Effects of somatic training on turnout in competitive Irish dance landings

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i. Abstract

Background: Irish dance has evolved rapidly throughout the years in terms of its athleticism, technical skills and aesthetics. In terms of technique, dancers must land from large leaps onto a single leg, without flexing their knee or dropping their heel. In particular, *turnout* is a key element of this dance form which involves external rotation of the lower limb, and must be sustained during the high impact landings. Limited availability and use of external hip rotation means that most dancers use friction on the floor to hold their foot in an exaggerated turned out position. Turnout caused by floor friction in the absence of hip external rotation moments are likely to result in large internal rotation moments at the knee and ankle, therefore increasing the risk of injury. As a means to improve alignment and reduce injury risk, somatic practice was investigated; a field of study that focusses on reducing muscular tension, enhancing kinaesthetic awareness and improving musculoskeletal alignment. By investigating the application of somatic practice as a prospective training method, we aim to provide insight into potentially improving *turnout* mechanisms and reducing risk of injury.

Objectives: The primary objective was to establish the relationship between hip external rotation and the internal/external rotation moments of the a) ankle and b) knee. The secondary objective was to evaluate the effectiveness of a somatic practice intervention in bringing about increased hip external rotation, and therefore *turnout.*

Materials and Methods: Thirteen (12 female; 64.9 ± 10.3 kg; 22 ± 2 y) competitive and performance Irish dancers completed a six week Alexander technique and Ideokinesis training programme, comprising of six 2-hour sessions. These particular somatic methodologies were chosen due to their musculoskeletal premise. The programme was designed with the purpose to increase and utilise external rotation at the hip by releasing

muscular tension and improving alignment of the whole body. Prior to the intervention, each participant performed a minimum of 10 *flys* (common Irish dance leap) onto a force plate whilst wearing reflective markers and while being recorded by a motion capture system. This data was analysed to evaluate hip rotation and knee and ankle internal/external rotation moments during an Irish dance landing. This procedure was repeated after completion of the programme.

Results and Discussion: Mean hip external rotation magnitude decreased as the landing of the *fly* reached maximum vertical force and was of a lower magnitude than reported from the literature (-10.9º ± 2.4). A negligible correlation was found between hip rotation angle at maximum vertical force for both moments at the same time point. However, when comparing the difference between the hip rotation angle and the foot toe-out angle (foot progression) to the knee and ankle internal rotation moments at maximum vertical force, low positive correlations were found (r = .15 [knee], r = .20 [ankle], p = < .01). Following the somatic practice intervention, no statistical differences between sessions were found but a slight increase in hip external rotation was observed. There was a large range of differences in movement profiles between participants, as well as a variety of responses to the somatic practice sessions.

Conclusion: The aesthetic and technical demands of Irish dance are in contrast to safe mechanics, potentially increasing overuse injury risk. Maximising hip turnout during landing should decrease internal/external rotation moments, as long as hip turnout affords the dancer better alignment between the femur and the foot. Reducing angular deviation about the longitudinal axis in this manner could help to navigate the demands of the dance style without compromising the aesthetic quality of the dancer. Somatic practices have the potential to improve body alignment, as well as kinaesthetic awareness, but further study needs to be conducted in order to consolidate this.

ii. Acknowledgements

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iii. Preface

The incentive for this research originated from my personal experience in Irish dance. I was a competitive C.L.R.G.[1] Irish dancer for the most part of seventeen years, which meant I trained at high intensity all year round for national and international competitions. While my teachers, my peers and I constantly focussed on effectively warming up, cooling down, stretching and strengthening, pain and injury was a relentless issue. Yet, it was perceived as inevitable. We were expected to be high on our toes throughout all movements and keep our knees perfectly extended. The style also demanded that we perform large leaps without flexing our knees or letting our heels touch the ground. Due to this, I believe that unlike many other forms of dance, Irish dance technique can be detrimental to the well-being of the dancer. I am now several years retired from competitive dance, and am still nursing multiple injuries attained from this dance style.

In relation to this, when I started my undergraduate study in the interest of biomechanics at the University of Otago, School of Physical Education, landing tasks were a common point of analysis in the learning laboratories. During these labs, I observed how every type of landing performed was different to the ones expected in Irish dance. Even when analysing 'stiff-legged' drop landings and discerning the extremely large ground reaction forces associated with them, I could not help but think how Irish dancers were expected to endure these forces repeatedly on only their forefoot, whilst still appearing graceful. This fuelled my incentive to find a way that Irish dancers could

[1] The Irish Dancing Commission (*An Coimisiún le Rincí Gaelacha)*

perform the dance style without constantly being subjected to such large forces and moments and therefore, reduce their risk of injury.

Though retired from competing, I have remained involved with the Irish dance community, helping to train dancers under the supervision of registered teachers. However, what I continue to notice is that the dance style is evolving faster than ever, but injury prevention and training methods are not evolving with it. Registered teachers also are not required to have any knowledge of training principles, musculoskeletal factors or injury prevention and rehabilitation techniques, yet the training load expected of dancers is that, if not higher, of a high performance athlete. This means that technique is not properly taught and dancers are incorrectly forcing their body into unsafe alignments, while the longevity of the dancer's health is ignored. We are continuing to use generic training, exercises and techniques on a dance style that rejects basic biomechanics. It is for these reasons that my desire emerged to find a technique that will meet the aesthetic demands of the dance form, whilst reducing the occurrence of pain and injury.

In 2018, for partial completion of my postgraduate diploma, a pilot study was conducted to determine if there was a correlation between straight-legged landings[2], turnout and injury rates. The participant for this study performed drop-jumps with a straight-legged landing in two conditions; landing leg turned out and landing leg in a parallel position. Ankle and knee moments, as well as joint angles, were analysed. Though this study was only conducted with one participant, the data indicated that the

[2] Refers to Irish dance technique in which the dancer should land on a single leg at the metatarsophalangeal joint, and should retain extension at the ankle and knee

internal knee moments increased when the leg was turned out, suggesting that maybe injury risk could be decreased if alignment in turnout was increased. Reducing internal and external rotation moments and the knee and ankle could reduce tensile and compression forces surrounding the joint, thus allowing the dancers to better withstand the landing forces associated with the Irish dance style. These reasons are the premise of this thesis.

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1. Introduction

Irish dance is a unique dance form with distinct characteristics entailing a non-moving posture with still arms held by the side of the body, contrasted with fast and intricate movements of the legs and feet. Centered on Irish nationalism and identity, Irish step dance has been around for centuries, gradually branching into a wide variety of traditional and modern styles (Holt, 2014). In that regard, modern-day Irish dance can be considered a hybrid; evolved from the traditional roots of Irish dance with modern social and cultural influences (O'Connor, 1998). As the dance style evolved, a sport was developed, placing an aesthetic art form into a competitive frame (Hall, 2008). In particular, following the debut and success of shows such as *Riverdance* and *Lord of the Dance*, the presence of Irish dance on a global platform encouraged the dance style to develop further (Mollenhauer, 2019). While the traditional elements remained relatively unchanged, such as posture, still arms and intricate footwork, the global popularity of the shows led movements in competition to become larger, sharper and faster (O'Connor, 1998). Due to the visual impact of the large horizontal movements Michael Flatley[3] used across the stage, adjudicators began to award marks for use of stage space and velocity of movement (O'Connor, 1988). In order to facilitate these movements, dancers began externally rotating or turning out the legs, which places the hip adductors in a better position for muscle fiber recruitment (Clippinger, 2007). Dancers also started to 'pull up', encouraging their legs to be maximally extended as often as possible in order to make their movements more dramatic. This means that they also attempt to land their

[3] Choreographer and lead dancer of *Riverdance, Lord of the Dance, Feet of Flames, Celtic Tiger* and other global Irish dance shows.

large leaps with an extended leg. Today, these components have all grown to become fundamentally aesthetic elements of Irish dance in competition.

