairs	○	○	○	○	○
7. Going down stairs	○	○	○	○	○
8. Walking on uneven ground	○	○	○	○	○
9. Stepping up and down curbs	○	○	○	○	○
10. Squatting	○	○	○	○	○
11. Sleeping	○	○	○	○	○
12. Coming up to your toes	○	○	○	○	○
13. Walking initially	○	○	○	○	○
14. Walking 5 minutes or less	○	○	○	○	○
15. Walking approximately 10 minutes	○	○	○	○	○
16. Walking 15 minutes or greater	○	○	○	○	○
17. Home responsibilities	○	○	○	○	○
18. Activities of daily living	○	○	○	○	○
19. Personal care	○	○	○	○	○
20. Light to moderate work (standing, walking)	○	○	○	○	○
21. Heavy work (push/pulling, climbing, carrying)	○	○	○	○	○
22. Recreational activities	○	○	○	○	○
Sports Module					
23. Running	○	○	○	○	○
24. Landing	○	○	○	○	○
25. Cutting, lateral movements	○	○	○	○	○
26. Ability to perform activity with your normal technique	○	○	○	○	○
27. Jumping	○	○	○	○	○
28. Squatting and stopping quickly	○	○	○	○	○
29. Low-impact activities	○	○	○	○	○
30. Ability to participate in your desired sports as long as you would like	○	○	○	○	○
Pain related to the foot and ankle	**No Pain**	**Mild**	**Moderate**	**Severe**	**Unbearable**
31. General level of pain	○	○	○	○	○
32. Pain at rest	○	○	○	○	○
33. Pain during normal activity	○	○	○	○	○
34. Pain first thing in the morning	○	○	○	○	○

Appendix 7

Mindful Attention Awareness Scale (MAAS)



