**Cardiff School of Sport**
**DISSERTATION ASSESSMENT PROFORMA:**
Empirical [1]

| | | | |
|---|---|---|---|
| ***Student name:*** | OLIVIA HALL VAN LAERE | ***Student ID:*** | ST10001845 |
| ***Programme:*** | SCRAM | | |
| ***Dissertation title:*** | THE EFFECT OF A SIX WEEK PROPRIOCEPTION PROGRAMME ON DYNAMIC ANKLE BALANCE IN ELITE TAEKWONDO ATHLETES | | |
| ***Supervisor:*** | ADELINE PHILLIPS | | |

| **Comments** | **Section** |
|---|---|
| | **Title and Abstract**<br><br>Title to include: A concise indication of the research question/problem.<br><br>Abstract to include: A concise summary of the empirical study undertaken. |
| | **Introduction and literature review**<br><br>To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/ question; an indication of any research expectations, (i.e., hypotheses if applicable). |
| | **Methods and Research Design**<br><br>To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol. |
| | **Results and Analysis** [2]<br><br>To include: description and justification of data treatment/ data analysis procedures; appropriate |

| | |
|---|---|
| | presentation of analysed data within text and in tables or figures; description of critical findings. |
| | **Discussion and Conclusions** [2]<br><br>To include: collation of information and ideas and evaluation of those ideas relative to the extant literature/concept/theory and research question/problem; adoption of a personal position on the study by linking and combining different elements of the data reported; discussion of the real-life impact of your research findings for coaches and/or practitioners (i.e. practical implications); discussion of the limitations and a critical reflection of the approach/process adopted; and indication of potential improvements and future developments building on the study; and a conclusion which summarises the relationship between the research question and the major findings. |
| | **Presentation**<br><br>To include: academic writing style; depth, scope and accuracy of referencing in the text and final reference list; clarity in organisation, formatting and visual presentation |

[1] This form should be used for both quantitative and qualitative dissertations. The descriptors associated with both quantitative and qualitative dissertations should be referred to by both students and markers.

[2] There is scope within qualitative dissertations for the RESULTS and DISCUSSION sections to be presented as a combined section followed by an appropriate CONCLUSION. The mark distribution and criteria across these two sections should be aggregated in those circumstances.

**CARDIFF METROPOLITAN UNIVERSITY**

**Prifysgol Fetropolitan Caerdydd**

**CARDIFF SCHOOL OF SPORT**

**DEGREE OF BACHELOR OF SCIENCE (HONOURS)**

**SPORT CONDITIONING, REHABILITATION AND MASSAGE**

# THE EFFECT OF A SIX WEEK PROPRIOCEPTION PROGRAMME IN ELITE TAEKWONDO ATHLETES

**SCRAM**

**OLIVIA HALL VAN LAERE**

**ST10001845**

OLIVIA HALL VAN LAERE

ST10001845

SCHOOL OF SPORT

CARDIFF METROPOLITAN UNIVERSITY

# THE EFFECT OF A SIX WEEK PROPRIOCEPTION PROGRAMME ON DYNAMIC ANKLE BALANCE IN ELITE TAEKWONDO ATHLETES

## Cardiff Metropolitan University

## Prifysgol Fetropolitan Caerdydd

### Certificate of student

I certify that the whole of this work is the result of my individual effort, that all quotations from books and journals have been acknowledged, and that the word count given below is a true and accurate record of the words contained (omitting contents pages, acknowledgements, indexes, figures, reference list and appendices).

Word count: 11,132

Signed: *O. Hall Van Laere*

Date: 20.3.13

### Certificate of Dissertation Tutor responsible

I am satisfied that this work is the result of the student's own effort.

I have received a dissertation verification file from this student

Signed: ________________________

Date: ________________________

**Notes:**

# Table of Contents

Page

## Chapter I



## Chapter II



## Chapter III

## Chapter IV



## Chapter V

## Chapter VI



## Chapter VII

# List of Tables

# List of Figures

# Acknowledgements

*Firstly, I have the greatest pleasure to thank Miss Adeline Phillips for her advice, support and expert knowledge throughout my three years at Cardiff Metropolitan University. Most importantly, I thank her efforts to aid me through the process and accumulation of my dissertation.*

*Thank you for Mr Grant Churchward and the students at Torbay Taekwondo School for your help and participation within my study.*

*A thank you is also directed to Robert Meyers for his help and advice through my data analysis on SPSS.*

*Finally, I owe a huge thank you to my mother and father for their help and encouragement through this challenging journey. Furthermore, thank you for the love, admiration and support I have received every day through the course of three years.*

# Abstract

***Context:*** Due to the adverse foot positioning taekwondo athletes perform, they are susceptible to ankle sprains. Initiating a proprioceptive programme as a means of injury prevention, it has been suggested that it can improve dynamic ankle balance. ***Objective:*** To determine whether dynamic ankle balance can be improved through a six week proprioception programme in elite taekwondo athletes. ***Design:*** A randomised control and intervention trial. ***Setting:*** All means of testing took place at the Torbay School of Taekwondo. ***Participants:*** 20 mixed gender sample were randomly assigned to a control ($n$ = 10) or experimental ($n$ = 10) group. ***Base line measure:*** Data was collected by means of the Star Excursion Balance Test (SEBT). Results were taken pre and post the six week block. ***Intervention:*** The experimental group took part in a six week proprioception programme that included progressions throughout. ***Results:*** Posterior (p=0.069), Posterior Lateral (p= 0.889), Lateral (p= 0.100) and Anterior Lateral (p= 0.921) dependant variables presented no significant interaction between the ‘group’ and ‘time’ conditions. Anterior Medial ($p$= 0.035) reach presented a main effect between the ‘group’ and Anterior ($p$= 0.000), Medial ($p$= 0.002) and Posterior Medial (p= 0.000) show significant interaction between the ‘group’ and ‘time’ conditions. The experimental group improved their dynamic balance on the variables that proved significant, thus supporting the hypothesis. ***Conclusions:*** The effect of the proprioception programme improved dynamic balance within four reaches of the SEBT protocol. It can be argued that the limitations of the study affected the outcome of the post scores; therefore they should be considered to further future research.

# CHAPTER I

## INTRODUCTION

## **1.0 Introduction**

Taekwondo is a martial art that originated from South Korea and has been renovated from a traditional self-defence and combating skill in Korea to a popular modern sport across the world (Fong and Gabriel, 2011). Taekwondo is a martial art based on the foundations of karate. The beginning of competitive karate began at a Japan championship in 1957, which initiated the noncontact rule and the athletes not having to wear protective equipment (Moneig, 2011). However, the Koreans sought to full contact competitions, which influenced the development of taekwondo from karate. It is clear within research that through elite participation in martial arts, the athletes are at a great risk of injury within training and competition.

As suggested by Zetaruk, Violan, Zurakowski and Micheli (2005) there is a higher risk of injury rate within the martial art of taekwondo than karate. This is due to its high impact of physiological stressors and technical effects upon the athlete (Casolino, Lupo, Cortis, Chiodo, Minganti *et al.,* 2012). Additionally, taekwondo appears to be safer for the younger athlete, particularly those performing recreationally at beginner to intermediate levels (Zetaruk *et al.,* 2005). Within present research there is an apparent argument between injury incidences within competition against injuries sustained within training. However a study conducted by Kazemi, Shearer, Choung, (2005) compared injuries from a competitive and training environment.

Higher extremity injuries posit as a key injury site for taekwondo artists. Injuries such as concussion, haematoma's and phalange fractures indicate that they occurred within a competitive scenario due to the brutality and severity of the injuries presented (Ziaee, Rahmani and Rostami, 2010). Correspondingly, a study conducted Pieter (1996) established that injuries occurring in high impact and full contact taekwondo, injuries occurring within the high extremity had a larger ratio than lower extremity. Conversely¸ lower extremity injuries such as ankle sprain is recognised through research as a common injury sites amongst martial artists, occurring within competition and training (Bahr and Engebretsen, 2009).

There is a lack of research of preventive strategies used in taekwondo to reduce the chances of ankle sprain amongst elite athlete. By producing preventive strategies, the occurrence of ankle sprain will reduce and decrease the chances of proprioception and balance being impaired through injury (Verhagen, Van Der Beek, Twisk, Bouter, Bahr and Mechelen, 2004).  As first recognised by Sherrington (1906), ‘‘Proprioception allows for the sensation of the body movement and position’’ (Hertel, 2008, p.4.). It has been suggested in research that the joint proprioceptors are damaged through ankle sprains such as lateral ligament eversion sprain (Lephart and Fu, 2000). In relation to this, Schaefer and Sandrey (2012) state that when a lateral ligament sprain occurs, dynamic balance is impaired as well as damage to the nervous and musculotendinous complex in the ankle.

Constructing prehabiliation programmes incorporating strengthening of the joint fibres and proprioceptive activity has been seen to decrease the chances of injury (Wang, 2011).  As suggested by Bressel, Yonker, Kras and Heath (2007) dynamic balance is the capability to implement an activity or task while the athlete continues to maintain a stable base of support. There are various procedures that can be investigated for ankle balance, strength and instability. It has been suggested within research, that the Star Excursion Balance Test (SEBT) is an accurate testing procedure for ankle balance (Gribble and Hertel, 2003). According to researcher Brummit (2012) the SEBT is proving to be a successful and predictive tool in foretelling injuries. The SEBT protocol is a dynamic ankle balance test that requires balance on one leg and maximum reach with the contralateral leg in 8 different directions (Bouillon and Baker, 2011).  However, similar tests such as the Y-balance test can be argued to be more effective and reliable, due to using an instrumented device (Plisky, Gorman, Butler, Kiesel, Underwood and Elkins, 2009). Conversely, the Y-balance test is restricted to only three planes of movement, which lacks sports specificity.

Due to the movements taekwondo athletes perform, the SEBT would be the appropriate protocol. Taekwondo athletes at elite level have the ability to move around the ring maintaining dynamic balance whilst performing offence movements against their competitor (Bridge, Jones and Drust, 2011). Furthermore, researchers distinguished that proprioception that is incorporated in sport specific training will increase dynamic balance and reduce the risk of injury rates amongst the athletes (Kemberely, 2001). According to Kim, Stebbins, Chai and Song (2011), a standardised taekwondo training sessions involves cardiovascular fitness, flexibility speed and agility. This indicates that there is a paucity of research that proprioception is included in taekwondo training or in an athlete's regime. Through the suggestion of various studies, it is believed that proprioceptive exercises can improve ankle balance and enhance stability and strength (Kemberley, 2001). Therefore, a research design can be formulated to analyse the effect of a proprioception programme on elite taekwondo athletes.

The programme will incorporate skill and sport specific movements whilst concentrating on initiating exercises that will enhance dynamic ankle balance. In addition, exercises will be developed to work towards as an intervention of ankle sprains due to the high incidence of this injury through research. By using the SEBT protocol, the athlete's dynamic balance can be measured and recorded accordingly without the costs of expensive equipment (Gribble *et al.,* 2003). In addition within the present rationale, the programmes duration will be six weeks. According to research studies by Mattacola *et al.,* (1997) and Kaminski, Buckley, Powers, Hubbard and Ortiz, (2002) proprioception programmes lasting a duration of six weeks or longer all retain positive results.

# CHAPTER II

## REVIEW OF LITERATURE

## 2.0 Review of Literature

### 2.1 Taekwondo

Taekwondo is administrated as 'the art of foot and hand' (Siana, Borum and Kryger, 1986). Kicking is the basic principle administrated within taekwondo and used offensively in competitive situations. Physiological characteristics such as speed, co-ordination and accuracy are all required of a taekwondo practitioner, to accomplish and perform the dynamics of the kick and its combinations successfully (Lystad, Pollard, Graham, 2008). Practised in over 184 countries worldwide, Taekwondo is deemed to be very popular amongst the general and sporting population (World Taekwondo Federation, 2009). Introduced as a demonstration sport in 1988 Korean Olympic Games, the world recognised the physiological demands and nature of the sport (British Taekwondo Control Board, 2005). Since the Olympic Games in Sydney in 2000, Taekwondo has gained full-medal status from athletes in participating countries (Kazemi, 2011).

The cycle starts at white belt where beginners are introduced to the wide variety of skill that taekwondo entails, including basic traditional skills and sparring styles. Due to careful supervision and little knowledge of fighting skill, beginners are at a lower risk of injury in training (Vortmittag, Calonje and Briner, 2009). Taekwondo training is a persistent routine undertaken to enhance the athlete's competitive level (Kazemi *et al.,* 2005). Elite athletes are faced with greater physiological demands as competition and training becomes rigorous, creating higher force generation through offensive movements, resulting in an elevated risk of lower extremity injury. This insinuates that elite counterparts are at a large risk of injury (Kazemi, Chudolinski, Turgeon, Simon, Ho and Coombe, 2009).

### 2.2 Injury incidence

In accordance to a recent study, injury prevalence and occurrence amongst Taekwondo practitioners remains a limiting factor in the participation of the sport, with athletes withstanding lower limb injuries (Ziaee *et al.,* 2010). Yet, previous research within kinetic studies identifies an elevated incidence of higher extremity injuries to head and neck through kicking techniques (Feehan and Waller, 1995). This study however, solely records injury incidence amongst body areas in Taekwondo athletes and fail to underpin specific injuries. Conversely, Kazemi, *et al.,* (2009) recorded injury incidence in relation to the body area and injuries sustained. The severity and type of the injury is determined from the environment the athlete is in. These injuries can occur through bouts of trainings or within a competitive scenario. Impact injuries primarily occur in competitive environments, especially sparring. In addition, research findings state that the injuries experienced by athletes within high contact sparring competition were primarily to upper extremities, such as haematomas to upper limbs and fractures to phalanges (Ziaee *et al.,* 2010). Similarly, Pieter (1996) states that within full contact taekwondo, the head, spine and trunk were the most frequently injured areas at a range of 8.0-69.0 compared to lower extremity injury ranging at 13.0-70.0. However this study solely looks at injury from a competitive perspective refraining from recording injuries occurring in a training environment into account. Whereas, a study conducted by Kazemi *et al.,* (2005) looks at the athletes pre habits before competition but also assesses the comparison of injury within training to competition.