In other words, the competitive nature of Irish dance has led dancers to experiment even further outside of the highly-structured confines of tradition, drawing an emphasis on the above elements which are now the basis of competition (O'Connor, 1998). One of the most fundamental technical and aesthetic elements in Irish dance is *turnout* which, as mentioned previously, involves rotating the legs externally. This is present in nearly all movements, and is especially emphasised by teachers during landings. However, dancers do not tend to utilise external rotation at the hip and rather, force their turnout by taking advantage of the friction of the floor to twist the tibia along the longitudinal axis (Champion & Chatfield, 2008; Shippen, 2011). Additionally, previous research has generated concern over the unique stiff-legged landing style. This style requires dancers to land large leaps on a single outstretched leg with an extended knee and plantarflexed ankle on their metatarsophalangeal joint (Klopp, 2017; McGuinness & Doody, 2006). As a result, landing forces cannot be effectively dissipated (Klopp, 2017). This means that, when performed according to judging criteria, the Irish dance technique increases the risk and potential prevalence of injury. However, to state that it is unsafe and must be changed challenges the historical development and current execution of Irish dance, being that this technique is a requirement for competition aesthetic (Quin, Rafferty, & Tomlinson, 2015). These landing forces, as well as the misalignments in the body that arise from exaggerating turnout at the feet, suggest that joint impact forces and joint internal rotation moments could be key contributors to the high rates of reported knee and ankle injuries (Cahalan & O'Sullivan, 2013; McGuinness & Doody, 2006; Stein et al., 2013). Internal rotation moments describe the combined

effect of internal structures of the joint to turn or resist external moments, such as friction on the floor. Poor alignment between the femur and foot increases these moments and consequently places increased stress on the internal structures of the joints.

Turnout or lack thereof, plays a large role in the magnitude of internal and external rotation moments occurring at the knee and ankle, due to misalignments from the hip to the foot. Previous literature indicates that a perfect turnout at the hip of 90 degrees from the midline of the body is anatomically and biomechanically rare (Champion & Chatfield, 2008; Shippen, 2011). This means that dancers tend to use tibial torsion in order to turn the feet out further than the hip, thus creating the illusion of a greater turnout which, in turn, can lead to knee and ankle valgus (Wild, Grealish, & Hopper, 2017). When landing large leaps such as the *fly*, the impact forces alongside knee and ankle valgus leads to high internal rotation moments, placing stress on the ligaments and structures of the joints (Orishimo et al., 2009). Furthermore, dancers need to retain the plantarflexion of their ankle during the entire duration of the landing phase, meaning that the high impact forces occur at the metatarsophalangeal joint – a joint not anatomically designed to withstand such large forces (Quin et al., 2015). The nature of the dance style means that dancers must withstand constant repetitive impacts in this position, which can lead to progressive microtraumas and overuse injuries (Noon, Hoch, McNamara, & Schimke, 2010; Walls et al., 2010). Multiple studies reported that foot and ankle injuries account for 75% of all reported injuries (Cahalan & O'Sullivan, 2013; McGuinness & Doody, 2006; Stein et al., 2013). 30% of foot and ankle injuries in professional Irish dancers were tarsal or metatarsal stress fractures, and 75% were Achilles tendinopathies; both believed to be caused due to overuse (Noon et al., 2010; Walls et al., 2010). Additionally, 37% of professional dancers have suffered from plantar

fasciitis, thought to be due to the constant plantarflexion of pointing the toes (Walls et al., 2010).

Previous literature has reported the prevalence of injuries in Irish dance, but there is little information about prevention considering the aesthetic constraints. Excessive muscular tension occurs in the dancer's body due to the overloading of joints, and can further misalign the body which, when subjected to large impact forces, increases injury risk. Furthermore, tension affects the aesthetic quality of the dancer by making the still and poised posture appear rigid and stiff with no ease of movement. It is for this reason that we have considered a field of practice that could not only retain the aesthetic integrity of the dance form, but also realign the body to reduce injury risk.

Somatic practice is the field chosen to explore in this study largely due to its holistic approach to movement. The techniques used in this field address self-awareness of bodily alignment and excessive muscular tension, and look at improving muscular efficiency. As Irish dance is judged in competition holistically[4], I believe it is important to consider the possibility that posture and habitual patterns have an effect on bodily alignment and degree of turnout. Strength and conditioning as well as flexibility and mobility programmes have all been applied but with few reports on how they affected injury risk (Quin et al., 2015; Walls et al., 2010; Wild et al., 2017). Nevertheless, strength and conditioning, along other exercise programs, are not the same field as somatics. Somatic practices suggest that by focussing on self-perception of the body and listening

[4] A common term used by dance teachers. Refers to dance as a whole-body movement, where the overall presence and 'feel' of the dancer is considered. Not to be confused with a somatic practice holistic definition.

to our muscles, we can bring about safe change, balance and movement efficiency (Saumaa, 2020). Furthermore, somatic practices have been increasingly applied to a variety of dance styles in recent years, such as ballet and contemporary dance (Brodie & Lobel, 2011; Eddy, 2006; Foley, 2017; Gerber & Wilson, 2010; Green, 2002; Molloy, Keogh, Krampe, & Guzmán, 2015; Weber, 2009). Yet, somatic practice appears to have only been applied to Irish dance in one other study, which used a single participant (Buck, 2012). Regardless, the findings from that study suggested it was feasible to continue researching the integration of somatic practices into Irish dance.

The overall purpose of this study is to examine the relationship between turnout and joint rotation moments, and how the application of somatic practices to Irish dance may affect this relationship, particularly during the *fly* jump. The *fly* is arguably the most common leap in Irish dance which involves the dancer taking off from one leg, switching legs in the air and landing on their toes on a single extended leg[5]. The primary objective of this study is to assess the association between external hip rotation and the external/internal rotation moments of the a) ankle and b) knee upon landing. It is hypothesised that there will be an inverse correlation between external hip rotation and internal rotation moments of both the ankle and knee. The secondary objective is to evaluate the effectiveness of a somatic practice intervention in bringing about increased 'turn-out' i.e. external thigh rotation. It is hypothesised that hip external rotation will increase following the somatic practice intervention.

This thesis has been divided into six main chapters, with this chapter being the first.

[5] See 7. Appendix A.

Chapter Two examines the current literature on Irish dance, biomechanical issues of the dance form and other factors affecting the execution of Irish dance such as pedagogies, adjudicators and competition. A review of somatic methodologies and their applications will also be included. First, I will discuss the qualities of Irish dance including the development of its unique posture and landing style and the issues that occur due to these characteristics. In particular, I will examine the mechanics of the *fly* movement; a large and common leap in competitive Irish dance that demonstrates the challenges of the style. I will then examine the literature surrounding this topic and discuss different biomechanical components that have the ability to affect the landings in this dance style. This will include looking at vertical ground reaction force, loading rate, alignment and turnout. Furthermore, I will investigate injury prevalence in competitive Irish dancers and discuss their possible causes. As mentioned earlier, the discussion will include other factors affecting the movement of the *fly* that are not biomechanical-related, such as dance teachers' pedagogies, influences of adjudication and nature of competition. Lastly, I will address the use and effects of somatic methodologies, primarily focusing on Alexander technique and Ideokinesis. These two techniques have been selected for their musculoskeletal and neuromuscular approach to movement which potentially can address certain areas of Irish dance effectively, such as alignment, artificiality in movement and rigid landings.

