MobEx MODEL: ITS EFFECT ON ANKLE DORSI-FLEXION RANGE OF MOTION, DYNAMIC BALANCE AND ANKLE FUNCTIONAL ABILITY MEASURES IN ATHLETES WITH AND WITHOUT PREVIOUS HISTORY OF LATERAL ANKLE SPRAIN

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SULTAN IDRIS EDUCATION UNIVERSITY

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ABSTRACT

Lateral Ankle Sprains (LAS) are the most common soft tissue injuries among athletes. This study aimed to examine the effects of a six-week MobEx Model Intervention Program on athletes without previous history of Lateral Ankle Sprains (W/OLAS) and athletes with a previous history of Lateral Ankle Sprains (WLAS), specifically to alter the intrinsic risk factors consist of ankle dorsiflexion range of motion, dynamic balance, functional ability of the ankle. A single blinded prospective randomized control trail with experimental cross-sectional research design was used in this study. The researcher recruited 33 athletes W/OLAS and 27 athletes WLAS independently. They were randomized into MobEx Group (MGR N=20), Placebo Group (PCR N=20) and Control Group (CGR N=20). The MGR undergone six weeks MobEx Model Intervention Program, the PGR received placebo intervention for six weeks and the CGR received no intervention. Baseline measurements were taken for DF ROM by Weight Bearing Lunge Test, dynamic balance by Modified Bass Test for Dynamic Balance, and foot and ankle ability measure for Activities of Daily Living (FAAM-ADL) and Sports Subscale (FAAM-SS) using Foot and Ankle Ability Measure questionnaire before and after the intervention. After one month, these variables were measured again for retention test. The MANOVA test results revealed that there are significant differences among all criterion measures at $\rho<0.05$ for athletes W/OLAS and athlete WLAS. Study findings indicated that MobEx Model Intervention Program revealed significant effects on intrinsic risk factors i.e. DF ROM and dynamic balance at $\rho = 0.000$, respectively. Thereby, improving, and enduring FAAM-ADL and FAAM-SS at $\rho = 0.000$ respectively for athletes W/OLAS and athlete WLAS. This study is suggesting that the intervention program is effective and clinically significance to alter intrinsic risk factors for lateral ankle sprains among athletes.

MODEL MOBEX: KESAN TERHADAP JULAT PERGERAKAN DORSIFLEKSI, PERGELANGAN KAKI, KESEIMBANGAN DINAMIK DAN PENGUKURAN KEMAMPUAN KEFUNGSIAN PERGELANGAN KAKI DALAM KALANGAN ATLET DENGAN DAN TANPA SEJARAH LATERAL ANKLE SPRAIN

ABSTRAK

Lateral Ankle Sprains (LAS) adalah kecederaan tisu lembut yang paling biasa dalam kalangan atlet. Kajian ini bertujuan untuk meneliti kesan Program Intervensi Model MobEx selama enam minggu pada atlet dengan sejarah kecederaan *Lateral Ankle Sprains* (W/OLAS) dan atlet tanpa sejarah kecederaan *Lateral Ankle Sprains* (WLAS), khusus untuk mengubahsuai faktor risiko intrinsik yang terdiri daripada julat pergerakan dorsifleksi pergelangan kaki, keseimbangan dinamik, kemampuan kefungsian pergelangan kaki. Reka bentuk penyelidikan rentas sektional dengan kawalan rawak prospektif buta tunggal digunakan dalam kajian ini. Penyelidik merekrut 33 atlet W/OLAS dan 27 atlet WLAS secara bebas. Mereka diagihkan secara rawak kepada Kumpulan MobEx (MGR N=20), Kumpulan Placebo (PCR N=20) dan Kumpulan Kawalan (CGR N=20). MGR menerima Program Intervensi Model MobEx selama enam minggu, PGR menerima intervensi plasebo selama enam minggu dan CGR tidak menerima apa-apa intervensi. Pengukuran *baseline* diambil untuk DF ROM menggunakan *Weight Bearing Lunge Test*, keseimbangan dinamik menggunakan *Modified Bass Test for Dynamic Balance*, dan pengukuran kemampuan kaki dan pergelangan kaki menggunakan *Activity of Daily Living* (FAAM-ADL) dan *Sports Subscale* (FAAM-SS) menggunakan soal selidik *Foot and Ankle Ability Measure* sebelum dan selepas intervensi. Sebulan kemudian, kesemua pemboleh ubah ini diukur semula untuk ujian retensi. Hasil ujian MANOVA menunjukkan terdapat perbezaan signifikan antara kesemua pengukuran kriteria pada $\rho<0.05$ untuk atlet W/OLAS dan atlet WLAS. Hasil kajian menunjukkan bahawa Program Intervensi Model MobEx memperoleh kesan signifikan terhadap faktor risiko intrinsik iaitu DF ROM dan keseimbangan dinamik pada $\rho=0.000$. Oleh demikian, FAAM-ADL dan FAAM-SS untuk atlet W/OLAS dan atlet WLAS berjaya dipertingkatkan dan dikekalkan ($\rho=0.000$). Kajian ini mencadangkan bahawa program intervensi tersebut adalah berkesan dan penting secara klinikal bagi mengubahsuai faktor risiko intrinsik *Lateral Ankle Sprains* dalam kalangan atlet.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

ADT	Anterior Drawer Test
AITFL	Anterior Inferior Tibiofibular Ligament
ATFL	Anterior Talofibular Ligament
CAI	Chronic Ankle Instability
CFL	Calcaneofibular Ligament
CGR	Control Group
CNS	Central Nervous System
COP	Center of Pressure
DF	Dorsiflexion
DF ROM	Dorsiflexion Range of Motion
DPA	Disablement in Physical Active Scale
FAAM	Foot and Ankle Ability Measure
FAAM ADL	Foot and Ankle Ability Measure for Activities of Daily Living
FAAM S	Foot and Ankle Ability Measure for Sports
FADI	Foot and Ankle Disability Index
FI	Functional Insufficiency
GTO	Golgi Tendon Organ
ICC	Intra Class Correlation Coefficients
LAS	Lateral Ankle Sprain
MBTDB	Modified Bass Test for Dynamic Balance
MGR	Mobilization Group
MI	Mechanical Insufficiency

MMT	Manual Muscle Test
MWM	Mobilization with Movement
NCAA	National Collegiate Athletic Association
NPRS	Numeric Pain Rating Scale
PB Ex	Proprioceptive Balance Exercise
PF	Plantar Flexion
PGR	Placebo Group
PITFL	Posterior Inferior Tibiofibular Ligament
PRISMA	Preferred Reporting Items for Systemic Reviews
WBLT	Weight Bearing Lunge Test
WLAS	With Lateral Ankle Sprain
W/OLAS	Without Lateral Ankle Sprain

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Sports holds predominant place in modern life. Pluto the great Greek philosopher wrote "Lack of activity destroys the good condition of every human being while movement and methodical exercise save and preserve it". Sports participation and appreciation have become integral part of life now days. The impact of sports on modern society has made it clear that sports are a very legitimate field of academic study.