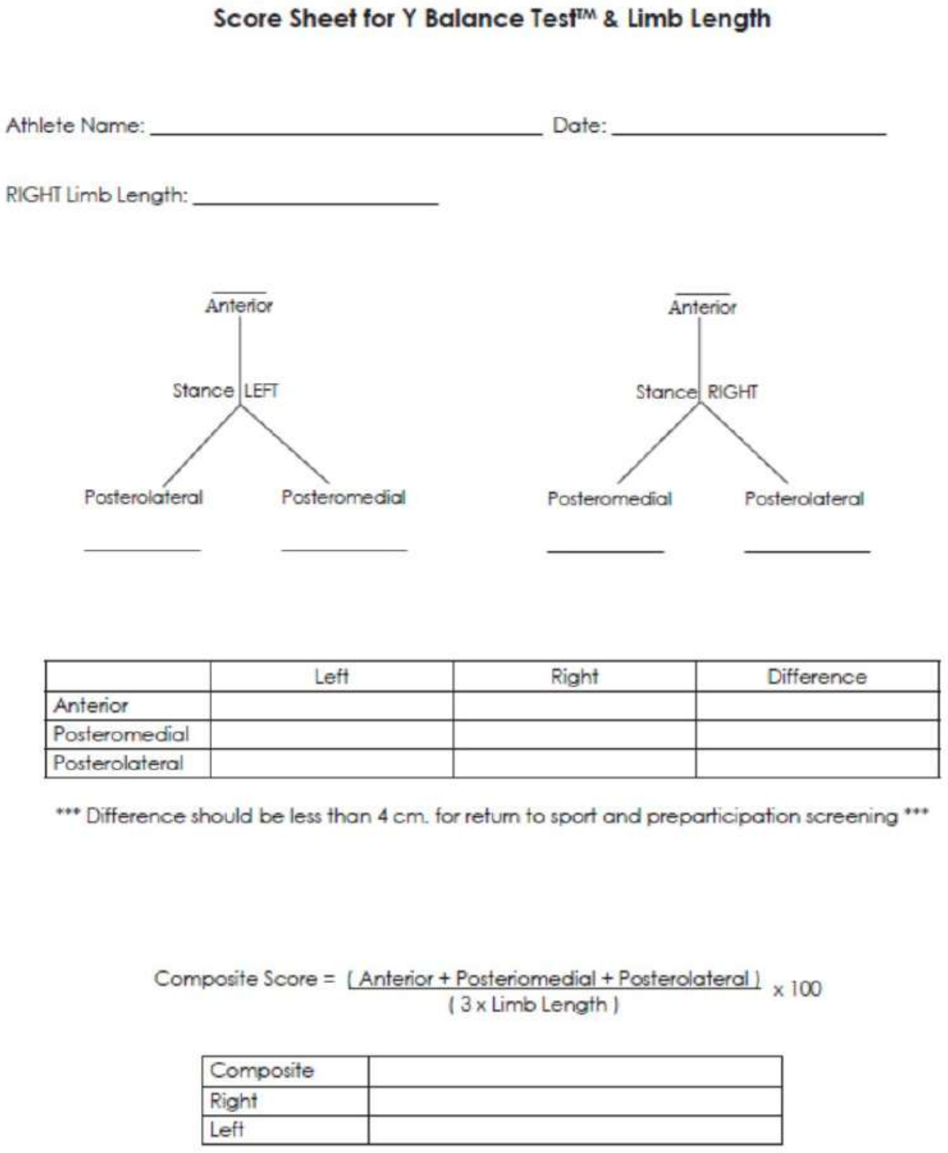
Please indicate the degree to which you agree with each of the following items using the scale below.		Almost always	Very frequently	Somewhat frequently	Somewhat infrequently	Very infrequently	Almost never
MAAS 1	I could be experiencing some emotion and not be conscious of it until some time later.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 2	I break or spill things because of carelessness, not paying attention, or thinking of something else.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 3	I find it difficult to stay focused on what's happening in the present.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 4	I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 5	I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 6	I forget a person's name almost as soon as I've been told it for the first time.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 7	It seems I am "running on automatic" without much awareness of what I'm doing.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 8	I rush through activities without being really attentive to them.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 9	I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 10	I do jobs or tasks automatically, without being aware of what I'm doing.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 11	I find myself listening to someone with one ear, doing something else at the same time.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 12	I go or drive places on "automatic pilot" and then wonder why I went there.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 13	I find myself preoccupied with the future or the past.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 14	I find myself doing things without paying attention.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
MAAS 15	I snack without being aware that I'm eating.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
	Item average						
	MAAS TOTAL						

Appendix 8

The Oxford Happiness Questionnaire

Question		Score
1. I don't feel particularly pleased with the way I am.	R	
2. I am intensely interested in other people.		
3. I feel that life is very rewarding.		
4. I have very warm feelings towards almost everyone.		
5. I rarely wake up feeling rested	R	
6. I am not particularly optimistic about the future.	R	
7. I find most things amusing		
8. I am always committed and involved.		
9. Life is good.		
10. I do not think that the world is a good place.	R	
11. I laugh a lot.		
12. I am well satisfied about everything in my life.		
13. I don't think I look attractive.	R	
14. There is a gap between what I would like to do and what I have done.	R	
15. I am very happy.		
16. I find beauty in some things.		
17. I always have a cheerful effect on others.		
18. I can fit in (find time for) everything I want to.		
19. I feel that I am not especially in control of my life.	R	
20. I feel able to take anything on.		
21. I feel fully mentally alert.		
22. I often experience joy and elation.		
23. I don't find it easy to make decisions.	R	
24. I don't have a particular sense of meaning and purpose in my life.	R	
25. I feel I have a great deal of energy.		
26. I usually have a good influence on events.		
27. I don't have fun with other people.	R	
28. I don't feel particularly healthy.	R	
29. I don't have particularly happy memories of the past	R	