When recognising common injuries in training, preventive strategies can be formulated. Lower extremity injuries particularly ankle sprains, posit as a frequent injury site among martial artists. An ankle sprain primarily causes damage to the lateral ligaments through excessive inversion, specifically the anterior talofibular ligament (Bahr *et al.,* 2009). As the foot rolls or initially ‘goes over’; the ankle is forced into plantar flexion disturbing neutral foot alignment (Norris, 2011). Ankle sprains may occur in a competitive environment or can be executed in training (Wang, 2011). A contemporary systematically reviewed study of ankle injury incidence in sports revealed that, martial arts sustained a weighted percentage of 91% of ankle sprains and 8.3% fractures to the ankle which indicates a high frequency in ankle sprain occurrence (Fong, Hong, Chan, Yung and Chan, 2007). Furthermore Vormittag *et al.,* (2009) advocate that the occurrence of ankle sprain is due to extreme inversion resulting in bearing weight on the outer edge of foot, damaging to lateral ligaments. It is believed that at the occurrence of ankle trauma, proprioception balance and stability are deemed to be impaired (Verhagen, *et al.,* 2004).

2.3 Proprioception and Balance

'Proprioception' was first recognised and introduced by Sherrington in 1906 (Evarts, 1981). It is a reaction the muscle creates in an irregular joint positioning and movement, resulting in impairment after injury (Baechle and Earle, 2000). It was initiated to describe the body's segments positioning and orientation, which then combining a series of Latin words to produce the expression ''One's own, the act of receiving'' (Lephart *et al.,* 2000). As a subsystem of the somatosensory system, proprioception processes the feeling of touch, temperature sensation and pain from musculoskeletal structures (Ogard, 2011). Within joint capsules, muscle tendons and skin, mechanoreceptors send information via the central nervous system where joint position sense and muscular response takes place (Ross, Linens, Wright and Arnold, 2011). It has been suggested that joint proprioceptors are damaged in the occurrence of injury such as the lateral ligament sprain to the ankle, due to joint receptor fibres having insignificant tensile strength (Lephart *et al.,* 2000).

Additionally, the damage to receptors caused by injury will cause joint deafferentation, diminishing message supply from the central nervous system to the injured joint to initially disrupt proprioceptive function (Freeman, 1965). It has been suggested, that proprioceptive deficits can initially be a primary factor in the occurrence of ankle sprains (Nyska and Mann, 2002). Research suggests that full weight bearing rehabilitation incorporating proprioceptive exercises can prevent the chances of re-injury (Wang, 2011). In conjunction with this, Bahr *et al.,* (2009) states that neuromuscular training incorporating proprioceptive rehabilitation exercises is thought to improve and strengthen the reflexes of the ankle and its overall proprioceptors at the joint.

Inhibited by the proprioceptive and central nervous system, balance allows the body to have postural stability in relation to the surroundings (Fatma, Kaya, Baltaci, Taskin and Erkmen, 2010). Dynamic balance is described to be; the ability for an athlete to perform a task while continuing to maintain a stable base of support (Bressel *et al.,* 2007). Research findings suggest that, developing balance in specific joints and co-ordinated postural control exercises are generally urbanized through proprioceptive intervention programmes (Kemberley, 2001). Relative to this, a study conducted by Mattacola *et al.,* (1997) reported that a six week proprioception programme can initially improve dynamic balance in conjunction with using equipment such as a single plane balance board protocol. However, changes occurred right the way through the programme within a particular exercise, which differed from each participant;  thus hindering the reliability and consistency of the findings. Conversely, balance was improved overall. Repeating these measures in a controlled manner with each participant within future research, may increase the validity of the results.

Although the results within Mattacola *et al.,* (1997) study presented diminutive validity, a wide range of proprioceptive exercises could have been introduced to increase the difference between pre and post programme test scores. This issue was initiated by Lephart, Pincivero, Giraldo and Fu (1997). The researchers applied exercises which redevelop altered cortical pathways and equipment such as trampets and wobble boards were utilized.  Norris (2011) states that eliminating visual input by blindfolding the athlete whilst on a balance board, is known to be effective at improving proprioception at the ankle. ‘‘Visual input is one of the most important aspects in proprioception’’ (Ergen and Ulkar, 2008, p.197). When the ankle is on an unstable surface, for instance a wobble board or a compliant foam surface, balance will be considerably diminished with the athletes eyes closed (Bernier and Perrin, 1998). Furthermore, a study conducted by Holm, Fosdahl, Aarsland, Fris, Risberg, Myklebust and Steen (2004) addressed the effect of neuromuscular training on proprioception and balance in the ankle, with female handball athletes. The results presented significant findings which gives a clear indication that using balance board and wobble board exercises as part of an intervention programme, dynamic balance and proprioception can be improved.

## 2.4 Testing for ankle balance

Numerous studies have explored for ankle instability, balance and proprioception. Researchers propose that a precise and correct testing procedure for dynamic ankle balance is the Star Excursion Balance Test (SEBT) (Gribble *et al.,* 2003).The purpose for the SEBT protocol is to recognise neuromuscular function as well as identifying the effectiveness of preventive measures such as prehabilitation programmes including proprioceptive exercises. This test measures the length the individual can reach with their contralateral foot along each 45 degree increment, without initially disrupting their balance.  However, researchers Plisky *et al.,* (2009) advocate that the Y – balance test increases reliability of the standardized SEBT as it is applied with an instrumented device to increase the efficacy of the measurements.  In opposition, Hosseinimehr and Norasteh (2010) conducted a study employing the SEBT to assess postural control in leg proprioception. The findings within this study presented significance between pre and post testing. Additionally, researchers noted that proprioceptive exercises incorporated in sport specific training will enhance dynamic balance and reduce the risk of injury rates.  In relevant research, it has been portrayed that Taekwondo training involves aspects of skeletal muscle fitness and flexibility, cardiovascular, speed and agility (Kim *et al.,* 2011). This gives an indication that there is a lack of research that proprioceptive exercises are included in Taekwondo training regime.

A study conducted by Yen and Fu (2008) looked at dynamic ankle balance comparing the scores amongst participants with the SEBT protocol and force plate measurements. All participants taking part had significant ankle instability. Participants performed a vertical jump on the force plate and were instructed to land on one foot, then repeat the protocol on the contralateral leg. All participants then performed the SEBT protocol in three directions anterior, posterior and medial. Scores presented for the SEBT protocol showed no significant difference between unstable and healthy ankles joints amongst all athletes. Although the protocol was controlled for every participant, the validity of the results could be improved in future research by changing the protocol to eight reaching directions instead of three (Gribble *et al.,* 2003)

Fatma *et al.,* (2010) carried out a study that scrutinized the effect of an eight week proprioception programme on postural control amongst taekwondo practitioners. The overall sample number consisted of 42 participants in total, who were then distributed into either a control group or a training group. Within this study a Biodex Control System was initiated as means of baseline measure. The findings presented that there was a significant interaction between pre and post results undertaken by the training group; thus gives a clear indication that postural control improved amongst the athletes who completed the eight week proprioception programme. However, the sample was uneven in the number of participants with 26 in the training group and 16 in the control group. In addition, the exercises conducted within the programme lacked in sport specific elements for the sample type undertaken within the study, therefore this provides a rationale for future research. Other previous research has used the Biodex Control System but distinctively implemented it as part of a balance programme incorporating sport specific drills (Malliou, Gioftsidou, Pafis, Beneka and Godolias, 2004).The athletes in this study had to remain balanced as they returned headers. Although the Biodex Control System is a reliable measure of dynamic balance, the protocol does not consider movement patterns, which limits the test to being sport specific.

The Romberg Test is a commonly used protocol to test postural sway and proprioception of the lower extremity. The subject assumes a position of single leg standing with their eyes open and arms rested by their sides. If the subject is able to maintain dynamic balance for 5-10 seconds, the athlete will be instructed to close their eyes (Norris, 2011). Modified variations of the Romberg protocol using force plates according to research, increases validity and the reliability of the results, as postural sway can be recorded by an appropriate instrumented device (Olmsted, Carcia, Hertel, Shultz, 2002). However, due to the cost of equipment and its lack in sport specific aspects, the SEBT protocol would be an appropriate test for taekwondo athletes. The SEBT protocol requires athletic tape and a tape measure, which will be more appropriate to access in comparison to a force plate.

The Y- balance test has been reported as being a systematic, reliable and efficient instrumented measure. However, the directional movement protocol is limited to anterior and posterior movements, which restricts the sport specificity of the test. Bridge *et al.,* (2011) states that advanced Taekwondo athletes have the ability to maintain dynamic balance whilst in a competitive state in the dimensions of the ring. In addition, taekwondo practitioners have the capability of maintaining stability through kicking and turning at high speeds (Fong, Cheung, Yan, Chiu, Lam and Tsang, 2012). Due to the movements Taekwondo athletes perform within their sport the SEBT is the appropriate protocol to test ankle balance due to the movement patterns presented in the test.

## 2.5 Rationale

There is an apparent gap in current literature in relation to why proprioceptive exercises are not included into a training regime of a taekwondo practitioner. Research will argue that taekwondo athletes will in some cases incorporate balance and proprioception in their general training through stances and kick holds where they must uphold dynamic balance (Lystad *et al.,* 2008). It has been suggested through studies that proprioception training can enhance ankle stability and balance, both of which are predisposing factors of ankle sprain (Kermeley, 2001). As a result, a research study can be devised by analysing the effect of a proprioception programme on dynamic ankle balance in elite taekwondo athletes. The programme will incorporate balance exercises and will work as an intervention towards preventing ankle sprains, due to the common occurrence in taekwondo as suggested by researchers. Equipment applied within the proposed research such as wobble boards and a trampet will contribute to the improvement of the participant's motor skills, proprioceptive ability and ankle stability (Lephart *et al.,* 1997). Research studies investigating dynamic ankle balance and proprioception which have used exercise programmes of six weeks or longer in duration have all presented positive results (Mattacola, *et al.,* 1997; Kaminski *et al.,* 2002). As part of the present rationale, a six week programme will be utilized for the proposed research. By using an appropriate protocol such as the SEBT, dynamic balance can be measured safely and effectively without the expense or use of specialised equipment. The data will be recorded and will be reassessed after the proposed proprioception programme to distinguish the validity of the research.

# CHAPTER III

## METHODOLOGY

## 3.0 Methodology

The quantitative study looks at the difference in the data between two groups within the participant sample. The SEBT is a protocol to monitor the degree of proprioceptive deficit (Norris, 2011). The participants individually completed the protocol under supervision of the researcher. Each participant touched a total of eight increments that were taped to the floor, with the distal end of their foot. In order for a successful and complete test, the participant had to bring their contralateral leg back to the centre of the star after each maximal reach from the increment. After pre testing, 10 of the participants completed a six week proprioception programme, consisting of one 30 minute session per week. The group was separated into two sessions to aid the time management of the process but also improve the reliability of supervision of the exercises. The programme focused solely on the improvement of proprioception at the ankle. The exercises included sport specific elements whether it involved variations of technique or competitive scenarios, which challenged the athletes to incorporate taekwondo aspects but also gain positive results from the exercise by utilizing the proprioception system.  Following on from the completion of the programme, the SEBT protocol was executed once more to compare the results from pre testing results.

### 3.1 Participants

The study employed 20 healthy participants of mixed genders to make up two groups, a control and an experimental group. All participants were elite athletes from red belt to black belt variations and had competed internationally. The age range of the participants was 18-35, due to a high risk of lower extremity injury within elite athletes sustained in this age group (Kazemi, 2011). All participants had to sign consent forms to state their willingness to take part and to know their rights within the study (Appendix A). Exclusion criteria for the study removed participants from the study if they had lower extremity injuries within the past 12 months. Participants free from injury were suitable to participate. The participants had to ensure they were able to attend every proprioception session as part of the programme, failure to do so would reduce reliability of post testing scores. Furthermore, four participants failed to meet these agreements and decided to withdraw from the study at their own accord. Therefore, 16 participants were divided into groups of 8 to continue the study.

3.2 Instrumentation

The test was performed in a Dojo where all the participants train, making it an easy location for the participants to travel to. The area was cleared of any obstruction so the test could run without any disruptions in a safe environment. The space within the area gave plenty of room for the participants to be tested under the supervision of the researcher. The star with a total of eight increments was taped on the floor using athletic tape, with each increment being a 45 degree angle apart from each other. A goniometer was used to measure the angles between each of the increments to increase the reliability of the test. The diagram of the designed protocol undertaken for a baseline measure is shown below, in figure 1.  The data collection was done as part of a group instead of individually to protect each of the participant's anonymity (Berg and Latin, 2004).

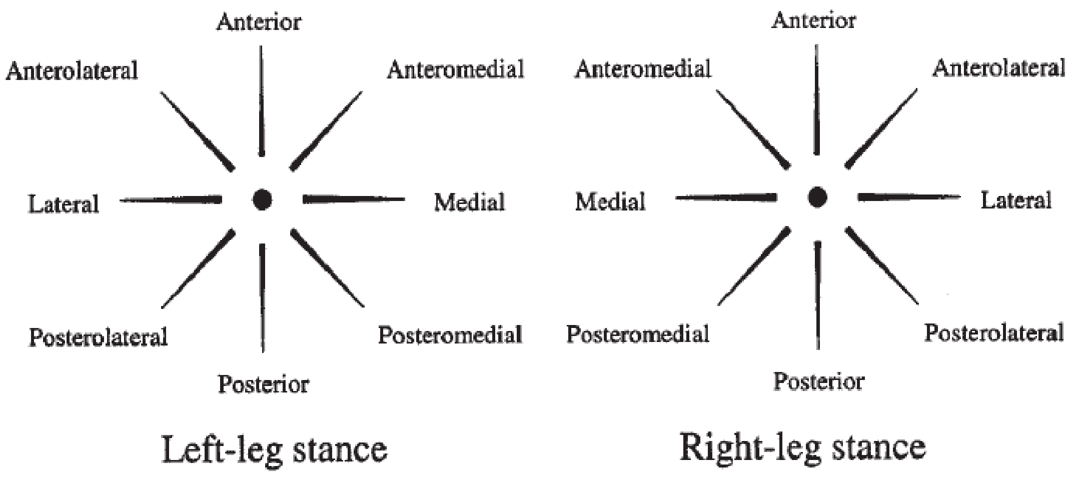


FIGURE 1 Reaching directions for the Star Excursion Balance Test.