Inhabitants in this day and age are keener in participating in sports and exercises for personal interest, leisure, relaxation, health and fitness purposes. Aside from its well-known health benefits, sports and leisure physical activity may cause sports injuries (Requa, Deavilla & Garrick, 1993). Sports injury is defined as injury to the body occurring in relation to sports, causing disability in daily life or reducing

enthusiasm for exercise, and is the major factor behind declines in athlete's performance (Kim, Chung, & Lee, 2013).

Sports injuries resulted in pain (Fahlstrom, Yeap, Alfredson, & Soderman, 2006), loss of playing or working time (Orchard & Hoskins, 2007), as well as medical expenditure (Knowles et al., 2007). Without adequate treatment and rehabilitation, sports injuries may also cause significant susceptibility in developing osteoarthritis (Lohmander, Englund, Dahl, & Roos, 2007) and other kinds of permanent sequelae (Marchi, Di Bello, Messi, & Gazzola, 1999). For world class and commercial sports teams, absence of key players due to unexpected injuries may result in defeats in major games and huge economic loss. Research related to sports injuries has progressed from topics related to aetiology, assessment, and treatment of the condition, to literature more recently that includes a strong focus on injury prevention as well.

Research related to injury prevention has seen significant growth in the past decades around several areas of musculoskeletal medicine. Soft tissue injuries represent one of the most common injuries associated with sport and activity, therefore, studies into how to best prevent these injuries from occurring are being recognized as essential. Physiotherapists are well positioned to play a role in sports injury prevention. They are trained to understand and evaluate incidence, severity, etiology, mechanism of injury, provide treatment for those injuries and manage with potential preventative solutions for them. As evidence-based practitioners, they are trained to integrate solutions based on clinical expertise, research evidence, and client values. In society, physiotherapists play roles ranging from clinical therapist to sports therapist to community sports coach

to educational consultant, and as such are in a key position to develop and implement injury prevention programmes.

Ankle sprain is the most common soft tissue injury in over a third of all sports worldwide (Fong, Hong, Chan, Yung, & Chan, 2008). It has been initially reported that seven out of 1000 people per year suffered from such injury in a Danish county hospital alone and approximately 45% of those occur during sport (Holmer, Sondergaard, Konradsen, Nielsen, & Jorgensen, 1994). Large economic costs are generated from the treatment of ankle sprains, for example the direct costs of ankle sprain management ranged from USD 292 to USD 2268 per patient depending on injury and severity of the injury has been reported (Bielska, Wang, Lee, & Johnson, 2019). In a 1-year prospective study, approximately 14% of all sports related injuries reporting to an accident and emergency department were ankle injuries, 81.25% of which were sprains (Fong, Man, Yung, Cheung & Chan, 2008).

A study of 16 years of NCAA (National Collegiate Athletic Association) injury surveillance data spanning from 1988 to 2004, found that, ankle sprains were the most common injury in college sport, making up approximately 15% of all injuries (Hootman, Dick, & Agel, 2007). By definition, these injuries were severe enough to restrict athlete participation in at least one subsequent game or practice; additionally, one in five sprains were severe enough to cause athletes to miss ten or more practices or games. As a result, ankle ligament injuries represent one of the most common injuries, requiring athletes to take time away from practice or game play.

Though the ankle is the most commonly injured joint during athletic participation (Nelson, Collins, Yard, Fields & Comstock, 2007) amongst ankle sprain injuries, 77% were lateral ankle sprains (LAS) (Gerber, Williams, Scoville, Arciero, & Taylor, 1998), making the lateral ligament complex the most often injured structure in sports and recreation (Garrick, 1977). Anandacoomarasamy and Barnsley (2005) reported that the athletes who sustain ankle injuries may experience symptoms lasting months to years following injury. They stated from their research that, only five of 19 athletes had full recovery with no pain, swelling, weakness, or giving way at an average follow up of 29 months. Similar findings are also reported in studies of the general population, with up to 72% of people reporting residual symptoms six to 18 months after injury (Braun, 1999).

In line with this, knowledge on the etiology of the LAS is relevant and essential for prevention and rehabilitation. The etiology of LAS is mostly multifactorial (Murphy, Connolly, & Beynnon, 2003). Several extrinsic factors and intrinsic factors may increase the risk of the sprain or future sprain. Extrinsic factors which include the equipment, playing surface, rule changes and playing time. Possible intrinsic factors include postural sway, range of motion, muscle strength, proprioception, and previous sprains.

Considerable predictability exists regarding the proposed risk factors and specific details of the mechanism injury for the lateral ankle ligaments. Robbins and Waked (1998) found evidence supporting the most common mechanism of lateral ankle ligament injuries from research including basketball, volleyball, gymnastics, and ballet. A large majority of these injuries occur when landing from a jump and/or unanticipated

foot placement on a sloped surface (e.g., someone's foot) or inappropriate positioning of the foot in space before contact with a surface. Thus, the most common mechanism of injury for LAS involves plantar flexion and inversion of the ankle and foot, which places excessive load on the anterior talofibular ligament (ATFL). With failure of this ligament, secondary restrain to inversion occurs by way of the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL) placing them at similar risk for injury. These ligaments provide structural stability to the ankle joint and are also thought to play a role in generating proprioceptive sensory inputs in terms of joint position and movement, due to their rich sensory innervations (Hertel, 2002). With such a pattern of ankle sprains, it would seem critical that methods to prevent this are to be explored.

1.2 Background of the study

Ankle injuries are very common in younger and active individuals, second only to the knee in the lower extremity sports-related injuries (Bahr, & Reeser, 2003; Fong et al., 2008). Several studies have been noted that sports require sudden stops, frequent jumping, directional changes, cutting and pivoting movements such as basketball, football, soccer, handball, netball and volleyball cause the highest percentage of these injuries (Fong et al., 2007; Bahr, 2002; Hosea, Carey, & Harrer, 2000). Involving all ankle injuries, ankle sprains accounts for more than 80%, and is also the most common single type of sport-related trauma among all body sites and types (Ferran & Maffulli, 2006; MacAuley, 1999; Garrick & Requa, 1998). Amongst ankle sprain injuries, 77% were lateral ankle sprains (LAS) (Gerber, et al., 1998) and 73% involved isolated

rupture or tear to the ATFL (Woods, Hawkins, Hulse, & Hodson, 2003; Renstrom & Konradsen, 1997).