Chapter Three will detail the methodologies of the study and describe the structure of the somatic practice sessions. Firstly, I will outline the descriptive data of participants involved, then procedures of the study will be described. The quantitative data collection procedures will be outlined first, included segment definitions from the 3D motion capture model used and how this data was processed. I will then describe the

intervention structure and key objectives, including a brief rationale behind these methods. Lastly, a description of how data was analysed will be presented.

In Chapter Four, the kinematic and kinetic data results from the study will be presented and evaluated, as well as the subsequent statistical analysis. I will begin by presenting the results from the primary objective, firstly outlining the nature of hip rotation during the *fly* landing. I will then assess how this affects the knee and ankle internal/external rotation moments, and outline the movement profile during the *fly* of both moments. I will then present the unforeseen effect of foot progression, or toe-out rotation, by firstly outlining its relationship with hip external rotation. This relationship will then be assessed relative to knee and ankle joint/rotation moments. Lastly, the results regarding the secondary objective will be presented. I will begin by describing the statistical differences between data collection sessions as a result of the somatic practice intervention and conclude by outlining changes in the variable movement profiles.

In Chapter Five, I will discuss how the results collected could assist in resolving the aforementioned issues and the implications of this research. Limitations, delimitations and potential for future research will also be addressed. This chapter will firstly discuss the results in terms of the biomechanical aspects of the *fly* and the individual differences of participants upon landing. Following this, participant responses to the somatic practice intervention will be examined, as well as how these responses influenced the biomechanics of the leap. I will then discuss the potential implications and applications of these findings to the dancers, teachers and Irish dance Commission. The chapter will conclude by acknowledging the limitations and delimitations of this study, as well as how this research path could be extended in the future.

Chapter Six will conclude the thesis by outlining the contribution of this study to the current literature in the dance science field and what it means for dancers and teachers

in the future. This chapter will also include a summary of the thesis and concluding statements.

2. Literature Review

2.1. Overview

Competitive Irish dance adheres to a strict aesthetic that is tightly regulated by teachers and adjudicators. This means that dancers are constantly working towards replicating an 'ideal' image. However, with this approach, technique and musculoskeletal factors are neglected when attempting to correct an issue in performance. Dancers and dance teachers tend to simply focus on correcting the movement by visual assessment and identifying distinct points of error in the movement (Quin et al., 2015). However, with this comes a lack of acknowledgement of the body as a kinetic chain, as a small change or compensation in any area of the body affects the posture and alignment of the rest. For example, research by Quinn, Rafferty & Tomlinson found that if a dancer was told to lift their leg higher, they would most likely do so forcefully and as a result, their trunk would flex, their pelvis would posteriorly tilt and their shoulders would roll forward and elevate (Quin et al., 2015). Small verbal cues such as the above not only disrupts the aesthetic quality of the dancer but can also create alignment issues within the body that can increase the risk of injury. This becomes detrimental in competition as dancers are judged holistically with distinct focus being placed on their elevation, carriage and sense of effortlessness (Hall, 2008).

External feedback is also problematic in Irish dance, as this form of feedback from teachers, peers, videos and mirrors result in dancers trying to replicate an external ideal image that their body may not yet be capable of (Nordin & Frankel, 2001). This means they can unknowingly accustom repetitive and faulty training techniques which can affect alignment and cause muscular imbalance (Nordin & Frankel, 2001). Addressing self-awareness of alignment and excessive muscular tension through somatic

practice has the potential to not only prove useful in reducing the risk of injury, but also in improving ease of movement in this dance form.

This chapter will firstly discuss the qualities of Irish dance, including the historical background and development of its unique posture and landing style. Literature will be examined surrounding different biomechanical components that play a role in the addressed issues of the dance style, including alignment, turnout, vertical ground reaction force and inter-individual variability. Following this, the sociocultural aspects influencing the dance style will be discussed such as pedagogies, adjudication and means of feedback and how they inadvertently affect the mechanics of the dance style. As a result of this, a cross-examination of the reports of injury in Irish dance will be presented, as well as an evaluation of how the injuries may have occurred, in relation to the aforementioned biomechanical and sociocultural components. Lastly, somatic practice techniques will be explored – namely Alexander technique and Ideokinesis – and a discussion of how they may benefit Irish dance and injury will be presented. This will include an evaluation of the literature surrounding applications of those techniques to other dance styles.

2.2. Why Irish Dance?

2.2.1. History and Evolution

Irish step dance has been present for centuries, originally performed to express Irish national identity within the context of colonialism (Foley, 2001). The Irish revolution occurring in the 1910s and early 1920s resulted in a paradigmatic shift in Irish culture, which meant that expressive forms of movement and speech became politicised

(Hall, 2008). This is believed to be responsible for the development of a distinct Irish dance posture, which is still and disciplined throughout all movements, despite the large and fast footwork (Klopp, 2017; Trégouët & Merland, 2013). However, historical or scientific evidence fails to provide reason as to how the Irish dance posture came about, and this is only one out of many legends.

Irish dance throughout the years has gradually branched into a wide variety of traditional and non-traditional styles ranging from competitive to improvisatory, informal performances to stage performances amongst many (Foley, 2001; Hall, 2008; Holt, 2014). Competitive Irish dance alone is hugely diverse, containing solo, *céili*[6] and recently contemporary sections. Within the solo dance category, there is a 'heavy' and 'light' style, characterised by the shoe they perform in. The 'heavy' style is predominantly rhythm-based, performed in a hard shoe with a fiberglass heel and forefoot, used to make 'taps' (Roeder, 2007). The 'light' style requires dancers to be soft on their toes with large kicks and leaps, and is performed in a leather soft shoe (also known as a pump, *ghillie* [female] or *reel* shoe [male]) (Roeder, 2007). It is also important to note that there are many Irish dance organisations across the world that value different aspects of the dance form and therefore can have differing aesthetics and style. For purposes of this study, when discussing Irish dance, I will be referring to 'light' style solo dancing as part of An Coimisiún le Rincí Gaelacha (C.L.R.G.), also known as The Irish Dancing Commission. This is due to C.L.R.G. being the largest Irish dance organisation in the world, with dancers in many countries, and it is also the most rapidly evolving style.

[6] A form of social team dancing (Hall, 2008)

2.2.2. Aesthetic and Injury

As stated earlier, Irish dance has been developed into a competitive sport which means that a strict aesthetic and technique has evolved. The most notable aspect of Irish dance is its distinct posture, which has been outlined previously. As the upper body is to remain rigid, arms must be kept at the dancer's side with their hands in loose fists, and remain there through all steps, jumps and leaps (Buck, 2012). In addition, the head must move with the body as one unit, meaning that 'spotting' or turning of the head for balance and direction is not allowed (Buck, 2012). In most movements, legs must be turned out or externally rotated, as well as crossed over[7], including leaps and jumps. Furthermore, landings out of every movement, including large leaps, must occur with little to no flexion in the leg.