**Figure 1**.  Star Excursion Balance Test (Gribble *et al.,* 2003).

## 3.3 Procedure

The protocol was prepared and completed within a quiet environment to avoid distraction to the participants and researcher. The protocol and the intervention programme were set in an athletic training facility (Dojo) to put in place a sporting environment for the athletes. Each participant proceeded with a trial run, before performing the test on both legs three times, to take an average to increase the reliability of the scores. Additionally, the distance that the participants achieved was measured and recorded in inches. A mistrial was defined as the following: (1) The participant planted the foot on the increment rather than a light touch on the reach leg to obtain balance (2) The stance leg moved from the centre of the star (3) the reach leg failed to withdraw back to the centre of the star after each reach. Once the test had been performed by all of the participants, the control group, as agreed, returned to their training regimes. Following the test, the other group began their 30 minute sessions for six weeks. After the six weeks had passed, the two groups repeated the same protocol.

## 3.4 Measurements

Due to the significant correlation between SEBT and limb length, each participant had the length of their anterior superior inferior spine (ASIS) to their lateral malleolus measured, to normalize the protocol (Gribble *et al.,* 2003)

## 3.5 Proprioception Programme

The proprioception programme applied to the experimental group had a six week duration incorporating one 30 minute session each week. The eight participants separated into two groups for the programme to allow optimal supervision of exercises. The participants had to ensure they were present 10 minutes before the session began to allow for a five minute standardised warm-up comprising of a pulse raiser, static and dynamic stretching. Exercises within the programme progressed each week incorporating equipment such as wobble boards and trampets, increasing the repetitions and sets of each exercise and increasing the sport specificity of the exercises. The proprioception training programme with progressions and explanations and warm-up stretches is presented in Appendix C.

## 3.6 Data Analysis

The pre and post raw data was accumulated on Microsoft Excel to show the overall mean scores. The data collection from the SEBT protocol was further analysed the SPSS 20.0 Programme. An independent T-test was used to analyse pre SEBT scores between the both groups to see if they matched at baseline prior to the intervention (Appendix B). A two-way mixed model ANOVA was then interpreted on the eight dependant variables to examine the condition (experimental and control) and the time (pre and post measures) on the overall mean scores (Appendix B). This analysis will give a clear insight whether the effect of the proprioception intervention programme improved ankle balance.

# CHAPTER IV

## RESULTS

## 4.0 Results

The sample originally consisted of 20 participants of a mixed gender (*n* = 20) but four participants failed to meet the inclusion criteria and where therefore withdrawn from the study. This gave a final sample size of 16 participants (*n* = 16). The average age of the control group was 23.75 (*sd* = 6.58) and the average limb length (inches) was 28.81 (*sd* = 3.10). The average age and limb length for the experimental group was 26.38 (*sd* = 5.21) and 30.09 (*sd* = 5.59).

### 4.1 Homogeneity of variance

The following tests determine whether the condition (control and experimental) has the same variance within pre scores.

#### 4.1.1 Independent T-test

An independent t-test was used to compare the pre-condition results within the control and experimental group.

**Table 1.** Independent T-test to determine the means at baseline between each dependant variable

| Dependant variable | F value | P value (Sig.) | t |
|---|---|---|---|
| Anterior | 1.066 | 0.319 | 1.838 |
| Anterior Medial | 2.140 | 0.166 | 0.934 |
| Medial | 1.404 | 0.256 | 2.228 |
| Posterior Medial | 0.341 | 0.431 | 1.497 |
| Posterior | 0.658 | 0.431 | -0.139 |
| Posterior Lateral | 0.231 | 0.639 | -0.404 |
| Lateral | 2.004 | 0.179 | -0.790 |
| Anterior Lateral | 0.561 | 0.466 | -0.355 |

There was no statistical significant difference between the entire eight dependant variables between the two groups in pre testing scores ($p$= 0.05). These results conclude that the groups are significantly matched at baseline.

4.2 Anterior

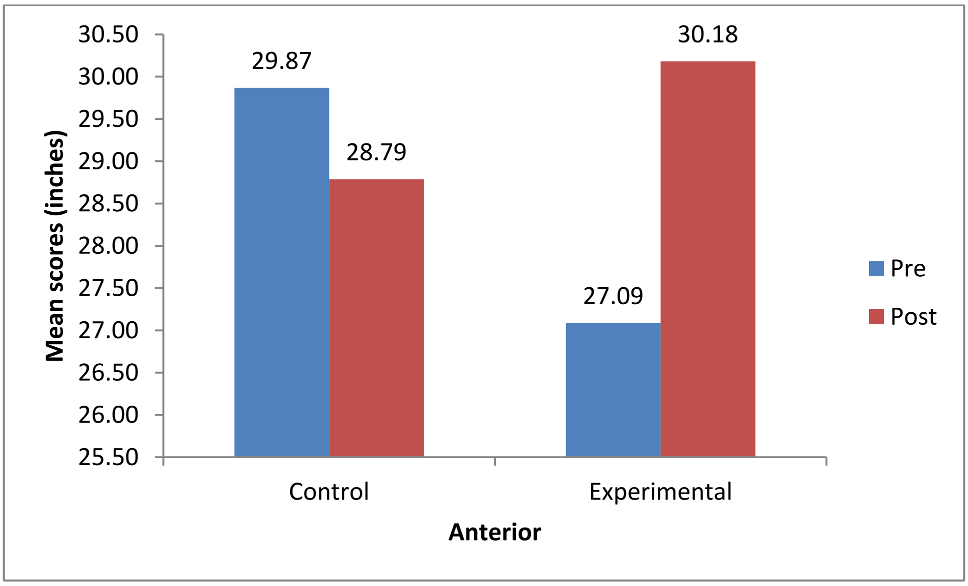


**Figure 2.** Anterior dependant variable composite results expressed as means

The means of the pre results of the control group was (29.87) and the mean post scores was (28.79). The means of the pre results of the experimental group was (27.09) and the mean post scores was (30.18). This shows that the control group scored higher on pre scores as opposed to the experimental group in the anterior reach of the SEBT. However, the experimental group scored a higher mean of scores as opposed to the control group.

4.2.1 Two way mixed model ANOVA results

**Table 2.** Tests of within-subjects effects of the anterior variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 6.302 | 0.025* |
| Group*time | 27.078 | 0.000* |

(* $P < 0.05$ – Sig. value)

There was a significant main effect in 'time' condition on the effect of the anterior results (f = 0.025, p = 0.025) There was also a significant interaction between the 'group' and 'time' on the anterior SEBT reach results. ($f$ = 27.078 $p$ = 0.000 <0.005). It is evident that there was a significant difference between pre and post scores of the experimental group as opposed to the control group.

4.3 Anterior medial

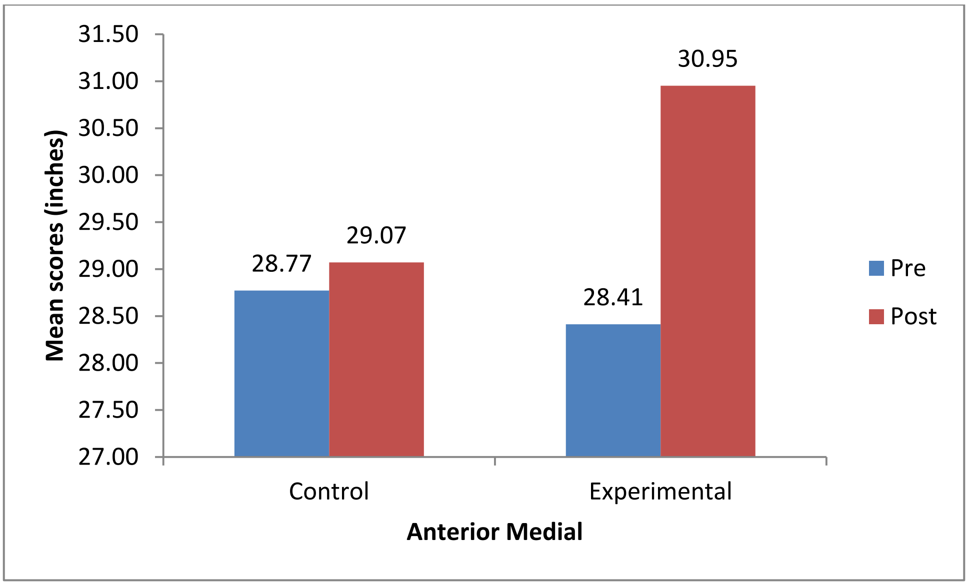


**Figure 3.** Anterior medial dependant variable composite results expressed as means

The means of the pre results of the control group was (28.77) and the mean post scores was (29.07). The means of the pre results of the experimental group was (28.41) and the mean post scores was (30.95). This shows that the control group scored higher on pre scores as opposed to the experimental group in the anterior medial reach of the SEBT. Both groups had a higher increase in mean in post scores. However, the experimental group scored a higher mean of scores as opposed to the control group.

4.3.1 Two way mixed model ANOVA results

**Table 3.** Tests of within-subjects effects of the anterior medial variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 5.439 | 0.035* |
| Group*time | 3.380 | 0.087 |

(* $P < 0.05$ – Sig. value)

There was a significant main effect in ‘time’ condition on the reach scores of the anterior medial variable ($f$ = 5.439 $p$= 0.035). There was no significant interaction between the conditions ‘group’ and ‘time’ on the anterior medial scores ($f$ = 3.380 $p$ = 0.087). However, there is in trend in improvement between pre and post score within experimental group.

4.4 Medial

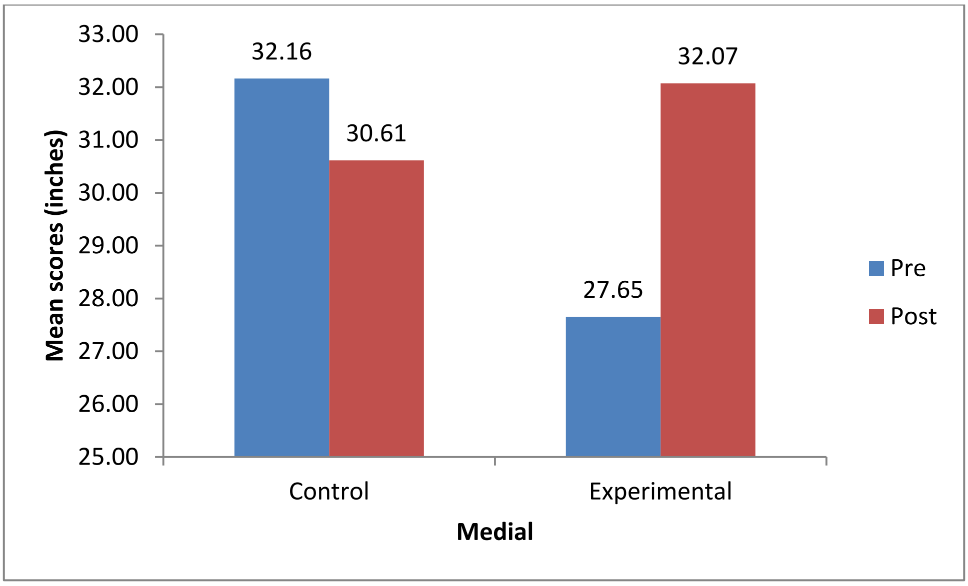


**Figure 4.** Medial dependant variable composite results expressed as means

The means of the pre results of the control group was (32.16) and the mean post scores was (30.61). The means of the pre results of the experimental group was (27.65) and the mean post scores was (32.07). This shows that the control group scored higher on pre and post scores as opposed to the experimental group in the medial reach of the SEBT.

4.4.1 Two way mixed model ANOVA results

**Table 4.** Tests of within-subjects effects of the medial variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 3.493 | 0.083 |
| Group*time | 15.051 | 0.002* |

(* $P < 0.05$ – Sig. value)

There was no main effect in the 'time' condition of the medial results ($f = 3.493$, $p = 0.083$) There was a significant interaction between the 'group' and 'time' on the medial SEBT reach results. ($f = 15.051$ $p = 0.002$). This shows that there was a significant difference between pre and post scores of the experimental group as opposed to the control group.

4.5 Posterior Medial

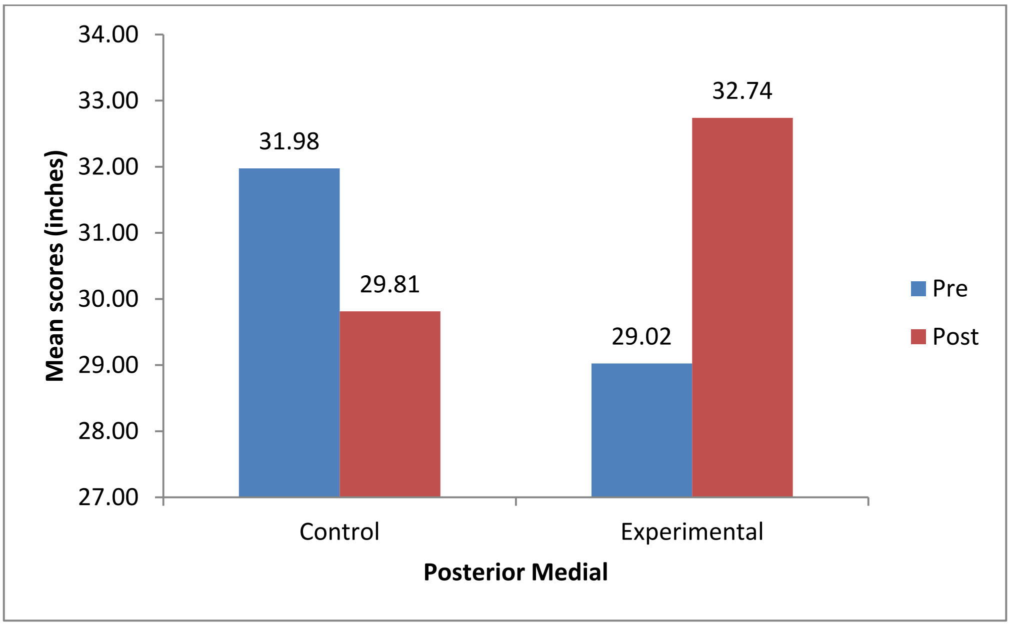


**Figure 5.** Posterior medial dependant variable composite expressed as means

The means of the pre results of the control group was (31.98) and the mean post scores was (29.81). The means of the pre results of the experimental group was (29.02) and the mean post scores was (32.74). This shows that both groups had increased post scores compared to pre scores. However, the experimental group scored a higher mean of scores as opposed to the control group in the posterior medial reach of the SEBT.