In general, sports injuries caused by modifiable or/and non-modifiable risk factors (Meeuwisse, 1994). The modifiable extrinsic risk factors such as human factors, protective equipment, sports equipment, and environment can cause an injury if an athlete is having any intrinsic risk factors. The intrinsic risk factors such as age, gender, anatomy, body composition, health, physical fitness, and skill level also could cause sports injury if the athlete exposed to an extrinsic risk factor. Both the extrinsic and intrinsic risk factors are modifiable but some of the intrinsic risk factors cannot be modified such as age and gender.

The possible modifiable intrinsic factor that may cause LAS includes postural sway (skill level), range of motion, proprioception (physical fitness), and history of previous sprains (health). Several studies have identified that, limited ankle (talocrural) joint dorsiflexion range of motion (DF ROM) as an important predisposing risk factor to ankle sprains (de Noronha, Refshauge, Herbert, Kilbreath, & Hertel, 2006; Willems et al., 2005; Pope, Herbert & Kirwan, 1998). A review done by de Noronha et al. (2006) stated that the preliminary factors to predict ankle sprains are DF ROM, postural sway, and perhaps proprioception. Amongst all those factors, DF ROM appears to be the best predictor to date considering the strength of the results and quality of the respective studies.

Impaired proprioception is another modifiable intrinsic risk factor that causes LAS frequently mentioned in the literatures. Literatures have demonstrated that

diminished proprioception, diminished postural control and delayed muscle reaction have been associated with the ankle sprains. Willems et al. (2005) found that less general balance; less movement coordination and decreased muscle reaction time have a significantly increased risk for LAS. In addition, the key for prediction of ankle sprains is the interaction of variables such as range of motion, proprioceptive factors, and postural sway (de Noronha et al., 2006).

While the prognosis for functional recovery in individuals with LAS is generally quite favourable, a subgroup of individuals with ankle sprains appears predisposed to continued pain and additional re-injury. The initial (primary) injury to the lateral ligament complex as LAS may lead to mechanical insufficiencies (MI) such as restricted accessory joint gliding, micro-subluxations and joint laxity; however concomitant injury to the peroneal muscles/tendons, superficial peroneal nerve, and the ankle joint proprioceptors may also lead to functional insufficiencies (FI) such as insufficiencies in proprioception, neuromuscular control, postural control, and strength directs to neuromuscular dysfunction, again increasing the susceptibility of the ankle to further injury (Hertel, 2002).

Limited DF ROM is one of the intrinsic risk factors, may be due to osteokinematic (physiological movement) or arthrokinematic (accessory movement) restrictions. Loss of accessory or physiological range of motion at the ankle joint (talocrural joint) may also alter motor control of the joint due to the disruption in neural feedback provided from mechanoreceptors embedded in the abnormally stressed tissues (Denegar & Miller, 2002; Hubbard & Hertel, 2006).

Freeman and London (1965) was the first to theorize that damage to the mechanoreceptors within the ankle joint may impair proprioception. According to them, the tensile strength of the joint receptors is less than that of the connective tissue in which they are embedded. Therefore, damage from an ankle sprain may not only damage joint ligaments and musculature, but also the sensory nerve fibres within the joint capsule (Docherty, Moore, & Arnold, 1998; Konradsen, Ravn, & Sorensen, 1993; Freeman & London, 1965). Any alteration or impairment in proprioceptive input requires the motor control programmes to compensate (Denegar & Miller, 2002; Hubbard, Olmsted-Kramer, Hertel, & Sherbondy, 2005). Failure to compensate can cause ankle instability (Hubbard et al., 2005) and thereby increase the risk of a sprain at the ankle (Glencross & Thornton, 1981; Konradsen, Olesen, & Hansen, 1998). Consequently, the initial incidence (primary injury) of LAS is because of the following modifiable intrinsic risk factors such as decreased DF ROM and decreased proprioception, causing less balance.

Decreased ankle joint DF ROM is also a common lingering impairment following LAS (Collins, Teys & Vicenzino, 2004; Green, Refshauge, Crosbie, & Adams, 2001; Vicenzino, Branjerdporn, Teys, & Jordan, 2006), as an intrinsic factor which can impact both walking and running gait patterns (Green et al., 2001). This impairment may also increase susceptibility to re-injury (Cosby, Koroch, Grindstaff, Parente, & Hertel, 2011) as secondary LAS. History of previous injury not only disturb the ankle joint ROM but also disturb the proprioception and there by the joint stability and balance which will consequently lead to ankle instability.

Based on the theory of injury causation model of Meeuwisse (1994), injury prevention generally focuses on modifiable risk factors: extrinsic factors or intrinsic factors. To date many studies were conducted towards the prevention of such sports injuries particularly on extrinsic risk factors and a very few on intrinsic risk factors that too barely on proprioception are available in the literatures. Popular existing interventions for preventing ankle sprains include tape, ankle braces, evertor muscle strengthening and proprioceptive training (Verhagen & Bay, 2012; McKeon & Mattacola, 2008). Braces and tape have been shown to be effective preventive methods against ankle sprains; however, they do have disadvantages too. For example, there are some evidences reported that braces may hinder elements of athletic performance (Dizon & Reyes, 2010; Cordova, Scott, Ingersoll, & Leblanc, 2005) while taping need to be skilfully applied, loosens with activity, and can irritate the skin (Dizon & Reyes, 2010; Verhagen et al., 2004). Exercise programmes may avoid those disadvantages; however, compliance is a potential barrier for the exercise programmes (Hubscher, et al., 2010; Verhagen & Bay, 2012).

A well accepted paradigm put forth by Hertel, (2002) suggests that the development of Chronic Ankle Instability (CAI) is also dependent of various mechanical insufficiencies (MI) and functional insufficiencies (FI). Later this was acknowledged and reported by van Reijn et al. (2008) that MI or FI or both are common even after initial LAS. Mechanical insufficiencies include joint laxity, restricted accessory joint gliding and micro-subluxations. Functional insufficiencies include insufficiencies in proprioception, neuromuscular control, postural control, and strength.