This competitive nature, as well as the development of professional shows, has led dancers into experimenting outside of the highly-structured confines of tradition, drawing inspiration from other dance styles such as ballet, contemporary dance and jazz (Holt, 2014). However, when still trying to adhere to the Irish dance aesthetic, risk of injury is increased, as these large leaps and explosive movements are still expected to be landed with straight legs and high on the dancer's toes (Klopp, 2017). For example, the Axel Paulson jump in figure skating, or *Axel*, has been used as inspiration for the 'ice-skater' leap in Irish dance. However, when figure skaters land this leap, their hip, knee and ankle are flexed and can take a period of time to stabilise the joints in the landing position (Mazurkiewicz, Iwańska, & Urbanik, 2018). By contrast, Irish dancers must land this leap on their toes with a straight leg and move straight into the next movement, which demonstrates the disregard for musculoskeletal capabilities. This means that many

[7] Crossover refers to a position in which dancers have one leg placed directly in front of the other (whilst in a turned-out position) with adduction of the hip past the midline of the body.

movements in Irish dance have a near impossible expectation, yet dancers will continue to strive for this standard. Additionally, these movements must all be performed with turned out feet, which adds another level of difficulty into these leaps.

Turnout is another unique aspect of Irish dance but unlike ballet, for example, the emphasis is primarily on the feet as opposed to external rotation of the whole leg (Hall, 2008). This is expected to be present in nearly all movements, for both when the dancer's leg is in the air and in contact with the ground, also known as dynamic turnout (Shippen, 2011). However, maintaining dynamic turnout whilst consistently extending the leg is difficult for most dancers. Furthermore, training of technique for turnout, or lack thereof, results in dancers using tibial torsion and friction of the floor to over-pronounce their turnout at the feet (Shippen, 2011). This means that the ankle is abducted more than the knee and hip, which distorts alignment and increases risk of injury when landing in this manner (Shippen, 2011). Nevertheless, in competition, turnout at the feet is prioritised and results in higher scores, therefore dancers will force this at all costs, overlooking their own longevity or health (Klopp, 2017).

It is evident that the aesthetic demands of the Irish dance style challenge the dancer's body. Furthermore, these demands can place additional load on the body due to high training volumes. Most high-performance and physically demanding sports are seasonal, and therefore have an off-season where the athlete can develop a base of strength, endurance, flexibility etc. (Brooks, Fahey, & Baldwin, 2005). This means that during competition season, the focus can simply be on maintaining these attributes, in order to reduce stress (Brooks et al., 2005). In Irish dance however, the placement of

competitions or *feiseanna*[8] mean that training is high volume and high stress all year round which can increase the risk of injury, supported by the large number of overuse injuries[9]. The age of dancers also plays a role in injury rates because, as with most artistic sports, dancers start and specialise young. This means that their performance peak usually occurs during growth and pubescent years. As a result, high levels of training occur while dancers have immature musculoskeletal systems, therefore the repetitive load and impact forces mean that their bone and cartilage are more exposed to injury (Armstrong, 2019). Additionally, the majority of the Irish dance population is female which also means that hormonal changes play a large role in injury risk. Decreased caloric intake as a result of body image issues and disordered eating, common in aesthetic sports, can lead to a disturbance in the menstrual cycle (Armstrong, 2019). Consequently, a decrease in bone mineral content may occur, therefore making dancers more susceptible to stress fractures and other overuse injuries.

Overall, the stylistic requirements within all Irish dance styles place the body under large impact forces and dynamic changes in alignment which could be a predominant factor in the injury prevalence of the dancers (Trégouët & Merland, 2013). However, fewer technique modifications can be made to negotiate the demands of the dance due to aesthetic constraints from an adjudicator's perspective (Kulig, Fietzer, & Jr., 2011). Dancers do not have the freedom to simply flex the knee in order to dissipate impact forces as it goes against the competitive aesthetic and consequently, dancers would lose points in competition. Unlike most other sports where better technique is

[8] A traditional Irish arts and culture festival. Today, the term *feis* is commonly used when referring to Irish dance competitions.

[9] Refer to 2.4.

presumed to reduce risk of injury, proper form for Irish dance is contrary to safe mechanics (Quin et al., 2015).

2.3. The Issues

2.3.1. Turnout

As mentioned earlier, an important aesthetic and functional aspect of competitive Irish dance is turnout. According to Grossman, turnout can be described as the total sum of a dancer's external hip rotation, torsion of the tibia and contributing forces from the floor (Grossman et al., 2008). While turnout is predominantly considered an aesthetic factor, externally rotating from the hip means that the iliofemoral ligament is in an optimal position, providing the dancers with stabilisation of the joint. This means that less muscular effort is required for turnout, leaving more power to be generated in order to execute the explosive and large lateral movements that are required in Irish dance (Clippinger, 2007). However, Irish dancers do not tend to learn the importance of turnout from the hip, and instead develop a habit of twisting the legs at the ankles (Hall, 2008). While this may seem an anatomical impossibility, articulations between the tarsals permit some inversion and eversion, therefore dancers can create a turnout at the feet while the knees face anteriorly[10] (Hall, 2008). Needless to say, while this allows the knees the remain together and crossed over, it is not safe practice (Shippen, 2011).

[10] See Figure 1.

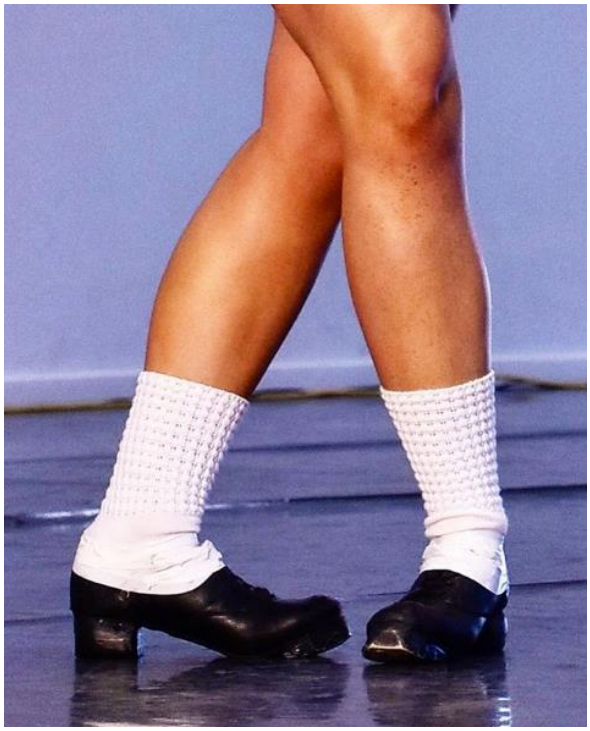

Figure 1: Dancer displaying a compensated turnout during crossover (courtesy of Vincent Mortimer, TIDA NZ Photographer)

An ideal turnout can be considered the placement of the feet 90º from the midline of the body. However, it is an anatomical rarity to achieve a perfect turnout, due to the shape of bony structures the hip (Champion & Chatfield, 2008; Shippen, 2011). As a general rule, there should be enough rotation so that when the heels touch, the toes point outward; a minimum of 45º (Khoo-Summers, Prather, Hunt, & Van Dillen, 2013). Joints that contribute to turnout position include the tibiofemoral, acetabulofemoral, and joints of the midfoot and forefoot (Khoo-Summers et al., 2013) but different studies have reported varying degrees of contributions to turnout across a variety of dance styles. Research conducted by Champion and Chatfield (2008) suggests that, even in an ideal turnout, only approximately 60° to 70° of turnout is contributed by the hip joint. The remainder of turnout occurs in the lower distal extremities, as dancers 'force' their feet to achieve a turnout beyond the position of the hips, which aesthetically distorts the position of the whole body (Shippen, 2011). Quanbeck et. al. suggested that the hip and

knee joints contributed 36% and 32% to turn out respectively (Quanbeck, Russell, Handley, & Quanbeck, 2017). More recently, a 2018 study conducted by Carter et. al. found that the hip joint contributed only 35% of functional turnout, with 42% coming from the foot and 22% coming from the knee (Carter, Duncan, Weidemann, & Hopper, 2018). However, a turnout that is greater at the ankles than it is at the hips means that the weight of the body moves medial to the joints, as opposed to the centre of them. This results in eversion of the foot and predisposes the knee, ankle and metatarsal joints to stress and high rotation moments (Quinn et al., 2015).