4.5.1 Two way mixed model ANOVA results

**Table 5**. Tests of within-subjects effects of the posterior medial variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 1.545 | 0.234 |
| Group*time | 22.121 | 0.000* |

(* $P < 0.05$ – Sig. value)

There was no main effect in the 'time' condition of the posterior medial results ($f$ =1.545, $p$ =0.234) There was a significant interaction between the 'group' and 'time' on the posterior medial SEBT reach results. ($f$ = 22.121 $p$ = 0.000). There was a significant difference between pre and post scores of the experimental group as opposed to the control group.

4.6 <u>Posterior</u>

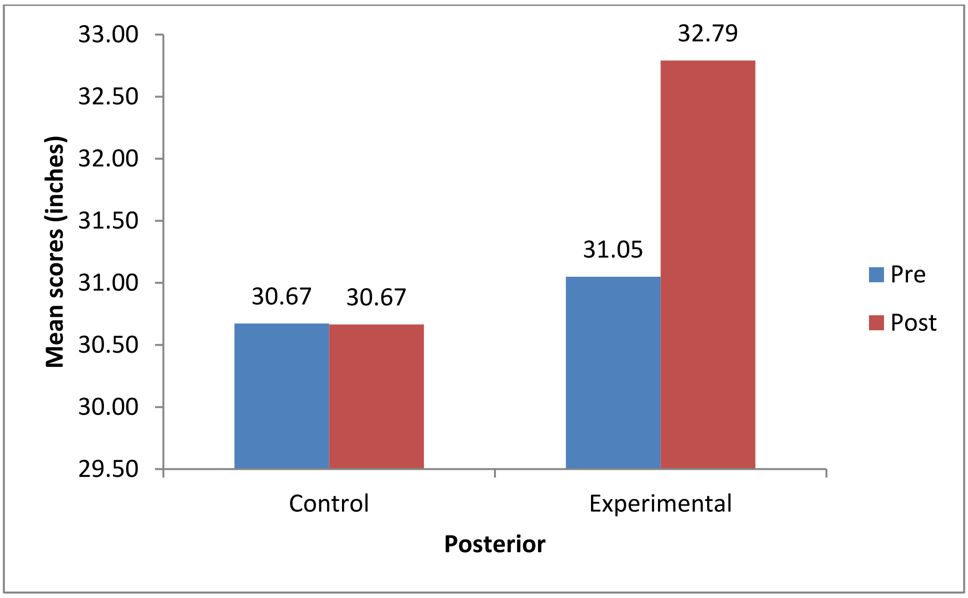


**Figure 6.** Posterior dependant variable composite expressed as means

The means of the pre results of the control group was (30.67) and the mean post scores was (30.67). The means of the pre results of the experimental group was (31.05) and the mean post scores was (32.79). The scores within the control group show no improvement in scores from pre to post. However, the experimental group scored a higher mean of scores as opposed to the control group in the posterior reach of the SEBT.

4.6.1 Two way mixed model ANOVA results

**Table 6.** Tests of within-subjects effects of the posterior variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 3.803 | 0.071 |
| Group*time | 3.869 | 0.069 |

(* $P < 0.05$ – Sig. value)

There was no main effect in the ‘time’ condition of the posterior results ($f$ =3.803, $p$ =0.071) There was no significant difference between the interaction of ‘group’ and ‘time’ on the posterior SEBT reach results. ($f$ = 3.869 $p$ = 0.069). However, there is in trend in improvement between pre and post score within experimental group.

4.7 Posterior Lateral

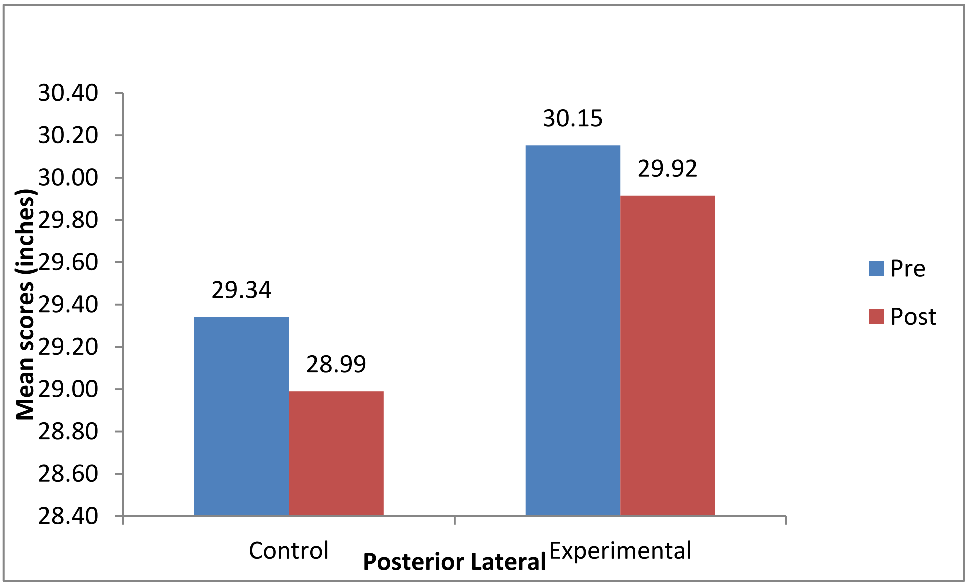


**Figure 7.** Posterior Lateral dependant variable composite expressed as means

The means of the pre results of the control group was (29.67) and the mean post scores was (28.99). The means of the pre results of the experimental group was (30.15) and the mean post scores was (29.92). This shows that both groups did not increase post scores compared to pre results for the posterior lateral reach of the SEBT.

4.7.1 Two way mixed model ANOVA results

**Table 7.** Tests of within-subjects effects of the posterior lateral variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 0.533 | 0.477 |
| Group*time | 0.020 | 0.889 |

(* *P* < 0.05 – Sig. value)

There was no main effect in the 'time' condition of the posterior lateral results (*f* =0.533 *p* =0.477) There was no significant difference between the interaction of 'group' and 'time' on the posterior SEBT reach results. (*f* =0.020 *p* = 0.889).

4.8 Lateral

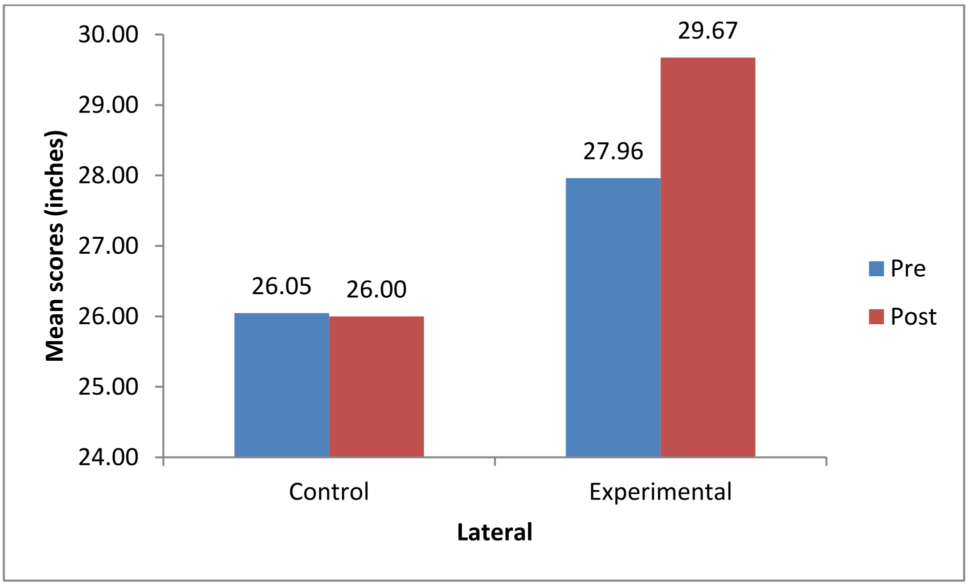


**Figure 8.** Lateral dependant variable composite expressed as means

The means of the pre results of the control group was (26.05) and the mean post scores was (26.00). The means of the pre results of the experimental group was (27.96) and the mean post scores was (29.67). This shows that the control group presented higher scores in pre testing compared to post testing. However, the experimental group scored a higher mean of scores as opposed to the control group in the posterior reach of the SEBT.

4.8.1 Two way mixed model ANOVA results

**Table 8.** Tests of within-subjects effects of the lateral variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 2.781 | 0.118 |
| Group*time | 3.098 | 0.100 |

(* $P < 0.05$ – Sig. value)

There was no significant differences in the ‘time’ condition on the effect of the posterior lateral results ($f$ =2.781 $p$ =0.118) There was no significant difference between the interaction of ‘group’ and ‘time’ on the posterior SEBT reach results. ($f$ =3.098 $p$ = 0.100). However, there is in trend in improvement between pre and post score within experimental group.

4.9 Anterior Lateral

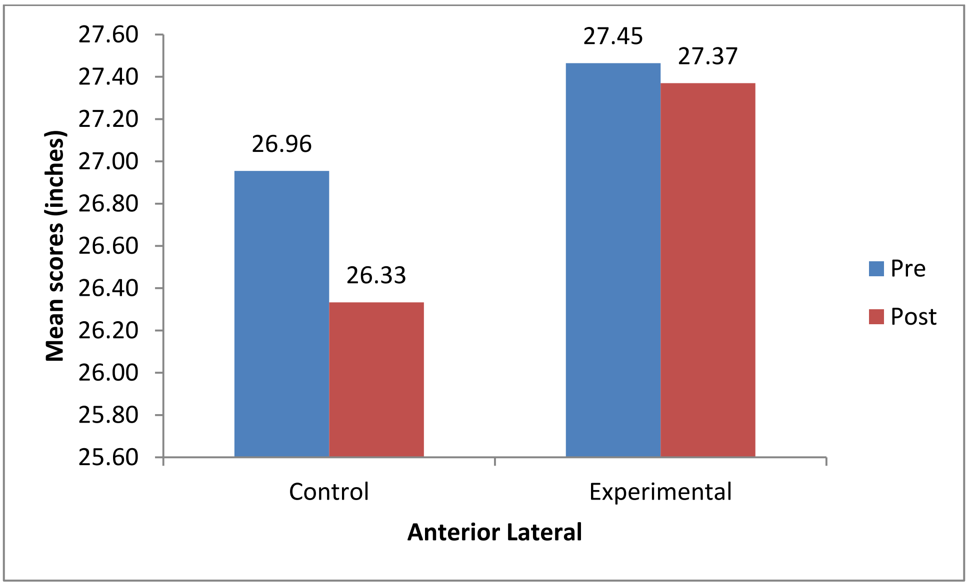


**Figure 9**. Anterior Lateral dependant variable composite expressed as means

The means of the pre results of the control group was (26.96) and the mean post scores was (26.33). The means of the pre results of the experimental group was (27.45) and the mean post scores was (27.37). Both groups presented higher means of results within pre testing compared to post testing in the anterior lateral reach of SEBT.

4.9.1 Two way mixed model ANOVA results

**Table 9.** Tests of within-subjects effects of the anterior lateral variable

| | F value | P value (sig.) |
|---|---|---|
| Time | 0.032 | 0.860 |
| Group*time | 0.010 | 0.921 |

(* $P < 0.05$ – Sig. value)

There was no significant differences in the 'time' condition on the effect of the posterior lateral results (*f* =0.032 *p* =0.860) There was no significant difference between the interaction of 'group' and 'time' on the posterior SEBT reach results. (*f* =0.010 *p* = 0.921).

# CHAPTER V

## DISCUSSION

## 5.0 Discussion

Ankle injuries are considered to be a common injury amongst the sporting and general population (Fong, *et al.,* 2007). The consequences of ankle sprains include deteriorated proprioceptive capability, on-going chronic instability and possible re-occurrence of injury (Raymond, Nicholson, Hiller and Refshauge, 2012). Copious amounts of research suggest that preventive strategies are imperative to reduce the risk of ankle sprain (Stasinopoulos, 2004; Verhagen and Bay, 2010). These include prophylactic measures such as ankle taping and bracing. Methods of taping has been suggested to minimize the occurrence of ankle sprains in martial arts particularly Taekwondo, as ankle sprains posit as an injury common amongst these athletes (Burke, 1981; Barua and Roosen, 2005).

However such means of this type of prevention can be deemed as expensive and time consuming as suggested by researchers Callaghan (1997) and Olmstead, Vela, Denegar and Hertel, (2004). Consequently, proprioceptive training is used comprehensively as a preventive measure against ankle sprains, as its method of training stimulates multiple planes of ankle movement. However there is a gap in research that explains why taekwondo athletes fail to apprehend proprioception and balance activity as means of injury prevention. Taking all these factors into consideration, it led to research the effect of a six week proprioception programme and its effect on dynamic ankle balance within elite taekwondo athletes. Within this section, the main findings of the given research is analysed in comparison with previous studies. Additionally, overall strengths and limitations of the study are addressed followed by inspired future research.

### 5.1 Theoretical Implications

#### 5.1.1 Main findings

The findings of the current investigation suggest that several SEBT reaches showed no significant interaction between pre and post scores, it has been suggested that the six week proprioception programme did not improve overall dynamic ankle balance within the intervention group. The Posterior ($p=0.069$) Posterior Lateral ($p=0.889$) Lateral ($p=0.100$) and Anterior Lateral ($p=0.921$)

reaches of the SEBT did not present any significant interaction between the ‘group’ and ‘time’ conditions, which testifies that there was no significant statistical difference between pre and post scores. However, there was a trend in improvement in pre and post scores within the intervention group as opposed to the control group. In spite of this the results show that, Anterior medial (*p=0.002*) presented a main effect between the ‘group’ which clarifies that there was a distinct improvement from pre to post scores within both control and experimental group. The remaining dependant variables, Anterior (*p=0.000*), Medial (*p=0.002*) and Posterior Medial (*p=0.000*) show significant interaction between the ‘group’ and ‘time’ conditions. Consequently, the dependant variables that indicate significant improvement between pre and post testing scores in the experimental group support the given hypothesis, that dynamic ankle balance was improved. The present findings for the investigation display a range of significance of the eight variables which can be subject to influencing factors of the study.