Anatomically, the talocrural (ankle) joint geometry dictates that posterior gliding of the talus is a coupled motion of ankle dorsiflexion (Williams, 1980). Denegar and colleagues (2002) also established a significant loss of posterior talar glide in individuals with unilateral ankle sprains, leading the researcher to put forward that there should be a positive association between posterior talar glide and dorsiflexion range of motion (DF ROM). Many clinicians use hands-on passive stretching techniques to improve limited joint mobility, such as ankle DF ROM. Hands-on passive stretching techniques, including mobilization and manipulation, vary on a dosage range involving the speed of iatrogenic force application. Mobilization typically involves a slow and sustained application of iatrogenic force, while manipulation is characterized by a rapid application of iatrogenic force (Davenport, Kulig, & Fisher, 2010).

A joint-mobilization technique known as mobilization with movement (MWM) developed by Mulligan, (1999) is of particular interest, because this method is the concurrent application of an accessory mobilization with active or passive physiological movement. This is one of the widely used techniques to increase the joint range of motion and to reduce pain by the clinicians as a tool of management recent days. There are literatures available about the efficacy of this technique especially on acute effects or immediate effects (Vicenzino et al., 2006; Collins et al., 2004). In the same time, there is very little evidence or no evidence on the applications of this manual therapy technique on long term retention effect on ankle dorsiflexion range of motion to thwart the risk of injury or re-injury (Weerasekara et al., 2020). In view of the fact that the application of this functional MWM in weight bearing position could be highly associated with increasing the joint range of motion especially in weight bearing positions on long term effects need a call for a study. As LAS occurred during sports

activities especially in weight bearing situations, this MWM technique may influence the accessory movements in talocrural joint to increase DF ROM by altering the posterior talar glide. In such an occurrence, the chances are very high, and the results will be long lasting if coupled with proprioceptive exercises.

The proprioceptive mechanism is essential for proper joint function in sports, activities of daily living, and occupational tasks (Lephart, Pincivero, & Giraldo, 1997). A proprioceptively rich environment is fundamental to optimum performance for any athletic performances. Proprioception is the cumulative neural input to the central nervous system (CNS) from mechanoreceptors located in the joint capsule, ligaments, muscles, tendons, and the skin (Ribeiro & Oliveira, 2007). Proprioception plays an essential role in balance control and ankle proprioception is perhaps the most important for that balance control (Han, Anson, Waddington, Adams, & Liu, 2015). Balance refers to the ability to maintain the center of gravity over the base of support without falling (Irrgang, et al., 1994). The ability to maintain balance requires the integration of proprioceptive input from the periphery with afferent information from the vestibular apparatus in the inner ear and vision.

Balance is important for the athletes to achieve the highest competitive level and to avoid lower limb injuries (Kiers, van Dieën, Dekkers, Wittink, & Vanhees, 2013; Hrysomallis, 2011). For athletes, an inefficient balance will result in falling, poor sport performance and upsurge possibilities for an injury or re-injury. Thus, assessment of balance to test the proprioceptive sensibility is valuable for identification of proprioceptive deficits and subsequent planning of the rehabilitation and injury prevention program. Enhancement of joint proprioception might be able to restore the

normal protective mechanism within the injured or normal joint (Han, Anson, Waddington, Adams & Liu 2015). Hence, proprioceptive balance training is used in rehabilitation following sports-related injuries and is becoming recognized as an important element in improving balance, sports specific performances and injury prevention in sports (Wälchli, Ruffieux, Mouthon, Keller & Taube 2018). Corresponding to this, the researcher of this study suggests incorporating proprioceptive balance exercises training to improve balance on athletes to reduce the risk of injury and to prevent initial (primary) LAS and recurrent (secondary) injury.

1.3 Statement of Problem

Lateral ankle sprain (LAS) as a primary injury often results in pain, disability, dysfunction, and time loss from activity, the requirement for treatment, and financial liability. Furthermore, athletes who sprain their ankle initially (primary injury) are prone to reinjure the same ankle, with recurrent ankle sprains (secondary injury) commonly leading to ongoing impairment and chronic ankle instability. LAS are clinically significant because they result in a substantial missed workdays and sports activity as well as potential early arthritic changes in the ankle joint (Fernandez, Yard & Comstock, 2007; Bahr & Reeser, 2003). Hence, the prevention of the primary LAS injury and secondary LAS injury is essential and critical to investigate.

According to van Rijn and colleagues (2008), following an initial primary sprain; the development of either mechanical insufficiency or and functional insufficiency is common, and these insufficiencies are foundations for the chronic ankle

instability (CAI) because of primary LAS (van Rijn, et al., 2008). Long-term CAI has also been linked to articular cartilage degeneration and osteoarthritis at the ankle (Valderrabano, Hintermann, Horisberger, & Fung, 2006).

The high incidence of ankle sprains, the associated economic burden related to treatment and management of LAS (Thacker et al., 1999) and the potential negative chronic consequences call for preventive measures. Over the past decade, the scientific literature regarding ankle sprain prevention has more than doubled. The main focus of those research has been on application of braces, taping and neuromuscular training which includes balance board exercises and others, above and beyond there is still scant scientific literature on any other modifiable risk factors apart from those measures especially preventing initial incidence of LAS.

Injury prevention generally focuses on modifiable risk factors i.e., extrinsic factors, or intrinsic factors. Though, the proprioceptive training programs are effective in reducing the LAS particularly for athletes with previous history of sprain, the body of knowledge remains unclear on primary prevention of LAS (Schiftan, Ross, & Hahne, 2015). In addition, a critical review conducted recently by Verhagen and Bay (2012) concluded that a combination of an external prophylactic measure (tape or brace) with neuromuscular training will achieve the preventive outcomes with minimal burden for the athlete. However, this result showed more of combination between the extrinsic risk factors and intrinsic risk factors perspective to prevent the LAS. In contrast, to date, there is no study has been carried out on the modification of two or more intrinsic risk factors perspective, especially on joint range of motion, proprioception, and previous history of injury.

In line with this, the researcher is interested to determine the efficacy of manual therapy procedures combined with proprioceptive balance training as a primary intervention to improve the ankle dorsiflexion range of motion, proprioception, and functional ability of the ankle in athletes with healthy ankle and with previous history of LAS. Thus, this study focuses mainly on to modify the intrinsic risk factors that could cause the lateral ankle sprains.