When landing large leaps in a turned out position, such as the *fly*, knee valgus may occur which in turn predisposes the dancer to an increased risk of knee injury (Orishimo, Kremenic, Pappas, Hagins, & Liederbach, 2009). In order to compensate for the degree of tibial twisting from the knee, the medial collateral ligament (MCL) and meniscus are strained, in addition to overutilising the internal rotator muscles (Huwyler, 2002). Furthermore, friction with the floor is utilised to hold the foot in this exaggerated turnout, meaning there is increased variability in external rotation of the leg throughout different steps in the dance (Quin et al., 2015). However, it is important to note that these studies reported on contemporary dance and ballet dancers who have the ability to flex their knee throughout movements. This means that they are able to take advantage of extra rotation at the knee when abducting their foot, due to the slackening of the ligaments (Clippinger, 2007). In Irish dance, turnout during the entirety of a movement is desirable, but without being able to utilise the friction on the floor, dancers cannot force their turnout to the same extreme, resulting in constant changes in the degree of turnout and therefore, constantly variability in dynamic alignment (Grossman et al., 2008).

Other than the individual variability of turnout, issues with turnout in Irish dance could also be related to a lack of initial training from teachers, which will be discussed further in section 2.3.5. It is important to note though, that while it is possible that some dancers are aware of their compensatory turnout, many tolerate these misalignments and pain that may be associated with this, as the illusion of greater turnout is prioritised (Grossman, Krasnow, & Welsh, 2005).

2.3.2. Alignment of the body

Alignment and posture of the body are essential components of being able to move safely, whether it be in day-to-day life, sport or dance. Alignment can be simply defined by "the arrangement of the body segments and skeletal structure in a vertical column with respect to the line of gravity" (Krasnow, Wilmerding, Stecyk, Wyon, & Koutedakis, 2011). Deviations from the structural norm of the body can be genetic, a result of injury or a developed habitual pattern (Quin et al., 2015). These deviations place increased stress on the musculoskeletal structure which, in Irish dance, are amplified by repeated load, impact and other demands of the style. With time and overuse, this can become detrimental to the dancer's musculoskeletal health (Quin et al., 2015). Common alignment issues in Irish dance include, but are not limited to postural deviations such as trunk flexion and shoulder protraction, anterior pelvic tilt, knee internal rotation and ankle eversion. These issues will now be further discussed.

Carriage and posture play a large role in the aesthetic quality of the dancer. Not only does it affect the performative presentation of the dancer in competition but correct

posture[11] is also important for safe dance practice (Quin et al., 2015). While the Irish dance aesthetic demands a neutral, upright posture across all movements, the body must be able to deviate slightly from the norm to allow for movement, and then return to a neutral base (Quin et al., 2015). This means that dancers need to understand how correct alignment of the body feels, and possess the ability and control to return to neutral quickly, therefore preserving the body's integrity (Quin et al., 2015). However, it is all too common for large kicks and fast movement from the legs to be achieved by excess bending and twisting of the torso and pelvis, resulting in an aesthetically displeasing performance and subjecting the dancer to high injury risk (Liederbach, Kremenic, Orishimo, Pappas, & Hagins, 2014). This is due to dancers prioritising presentation of the lower body over their posture, often as a result of isolated feedback from teachers. Little technique development of posture is provided by teachers and it is common for them to encourage holding the hands behind the back in order to keep the arms in. While this does hide movement of the hands, it results in retraction of the scapulae, protrusion of the chest and anterior trunk flexion (Hall, 2008). Furthermore, dancers have reported the feeling of chasing alignment corrections, where fixing one part of their posture causes issues in another; an example of the body's kinetic chain (Quin et al., 2015). Trunk alignment has a large effect on the position of the body's centre of mass and when this shifts, higher loads can persist onto certain joints and soft tissues (Schafer, 1987). Liederbach et. al. (2014) found that anterior trunk flexion and lateral lean was common in dancers, particularly when fatigued. Trunk lean lateral to the supporting leg is believed to be a mechanism for controlling landing forces but as a result, hip adduction occurs,

[11] Correct posture here refers to "the relationship between the skeleton and the muscles, as well as different body parts, that determines how the body maintains its functional alignment" (Quin et al., 2015).

meaning the body is not in a safe position to dissipate impact forces (Liederbach et al., 2014). Anterior trunk flexion or a forward lean can be addressed by externally rotating at the hip; this is the most effective strategy adopted by dancers when performing high leg lifts during leaps, as it increases the range of motion of the working leg (Daprati, Iosa, & Haggard, 2009). The anatomical structure of the hip means that the greater trochanter of the femur bypasses the pelvic bones only when externally rotated (Huwyler, 2002). However, as mentioned in the previous section, Irish dancers lack the ability to externally rotate at this joint.

Another common issue observed in Irish dancers is an anterior pelvic tilt or 'sway back'. The pelvis position is considered neutral when the anterior superior iliac spine (ASIS) and pubic symphysis are in the same frontal plane (Clippinger, 2007). This position best supports efficient movement of the lumbosacral and hip joints as the surrounding tissues are under the least amount of tensile and shear stress (Quin et al., 2015). However, an anterior pelvic tilt occurs when the ASIS rotates further forward than the pubic symphysis and can be characterised by an arching of the lower back (Quin et al., 2015). This means that the iliopsoas, rectus femoris and back extensors are shortened as a result of overload, and the abdominal and gluteal muscles are weaker (Quin et al., 2015; Weiss & Zlatkowski, 1996). Not only does this affect stability and control of the trunk, but overloading the iliopsoas primarily limits how much the femur can externally rotate, therefore limiting available turnout at this joint (Quin et al., 2015). Overall, the 'sway back' posture predisposes the dancer to shear forces at the knee during landings and torsion forces throughout the lower limb during turnout that is over-pronounced at the feet.