Appendix 9



Score Sheet for Y Balance Test™ & Limb Length

Athlete Name: ______________________________ Date: ____________________

RIGHT Limb Length: ________________

Anterior

Stance LEFT

Posterolateral Posteromedial

Anterior

Stance RIGHT

Posteromedial Posterolateral

	Left	Right	Difference
Anterior			
Posteromedial			
Posterolateral			

*** Difference should be less than 4 cm. for return to sport and preparticipation screening ***

$$\text{Composite Score} = \frac{(\text{Anterior} + \text{Posteriomedial} + \text{Posterolateral})}{(3 \times \text{Limb Length})} \times 100$$

Composite	
Right	
Left	

Appendix 10

Y-balance chronic ankle instability participant testing procedure

Electroencephalogram participants recording procedure

Appendix 11

Study protocol

The **CONTROL group** is the one received established 'Conventional Physiotherapy (CP) protocol'. The same standard protocol was applied to the **EXPERIMENTAL group**, in addition, to the **Video assisted Mindful deep breathing (VAMDB)**.

Control group (Conventional Physiotherapy)					**Experimental group (Conventional Physiotherapy+ Video assisted Mindful deep breathing)**	
Recommended Guidelines for Early Functional Rehabilitation						
Week	Component	Procedure	Frequency, Duration	Comments	Procedure	Frequency, Duration
1	**Range of Motion Passive range of motion**	Clinician applies light pressure to facilitate stretch	Pain-free stretch for 15–30 s 3 10 repetitions, 3–5 times /d		Comfortable sitting posture: Video-aided mindfulness deep breathing (VAMDB) – Participants Breath-in while appearance of pedals and Breath-out while disappearance of the Pedals in the flowers	3 min - visual guiding on deep breathing with 6 deep breath per minute * 2 times in a day (after Conventional physiotherapy treatment in physio centre and one time in home before sleep)
	Achilles tendon, stretch, nonweight bearing	Use towel to pull foot toward face	Pain-free stretch for 15–30 s 3 10 repetitions, 3–5 times /day	Maintain extremity in a nongravity position with compression		
	Achilles tendon stretch weight bearing	Stand with heel on the floor and bend at the knees	Pain-free stretch for 15–30 s, 3– 5 times day			
	Alphabet exercises	Move the ankle in multiple planes of motion by drawing the alphabet in lowercase and uppercase motions	2–3 times per hr 4–5 times days	Can be performed in conjunction with heat or cold therapy		
	Strength Training (Isometric)	Resistance can be provided by an immovable			Comfortable sitting posture:	3 min - visual guiding on deep breathing

2 **(exercise follow with week 1)**		object (eg, wall or floor) or the contralateral foot			Video-aided mindfulness deep breathing (VAMDB) – Participants Breath-in while appearance of pedals and Breath-out while disappearance of the Pedals in the flowers	with 6 deep breath per minute * 2 times in a day (after Conventional physiotherapy treatment in physio centre and one time in home before sleep)
	Plantar flexion	Push foot downward (away from the head)	Hold muscle contraction for 5–10 s	Strengthening can be accomplished in a pain-free range of motion		
	Dorsiflexion	Pull foot upward (toward the head)	5–10 repetitions per direction			
	Inversion	Push foot inward (toward the midline of the body)	Repeat 3–5 times /day			
	Eversion	Push foot outward (away from the midline of the body)				
3 **(follow with week 1&2)**	**Strength Training (Isotonic)**	Resistance can be provided by the contralateral foot, rubber tubing, weights, or the clinician			Comfortable sitting posture: Video-aided mindfulness deep breathing (VAMDB) – Participants Breath-in while appearance of pedals and Breath-out while disappearance of the Pedals in the flowers	3 min - visual guiding on deep breathing with 6 deep breath per minute * 2 times in a day (after Conventional physiotherapy treatment in physio centre and one time in home before sleep)
	Plantar flexion	Push foot downward (away from the head)	Maintain muscle contraction for 4–10 s for concentri	Strengthening can be accomplished in full range of motion and		