Hence, this study proposing a model named MobEx Model Intervention Program which is mainly focusing on improving the DF ROM by altering the restricted posterior glide through mobilization with movement as a mechanical insufficiency component and enhancing proprioception by improving balance through neuromuscular proprioceptive balance training as a functional insufficiency component. As a result, this proposed MobEx Model Intervention Program is hoped to be able to reduce the incidence and prevent the risk of getting LAS by increasing DF ROM, balance, and ankle functional ability.

1.4 Research Objectives

Since there is lack of evidence related to altering the intrinsic risk factors which causes a sports injury among athletic population, an intervention program is inevitable, hence, this study was designed with the aim to determine the effect of MobEx Model Intervention Program on intrinsic risk factors among athletes. Thus, the main objectives of this study are:

1.4.1 To investigate the immediate and long-term re-tension effectiveness of six-week MobEx (Mobilization with Movement and Proprioceptive Balance Exercises) Model Intervention Program, particularly its impact on ankle DF ROM, Dynamic balance, Foot and Ankle Functional Ability Measures in Activities of Daily living scores and Ankle Functional Ability measures in Sports Subscale scores among athletes with and without a history of LAS in reducing the risk of injury.

1.4.2 To compare the training effects of six-week MobEx Model Intervention Program on ankle DF ROM, Dynamic balance, Foot and Ankle Functional Ability Measures in Activities of Daily living scores and Ankle Functional Ability measures in Sports Subscale scores between athletes with and without a history of LAS in reducing the risk of injury.

1.5 Specific Objectives

Before evaluation protocols are considered for use in the clinical setting to evaluate the ankle DF ROM and dynamic balance, the ability to obtain reliable and valid measurements should be demonstrated. The demonstration of acceptable levels of reliability and validity for such testing protocols would strengthen the ongoing use of similar protocols in clinical and research settings. In light of preceding discussion and for the purpose of present investigative objectives, this research study is initiated with test re-tests reliability study of the criterion measures followed by the effectiveness study. Thus, the specific objectives of this study are as follows:

1.5.1 To explore test-retest reliability of Weight Bearing Lunge Test to assess ankle joint dorsiflexion range of motion.

1.5.2 To explore test-retest reliability of Modified Bass Test of Dynamic Balance to assess balance.

1.5.3 To determine the effects of the six-week MobEx (Mobilization with Movement and Proprioceptive Balance Exercises) Model Intervention Program on ankle DF ROM, Dynamic Balance, Foot and Ankle Functional ability Measures in Activities of Daily Living Scores and Foot and Ankle Functional ability Measures in Sports Subscale Scores in athletes without a history of LAS.

1.5.4 To determine the re-tension effects one month after the six-week MobEx (Mobilization with Movement and Proprioceptive Balance Exercises) Model Intervention Program on ankle DF ROM, Dynamic Balance, Foot and Ankle Functional ability Measures in Activities of Daily Living Scores and Foot and Ankle Functional ability Measures in Sports Subscale Scores in athletes without a history of LAS.

1.5.5 To determine the effects of the six-week MobEx (Mobilization with Movement and Proprioceptive Balance Exercises) Model Intervention program on ankle DF ROM, Dynamic Balance, Foot and Ankle Functional ability Measures in Activities of Daily Living Scores and Foot and Ankle Functional ability Measures in Sports Subscale Scores in athletes with a history of LAS.

1.5.6 To determine the re-tension effects one month after the six-week MobEx (Mobilization with Movement and Proprioceptive Balance Exercises) Model Intervention Program on ankle DF ROM, Dynamic Balance, Foot and Ankle Functional ability Measures in Activities of Daily Living Scores and Foot and Ankle Functional ability Measures in Sports Subscale Scores in athletes with a history of LAS.

1.6 Research Hypothesis

To meet the objectives of this research study, the research hypotheses were formulated as follows**:**

1.6.1 Alternative Hypothesis (H_A1):

There would be significant differences in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes without a previous history of LAS (W/OLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.2 Null Hypothesis (H_O1):

There would be no significant differences in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily

Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes without a previous history of LAS (W/OLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.3 Alternative Hypothesis (H_A2):

There would be re-tension effects in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes without a previous history of LAS (W/OLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.4 Null Hypothesis (H_O2):

There would be no re-tension effects in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes without a previous history of LAS (W/OLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.5 Alternative Hypothesis (H_A3):

There would be significant differences in of ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes with a previous history of LAS (WLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.6 Null Hypothesis (H_O3):

There would be no significant differences in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes with a previous history of LAS (WLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.7 Alternative Hypothesis (H_A4):

There would be re-tension effects in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes with a previous history of LAS (WLAS) between MobEx Intervention

Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.6.8 Null Hypothesis (H_O4):

There would be no re-tension effects in ankle Dorsiflexion Range of Motion, Dynamic Balance, Foot and Ankle Functional Ability Measures in Activities of Daily Living scores and Foot and Ankle Functional Ability Measures in Activities of Sports Subscale among athletes with a previous history of LAS (WLAS) between MobEx Intervention Group (MGR), Placebo Intervention Group (PGR) and Control Group (CGR) after six weeks of MobEx Model Intervention Program.

1.7 Conceptual and Theoretical Framework of Research

The common modifiable risk factors for an occurrence of LAS primarily and secondarily are because of, reduced range of motion, impaired proprioception, and a previous history of LAS. As decreased DF ROM is one of the risk factors for an initial LAS, this conceivably will affect the proprioceptive inputs which could increase the chance for an initial LAS. Later to LAS, the reduced DF ROM and impaired proprioception are common sequels. Hence, in this study, the researcher is mainly focusing to modify these risk factors by introducing MobEx Model Intervention Program in order to reduce the incidence of LAS and to prevent it. Figure 1.1 is illustrating the conceptual framework of this research.