### 5.1.2 Comparing the results

The results of the given investigation correspond with the similar findings found by Leavey, Sandrey and Dahmer, (2010) where the researchers conducted a SEBT as a means of testing the comparative effects of dynamic balance, gluteus medius strength and postural control within a combined six week programme. The results show that posterior medial, posterior and posterior lateral had significant interaction between pre and post scores within the intervention group as opposed to the control group. Leavey *et al.,* (2010) suggest that the reaches within posterior directions were the easiest and undemanding reaches to perform. This harmonises the significant post results of the posterior medial reach; however it is conflicted against posterior and posterior lateral reaches as they did not show any significant interaction between pre and post scores within the experimental group. The intervention programme was comparable to the current study with the purpose of proprioception exercises; however gluteus medius exercises were included as they suggested, gluteus medius strength impacts on postural control. This is dissimilar to the current study, which aims to address the effect of a proprioception intervention on dynamic ankle balance.

In spite of this, a study conducted by Valovich McLeod, Armstrong, Miller and Sauers (2009) investigated the effect of a six week neuromuscular training programme on dynamic balance in basketball athletes. The findings show that anterior medial, medial and posterior presented significant interaction between the group x time ($<0.05$). The intervention similar to the current study incorporated balance and proprioception but contradictory to the current investigation it also included plyometrics, aspects of agility and strengthening exercises. However, the additional implementation of training can determine the significance within the post scores, therefore it can be justified that if further training modalities i.e. plyometric exercises, had been incorporated into the intervention, there may have been an increased improvement in post scores.

Researchers Fitzgerald, Trakarnratanakul, Smyth and Caulfield (2010) conducted a study by looking at the effect of a wobble board training programme on dynamic postural ability by using the means of the SEBT protocol as a baseline measure. The study comprised of 22 healthy participants and randomly assigned to a control and intervention group, similar to the current investigation. The results show that both control and intervention group, demonstrate a significant improvement in pre to post scores within both groups for the posterior medial and posterior lateral directional reach ($p = < 0.008$). This indicates that the participants solely improved within the posterior direction which is dissimilar to the current investigation where participants improved in the posterior medial direction but also anterior and medial reaches. This could be due to participants not performing a given warm up to increase the range of movement, due to the noticeable importance of hip and knee flexion for reach distance and to achieve performance stability (Robinson, Phillip and Gribble, 2008). This can concur as to why the participants within the present investigation did not significantly improve dynamic balance performance over the entire eight reach directions, due to implicating factors such as inadequate range of movement. In addition, Hertel, Braham and Hale Olmsted-Kramer (2006) state that testing the anterior medial, medial and posterior medial reach directions for the SEBT; will give an indication of greater sensitivity and susceptibility to functional deficiencies within chronic ankle instability. This supports the findings of the current studies that anterior medial, medial and posterior medial SEBT reaches significantly improved from pre to post scores, thus insinuates that the participants did not present any ankle instability but improved dynamic ankle balance.

There is a plethora of research that conducts SEBT as means of a baseline measure. The current study looked at the performance over eight reaches of the SEBT, however previous research utilise modified and altered means of the SEBT. It has been suggested that the reaches should be minimised down to three reach directions (posterior medial, anterior and posterior lateral) due to time consumption and variance presented across participants for the eight reach directions (Coughlan, Fullam, Delahunt, Gissane and Caulfield, 2012). However, the participants within the given study did not show variance post scoring of the SEBT as significant improvement was only perceived within four out of the eight directional reaches. In addition, the eight incremented directional reaches were all evaluated to initiate multi directional movements for the given study, as its sport specific suitability is appropriate for taekwondo athletes as opposed to the Y-balance test and modified SEBT.

The SEBT was used within the given investigation as a baseline measure to assess dynamic ankle balance in elite taekwondo athletes. As suggested by Hertel *et al.,* (2006) participants should demonstrate six trials on each directional movement so that the earliest trial of the movement is recorded it will not convey the true outcome of the SEBT performance. As opposed to this, within the current study, the participants were notified to perform three times on each leg, thus suggesting inaccurate results. However Couglan *et al.,* (2012) conducted three trials in concurrence to the present study for the SEBT protocol. In spite of this, three trials were initiated for the Y-balance and modified SEBT which assessed three directional planes of movement. It can be argued that three trials are only needed for Couglan *et al.,* (2012) study, due to the simple three movement patterns as opposed to the eight multidirectional reaches that the SEBT requires. However, Munro and Herrington (2010) state that maximum normalised excursion distance scores are stable following four trials, thus it can be considered to simplify to four trials as opposed to six trials as subsequently recommended by Hertel *et al.,* (2006). Therefore it can be justified that within future research, participants should be required to perform adequate trials before recording results to decrease the learning effect, as this may hinder the reliability of the results.

### 5.1.3 Level of training

The level of training in balance and proprioception amongst the participants can be seen as a contributing factor as to why limited significance was shown within post results. Taekwondo athletes are obligated to be proficient in a number of physical skills as part of their sport. Although there is limited research as to why taekwondo practitioners fail to include proprioception exercises within their training schedules and classes, it has been suggested that balance is trained through techniques such as single leg holding stances and various kicking combinations (Fong *et al.,* 2012). This statement is supported by findings from Leong and Tsang (2011) who stated that taekwondo practitioners have enhanced balance ability as opposed to their sedentary counter parts within the study. The SEBT requires maintaining a base of support without comprising their balance through the movements of the test (Gribble *et al.,* 2003*).*

It can be valued that the SEBT movement patterns are somewhat mimicked within movement styles in taekwondo, which can argue the participants advantageous capability as opposed to individuals who are not recreationally active. The level of training amongst the participants suggests why the all of the SEBT reaches were not significantly improved pre to post testing, due to the athletes having proficient skill in balance.  In addition, the level of balance and proprioceptive ability can be argued to have an impact on the results. Using recreational level athletes or non-sporting individuals for future research, can perhaps produce different results. However, an independent t-test was devised between the control and experimental group to assess any differences in scores at baseline. Therefore, any differences within scores in pre testing were not determined by the level of skill between the groups.

### 5.1.4 Compliance to the study

The compliance to the study should be adhered and distinguished when interpreting the experimental group's results. Each participant within the experimental group failed to attend 100% of the sessions within the programme, jeopardising the effect of the potential to improve proprioceptive capability and dynamic ankle balance. The participants failed to attend an approximated average of one session per individual. However, significant improvements within post scores can imply that several participants attended sessions of the final stages of the programme where the progressions initiate and maximise proprioceptive activity. Conversely, participants that failed to attend sessions that began with basic principles of an exercise but attended a session that comprised of progressions, the participants may have been compromised by not learning the foundations of the skill. The impact of poor attendance on the behalf of the participants reflected on the post scores of the experimental group.

Although there was a significant improvement on three of the SEBT reaches (anterior, medial and posterior medial) a higher compliance to the study could have improved the entire range of post scores amongst the participants. This is supported by researchers Hupperets, Verhagen and Mechelen (2009) who stated that, although the investigation in the prevention of ankle sprain re-occurrence deemed significant, an increase in compliance within the programme could have pronounced significant differences within the groups (control and intervention). For future research, exclusion criteria should be included within the study to ensure the attendance of the participants does not interfere or affect the outcome of the results. This is supported by Valovich McLeod *et al.,* (2009) who excluded participants from post testing if they didn't attend a minimum of 50% of the entire sessions.

## 5.2 Previous Literature

### 5.2.1 Duration of the programme

The length of the programme for the current investigation of six weeks was chosen on the evidence assumed in research on the improvement of ankle balance, proprioception, and the means of the programme being perceived as a suitable modality for the prevention of ankle sprains. Hupperets *et al.,* (2009) and Valovich McLeod *et al.,* (2009) validated, that six week programmes significantly improved proprioception and balance amongst the healthy participants. However it can be argued within the current study, that between the control and intervention group no statistical significance presented in results, due to the proposed length of the programme. This concept is reinforced from findings of Lee and Lin (2009) they discovered that a 12 week proprioception programme significantly developed and improved ankle instability. In concurrence with these findings, researchers Fatma *et al.,* (2010) detected that a proprioception programme with a duration of eight weeks, improved overall postural control in the taekwondo athletes. However, this study is diverse to the study as they tested for postural control on a Biodex system while the present investigation tested for dynamic ankle balance using the SEBT protocol as a baseline measure.

Conversely, studies with as little intervention as four weeks have deemed successful. This is supported by Mattacola *et al.,* (1997) and Clark and Burden, (2005) that programmes with the duration of four and five produced effective and improved results. Furthermore a six week programme was chosen for the present study due vast amounts of research presenting significant results (Holm, *et al.,* 2010; Mattacola *et al.,* 1997; Hupperets *et al.,* 2009; Valovich McLeod *et al.,* 2009). However, it can be disputed that the length of the proposed programme was too short to present a vast significance in the improvement of dynamic ankle balance amongst the participants within the experimental group.

Due to the participants demanding training schedule, they only attended one 30 minute exercise session for six consecutive weeks as several sessions within each week deemed impractical. However, other studies included two sessions a week (Verhagen, Bobbert, Inklaar, Kalken, Beek, Bouter and Mechelen, 2005; Valovich Mcleod, et al., 2009; Malliou, et al., 2004). The ability of having two sessions a week is suggested to increase the reliability and validity of the progressions of each of the exercises. On the other hand, the interpretation of one session per week is considered appropriate and supported by Eils and Rosenbaum (2001).

5.2.2 Content of the programme

Lower extremity exercises were employed and manipulated within this study to stimulate neuromuscular sense amongst the athletes (Baechle *et al.,* 2000). The content of the programme was modified and constructed specifically to the athletes, through previous research. The programme in the given study was aimed to improve proprioceptive acuity and balance amongst the participants within the experimental group. In addition, the exercises incorporated, aimed to activate conscious and unconscious motor programming whilst performing lower extremity exercises integrating dynamic balance (Lephart, Pincervero and Rozzi, 1998). Additionally, static and dynamic balance is intended to improve through exercises due to being formative elements in the prevention of ankle sprain (Kemberley, 2001). Progressions made for each exercise aimed to stress motor control and improve neuromuscular ability (Valvovich Mcleod, *et al.,* 2009).

Utilizing equipment such as wobble boards, trampets and balance disks aims to redevelop cortical pathways and improve overall ankle balance and proprioception (Lephart *et al.,* 1997). In studies that utilised additional training modalities (i.e balance equipment) there has been significant improvement amongst the participants. Conversely, a study conducted by Mattacola *et al.,* (1997) incorporated exercises on a single plane balance board within the intervention and findings presented increased postural control. However, other studies suggest that incorporating and utilizing a range of proprioceptive exercises and equipment will increase motor control and improve and redevelop cortical pathways (Lephart *et al.,* 1997).

Taking this into consideration the exercises involving equipment (trampets, wobble board and balance disks) were progressed each week challenging the participants. Due to familiarisation of the techniques adhered on the equipment; the progressions included diminishing sensory inputs such as visual and vestibular due to the participants relying on these systems within the exercises. When visual input is impaired, the ability to balance can be deemed as challenging (Ergen *et al.,* 2008; Norris, 2011). A study conducted by, Chong, Ambrose, Carzoli, Harbison and Jacobson (2001) stated, due to the nervous system utilizing a variety of sensory systems through proprioceptive activity, participants failed to improve ankle dynamic balance on certain exercises due to the reliance of visual systems. In spite of this, other research indicates that eradicating visual sensory input whilst on trampets and wobbles boards, proprioception at the ankle joint improves (Bernier *et al.,* 1998; Verhagen et al., 2004).

The content of the programme was designed specifically for the participants to their sport. As stated by Gioftsidou and Malliou (2006) it is imperative that proprioceptive and balance programmes ought to be adjusted and particularised to the athletes sport. Within the present study elite athletes were selected due to research suggesting, the vast susceptibility to ankle sprains taekwondo athletes have due to the nature of the sport and level of participation (Wang, 2011). Therefore, exercises within the programme were adapted to their level of skill as opposed to participants that are not physically active within the general population. In addition, findings from a study by Eils, Schroter, Gerss and Rosenbaum (2010) conducted on elite male and female basketball athletes within a six week programme can indicate similarities in results, between the elite taekwondo participants in the current investigation, due to the similar demanding exercises prescribed within the study. However, the programme within the Eils *et al.,* (2010) initiated a multi station programme which was incorporated into the basket baller's regular training, whilst this current study investigated step by step exercises with constructive progressions. The study also assessed for ankle injury occurrence, whereas the present investigation looks to see if the proprioception programme has an effect on dynamic ankle balance. The exercises within the programme each had taekwondo specific progression elements, challenging the participants at sport skill level but also balance and proprioceptive capability was challenged.

## 5.3 Limitations

### 5.3.1 Sample size

The number of participants within this investigation (*n*=16) is considered to be a comparatively small sample as opposed to studies in previous research. Previous studies have used vast sample of participants such as Verghaen *et al.,* (2004) study (*n*= 1127). In addition, studies using larger samples, identify significant improvement in results (McGuine *et al.,* 2006; Panics *et al.,* 2008; Lust, Sandrey, Bulger and Wilder, 2009; Eils *et al.,* 2010). Furthermore, a larger sample should be used for future research to increase reliability of the results and increase the variance of differences in post scores.

### 5.3.2 Gender

The gender within the sample was mixed within the control and experimental group. It can be argued that gender differences can influence the results. This is supported by a study conducted by Gribble *et al.,* (2003), that show there are significant differences between men and women in a range of dynamic and functional measures. The findings of Gribble *et al.,* (2003) study state, that reaching distances were significantly higher for male participants as opposed to female reach scores. Therefore, for future research, the sample should be equal genders to be distributed over control and intervention group. In addition, male and female scores can be compared and analysed within future research due to the influence it can initiate on the results as previously mentioned.

### 5.3.3 Injury prevention

Although the results of the current investigation showed a significant improvement of four out of the eight directional reaches pre to post testing, it is indistinguishable that the six week proprioception programme can prevent ankle injuries. Proprioceptive exercises is intended to prevent the means of ankle injury by strengthening reflexes of the ankle, mechanoreceptors and surrounding muscles and connective tissue (Bahr *et al.,* 2009). This is supported by a study conducted by Mandelbaum, Silvers, Watanbe, Knarr, Thomas, Griffin and Garrett (2005) which findings present that proprioceptive training with a duration of two football seasons resulted in 88 (74%) fewer ACL and lateral ligament ankle injuries when compared with athletes within the control group. Future research within this study should be deliberated in conducting a surveillance reporting system, which records injury incidence and its severity for each participant through the duration of the programme. A reliable surveillance system successfully used within research is the Injury Surveillance System (ISS) (Pieter, Fife and O'Sullivan, 2012). However this must be integrated over longer duration and a larger sample, therefore this has to be further researched.