			c and eccentric components	incorporate concentric and eccentric contractions in nonweight-bearing position		
	Dorsiflexion	Pull foot upward (toward the head)	2 sets of 10 repetitions per direction			
	Inversion	Push foot inward (toward the midline of the body)				
	Eversion	Push foot outward (away from the midline of the body)	Repeat 3–5 times /day			
	Toe curls and marble pick-ups	1. Place foot on a towel. Curl toes, moving the towel toward the body. 2. Use toes to pick up marbles or other small objects.	2 sets of 10 repetitions, 3–5 times /day	Strengthening can be accomplished throughout the day at work or at home		
	Toe raises, heel walks, toe walks	Lift the body by rising up on the toes Walk forward and backward on the toes and Heels	3 sets of 10 repetitions; progress walking as tolerated	Strengthening can be accomplished using the body as resistance in a weight-bearing position		

Proprioceptive Training Components of Intermediate Functional Rehabilitation*

Week	Component	Procedure	Frequency, Duration	Comments	Procedure	Duration
4 (follow with	Circular wobble board	Rotate board in clockwise and counterclockwise directions nonweight-bearing and weight-	5–10 repetitions, 2–3times /d	Exercises can be performed with eyes open or closed and with or without resistance	Comfortable sitting posture: Video-aided mindfulness deep breathing (VAMDB) –	3 min - visual guiding on deep breathing with 6 deep breath per minute * 2

week 3 exercise)		bearing for bilateral and unilateral stance			Participants Breath-in while appearance of pedals and Breath-out while disappearance of the Pedals in the flowers	times in a day (after Conventional physiotherapy treatment in physio centre and one time in home before sleep)
	Walking on different surfaces	Walk in normal or heel-to-toe fashion over various surfaces (eg, hard floor, uneven carpet, different foam pads)	20–50 ft (6.10–15.24 m), 5–10times /day	Exercises can be performed with eyes open or closed and with or without resistance		
	Manual proprioceptive neuromuscular facilitation exercises	Clinician provides degrees of resistance and random perturbations as athlete moves the foot through functional patterns	5–20 repetitions 1–2 times/day	Velocity and resistance can be varied to stimulate sensory feedback		
Return to Activity Components of Advanced Functional Rehabilitation						
Week	Component	Procedure	Frequency, Duration	Comments	Procedure	Duration
5 (Follow with week 4 exercise)	Wobble-board exercises	Athlete balances on wobble board with rubber-tubing resistance or after light perturbations from the clinician	5–20 repetitions, 1–2 times /d	Increase difficulty by varying surfaces and alternating eyes open and eyes closed	Comfortable sitting posture: Video-aided mindfulness deep breathing (VAMDB) – Participants Breath-in while appearance of pedals and Breath-out while disappearance of the Pedals in the flowers	3 min - visual guiding on deep breathing with 6 deep breath per minute * 2 times in a day (after Conventional physiotherapy treatment in physio centre and one time in
	Functional exercise on differen	Athlete performs functional activities on	5–20 repetitions, 1–2 times/d	Increase difficulty by perfor		

	t surfaces and with resistance	variable surfaces, eg, trampoline, foam, in water with resistance		ming skills on unstable surfaces and with varied velocity of movement		home before sleep)
6 (Follow with week 5 exercise)	Walk-jog	50% walking and 50% jogging in straight direction, forward, backward, and pattern running	Increase distance by À-mile (.2-km) increments	Increase intensity and incorporate activity-specific training		
	Jog-run	50% jogging and 50% running in straight direction, forward, backward and pattern running	Increase distance by À-mile (.2-km) increments	Increase intensity and incorporate activity-specific training		

*Athlete can perform activities with varying external support to stimulate sensory and proprioceptive feedback. Use of a semirigid orthotic may provide somatosensory benefits and neutral alignment for proper muscle activation and reduce unnecessary strain on already stressed soft tissue