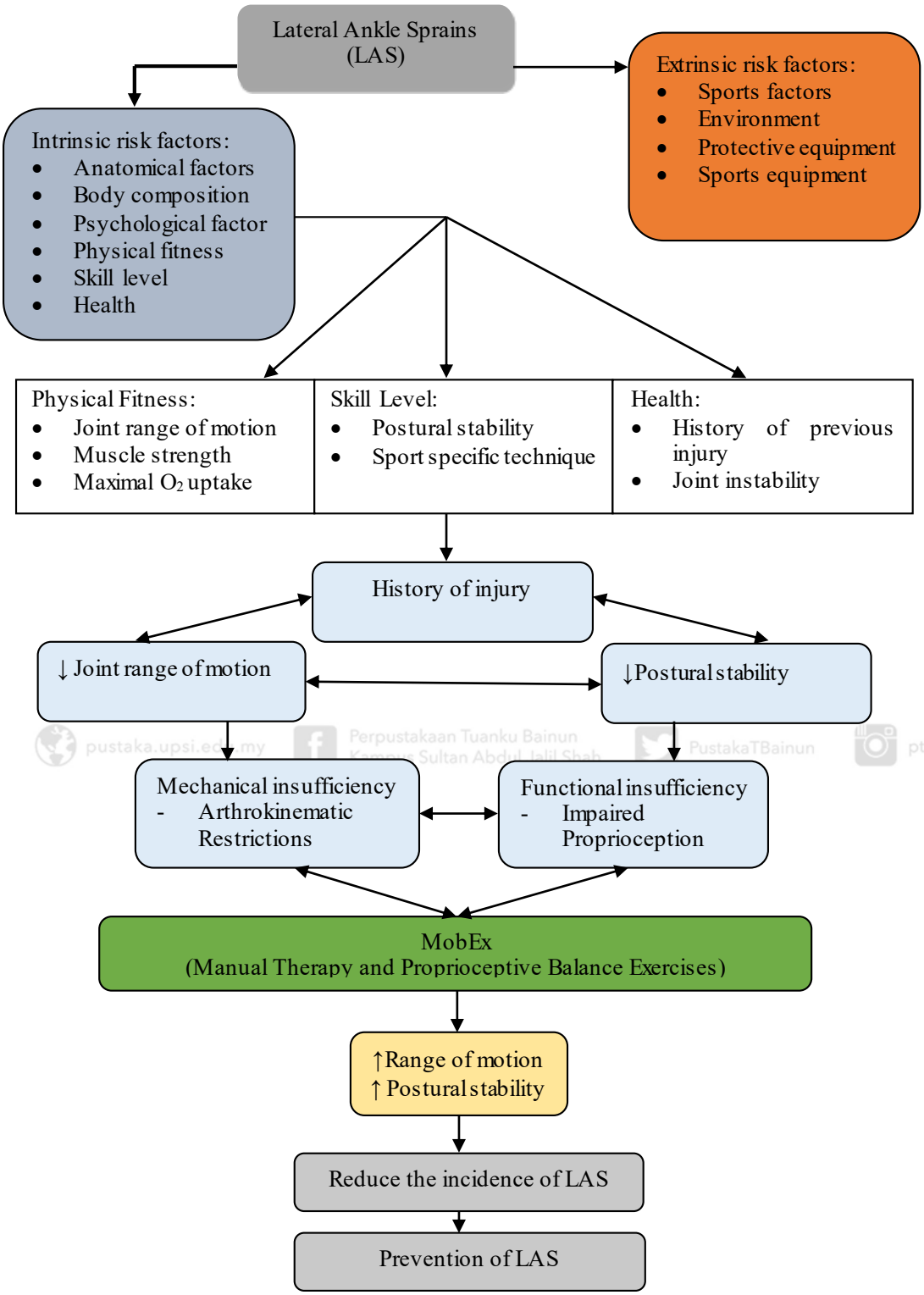

Figure 1.1. Conceptual Framework

This MobEx Model Intervention Program is hypothetically interacting with these risk factors which may influence DF ROM and proprioception. The intervention effect on DF ROM, proprioception and thereby balance may perhaps reduce the incidence of lateral ankle sprains and thus perchance prevent lateral ankle sprains primarily and secondarily. This conceptual framework is developed based on the dynamic systems theory as it is explaining strategies of sensorimotor development and its interactions to complete the tasks. The conceptual framework is also developed based on utilization of construct in classical conditioning theory which will be used to explain the effects of MobEx Model Intervention Program on athletes with and without having previous history of LAS. The success of an intervention is not only based on its formation, but also on athlete's behaviour towards the intervention. Thus, instead of highlighting only on the physiological effects of MobEx Model Intervention Program, this conceptual framework also focuses on the learning and re-learning process in the development and maintenance of desired outcomes from the MobEx Model Intervention Program.

According to the Meeuwisse, (1994) injury causation model the modifiable intrinsic risk factors such previous history of injury, joint range of motion and postural stability could cause the sports injury if the athlete exposed to an extrinsic risk factor. Based on this injury causation model the theoretical context for this study is formulated. In addition, rendering to dynamic systems theory, the human body is a system composed of many interacting parts which is commonly known as degrees of freedom that can be organized in a variety of ways to accomplish movement goals (Davids & Glazier, 2010). The dynamic system's characteristic feature is its ability to adapt to

changing demands both internally and externally. Figure 1.2 is describing the theoretical framework of this research.