## 5.4 Strengths

### 5.4.1 Sample type

Previous research has used previously injured participants with a history of ankle sprain or chronic instability (Bernier *et al.,* 1997; Eils *et al.,* 2001; Stasniopoulos, 2004; Schafer *et al.,* 2012). The current study uses healthy participants with no history of ankle sprains. In addition, the use of proprioception programmes with a sample with no history of ankle instability or other concurring injuries is widely un researched, thus provides a rationale for the current study. It has been suggested that using recreational athletes certifies that the results can be generalised due to the vast occurrence of ankle sprains within general population as well as sporting. However, the present study used elite taekwondo athletes due to the importance of dynamic ankle balance placed on the athletes as well as the susceptibility the athletes for ankle injury, due to the adverse movement positions within competition and general training (Zetaruk *et al.,* 2005). This is supported by research conducting studies that employ elite sporting athletes and as a consequence, skill level of proprioception and balance can be liable for the significant improvement in the results (Eils *et al.,* 2001).

The age range of the participants was 18-30 due to the insight in previous research stating that athletes between these ages are more susceptible to ankle injuries. In addition, it has been suggested that there can be a negative relationship between SEBT scores and age. This is supported by Bouillon *et al.,* 2010) who discovered that participants over the age of 60 produced negative results due to degenerative balance deficits; additionally differences in pre to post results were found in young to middle aged participants. Furthermore, the participants in the experimental group within the present study, showed significant improvement in results between pre and post results thus concluding that the six week proprioception programme was effective on dynamic ankle balance within four of the directional reaches of the SEBT.

### 5.4.2 Protocol for baseline measure

There are countless studies that have investigated for dynamic balance ability, postural control and ankle instability. Previous research has identified that the use of force plates, measures dynamic balance with participants with ankle instability (Malliou *et al.,* 2004; Yen *et al.,* 2008; Fatma et al., 2010). However the current study looked to investigate dynamic ankle balance with healthy participants. Therefore a specific appropriate protocol should be adhered, as suggested by research. The Y balance test as suggested by Plisky *et al.,* (2009) is an improved adapted SEBT due its improved reliability of using an instrumented device, a reach indicator. This allows the researcher to record the measurements effectively without the miss interpretation of results by human error. However, the Y balance test only assesses dynamic balance through three planes of movement (Anterior, Posterior lateral and Posterior medial) which limits the test being specific to taekwondo athletes. Therefore, due to the multidirectional incremented reaches of the test, the SEBT was initiated for the present study.

The current study is coherent with that of previous studies that look at the effect of exercises intervention when using SEBT as a means of a base line measure (Filipa, Byrnes, Paterno, Myer and Hewett, 2010). Sarshin, Mohammadi and Por (2011) state that when performing the SEBT, surrounding muscles and the joints stabilising the lower limb, active and sensitive proprioceptive and neuromuscular control are vital to remain balanced in single leg stance, whilst performing the reaches. This also supports the current study, as taekwondo athletes must obtain balance through various kicking techniques whilst in a single leg stance. However there is a gap in the research of the use of the SEBT to assess the effect of dynamic ankle balance after a six week proprioception programme in healthy participants. Furthermore the findings of this current study can be added within literature; thus it can be justified that the SEBT is an appropriate baseline measure for dynamic ankle balance.

### 5.4.3 Practical implications

The aim of the current investigation was to assess the effect of a six week proprioception programme on dynamic ankle balance in elite taekwondo athletes. In spite of this, it is important to distinguish studies that have analysed proprioception programmes that reduce the risk of ankle injuries and the use of proprioception as a means of ‘prehabiliation’ for the prevention and re-occurrence of lower limb injury. In addition, the findings of the present study show that the effect of the six week proprioception intervention programme improved dynamic ankle balance due to the increase in scores in four out of eight reaches of the SEBT. Therefore the given hypothesis of the study can be assumed. The findings of the results are in agreement with previous studies Hertel *et al.,* (2006) and Fitzgerald *et al.,* (2010). As a result of the significant findings, it can be perceived that the proprioception exercises adhered within the programme permitted the participants to improve neuromuscular ability, motor control and balance. However, the findings within the present study did not show significance for all of the eight directional reaches which can argue whether the proprioception programme can be used as a means of injury prevention. Nonetheless, the present study had several strengths and limitations which could have affected the significance and reliability of the results.

## 5.5 Future research

The SEBT protocol is a dynamic single limb balance test that examines dynamic balance (Bressel *et al.,* 2007; Hale, Hertel and Olmstead-Kramer, 2007) and is also recognised as a predictor of lower extremity injury (Aminaka and Gribble, 2008; Aggarwal, Zutshi, Munjal, Kumar and Sharma, 2010). Future research should consider substantiating the reliability of the protocol due to previous researching suggesting altered and improved variations of the SEBT such as the Y-balance test and force place measurements. But due to the SEBT being cost effective and equipment and instrumentation was minimalized, it deemed appropriate for the current study.

It should be considered that the SEBT protocol may be used alongside the proprioception programme as a means of training. In addition for future research exercise intervention such as plyometrics, agility and strengthening of the surrounding lower extremity can influence a greater significance within the results. This was proven lucrative for researchers Valovich McLeod *et al.,* (2009) who discovered that proprioception interventions that included agility, plyometrics and strengthening improved dynamic balance results between pre and post testing.

The current studies programme had duration of six weeks. While researchers Lee *et al.,* (2009) and Fatma *et al.,* (2010) used 12 and eight week programmes which presented significant improvement in scores. Therefore, it should be considered to construct a proprioception intervention with a longer duration to stimulate a greater significance in results specifically to the reaches within the SEBT that did not show any statistical significance in the current research.

The existing study looked to improve dynamic ankle balance through a six week proprioception programme, with an indication whether it could prevent ankle injuries. However within the present study, there was no direct analysis whether the participants were at a reduced risk of injury. Within future research, a record of injuries occurring throughout the programme should be recorded as a means of a surveillance system.

To conclude, the six week proprioception programme improved dynamic ankle balance amongst the athletes within the experimental group; thus can be deemed as an appropriate intervention to include in taekwondo training. Maintaining a prolonged programme by incorporating it into a training regime will increase further performance; furthermore it can also act as means of a ‘prehabilaition’ for the prevention of ankle sprains. Furthermore, within future research, limitations should be scrutinised in attempt to reinforce and fortify future studies.

# CHAPTER VI

## CONCLUSION

## 6.0 Conclusion

The aim of the study was to establish whether a six week proprioception programme improved ankle balance amongst healthy elite taekwondo athletes. In addition, the improvement of dynamic ankle balance amongst the athletes can predict whether the participants are at reduced risk for ankle injury. The baseline measure used within the current investigation was the Star Excursion Balance Test (SEBT). The outcome of the results can instigate that proprioceptive training is imperative within a taekwondo athletes training regime thus decreasing the chances of ankle sprains, a predisposing injury to the elite athletes.

Ankle injury posits as a common injury amongst athletes and general population (Fong *et al.,* 2007; Bahr *et al.,* 2009; Norris *et al.,* 2011). Ankle sprains occurring in taekwondo are common and transpire in competitive environments as well as training (Wang, 2011). As previously mentioned, by identifying communal injuries, preventive strategies can be produced. Several prophylactic modalities for the ankle where used as means of injury prevention such as taping and bracing, however they deem expensive and it has been suggested that it can decrease performance in sporting athletes (Baura *et al.,* 2005). Therefore proprioception programmes have been investigated as a reliable, cost effective method in the prevention of injury.

The main findings of the study present that dynamic ankle balance had a significant interaction between pre and post scores of the intervention group of four multidirectional reaches of the SEBT. The anterior ($p= 0.000$) medial ($p=0.002$) and posterior medial ($p=0.000$) all show significant differences pre to post testing within the experimental group. Therefore the results support the given hypothesis that dynamic ankle balance can be improved from a six week proprioception programme. However, it can be justified that many factors affected the impact of the results, such as the small sample size. Previous researchers used greater sample sizes and have proved significant results (McGuine *et al.,* 2006; Panics *et al.,* 2008; Lust, et al., 2009; Eils *et al.,* 2010). Therefore a larger sample size should be adhered to increase reliability in results. Conversely, previous research suggests that a larger duration of the intervention produces a greater significance in results. This is supported by Lee *et al.,* (2009) who conveyed a 12 week programme as opposed to a six week programme and Fatma *et al.,* who analysed an eight week programme.

It is believed that the improvement of pre to post scores within the experimental group is due to the exercise content of the proprioception programme. The aim of the intervention within the group was to improve dynamic balance, enhance joint and body positioning and stress neuromuscular control (Kemberley, 2001; Valovich McLeod *et al.,* 2010). It was anticipated, that movement patterns within the exercises incorporated within the programme were to strengthen and stabilise the ankle. Progressions were made within the study with the use of equipment such as wobble boards and trampets to challenge the participants. In addition progressions were constructed to stress motor control and challenge visual and vestibular systems (Lephart *et al.,* 1998). However the exercises do not precisely correspond with those in previous studies; conversely the exercises within the given study were adapted from previous exercises used within proprioception programmes and were constructed specifically for the taekwondo participants.

In summary, this study provides a considerate understanding and employment in the use of a six week proprioception programme in the improvement of ankle balance. However, limitations of the study should be noted and refined for greater significance and improvement within future research.

# CHAPTER VII

## REFERENCES AND APPENDICES

Aggarwal, A., Zutshi, K., Munjal, J., Kumar, S., & Sharma, V. (2010). Comparing stabilization training with balance training in recreationally active individuals. *International Journal Rehabilitation Therapy*, **17** (1), 244-251.

Aminaka, N., & Gribble, P. A. (2008). Patellar taping, patellofemoral pain syndrome, lower extremity kinematics and dynamic postural control. *Journal of Athletic Training*, **43,** 21-28.

Arminger, P., & Martyn, M (2010). *Stretching for Functional Stretching*. Baltimore: Lippincott Williams & Wilkins. 105-108.

Ashton-Miller, J. A., Wojtys, E. M., Huston, L. J., & Fry-Welch, D. (2001). Can proprioception really be improved by exercises?. *Knee surgery, sports traumatology, arthroscopy*, **9** (3), 128-136.

Ayer, J. (2009). *World Taekwondo Federation.* Available: http://www.wtf.org/wtf_eng/main/main_eng.html. [Last accessed 31.4.11].

Baechle, T., & Earle, R (2000). *Essentials of Strength Training and Conditioning*. USA: Human Kinetics. 537.

Bahr, R., & Engebretsen, L (2009). *Sports Injury Prevention*. West Sussex: Blackwell Publishing . 40-44.

Balint, G., & Spulber, F. (2011). Testing the Dynamic and Proprioception in a Team of Romanian Jumping Athletes. *Journal of Physical Education in Sport*, **12** (1), 46-49.

Baura, N., & Roosen, A. (2005). *Martial Arts Injuries Prevention and Management*. Ramsbury (UK): The Crosswood Press. 111-167.

Berg, K., & Latin, R (2004). *Research methods in health, physical education, exercise science and recreation* . USA: Lippincott Williams & Wilkins. 18-19.

Bernier, J., & Perrin, D. (1998). Effect of Coordination Training on Proprioception of the Functionally Unstable Ankle. *Journal of Orthopaedic and Sports Physical Therapy*, **27** (1), 264-275.

Bouillon, L., & Baker, J. (2011). Dynamic Balance Differences as Measured by the Star Excursion Balance Test Between Adult-aged and Middle-aged Women . *Journal of Sports Physical Therapy*, **1** (1), 466-468.

British Taekwondo Control Board. (2005). *British Taekwondo*. Available: http://www.britishtaekwondo.org.uk/what-is-taekwondo.html.[Last accessed 31.4.11].

Bressel, E., Yonker, J.C., Kras, J., & Heath, E.M. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. *Journal of Athletic Training,* **43** (3), 357-373.

Bridge, C., Jones, M., & Drust, B. (2011). The Activity Profile in International Taekwondo Competitions Modulated by Weight Category. *International Journal of Sports Physiology and Performance*, **6** (1), 344-346.

Brummit, J. (2012). Assessing Athletic Balance with the Star Excursion Balance Test. *NSCA Performance Training Journal*, **7** (3), 7.

Burke, D. R. (1981). *Treating Martial Arts Injuries.* 1st ed. Burbank (CA): Ohara Publications. 17-9.

Callaghan, M. J. (1997). Role of ankle taping and bracing in the athlete. *British Journal of Sports Medicine*, **31** (2), 102-108.

Casolino, E., Lupo, C., Cortis, C., Chiodo, S., Minganti, C., Capranica, L., & Tessitore, A. (2012). Technical and tactical analysis of youth taekwondo performance. *The Journal of Strength & Conditioning Research*, **26** (6), 1489-1494.

Chong, R. K., Ambrose, A., Carzoli, J., Harbison, L., & Jacobson, B. (2001). Source of improvement in balance control after a training program for ankle proprioception. *Perceptual and Motor Skills*, **92** (1), 265-272.

Clark, V. M., & Burden, A. M. (2005). A 4-week wobble board exercise programme improved muscle onset latency and perceived stability in individuals with a functionally unstable ankle. *Physical therapy in sport*, **6** (4), 181-187.

Coughlan, G. F., Fullam, K., Delahunt, E., Gissane, C., & Caulfield, B. M. (2012). A Comparison Between Performance on Selected Directions of the Star Excursion Balance Test and the Y Balance Test. *Journal of Athletic Training*, **47** (4), 366-371.

Demura, S., & Yamada, T. (2010). Proposal for a practical star excursion balance test using three trials with four directions. *Sport Sciences for Health*, **6** (1), 1-8.

Eils, E., Rosenbaum, D. (2001). A multi-station proprioceptive exercise program in patients with ankle instability. *Medicine and Science in Sports and Exercise*, **33** (12), 1991-1998.

Eils, E., Schröter, R., Schröder, M., Gerss, J., & Rosenbaum, D. (2010). Multistation proprioceptive exercise program prevents ankle injuries in basketball. *Medicine and science in sports and exercise*, **42** (11), 2098-2100.