Now that postural alignment issues have been discussed, I will examine alignment in the lower extremities; knee internal rotation and ankle eversion. Correct knee alignment refers to the orientation of the patella in a direct line over the second metatarsal (Quin et al., 2015). This should be present in both parallel and turned out positions. However, it is very common for dancers of all technical styles to experience knee internal rotation. This is an issue because it subjects dancers to increased stresses and torques at the knee, particularly when the knee is flexed in order to dissipate landing forces (Quin et al., 2015). While the Irish dance aesthetic requires the landing to occur on an extended knee, many dancers involuntarily flex the knee when coming out of large leaps (Orishimo et al., 2009). As mentioned in the previous section, an exaggerated turnout at the feet can increase the amount of internal knee rotation, and this flexion can amplify the torques occurring at the knee. Furthermore, internal knee rotation increases the likelihood of ankle eversion, often known as pronation of the foot (Carter, Bryant, & Hopper, 2019). When a dancer is up on the ball of their foot (metatarsophalangeal joints), distribution of weight on the foot should be equal between the first and fifth metatarsal (Quin et al., 2015). However, increasing *foot* turnout by use of floor friction means that dancers are more likely to evert/pronate, therefore increasing internal rotation moments at the ankle, and subjecting the dancer to an increased risk of injury in the lower extremity (Clippinger, 2007).

2.3.3. Vertical Ground Reaction Force and Joint Loading

A large issue that comes with the Irish dance aesthetic expectations are the large landing forces associated with maintaining constant extension of the legs. Without allowing flexion at the joints, there are very few ways the dancers can land as to dissipate ground reaction forces. As stated in Chapter 1, Irish dance aesthetic requires dancers to

land on their toes – ideally at the metatarsophalangeal joint or even more distally - with an extended knee and without bringing their heel down (Quin et al., 2015). This is different to other forms of technical dance such as ballet, in which the dancers are trained to land on the forefoot initially and then bring their heel down to dissipate the landing forces (Orishimo et al., 2009). As stated earlier, the metatarsophalangeal joint is an area of the body that is not anatomically designed to dissipate such large landing forces, which means high impact forces place a lot of stress on these joints (Quin et al., 2015).

In order to achieve height on the toes, dancers have to force the arch of the foot, extending the ankle as much as possible whilst the weight is carried on the fat pads of the toes and foot (Hall, 2008). Idealistically, the foot retains the extension whether the weight is on it or not (Hall, 2008). However, landing on the forefoot means that the ankle will try to dorsiflex due to activation of the triceps surae. This creates a torque at the ankle that reduces the load by converting translation kinetic energy into rotational kinetic energy (Lieberman et al., 2010). Due to the aesthetics of Irish dance, dancers must resist this torque by constantly contracting their gastrocnemius which inevitably places excessive loads on the tibia that is then multiplied upon landing. In addition to this, leaps comprise of a short landing phase, due to the need to immediately move onto the next steps in the sequence. This means that there are high compressive loads placed on all joints in the lower extremity of the dancer (Gorwa, Dworak, Michnik, & Jurkojć, 2014).

Stress and loading on joints of the foot, ankle and knee upon landing can be intensified with malalignments in the body, particularly when forcing the feet into a turned out position. When these joints are at the end of their range of motion, compression forces are transferred into tensile loading of the ligaments surrounding the structures (Simmel, 2014). This is in order to prevent further movement as an attempt to realign the joint. However, repeated overload associated with that of a dancer can result

in the ligaments becoming permanently lengthened, therefore unable to protect the joint (Quin et al., 2015; Simmel, 2014). While we cannot change the impact forces associated with the demands of the dance style, this highlights the importance of maintaining good alignment throughout all movements and landings.

2.3.4. Inter-Individual Variability

As with most sports, there is degree of variability that will occur between dancers in all movements, due to muscular discrepancies and physical competencies. Previous studies have reported differences in elite competitive athletes, such as javelin throwers and powerlifters, and suggest that high-level performance can be achieved through a wide range of biomechanical solutions (Campos, Brizuela, & Ramón, 2004; Flanagan, Kulik, & Salem, 2015; Kristiansen, Rasmussen, Sloth, & Voigt, 2019). While there are no studies on inter-individual variability in Irish dance to this researcher's knowledge, we can presume that variability between high-level dancers is present. Additionally, in artistic forms of movement, an individual's expressive style is reflected, despite being regulated by technique (Kawano & Kuno-Mizumura, 2019). This means that there are inter-individual differences in the way dancers execute their movements, and these movements change not only as the dancers grow their skill comprehensiveness, but also as they develop their own style. Furthermore, the teacher's methods and stylistic preferences will affect how the dancer develops their movements, which often creates clear visual differences in the style of a dancer. This can be identifiable on stage, and can give the dancer a clear advantage or disadvantage during competition, which will be discussed further in the following section.

2.3.5. Teaching, Adjudication and Mirrors

Issues involved with teaching and adjudicating can influence the biomechanical factors that have been previously discussed. Unlike the strict aesthetic demands of the dance style, guidelines for teaching and judging practice are not as clear, and while it is a rigorous process to become a qualified Irish dance teacher (T.C.R.G.) and a qualified adjudicator (A.D.C.R.G.)[12], there are still many issues that arise in regards to teaching and competition.

Adjudication in competition is largely subjective with no set point system, meaning that impressions of the dancer are holistic, immediate and often ineffable (Hall, 2008). Due to this, the way adjudicators evaluate technical skills, such as turnout, is simply up to the discretion of that particular adjudicator. Categories of evaluation are outlined as an attempt to regulate marks; these categories are carriage, timing, execution and overall impression (Hall, 2008). However, these are not enforced during adjudication in competition, which means results can be subject to social and political influences (Mollenhauer, 2019). Unlike other sports where the referees or umpires may affect the final result, the adjudicators decision *is* the final result, and cannot be changed or challenged (Hall, 2008). Consequently, it becomes difficult to define the 'ideal' Irish dance technique based on objective marking criteria, as different adjudicators look for different qualities in dancers, therefore the end results come down to personal preference. This often leads to teachers catering towards teaching styles they believe certain judges will like (Hall, 2008). Additionally, adjudicators need to be active teachers, which means their results in competition will predominantly reflect the style they teach in their dance

[12] Refer to 7. Appendix B. for T.C.R.G. and A.D.C.R.G. examination guidelines.

school. In other words, the way dancers are judged and the way dancers are taught are interlinked (Hall, 2008).

Another key issue is that teachers are not required to have any formal understanding of anatomy and physiology of a dancer, or how to prevent and accommodate injuries. Teachers are not required to have any knowledge regarding training principles and in any other sporting or dancing situation, would not be considered qualified or capable to give any form of training advice. This is thought to because in the 19th Century, Irish dance teacher's and adjudicators were experts of Irish culture, not of physical activity (Mollenhauer, 2019). As a result, the examinations[13] designed to become a registered teacher and adjudicator were based on Irish culture and musicality, not anatomical knowledge, and have not developed alongside the dance style. This means that dancers could be misdirected in terms of how to develop a movement, and with a high training load, could be subjected to increased risk of injury (Skrinar, 1988). This corresponds with the biomechanical issues involved with the dance style, particularly surrounding turnout. Research has suggested that poor technique in order to force turnout is the single largest contributing factor to overuse injuries in the lower extremity, therefore teachers need to understand the musculoskeletal mechanisms of turnout to be able to teach proper technique (Quin et al., 2015). Verbal cues used by the teacher without this knowledge, such as 'pull up' and 'glue the knees together', can make it difficult for a dancer to implement, as the cues give no mechanical instruction on how to improve the movement (Hall, 2008). Additionally, an understanding of pedagogical and child development strategies is not required in order to become a registered teacher. This can be problematic because the early age at which dancers tend to start training

[13] Refer to 7. Appendix B.

mean the teachers are highly involved with them during their developmental years. As a result, methods used in the dance class can affect the dancers psychological and physical development. On this note, it is also important to address how dancers are encouraged to teach their peers. This is usually due to unbalanced ratio of dancers to teachers in the dance class. The issue with this however, is that dancers tend to reteach what they have learned from their own teacher, meaning that if they have learned improper technique, this technique will get taught to even more dancers. Furthermore, they are also more likely to reproduce similar teaching patterns and language.