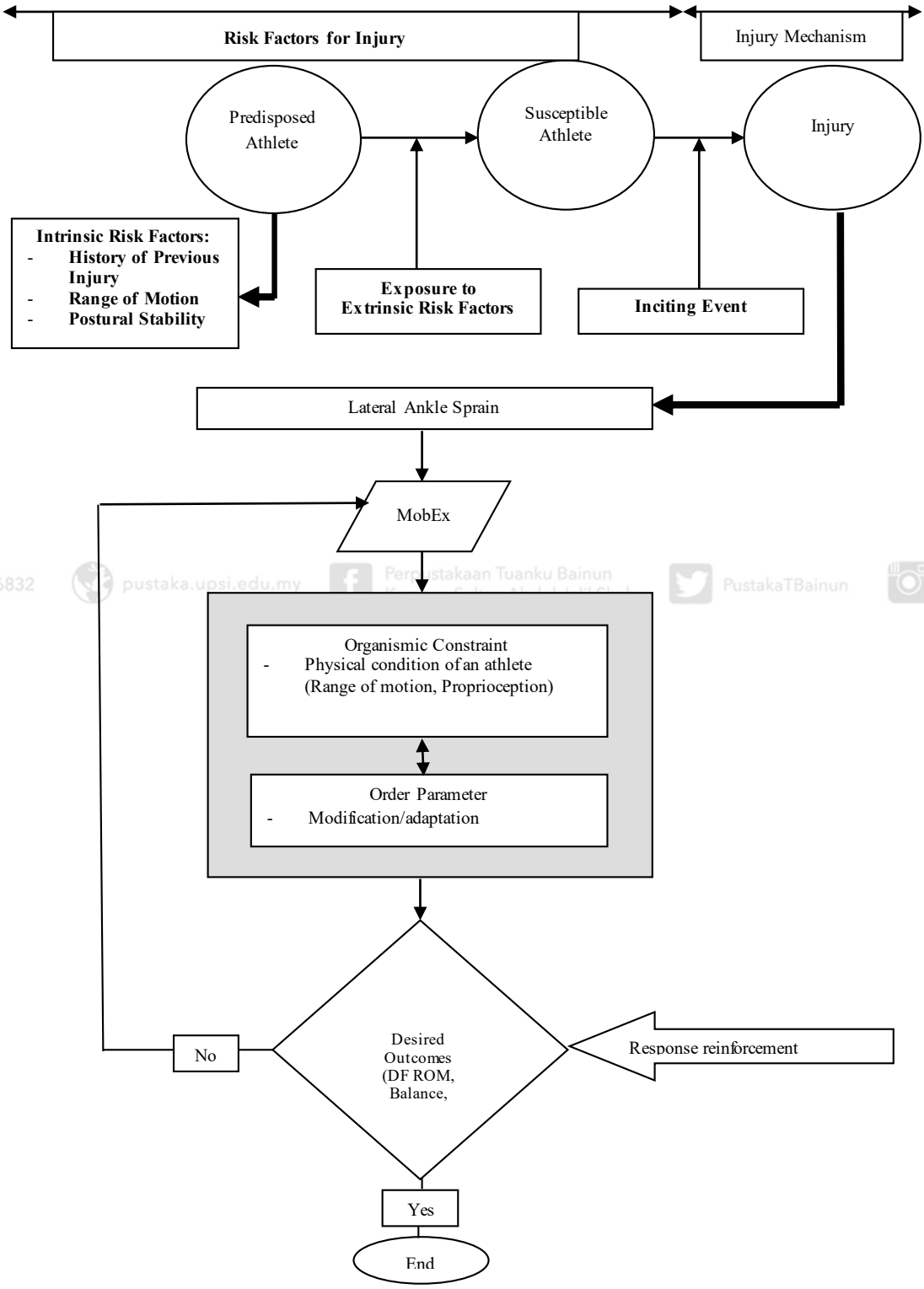

Figure 1.2. Theoretical Framework

In general, a movement goal is achieved by the interactions of the sensorimotor system. The organization of this sensorimotor is either constraints or shaped by interactions of (i) health of an individual (organismic constraint), (ii) task being performed by the individual (task-oriented constraint) and (iii) environment in which the movement goal is performed (environment constraint) (Hoch & McKeon, 2010; McKeon & Hertel, 2006). The ability of sensorimotor system is usually recognizing spontaneously about the movement strategies and react accordingly in given environment (functional variability). However, too much of this ability or too little of this ability will definitely impair the individual's ability to manage with the changing demands (Stergiou, Harbourne, & Cavanaugh, 2006).

Lateral ankle sprains increase the organismic constraints such as reduced DF ROM, impaired proprioception acting on the sensorimotor system and significantly hindering the sensorimotor system's ability to accomplish movement goals as portrayed in Figure 1.2. Consequently, receptors in the injured parts of the system cannot be used in movement solution development, thus altering functional variability after an LAS occurs (Wikstrom, Hubbard-Turner, & McKeon, 2013). Thus, a new pattern of movements is expected to be developed when there is a shift in somewhere in the interactions of these dynamic systems. Hence, by exploiting this theory, MobEx Model Intervention Program is presumed to expand a distinct pattern of developments by modifying two different intrinsic risk factors to achieve the movement task.

The classical conditioning theory is widely accepted as a conceptual model in the field of therapeutic sciences as it is used to explain the learning process where the stimulus associates with particular physiological and/or emotional response.

Consequently, the researcher is using this theory to develop, explain and conceptualize the MobEx model along with dynamic systems theory. According to Ivan Pavlov, conditioning is a reflexive or automatic type of learning in which a stimulus acquires the capacity to evoke a response that was originally evoked by another stimulus (Pavlov & Anrep, 2003). The classical conditioning theory proposed that the effect of intervention is a conditioned response that occurs from the presentation of conditioned stimulus. According to this theory, an individual's body would response favourably if the individual continues to receive the desired stimulus. This theory is used to explain clearly that the desired outcomes of intervention (conditioned response) reaction to the intervention (unconditioned response) MobEx Model Intervention Program effects (unconditioned stimulus) be able to alter from intervention, i.e., MobEx Model Intervention Program (conditioned stimulus).

By combining the dynamic systems theory and classical conditioning theory, the MobEx Model Intervention Program will endow with opportunity for athlete's perception to learn and re-learn the arthrokinematic movements and developing a new pattern of movement by making new interactions using the dynamic systems theory. Insight with this, the researcher conceptualized the research framework to test the hypothesis of this research.

1.8 Operational Definition

The following terms were adopted for the operational use of this study:

1.8.1 Accessory Movements

Accessory movements are movements in the joint and surrounding tissues that are necessary for normal range of motion but that cannot be actively performed by the patient (Mulligan, 1993).

1.8.2 Athletes

Students from the Sultan Idris Education University, those who are all representing university as sportsmen or sportswomen for a coach-directed competition, practice, or conditioning session.

For this study, athletes are defined as:

i. Athletes without previous history of LAS – those who do not have any previous history of LAS and not taken time off for ankle injury.

ii. Athletes with previous history of LAS – those who have any previous history of LAS within past 12 months and taken one or more days' time off for that injury.

1.8.3 Balance

Balance is a multidimensional concept, referring to the ability to move the body in equilibrium with gravity via interaction of the sensory and motor system (Kisner, Colby and Library, 2007).

1.8.4 Lateral Ankle Sprain (LAS)

Lateral ankle sprain (LAS) is a common musculoskeletal injury in which the lateral ligaments of the ankle partially or completely tear due to sudden stretching. LAS involve a hyper supination/inversion of the foot, which may damage the anatomical structures in the lateral ankle (Garrick, 1977).

For this study, LAS is defined as trauma that:

i. Disturbed the lateral ligaments of the ankle,
ii. Occurred during a coach directed competition, practice, or conditioning session, and
iii. Caused the athlete to miss the rest of practice or competition or miss the next scheduled coach-directed practice or competition.

1.8.5 MobEx Model Intervention Program

MobEx is a term coined by the researcher to achieve the aims of this current study, which consists of application of manual therapy and proprioceptive balance exercises

during preseason training. The manual therapy application i.e., mobilization with movement in weight bearing position is employed to alter the dorsiflexion range of motion and to alter proprioception, the proprioceptive balance exercises are utilized.