Ergen, E., & Ulkar, B. (2008). Proprioception and ankle injuries in soccer. *Clinics in Sports Medicine*, *27*(1), 195-217.

Evarts, E. V. (1981). Sherrington's concept of proprioception. *Trends in Neurosciences*, **4**, 44-46.

Fatma, A., Kaya, M., Baltaci, G., Taskin, H., & Erkmen, N. (2010). The Effect of an Eight Week Proprioception Training Programme on Dynamic Postural Control in Taekwondo Athletes. *Journal of Science Sport and Health*, **10** (1), 93-96.

Feehan, M., & Waller, A. (1995). Precompetition injury and subsequent tournament performance in full-contact taekwondo. *British Journal Sports Medicine*, **29** (4), 258-262.

Filipa, A., Byrenes, R., Paterno, M., Gregory, D., Hewett., T. (2010). Neuromuscular training improves performance on the star balance excursion balance test in young female athletes. *The Journal of Orthopaedic and Sports Physical Therapy,* **40** (9), 551.

Fitzgerald, D., Trakarnratanakul, N., Smyth, B., & Caulfield, B. (2010). Effects of a wobble board-based therapeutic exergaming system for balance training on dynamic postural stability and intrinsic motivation levels. *Journal of Orthopaedic Sports Physical Therapy*, **40** (1), 11-19.

Fong, S. S. M., Cheung, C. K. Y., Ip, J. Y., Chiu, J. H. N., Lam, K. L. H., & Tsang, W. W. N. (2012). Sport-specific balance ability in Taekwondo practitioners. *Journal of Human and Exercise Science,* **7** (2), 520-524.

Fong, D. T. P., Hong, Y., Chan, L. K., Yung, P. S. H., & Chan, K. M. (2007). A systematic review on ankle injury and ankle sprain in sports. *Journal of Sports Medicine*, **37** (1), 73-94.

Fong, S. S., & Gabriel, Y. (2011). Does Taekwondo training improve physical fitness. *Physical Therapy in Sport*, **12** (2), 100-106.

Freeman, M. A. R. (1965). Instability of the foot affer injuries to the lateral ligament of the ankle. *Journal of Bone & Joint Surgery, British Volume*, **47** (4), 669-677.

Gioftsidou, A. F., & Malliou, P. K. (2006). Preventing lower limb injuries in soccer players. *Strength & Conditioning Journal*, **28** (1), 10-13.

Gribble, P., & Hertel, J. (2003). Considerations for normalizing measures of the star excursion balance test. *Measurement in Physical Education and Exercise Science*, **7** (2), 89-100.

Gribble, P., Hertel, J., & Plisky, P. (2012). Using the Star Excursion Balance Test to Assess Dynamic Posturai-Control Deficits and Outcomes in Lower Extremity Injury: A Literature and Systematic Review . *Journal of Athletic Training*, **47** (3), 339-353.

Hale S. A., Hertel, J., & Olmstead-Kramer, L. C. (2007). The effect of a 4-week comprehensive rehabilitation programme on postural control and lower extremity function in individuals with chronic ankle instability. *Journal of Orthopaedic Sports Physical Therapy*, **37** (3), 303-311.

Hertel, J. (2008). Sensorimotor deficits with ankle sprains and chronic ankle instability. *Clinics in Sports Medicine*, **27** (3), 353-370.

Hertel, J., Braham, R. A., Hale, S. A., & Olmstead-Kramer, L. C. (2006). Simplifying the star balance excursion test: Analyses of subjects with and without chronic ankle instability. *Journal of Orthopaedic  Sports Physical Therapy*, **36**, 131-137.

Holm, I., Fosdahl, M. A., Friis, A., Risberg, M. A., Myklebust, G., & Steen, H. (2004). Effect of neuromuscular training on proprioception, balance, muscle strength, and lower limb function in female team handball players. *Clinical Journal of Sport Medicine*, **14** (2), 88-94.

Hosseinimehr, H., & Norasteh, A. (2010). The Role of Leg and Trunk Muscles Proprioception on Static and Dynamic Postural Control. *Journal of Sport Education and Sport*, **26** (1), 83-85.

Hupperets, M. D., Verhagen, E. A., & Van Mechelen, W. (2009). Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. *BMJ: British Medical Journal*, 1-6.

Kaminski, T., Buckley, B., Powers, M., Hubbard, T., & Ortiz, C. (2003). Effect of strength and proprioception training on eversion to inversion strength ratios in subjects with unilateral functional ankle instability . *British Journal of Sports Medicine*, **37** (1), 410-415.

Kazemi, M. (2011). Relationships between injury and success in elite taekwondo athletes. *Journal of Sports Sciences*, **30** (3), 279.

Kazemi, M., Chudolinski, A., Turgeon, M., Simon, A., Ho, E., & Coombe, L. (2009). Nine year longitudinal retrospective study of Taekwondo injuries. *JCCA*, **53** (4), 272-281.

Kazemi, M., Shearer, H., & Choung, Y. S. (2005). Pre-competition habits and injuries in Taekwondo athletes. *BMC Musculoskeletal Disorders*, **6** (1), 26.

Kemerley, A.S. (2001) The Effects of External Martial Arts Training on Selected Measures of Balance. *Doctor of Philosophy Degree The University Of Mississippi.* ***7*** (12), 100.

Kim, H. B., Stebbins, C. L., Chai, J. H., & Song, J. K. (2011). Taekwondo training and fitness in female adolescents. *Journal of Sports Sciences*, **29** (2), 133-138.

Leavey, V. J., Sandrey, M. A., & Dahmer, G. (2010). Comparative effects of 6-week balance, gluteus medius strength, and combined programs on dynamic postural control. *Journal of Sports Rehabilitation*, **19** (3), 268-287.

Lee, A. J., & Lin, W. H. (2008). Twelve-week biomechanical ankle platform system training on postural stability and ankle proprioception in subjects with unilateral functional ankle instability. *Clinical Biomechanics,* **23** (8), 1065-1072.

Leong, H. T., Fu, S. N., Ng, G. Y., & Tsang, W. W. (2011). Low-level Taekwondo practitioners have better somatosensory organisation in standing balance than sedentary people. *European Journal of Applied Physiology*, **111** (8), 1787-1793.

Lephart, S. M., & Fu, F. H. (2000). *Proprioception and neuromuscular control in joint stability*. Human Kinetics: preface xvii.

Lephart, S., Pincivero, D., Giraido, J., & Fu, F. (1997). The Role of Proprioception in the Management and Rehabilitation of Athletic Injuries. *The American Journal of Sports Medicine*, **25** (1), 130-136.

Lephart, S. M., Pincivero, D. M., & Rozzi, S. L. (1998). Proprioception of the ankle and knee. *Sports medicine*, **25** (3), 149-155.

Lust, K. R., Sandrey, M. A., Bulger, S. M., & Wilder, N. (2009). The effects of 6-week training programs on throwing accuracy, proprioception, and core endurance in baseball. *Journal of sport rehabilitation*, **18** (3), 407-409.

Lystad, P., Pollard, H., & Graham, P. (2009). Epidemiology of injuries in competition taekwondo: A meta-analysis of observational studies. *Journal of Science and Medicine in Sport*, **12** (1), p614-621.

Malliou, P., Gioftsidou, A., Pafis, G., Beneka, A., & Godolias, G. (2004). Proprioceptive training (balance exercises) reduces lower extremity injuries in young soccer players. *Journal of Back and Musculoskeletal Rehabilitation*, **17** (1), 101-104.

Mandelbaum, B. R., Silvers, H. J., Watanabe, D. S., Knarr, J. F., Thomas, S. D., Griffin, L. Y.,  & Garrett, W. (2005). Effectiveness of a Neuromuscular and Proprioceptive Training Program in Preventing Anterior Cruciate Ligament Injuries in Female Athletes 2-Year Follow-up. *The American journal of sports medicine*, **33** (7), 1003-1010.

Mattacola, C., & Lloyd, J. (1997). Effects of a 6 Week Strength and Proprioception Training Programme on Measures of Dynamic Balance: A single case design. Journal of Athletic Training, **32** (2), 129-13.

McCurdy, K., & Langford, G. (2006). The Relationship between Maximum Unilateral Squat Strength and Balance in Young Adult Men and Women. *Journal of Sports Science and Medicine*, *5*, 282-288.

McGuine, T. A., & Keene, J. S. (2006). The effect of a balance training program on the risk of ankle sprains in high school athletes. *The American Journal of Sports Medicine*, **34** (7), 1103-1111.

Moneig, U. (2011). The Evolution of Kicking Techniques in Taekwondo. *Journal of Asian Martial Arts*. 20 (1), 8-29.

Munro, A. G., Herrington, L. C. (2010). Between-session reliability of the star excursion balance test. *Physical Therapy in Sport*, **11** (4), 128-132.

Norris, C (2004). *Sports Injuries Diagnosis and Management*. 3rd ed. London: Elsevier Limited. 272-273.

Nyska, M., & Mann, G. (2002). *The unstable ankle*. Human Kinetics Publishers: 193-197.

Ogard, W. K. (2011). Proprioception in Sports Medicine and Athletic Conditioning. *Strength & Conditioning Journal*, **33** (3), 111.

Olmstead, L., Carcia, C., Hertel, J., & Shultz, S. (2002). Efficacy of the Star Excursion Balance Tests in Detecting Reach Deficits in Subjects with Chronic Ankle Instability. *National Athletic Trainers' Association, Inc. Pub Med,* **37** (4), 501-506.

Olmsted, L. C., Vela, L. I., Denegar, C. R., & Hertel, J. (2004). Prophylactic ankle taping and bracing: a numbers-needed-to-treat and cost-benefit analysis. *Journal of Athletic Training*, **39** (1), 95.

Osborne, M. D., & Rizzo, J. T. (2003). Prevention and treatment of ankle sprain in athletes. *British Journal of Sports Medicine*, **33** (15), 1145-1150.

Panics, G., Tallay, A., Pavlik, A., & Berkes, I. (2008). Effect of proprioception training on knee joint position sense in female team handball players. *British Journal of Sports Medicine*, **42** (6), 472-476.

Pieter, W. (1996). Martial arts. *Epidemiology of Sports Injuries*, 268-283.

Pieter, W., Fife, G. P., & O'Sullivan, D. M. (2012). Competition injuries in taekwondo: a literature review and suggestions for prevention and surveillance. *British Journal of Sports Medicine*, **46** (7), 485-491.

Plisky, P., Gorman, P., Butler, R., Kiesel, K., Underwood, F., & Elkins, F. (2009). The Reliability of an Instrumented Device for Measuring Components of the Star Excursion Balance Test. *North American Journal of Sports Physical Therapy*, **4** (2), 92-93.

Raymond, J., Nicholson, L. L., Hiller, C. E., & Refshauge, K. M. (2012). The effect of ankle taping or bracing on proprioception in functional ankle instability: A systematic review and meta-analysis. *Journal of Science and Medicine in Sport*, 15 (5), 386-392.

Robinson, R. H., & Gribble, P. A. (2008). Support for a reduction in the number of trials needed for the Star Excursion Balance Test. *Archives of Physical Medicine and Rehabilitation*, **89** (2), 364-370.

Romero-Franco, N., Martínez-López, E., Lomas-Vega, R., Hita-Contreras, F., & Martínez-Amat, A. (2012). Effects of Proprioceptive Training Program on Core Stability and Centre of Gravity Control in Sprinters. *The Journal of Strength & Conditioning Research*, **26** (8), 2071-2077.

Ross, S. E., Linens, S. W., Wright, C. J., & Arnold, B. L. (2011). Balance assessments for predicting functional ankle instability and stable ankles. *Gait & posture*, **34** (4), 539-542.

Sarshin, A., Mohammadi, S., & Por, H. B. (2011). The effects of functional fatigue on dynamic postural control of badminton players as measured by Y balance test. *Biology of Exercise*, **7** (2), 26-31.

Schaefer, J. L., & Sandrey, M. A. (2012). Effects of a 4-Week Dynamic-Balance-Training Program Supplemented With Graston Instrument-Assisted Soft-Tissue Mobilization for Chronic Ankle Instability. *Journal of Sport Rehabilitation*, **21** (4), 313.

Siana, J. E., Borum, P., & Kryger, H. (1986). Injuries in taekwondo. *British Journal of Sports Medicine*, **20** (4), 165-166.

Stasinopoulos, D. (2004). Comparison of three preventive methods in order to reduce the incidence of ankle inversion sprains among female volleyball players. *British Journal of Sports Medicine*, **38** (2), 182-185.

Terry, C. M. (2006). The martial arts. *Physical Medicine Rehabilitation Clinic N Am*, **17** (3), 645-76.

Valovich McLeod, T. C. (2008). The Effectiveness of Balance Training Programs on Reducing the Incidence of Ankle Sprains in Adolescent Athletes. *Journal of Sport Rehabilitation,* **17** (1), 316-323.

Valovich McLeod, T. C., Armstrong, T., Miller, M., & Sauers, J. L. (2009). Balance improvements in female high school basketball players after a 6-week neuromuscular-training program. *Journal of Sport Rehabilitation*, **18** (4), 465.

Verhagen, E. A. L. M., & Bay, K. (2010). Optimising ankle sprain prevention: a critical review and practical appraisal of the literature. *British Journal of Sports Medicine*, **44** (15), 1082-1088.

Verhagen, E., Bobbert, M., Inklaar, M., Van Kalken, M., Van Der Beek, A., Bouter, L., & Van Mechelen, W. (2005). The effect of a balance training programme on centre of pressure excursion in one-leg stance. *Clinical Biomechanics*, **20** (10), 1094-1100.

Verhagen, E., Van Der Beek, A., Twisk, J., Bouter, L., Bahr, R., & Van Mechelen, W. (2004). The effect of a proprioceptive balance board training program for the prevention of ankle sprains a prospective controlled trial. *The American Journal of Sports Medicine*, **32** (6), 1385-1393.

Vormittag, K., Calonje, R., & Briner, W. (2009). Foot and Ankle Injuries in the Barefoot Sports. *American College of Sports Medicine*, **8** (5), 262-266.

Wang, R. (2011). The Twist 'Fit to Fight' . *Royal College of Physicians and Surgeons of Canada - Blackbelt publishers,* **3** (1), 38.