It is clear that the pedagogies of the teacher can influence the mechanics of a dancer. From the researcher's personal experience with Irish dance teachers, many teach with an authoritarian style, commonly justified as the 'Irish mannerism'. According to Lakes (2005), an authoritarian personality is controlling, punitive and has little empathy for the weak or injured. They tend to be demanding, yet unresponsive to an individual student's needs, meaning it is a non-autonomy-supportive teaching method (Chaffee, Noels, & McEown, 2014). A teacher using this style tends to use constant negative reinforcement and criticise aspects of the performance routinely (Gerena, 2015). They may also use unchanging verbal prompts with no extra assistance until the student gets it right, dismiss questions and demean questioners, as well as make unfair comparisons to other students (Lakes, 2005). A common characteristic of this authoritarian style is the teacher being silent and withholding feedback, and only giving backhanded compliments (Lakes, 2005). If dancers do not get the steps right quickly or apply their corrections instantly, this can result in frustration, impatience and ignoration from the teacher (Lakes, 2005).

The negative effects of this teaching style are commonly reported in research studies, stating that it is detrimental to a student's competence, self-esteem and engagement in learning (Chaffee et al., 2014; Lakes, 2005). However, it is important to note some counter-arguments to this method which state that by producing pain in the classroom and testing a student's insecurities, the teacher can ascertain their breaking point and therefore determine what kind of pressure they can be placed under (Lakes, 2005). Furthermore, students begin to build their desires and needs around the teacher, and work harder to achieve these goals to earn the approval of the teacher. Chaffee et al. (2014) and Lakes (2005) state that the primary goal of teaching is to encourage the students to become autonomous or self-directed in their learning. It is argued that whether a student responds negatively or positively to the authoritarian style depends on the personality of that individual, as some could become more resilient in response (Chaffee et al., 2014). This method of teaching can also create some issues surrounding the 'no pain, no gain' culture embedded in Irish dance. Dancing on pain and injury is often glorified by teachers, and dancers often continue to do so, for fear of missing out on class or disappointing the teacher (Quin et al., 2015). However in doing so, dancers are ignoring the warning signs of injury, such as pain signals, which can lead to higher damage of the area and/or secondary injuries (Quin et al., 2015).

The authoritarian-style of teaching is common, but it must be noted that not all teachers in Irish dance teach with this method. In teaching – similar to learning – there is no 'one size fits all' approach. Nevertheless, all teachers place a focus on refining their dancers' movements as the dancer progresses to the intermediate and advanced level. Some teachers also stress the idea of relaxation and control in the movements without rigidity (Holt, 2014). Holt's experience with one particular teacher showed an emphasis

on the internal feel of the movement, stating that “if she were to release her weight more, it would correct her rhythm” (Holt, 2014, p. 21). This is a different approach to most teachers, who focus on listening and correcting movements from an external aural or visual source (Holt, 2014). The differences in teaching styles emphasises the many different ways Irish dancers will perform, with each dance school having a distinct ‘style’ emerging through their movements and choreographies. However, Holt’s example of releasing the body indicates that a focus should be placed on reducing muscular tension in Irish dance, as this will mean that movements have the potential to become more coordinated and defined. This is especially important for a dance style that emphasises a non-rigid but still posture.

Lastly, while feedback from the teacher heavily influences the dancer’s technique, an often unconsidered issue in the dance class is the presence of mirrors. Mirrors are a great tool for learning, but they can affect the way a dancer perceives themselves and inhibits their ability to use other kinaesthetic senses to correct their movements (Gerena, 2015; Hutt, 2010). Furthermore, mirrors turn 4D bodies into 2D images which distorts the perceived movement (Williams, 2011). The dancer further distorts their movement patterns by facing their head towards the mirror, but not changing the orientation of their body (Williams, 2011). This also can lead to fatigue within the body faster as the head in an unbalanced position not only fatigues the surrounding muscles but also affects the proprioceptive mechanisms, confusing the sensory receptors of where the head is in relation to the body (Todd, as cited in Williams, 2011). Additionally, the use of mirrors in a dance class essentially teaches the students to ignore their kinaesthetic awareness and focus on what they see in the mirror.

2.4. Prevalence of Injury

Now that biomechanical and sociocultural issues have been discussed, we will evaluate how they affect risk of injury. As previously mentioned[14], competitive Irish dancing has a 'light' and 'heavy' style, both with different movement qualities and techniques. However, the risk of injury is equally high in both (Cahalan & O'Sullivan, 2013). Irish dancers land on an extended leg which, in conjunction with their large leaps and rigid posture, results in a high risk of musculoskeletal and joint injuries (Cahalan & O'Sullivan, 2013). Buck (2012) states that because steps always begin on the 'right foot', the right side of the body is worked more. This results in a higher number of traumatic injuries on the right side (Stein et al., 2013). Most studies have found that the foot and ankle are most commonly injured in Irish dance, with lower limb injuries accounting for 75% of all reported (Cahalan & O'Sullivan, 2013; McGuinness & Doody, 2006; Stein et al., 2013). Furthermore, one study showed that 75% of a professional Irish dance troupe had Achilles tendinopathies, presumably from excessive landing forces that occur when landing on the toes (Walls et al., 2010). Irish dancers also, as mentioned previously, often dance in hard shoes which have a heel. This constant use of heels, alongside being on their toes most of the time, means that the Achilles tendon will shorten, therefore incur strain when performing lengthening movements (Siev-Ner, 2000).

In order to resolve the issue of constant pain and injury, teachers and dancers quite often bring new techniques into the classroom. This could include movement forms such as pilates, yoga, ballet exercises and strengthening exercises, amongst others. Because Irish dance is predominantly anaerobic with short bursts of high muscular power, plyometric training is often integrated (Quin et al., 2015). While there is some

[14] Refer to 1.2.1

benefit to this type of cross-training, such as the development of muscular power and strength, dancers still often fail to bring these benefits into the dance class, and resume their habitual, detrimental patterns. It is for this reason that the incorporation of somatic values into the dance class could be beneficial. This is because somatic practice is not a body conditioning or exercise programme but rather, a tool to improve self-perception and consciousness (Saumaa, 2020). Somatic practice has the potential to encourage more efficient movement pathways during dance, rather than simply adding more and more movement styles or training regimes on top of the current technique.

2.5. Somatic Practice

2.5.1. What is Somatic Practice?

Somatic practice is a field of movement study that encourages the learner to focus on postural changes and movement evaluation, allowing them to become aware of the body in a holistic sense. Thomas Hanna states that there are two key perspectives of the body, known as first-person and third-person perception (Hanna, 1998, as cited in Green, 2002). Somatic practice focusses of first-person perception or in other words, looks at the body from the "inside out, where one is aware of feelings, movements and intentions, rather than looking objectively from the outside in" (Hanna, 1998, as cited in Green, 2002, p. 114). In other words, somatic practice emphasises the idea of internal awareness and sensory perception.