APPENDIX 12

Data Normality distribution

Objective 1 – Baseline data

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
CAI Group	Statistic	df	Sig.	Statistic	df	Sig.
VAS (pain intensity)	.174	33	.012	.932	33	.041
BPI (pain intensity)	.145	33	.074	.967	33	.399
BPI (pain interference)	.108	33	.200*	.979	33	.753
CAIT	.142	33	.090	.942	33	.078
FADI	.098	33	.200*	.950	33	.133
YBT	.074	33	.200*	.986	33	.940
MAAS	.118	33	.200*	.962	33	.294
HAPP	.154	33	.046	.965	33	.347
Frontal_Alpha	.115	33	.200*	.974	33	.590
Frontal__Beta	.111	33	.200*	.959	33	.241
Frontal__Theta	.163	33	.026	.945	33	.094
Occipital__Alpha	.108	33	.200*	.983	33	.874
Occipital _Beta	.102	33	.200*	.936	33	.050
Occipital _theta	.168	33	.019	.926	33	.027
Lefttemporal_Alpha	.093	33	.200*	.970	33	.471
Lefttemporal_Beta	.154	33	.046	.951	33	.142
Lefttemporal_Theta	.130	33	.171	.951	33	.142
Righttemporal__Alpha	.074	33	.200*	.975	33	.629
Righttemporal _Beta	.078	33	.200*	.975	33	.622
Righttemporal_Theta	.120	33	.200*	.974	33	.587

*. This is a lower bound of the true significance.

a. Group = CAI Group

b. Lilliefors Significance Correction

Tests of Normality[a,b,c,d]

Healthy Control Group	Kolmogorov-Smirnov[e]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
VAS (pain intensity)	.401	23	.000	.651	23	.000
BPI (pain intensity)	.383	23	.000	.666	23	.000
BPI (pain interference)	.133	23	.200*	.962	23	.510
CAIT	.137	23	.200*	.938	23	.163
FADI	.126	23	.200*	.957	23	.411
YBT	.157	23	.146	.944	23	.223
MAAS	.205	23	.013	.957	23	.399
HAPP	.097	23	.200*	.988	23	.991
Frontal_Alpha	.180	23	.053	.876	23	.008
Frontal__Beta	.117	23	.200*	.961	23	.483
Frontal__Theta	.138	23	.200*	.963	23	.520
Occipital__Alpha	.161	23	.126	.927	23	.095
Occipital _Beta	.140	23	.200*	.940	23	.178
Occipital _theta	.161	23	.126	.942	23	.200
Lefttemporal_Alpha	.206	23	.013	.886	23	.013
Lefttemporal_Beta	.102	23	.200*	.976	23	.830
Lefttemporal_Theta	.283	23	.000	.863	23	.005

*. This is a lower bound of the true significance.

a. Group = HEALTHY CONTROL

Note:
BL-Baseline at week 1
CAIT: Cumberland Ankle instability Tool, FADI: Foot and ankle disability index,YBT=Y-balance test; MAAS: Mindful Attention Awareness Scale, QHQ: Oxford Happiness Questionnaire

Objective 2 – Baseline data

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
Experimental Group	Statistic	df	Sig.	Statistic	df	Sig.
VAS (pain intensity)	.213	16	.050	.934	16	.278
BPI (pain intensity)	.157	16	.200*	.967	16	.791
BPI (pain interference)	.142	16	.200*	.968	16	.799
CAIT	.150	16	.200*	.930	16	.241
FADI	.148	16	.200*	.925	16	.205
YBT	.102	16	.200*	.949	16	.472
MAAS	.167	16	.200*	.958	16	.618
HAPP	.222	16	.034	.900	16	.080
Frontal_Alpha	.136	16	.200*	.967	16	.785
Frontal__Beta	.142	16	.200*	.935	16	.290
Frontal__Theta	.169	16	.200*	.940	16	.354
Occipital__Alpha	.102	16	.200*	.968	16	.811
Occipital _Beta	.109	16	.200*	.965	16	.758
Occipital _theta	.239	16	.015	.887	16	.049
Lefttemporal_Alpha	.238	16	.016	.902	16	.086
Lefttemporal_Beta	.205	16	.072	.914	16	.134
Lefttemporal_Theta	.216	16	.044	.923	16	.188
Righttemporal__Alpha	.113	16	.200*	.974	16	.896
Righttemporal _Beta	.106	16	.200*	.966	16	.765
Righttemporal_Theta	.128	16	.200*	.982	16	.976