1.8.6 Mobilization with Movement

Mobilization with movement (MWM) is the concurrent application of sustained accessory mobilization applied by a therapist and an active physiological movement to end range applied by the patient. Passive end-of-range overpressure, or stretching, is then delivered without pain as a barrier (Mulligan, 1993).

1.8.7 Physiological Movements

Physiological movements are movements the patient can do voluntarily (e.g., the classic or traditional movements, such as flexion, abduction, and rotation). The term osteokinematics is used when these motions of the bones are described (Kisner, Colby and Library, 2007).

1.8.8 Primary Prevention

Primary prevention can be defined as preventing a target problem or condition in an individual or in a community at risk (Kisner, Colby and Library, 2007). In this study, the primary prevention is defined as preventing LAS for an athlete with intrinsic risk factors and without previous history of LAS.

1.8.9 Proprioception

Proprioception refers specifically to conscious and unconscious appreciation of joint position (Mountcastle, 1980). Proprioception is one's ability to integrate the sensory signals from various mechanoreceptors to thereby determine body position and movements in space (Han, et al, 2015) and it plays a crucial role in balance control (Clark, Röijezon and Treleaven, 2015). Deficits in proprioception are commonly evaluated with static measures of balance, or with dynamic measures of balance.

1.8.10 Proprioceptive Balance Exercises

Proprioceptive balance exercises (PB Ex) are a group of exercises which consists of stability, strength and power exercises that are mainly designed to improve the balance of the athlete. Proprioceptive balance exercises training is widely used in rehabilitation, sports, and injury prevention programs to re-strengthen the muscles and ligaments and to restore proprioception of the damaged structures (Zech, et al., 2010).

1.8.11 Secondary Prevention

It is defined as decreasing the duration and severity of disease (Kisner, Colby and Library, 2007); and for the purpose of this study is defined as preventing LAS for an athlete with intrinsic risk factors and with previous history of LAS.

1.9 Limitations of Study

The current study also has some limitations as like other studies. Athletes in this study athletes were between 19-26 years of age athletes; therefore, the results may not represent the other age group population. The results of this study may also be influenced by the willingness and efforts of the subjects in performing the test procedures and intervention protocols. However, the subjects were persistently encouraged to perform at their best. They were also instructed to acknowledge the researcher of any symptoms of pain or injuries if any before, during and after the session.

Although this study attempted to imply the activation of knee and hip muscles during proprioceptive balance training, those criteria were not measured due to unavailability of the appropriate equipment. Nonetheless, the researcher acknowledged that an intervention would be more reliable if activation of related measures were measured. Regardless, this study was undertaken to determine the effects of the new model of intervention program to improve ankle dorsiflexion range of motion, proprioception, and functional ability of the ankle to reduce the incidence of injuries especially lateral ankle ligament complex; hence, the criterion measured were considered most appropriate in the context of the study.

The subjects with chronic ankle instability and bilateral lateral ankle sprains were not included, therefore, the results may not represent the other demographic variables. The effect of following environmental factors such as climatic conditions, humidity was not considered for this study though some evidence presenting that cold

environment may influence the proprioception because it is hard for the researcher to control the athlete's exposure to those environments.

1.10 Delimitations of Study

The subjects for the pilot study and test re-test study were delimited to the athletes from the Sultan Idris Education University (UPSI) non-combat sports team as a player for any form of organized sports competition organized by UPSI. They were between 19 and 26 years of age. The subjects were also not undergoing any kind of treatment for any health issues at the time of the study.

The subjects in the intervention study were delimited to athletes with and without a history of the Lateral Ankle Sprain (LAS). They were between 19 and 26 years of age who have been representing Sultan Idris Education University in non-combat contact sports for any form of organized sports competition. The subjects in this study were classified as athletes without previous history of lateral ankle sprain if they (1) involved in any kind of non-combat sporting activity and without previous history of LAS for more than 24 months at the time of this study. (2) with < 12 degrees of ankle DF ROM. The Athletes involved in any kind of sporting activity and with previous history of unilateral LAS not more than 12 months' time were classified as the subjects with a previous history of LAS. The study subjects were delimited to those who met the inclusion criteria.

All subjects were screened by a qualified and experienced physiotherapist. All the assessments and training sessions were conducted at the Sports Rehabilitation Laboratory, Faculty of Sports Science and Coaching, Sultan Idris Education University, Tanjung Malim. In order to reduce the threat of unfamiliar environment, the researcher and the subject were present in the laboratory during the intervention sessions.

1.11 Significance of the Study

As the Lateral Ankle Sprains (LAS) are one of the common and leading soft tissue injuries among athletes, this epitomises a conceivable constraint for an athlete to accomplish optimal sports performances. Though, many preventive measures have been designed and instigated to prevent LAS; however, they reported success only on athletes with a previous ankle sprains (secondary injury) that too in short period of time and not on the athletes without previous history of any ankle sprains (primary injury). Hence, there is a question on how to prevent this LAS initially and also secondarily.

For the reason that, this study is important. This study is based on the need of information regarding the effect of modifiable intrinsic risk factors to reduce the incidence of initial (primary) LAS and recurrent (secondary) LAS, thereby to prevent both primary LAS and secondary LAS. This research would enhance the collective understanding of the effectiveness of manual therapy procedure and proprioceptive balance exercises to reduce the current and future disability in athletes with or without previous history of lateral ankle sprains.

This research would provide first-hand information regarding the characteristics of athletes with lateral ankle sprains that may predict successful preventive measure with manual therapy procedure and proprioceptive balance exercises. If the novel approach of MobEx Model Intervention Program would have positive results and effects to reduce the initial incidence of LAS, it would categorically help as a reference for the health care providers, coaches, athletes to reduce the initial incidence of LAS in future. In addition to that, the expected positive effects of the MobEx Model Intervention Program on athletes with previous history of LAS would also help the health care providers to reduce the recurrent incidence of LAS.

It would also be able to reduce the economic burden for the athletes and the team in terms of reducing the costs to buy external supports and other supportive prophylactic measures to prevent LAS. Moreover, this MobEx Model Intervention program would also help to reduce the health-related complications such as development of degenerative disorders, disability and so later in athlete's life.

1.12 Summary

This chapter introduced the focus of this study in terms of background and statement of problem. It also discussed a clear direction of this study from its objectives, and hypothesis of this study. Conceptual and theoretical frameworks developed for this study also discussed. The operational definition also stated in this chapter to make terms used in this study understandable. In addition, the limitations, delimitations, and significance of this study also enumerated.