World Taekwondo Federation. (2009). *www.wtf.org.* Available: http://www.wtf.org/wtf_eng/site/about_taekwondo/taekwondo.html.[Last accessed 31.2.11]

Yen, S. R., & Fu, L. L. (2008). Dynamic Balance Assessed by Force Plate and Star Excursion Balance Test in Taekwondo Athletes with Ankle Instability. *Journal of Medicine & Science in Sports & Exercise*, **40** (5), 441.

Zetaruk, M. N., Violan, M. A., Zurakowski, D., & Micheli, L. J. (2005). Injuries in martial arts: a comparison of five styles. *British Journal of Sports Medicine*, **39** (1), 29-33.

Ziaee, V., Rahmani, S., & Rostami, M. (2010). Injury rates in Iranian Taekwondo athletes; a prospective study. *Asian Journal of Sports Medicine*, **1** (1), 24-27.

# APPENDIX A

**A1: CARDIFF METROPOLITAN PARTICIPATION SHEET**

**CARDIFF SCHOOL OF SPORT**
**RESEARCH PARTICIPATION SHEET**

**Project Title:** The effect of a six week proprioception programme on dynamic ankle balance in elite Taekwondo athletes

This document will provide a run through of the following …

1) the aim and brief background of the research
2) my role as the researcher,
3) your role as a participant,
4) beneficial aspects in taking part
5) how data will be collected
6) how the data / research will be used.

The purpose of this document is to assist you in making an *informed* decision about whether you wish to be included in the project, and to promote the research of the study.

**1) Background and aims of the research**

Ankle ligament sprains are common amongst martial artists and are frequent within taekwondo. There are gaps within the research in proprioception training not included within taekwondo training regimes. Researchers believe that proprioception training exercises and programmes can aid the prevention in ankle ligament sprains and improve pre disposing factors such as dynamic ankle balance and instability. The aim of this study is to see if the effect of a proprioception programme improves dynamic ankle balance in elite Taekwondo athletes.

**2) My role as the researcher:**

The project involves me Olivia (the researcher) who will be supervising and conducting the testing procedures for both the control and intervention group. I will also be supervising and instructing the proprioception programme at every session for the entire six weeks.

**3) Your role as a participant:**

Your role within the control group will be to take part within the Star Excursion Balance Test (SEBT) and repeat after six weeks. Your role within the intervention group is to do the same protocol as the control group, but also take part within a six week proprioception programme as well as your training regime with the control group.

**4) Benefits of taking part:**

You will be able to know and find out how good your balance in both groups, experience something new and having a good sense of praise for taking part and helping the research study take place. Participants within the intervention group will be able to experience proprioception exercises and will begin to learn the reasons why you as athletes will benefit from the exercises physically and how they will also prevent you from injury or reoccurrence.

**5) How data will be collected:**
As alluded to above, data will be collected from the measurements in centimeters (CM) within the test pre and post the programme.

**6) How the data / research will be used:**
In agreeing to become a *voluntary* participant, you will be allowing me to use your test results to compare against both groups, pre and post the programme. The data will be analysed to discover the outcome of the study. Your personal data will be anonymous and will not be reported alone, but within the total sample of participants.

## Your rights

Your right as a *voluntary* participant is that you are free to enter or withdraw from the study at any time. This simply means that you are in full control of the part you play in informing the research, and what *anonymous* information is used in its final reporting.

## Protection to privacy

Concerted efforts will be made to hide your identity in any written transcripts, notes, and associated documentation that inform the research and its findings. Furthermore, any personal information about you will remain *confidential* according to the guidelines of the Data Protection Act (1998).

## Contact

If you require any further details, or have any outstanding queries, feel free to contact me by email below.

Olivia Hall Van Laere
Undergraduate Bsc Hons, Sports Conditioning Rehabilitation and Massage
st10001845@outlook.uwic.ac.uk
oliviahallvanlaere@hotmail.co.uk

**A-2: INFORMED CONSENT FORM**

# CARDIFF SCHOOL OF SPORT
# INFORMED CONSENT FORM

CSS Reference No:
Title of Project: The effect of proprioception intervention programme on dynamic ankle balance in elite Taekwondo athletes
Name of Researcher: Olivia Hall Van Laere

---

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet dated ………. for this evaluation study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that it is possible to stop taking part at any time, without giving a reason. ☐

3. I also understand that if this happens, our relationships with the Cardiff Metropolitan University, or our legal rights will not be affected ☐

4. I understand that information from the study may be used for
Reporting purposes, but I will not be identified. ☐

5. I agree to take part in this study on ….<u>THE EFFECT OF A SIX WEEK PROPRIOCEPTION PROGRAMME ON DYANMIC ANKLE BALANCE IN ELITE TAEKWONDO ATHLETES.</u> ☐

Name of Participant

________________________________________
Signature of Participant
Date:

________________________________________
Name of person taking consent
Date:

________________________________________
Signature of person taking consent

________________________________________

# APPENDIX B

# B-1: Independent Samples T-Test

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| anteriorpre | Equal variances assumed | 1.066 | .319 | 1.838 | 14 | .087 | 2.78250 | 1.51378 | -.46423 | 6.02923 |
| | Equal variances not assumed | | | 1.838 | 11.851 | .091 | 2.78250 | 1.51378 | -.52033 | 6.08533 |
| antmedialpre | Equal variances assumed | 2.140 | .166 | .934 | 14 | .366 | 1.35875 | 1.45430 | -1.76042 | 4.47792 |
| | Equal variances not assumed | | | .934 | 11.463 | .369 | 1.35875 | 1.45430 | -1.82645 | 4.54395 |
| medialpre | Equal variances assumed | 1.404 | .256 | 2.228 | 14 | .043 | 4.51063 | 2.02455 | .16839 | 8.85286 |
| | Equal variances not assumed | | | 2.228 | 12.972 | .044 | 4.51063 | 2.02455 | .13587 | 8.88538 |
| postmedpre | Equal variances assumed | .341 | .569 | 1.497 | 14 | .156 | 2.95187 | 1.97134 | -1.27622 | 7.17997 |
| | Equal variances not assumed | | | 1.497 | 13.274 | .158 | 2.95187 | 1.97134 | -1.29803 | 7.20178 |
| posteriorpre | Equal variances assumed | .658 | .431 | -.139 | 14 | .891 | -.37812 | 2.71568 | -6.20267 | 5.44642 |
| | Equal variances not assumed | | | -.139 | 13.986 | .891 | -.37812 | 2.71568 | -6.20321 | 5.44696 |
| postlatpre | Equal variances assumed | .231 | .639 | -.404 | 14 | .692 | -.81000 | 2.00494 | -5.11017 | 3.49017 |
| | Equal variances not assumed | | | -.404 | 12.775 | .693 | -.81000 | 2.00494 | -5.14917 | 3.52917 |
| lateralpre | Equal variances assumed | 2.004 | .179 | -.790 | 14 | .443 | -1.91687 | 2.42702 | -7.12231 | 3.28856 |
| | Equal variances not assumed | | | -.790 | 11.805 | .445 | -1.91687 | 2.42702 | -7.21457 | 3.38082 |
| antlatpre | Equal variances assumed | .561 | .466 | -.355 | 14 | .728 | -.51063 | 1.43760 | -3.59397 | 2.57272 |
| | Equal variances not assumed | | | -.355 | 10.149 | .730 | -.51063 | 1.43760 | -3.70745 | 2.68620 |

# B-2: Two way mixed model ANOVA (test within-subject contrasts)

## Anterior

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | Anterior | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Anterior | Linear | 8.125 | 1 | 8.125 | 6.302 | .025 |
| Anterior * group | Linear | 34.913 | 1 | 34.913 | 27.078 | .000 |
| Error(Anterior) | Linear | 18.051 | 14 | 1.289 | | |

## Anterior Medial

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | Anteriormedial | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Anteriormedial | Linear | 16.131 | 1 | 16.131 | 5.439 | .035 |
| Anteriormedial * group | Linear | 10.024 | 1 | 10.024 | 3.380 | .087 |
| Error(Anteriormedial) | Linear | 41.525 | 14 | 2.966 | | |

## Medial

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | Medial | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Medial | Linear | 16.524 | 1 | 16.524 | 3.493 | .083 |
| Medial * group | Linear | 71.207 | 1 | 71.207 | 15.051 | .002 |
| Error(Medial) | Linear | 66.236 | 14 | 4.731 | | |

## Posterior Medial

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | PostMedial | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| PostMedial | Linear | 4.824 | 1 | 4.824 | 1.545 | .234 |
| PostMedial * group | Linear | 69.075 | 1 | 69.075 | 22.121 | .000 |
| Error(PostMedial) | Linear | 43.716 | 14 | 3.123 | | |

## Posterior

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | Posterior | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Posterior | Linear | 6.007 | 1 | 6.007 | 3.803 | .071 |
| Posterior * group | Linear | 6.112 | 1 | 6.112 | 3.869 | .069 |
| Error(Posterior) | Linear | 22.114 | 14 | 1.580 | | |

## Posterior Lateral

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | PosteriorLateral | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| PosteriorLateral | Linear | .689 | 1 | .689 | .533 | .477 |
| PosteriorLateral * group | Linear | .026 | 1 | .026 | .020 | .889 |
| Error(PosteriorLateral) | Linear | 18.099 | 14 | 1.293 | | |

## Lateral

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | Lateral | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Lateral | Linear | 5.536 | 1 | 5.536 | 2.781 | .118 |
| Lateral * group | Linear | 6.169 | 1 | 6.169 | 3.098 | .100 |
| Error(Lateral) | Linear | 27.874 | 14 | 1.991 | | |

## Anterior Lateral

**Tests of Within-Subjects Contrasts**

Measure: MEASURE_1

| Source | AnteriorLateral | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| AnteriorLateral | Linear | .030 | 1 | .030 | .032 | .860 |
| AnteriorLateral * group | Linear | .009 | 1 | .009 | .010 | .921 |
| Error(AnteriorLateral) | Linear | 12.807 | 14 | .915 | | |

# APPENDIX C

## C-1: Proprioception intervention with progression week 1-6

| Exercise | Description | Week 1-2 | Week 3-4 | Week 5-6 |
|---|---|---|---|---|
| **Stork Stand (McCurdy and Langford, 2006).** | -Foot of the floor, single leg stand<br>-Cross arms across chest<br>-Maintain balance<br>-To be performed on both legs | -Maintain balance for 30 seconds | -Maintain balance for 40 seconds<br>-Eyes closed | -Maintain balance for 1 minute<br>-Eyes closed<br>-Partner asks them questions while balancing, to challenge them further<br>**Week 6: x2** |
| **Dura-disk (balance disc)** | -Single leg balance<br>-Maintain postural control<br>-Avoid falling of the disk<br>-To be performed on both legs | **1st exercise**<br>-Maintain balance for 30 seconds<br>**2nd exercise**<br>-Contralateral leg in a side kick position for 10 seconds | **1st exercise**<br>-Maintain balance for 40 seconds<br>**2nd exercise**<br>-Contralateral leg in a side kick position for 15 seconds | **1st exercise**<br>-Maintain balance for 1 minute<br>-Eyes closed<br>**2nd exercise**<br>-Contralateral leg in side kick position for 30 seconds<br>**3rd exercise**<br>-Perform continuous quick sidekicks with contralateral leg whilst balancing |
| **Trampete exercises** | **1st exercise**<br>-Single leg bounces on the centre logo of the trampete<br>-Cross arms across chest<br>-To be performed on both legs<br>**2nd exercise**<br>-Athlete jumps onto the centre of the trampete then jump off and land<br>- Maintain balance<br>- To be performed on both legs<br>**3rd exercise**<br>-Athlete starts on the centre of the trampete<br>-Jumping turning kick off the trampete and land<br>-To be performed on both legs.<br>**These exercises are to be performed as a circuit <u>TWICE</u>** | **1st exercise**<br>-20 bounces (remaining on the centre of the trampete – use the logo as an aim)<br>**2nd exercise**<br>-Jump on trampete with two feet, land with two feet.<br>(10 reps) | **1st exercise**<br>-30 bounces (remaining on the centre of the trampete- use the logo as an aim<br>**2nd exercise**<br>-Jump on trampete with two feet, land on one foot (10-15 reps)<br>**3rd exercise**<br>-Jumping turning kick off the trampete and land with two feet<br>(20 reps) | **1st exercise**<br>-30-35 bounces (remaining on the centre of the trampete-use the logo as an aim) with eyes closed<br>**2nd exercise**<br>-Jump on the trampete with 1 foot and land on same foot. Repeat on the other leg. (20 reps)<br>**3rd exercise**<br>-Jumping turning kick off trampete and land with two feet (20 reps)<br>-Jumping turning kick off trampete land on one foot (repeat on other leg) (10 reps) |
| **Wobble board exercises** | Wobble board varying in levels of difficulty | -Slow rocks left to right, front to back (5 reps in each direction) | -Medium speed rocking left to right, front to back (10 reps in each direction) | -Increase the size of the sphere<br>-Balance bilaterally avoid the edges touching the floor (60 seconds) |

## C-2: Warm- up stretches

| | **Exercise** | |
|---|---|---|
| **Ankle Plantar Flexors** | Gastrocnemius – stand 3-4 feet away from a wall. Step forward and place hand s on the wall with one foot in front of the other. Slowly move the hips forward, keeping the back leg extended and both heels on the ground (Armiger and Martyn, 2010).<br><br>Soleus – Step forward with 15 inches between front and back foot and place hands on hips for support and stability. Supinate back foot and slowly sink down by flexing back knee while keeping the back heel on the ground (Armiger *et al.,* 2010). | **-Hold all stretches for 8-10 seconds**<br><br>**-Stretches to be performed on both legs** |
| **Ankle Dorsi Flexors** | Tibalis Anterior – assume a sitting position on either a chair or on the floor. Cross over the foot over the contralateral knee. Grasp the forefoot and plantar flex your ankle, while everting and abducting (Armiger *et al.,* 2010). | |
| **Ankle Invertors/Evertors** | Tibialis Posterior – assume a lunge position, roughly two feet apart. Flex the back knee and dorsi flex the back ankle whilst guiding the knee anterior-laterally while keeping the foot flat on the floor. The athlete may use the front leg to lean on for support. (Armiger *et al.,* 2010).<br><br>Peroneus Brevis – place the plantar surface of the foot on top of the other foot and invert the top foot and ankle with simultaneous knee flexion (Armiger *et al.,* 2010).<br><br>Peroneus Longus – same as above but emphasise the position of the top foot, move it further over the dorsal surface (Armiger *et al.,* 2010). | |