*. This is a lower bound of the true significance.

a. Group = Experimental Group

b. Lilliefors Significance Correction

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
Control Group	Statistic	df	Sig.	Statistic	df	Sig.
VAS (pain intensity)	.159	17	.200*	.906	17	.086
BPI (pain intensity)	.140	17	.200*	.975	17	.897
BPI (pain interference)	.106	17	.200*	.974	17	.886
CAIT	.173	17	.189	.960	17	.635
FADI	.099	17	.200*	.969	17	.795
YBT	.145	17	.200*	.967	17	.759
MAAS	.173	17	.190	.907	17	.088
HAPP	.118	17	.200*	.979	17	.951
Frontal_Alpha	.146	17	.200*	.951	17	.470
Frontal__Beta	.162	17	.200*	.934	17	.250
Frontal__Theta	.187	17	.117	.925	17	.180
Occipital__Alpha	.129	17	.200*	.978	17	.932
Occipital _Beta	.159	17	.200*	.900	17	.068
Occipital _theta	.163	17	.200*	.897	17	.060
Lefttemporal_Alpha	.193	17	.094	.884	17	.036
Lefttemporal_Beta	.138	17	.200*	.929	17	.207
Lefttemporal_Theta	.129	17	.200*	.958	17	.600
Righttemporal__Alpha	.130	17	.200*	.956	17	.551
Righttemporal _Beta	.088	17	.200*	.961	17	.653
Righttemporal_Theta	.132	17	.200*	.960	17	.633

*. This is a lower bound of the true significance.

a. Group = Control Group

b. Lilliefors Significance Correction

Note:
CAIT: Cumberland Ankle instability Tool, FADI: Foot and ankle disability index,YBT=Y-balance test; MAAS: Mindful Attention Awareness Scale, QHQ: Oxford Happiness Questionnaire

Primary Outcome Interventions Effects Using Two-Way Repeated-Measures ANOVA.

Variable	Time point	Control group (CG)	Experimental group (EG)	Group effect	Time effect	Group × Time Interaction
		M(SD)	*M(SD)*		*p-value*	
VAS	BL	4.47±1.36	4.33±1.45	0.498	**<0.001**^{b}	0.696
	MI	2.40±1.03	2.40±0.83			
	PI	1.06±0.90	0.87±0.91			
	FU	0.60±0.82	0.20±0.41			
BPI	BL	4.25±1.07	4.3±0.96	0.934	**<0.001**^{b}	0.385
	MI	2.47±0.66	2.68±0.52			
	PI	1.1±0.40	1.12±0.53			
	FU	0.48±0.43	0.20±0.30			
BPI- Pain Interference	BL	2.45±0.73	2.47±0.59	0.271	**<0.001**^{b}	0.207
	MI	1.15±0.44	1.09±0.34			
	PI	0.51±0.19	0.39±0.17			
	FU	0.36±0.33	0.03±0.08			

Data are given as M: Mean & SD: Standard Deviation.
VAS: Visual Analogue Scale, BPI: Brief Pain Inventory
BL-Baseline at week 1; MI-Mid-intervention at end of week 3; PI- Post-intervention at end of week 6; FU-Follow-up at end of week 12.
d: Cohen's d response mean effect size between time effect
b: Significant improvement in time effect, time and group interaction effect, $p < 0.05$.

Secondary outcome Interventions Effects Using Two-Way Repeated-Measures ANOVA

Variable	Time point	Control group (CG)		Experimental group (EG)		Group effect	Time effect	Group × Time Interaction
		M(SD)	*d*	*M(SD)*	*d*		*p-value*	
CAIT	BL	20.27±2.38		19.73±4.17		0.953	**<0.001^{b}**	0.123
	MI	24.27±2.22		23.67±3.50				
	PI	27.27±1.16		27±3.02				
	FU	27.87±1.20		29.07±1.49				
FADI	BL	121.80±6.25		120.26±7.27		0.602	**<0.001^{b}**	0.240
	MI	125.26±4.48		126.20±5.19				
	PI	129.80±2.86		131.06±3.94				
	FU	133.66±2.22		135.66±0.72				
Y-Balance	BL	74.65±7.07		76.33±5.71		0.223	**<0.001^{b}**	0.188
	MI	76.77±8.31		82.33±6.52				
	PI	83.20±8.16		85.76±7.77				
	FU	82.92±9.03		85.94±8.28				
MAAS	BL	63.20±11.07		62.47±12.02		0.328	**<0.001^{b}**	**0.001^{b}**
	MI	64.73±10.45		66.73±11.89				
	PI	65.40±10.70		71.13±10.14*				
	FU	64.93±10.73		73.06±9.54*				
OHQ	BL	4.12±0.50		4.32±0.58		0.399	**<0.001^{b}**	0.287
	MI	4.27±0.65		4.41±0.56				
	PI	4.48±0.61		4.57±0.59				
	FU	4.43±0.59		4.69±0.50				
Frontal								
Alpha	BL	1.32±0.54		1.30±0.82		0.476	0.760	0.901
	MI	1.28±0.58		1.40±0.70				
	PI	1.27±0.45		1.43±0.55				
	FU	1.40±0.49		1.48±0.65				
Beta	BL	1.29±0.59		1.23±0.67		0.346	0.677	0.890
	MI	1.51±0.54		1.29±0.70				
	PI	1.39±0.45		1.31±0.65				
	FU	1.38±0.23		1.22±0.53				
Theta	BL	1.58±0.62		1.55±0.90		0.786	0.904	0.941
	MI	1.46±0.89		1.55±0.94				
	PI	1.42±0.66		1.45±0.71				
	FU	1.49±0.44		1.34±0.79				
Occipital								
Alpha	BL	1.25± 0.59		1.19±0.58		0.294	**0.016^{b}**	0.654
	MI	1.38±0.82		1.60±0.44				

	PI	1.46±0.64	1.68±0.39			
	FU	1.50±0.27	1.72±0.77			
Beta	BL	1.09±0.62	1.01±0.54	0.389	0.884	0.718
	MI	0.99±0.41	1.13±0.53			
	PI	0.98±0.55	1.08±0.40			
	FU	1.02±0.37	1.23±0.54			
Theta	BL	1.27±0.70	1.16±1.09	0.496	0.607	0.860
	MI	1.06±0.80	1.15±0.70			
	PI	1.10±0.64	0.95±0.87			
	FU	1.07±0.66	0.83±0.72			
Left temporal Alpha	BL	1.26±0.43	1.24±0.78	0.633	0.573	0.899
	MI	1.11±0.84	1.22±0.58			
	PI	1.05±0.59	1.06±0.58			
	FU	1.12±0.46	1.30±0.47			
Beta	BL	1.51±0.45	1.39±0.69	0.687	0.752	0.246
	MI	1.40±0.69	1.29±0.47			
	PI	1.26±0.48	1.36±0.75			
	FU	1.20±0.47	1.56±0.48			
Theta	BL	1.34±0.78	1.38±0.87	0.780	0.338	0.452
	MI	1.48±0.93	1.55±0.66			
	PI	1.30±0.77	1.41±0.75			
	FU	1.44±0.51	1.78±0.61			
Right temporal Alpha	BL	1.59±0.47	1.51±0.54	0.719	0.389	0.753
	MI	1.33±0.76	1.50±0.58			
	PI	1.33±0.60	1.28±0.50			
	FU	1.34±0.49	1.47±0.58			
Beta	BL	1.68±0.52	1.65±0.57	0.738	0.543	0.630
	MI	1.58±0.59	1.74±0.80			
	PI	1.56±0.57	1.42±0.62			
	FU	1.45±0.56	1.63±0.62			
Theta	BL	1.63±0.64	1.58±0.72	0.501	0.704	0.715
	MI	1.62±0.87	1.79±0.65			
	PI	1.52±0.81	1.49±0.54			
	FU	1.48±0.55	1.78±0.71			

Data are given as M: Mean & SD: Standard Deviation.
CAIT: Cumberland Ankle instability Tool, FADI: Foot and ankle disability index, MAAS: Mindful Attention Awareness Scale, QHQ: Oxford Happiness Questionnaire

BL-Baseline at week 1; MI-Mid-intervention at end of week 3; PI- Post-intervention at end of week 6; FU-Follow-up at end of week 12.

d: Cohen's d response mean effect size between time effect

b: Significant improvement in time effect, time and group interaction effect, $p < 0.05$.

*Significant improvement from baseline to follow-up sessions, $p < 0.05$.

Appendix 13

Published and Conference abstracts

Abstract 1

A pilot study: Neurophysiological Study on the Effect of Chronic Ankle Pain Intervene with Video Assisted Mindful Deep Breathing

Conference: 2018 IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES) DOI: 10.1109/IECBES.2018.8626731

Chronic ankle pain are reasonably common among sports injuries that leads to chronic ankle instability (CAI). When ankle gives way, pain and recurrent sprains are the characteristics of CAI reported among repeated ankle injuries. This situation may bring down life's quality that possibly leads to neurophysiological changes due to depression, anxiety and stress. Mindfulness for pain management has been popular in recent decades. Here, we aim to employ a new and standardization on the tool for the recruited participants to do the mindful deep breathing. Therefore, a validated method video assisted mindful deep breathing (VAMDB) can improve on conflict monitoring, to modulate brain network dynamics underlying in the pain waves experience in this study. Characterization on brainwaves changes with electroencephalogram (EEG) study for the pre- and post-intervention on the neurophysiological response of brain among collegiate athletes are reported here. A total of 12 participants aged between 18 and 25 years were recruited. 8 participants with chronic ankle pain from INTI physiotherapy centre were grouped into intervention (INT) n=4, and nonintervention (NINT) n=4 respectively. Another 4 participants without pain and intervention was assigned as control group

(CONT). The data was processed with MATLAB and analysed by ANCOVA within the group (INT, NINTand CONT). The pre- and post-treatment effect was significant within the subject factor. Delta, theta, alpha, beta and gamma bandwidths in occipital region shows significant effect on VAMDB between pre and post intervention. This pilot study is the first to explore the 3-min short duration VADMB among ankle pain participants.

Keywords: Ankle pain, chronic ankle instability, EEG, mindfulness, neurophysiology, Video assisted mindful deep breathing

Abstract 2

A Narrative Review on Mindfulness Practices in Optimizing Performance among Sports Individuals

Journal of Experimental Biology and Agricultural Sciences 9(Spl-1-GCSGD_2020):S62-S70.

DOI: 10.18006/2021.9(Spl-1-GCSGD_2020).S62.S70

Mindfulness practice has become an increasingly popular intervention in optimizing athletic performance in sports. Numerous studies have reported on applying mindfulness for improving the performance of various sports such as tennis, table tennis, shooting, cricket, archery, golf, running, hockey, swimming, and cycling. This narrative review addresses different existing mindfulness programs that enhance sports performance, the outcome measures of mindfulness therapy, and identifies the anxiety and depression that affect the performance of sports individuals. To cope with the issues, the efficacy of mindfulness in performance enhancement and future research directions on mindfulness needs attention.

Keywords: Athletes, Depression, Mindfulness, Sports anxiety, Sports performance