There are many approaches to somatic work, all of which have a different emphasis on how to cultivate self-awareness. These active modalities assist learners in releasing excessive tension in muscles, enabling the body to become more relaxed and therefore, play a key role in managing the body's nervous system. Such techniques have

been successfully applied in the theatre, helping actors, singers and dancers to improve their internal awareness and therefore, improve their postural control as well as neuromuscular and movement patterns (Green, 2002). Given their success in these disciplines, it is apparent that it may be of benefit to dancers outside of the theatre, and could be applied to competition.

Somatic practices place a high value on the alignment of the body and postural control or in other words, they address tensions in the body that have being amplified by misalignments. As stated earlier by Donna Krasnow, alignment primarily refers to the deviation from the vertical skeletal column. However, Kleinman (as cited in Green, 2002) suggests that alignment should be looked at from a holistic approach, meaning that our emotional state and experiences have an influence on how we hold our posture. This is because these mental processes affect our unconscious neuromuscular activity (Krasnow, Monasterio, & Chatfield, 2001). Furthermore, emotional and environmental influences may be the basis of misalignments within the body, such as rounded or slumped shoulders that may be a result of constantly sitting at a desk, or of feeling emotionally down (Green, 2002). Muscles in the body can carry emotions, resulting in excess muscular tension in certain areas of the body. By learning to listen to the muscles, we can understand our emotional problems first, which makes it easier to target physical tensions (Saumaa, 2020). When looking at the alignment of the body from this holistic approach, it is observable that ideal alignment is difficult to achieve as there is subconscious motivation to hold on to these inefficient energy patterns (Green, 2002). Creating awareness of these motivations is key to releasing tension and therefore, correcting misalignments of the body. This could be useful in dance because not only

will it improve the aesthetic quality of movement, but also will promote safe practice by using healthier muscular patterns.

Somatic practice plays a key role in affecting the biomechanical movement of the body. Through direct body experiences and considering the proprioception of the body, a range of anatomical principles are explored (Green, 2002). Learners of somatic practices gain a better understanding of how the sequencing of muscles for a particular movement will become more efficient, as well as how it affects the internal bodily processes such as breathing (Green, 2002). Encouraging learners to become aware of these bodily processes, as well as their mental state, will enable them to better control their posture and alignment. Lessinger (as cited in Krasnow et al., 2001) states that "improvement of alignment is best achieved through the kinaesthetic sense rather than through visual assessment and mechanical forcing of corrections" (p. 10), emphasising the importance of incorporating other aspects of the exteroceptive system. As mentioned earlier in this chapter, the mechanical forcing of corrections is very common amongst Irish dancers and their teachers. As a result, applying somatic practices to dancers has the potential to be beneficial in terms of controlling alignment and in turn, reduce the risk of injury.

Given that somatic practice is developed largely on our sensory awareness, it is important to understand what senses we can use. Our body's central nervous system draws kinaesthetic awareness from our proprioceptive senses (Chaitow & DeLaney, 2011). The proprioceptive system refers to senses that can determine the body's orientation, motion, and balance amongst others (Chaitow & DeLaney, 2011). The information provided by our sensory receptors allows us to respond accurately and appropriately to external stimuli (Brodie & Lobel, 2011). In the dance class, this is

commonly pain, imbalance and perceived errors in visual information, particularly from mirrors (Brodie & Lobel, 2011). Somatic practice gives dancers the opportunities to develop their sensory receptors, meaning that they could heighten their senses, interpret what it means on a broader scale, and encourage new pathways of response to the stimuli (Good, 2015). By encouraging these new pathways, they would break the habitual response and therefore, reorganise their neuromuscular patterns. As a result of this motor learning, dancers would be able to move in a more coordinated, consistent and efficient manner (Good, 2015).

While it can be difficult to incorporate somatic values into technical dance classes, predominantly due to time constraints, it can still be approached via neuromuscular reordination (Good, 2015). Every time a dancer learns a new step or takes a new approach to a previously learned one, the process of motor learning is in play. This is because the body uses its kinaesthetic senses to analyse where the body is in space and reorganises the body into the desired movement, largely based on proprioception (Good, 2015). Furthermore, somatic practices are not based around particular dance movements or music, but focus on improving the coordination of breath, and self-awareness of posture, alignment and body in space (Molloy et al., 2015). This means that not only do dancers have the potential to improve their dance movements, but also could extend to their ease of movement in daily activities (Molloy et al., 2015).

2.5.2. Alexander Technique

The Alexander technique allows a student to identify and correct bad postural habits by becoming aware of the body in relation to the mind. Similarly to Ideokinesis, which will be discussed in the next section, imagery is used to redirect the neuromuscular pathways (Good, 2015). This, in turn, corrects alignment and coordination of the body

and allows the performer to move with ease (Good, 2015; Madden, 2014; Nettl-Fiol, 2006). The technique was originally founded by F. M. Alexander to overcome a vocal issue he had during his acting career; he realised that physical, mental and emotional tension he held in his body was affecting his breathing (Madden, 2014). Alexander found that he needed to lengthen and widen his back to release tension in his neck that was straining his voice and breathing. He identified the relationship between the head, neck and back acts as the main organiser of any form of dynamic movement, thus terming this relationship 'primary control' (Nettl-Fiol & Vanier, 2011). This relationship suggests that if there is a central organising system led by the head, excess tensions in the body should not be present (Nettl-Fiol & Vanier, 2011). By releasing these tensions and focusing on re-educating the body from its habitual restraints, breathing and posture became a lot more natural (Madden, 2014). The technique embodies a clear set of principles that allow for the psychophysical training of the student, meaning that the body is fully prepared to respond with the correct amount of tension (Reeve, 2013). These principles include the 'non-doing', 'means-whereby', 'inhibition' and 'direction'.

The basis of the Alexander technique can be centred around 'non-doing' (Raynor, 2010). 'Non-doing' suggests that one should have an overall intention to be process-orientated, rather than result-orientated. This concept encourages students to stop adding movements into their techniques to try and correct errors, but rather focus on eliminating the error altogether by identifying its origin (Raynor, 2010). This prevents dancers from countering tension with more tension (Nettl-Fiol & Vanier, 2011). Alexander stated that "when you stop doing the wrong thing, the right thing does itself" (Nettl-Fiol & Vanier, 2011, p. 175), which shows that by taking this approach, the dancer will promote choice over habit (Nettl-Fiol, 2006). Furthermore, focussing on direction rather than movement

ensures the body releases excess tension and allows it to move into expansion, where the postural reflexes will allow free movement (Raynor, 2010). This means that lengthening, widening and expanding of movement will happen by itself (Raynor, 2010). Freeing up the body allows it to re-educate itself by releasing excess tension, as this will also ease any pains caused by habitual muscular misuse and alignment (Nettl-Fiol, 2006).

The second principle is the means-whereby stage which allows the dancer to focus on their whole self and how every aspect of their body moves (Nettl-Fiol & Vanier, 2011). This entails a series of procedures that are indirect, rather than direct, meaning that the dancer focusses on how they are moving instead of what they are trying to accomplish (Nettl-Fiol & Vanier, 2011). By constructing a mental image of how the dancer's body moves, it means that the dancer is more process-orientated than result-orientated (Batson, 2008). In doing so, the fluency between movements will improve as the body becomes more coordinated and the dancer becomes more aware of their movements.

Following this, the inhibition principle is implemented. This stage focuses on intervening our initial response to a stimulus, in an attempt to deconstruct habitual actions (Nettl-Fiol, 2006). This is important for dancers because, as mentioned earlier, often they correct their movements with another movement. Inhibition means that they stop the body from simply replacing an unwanted action and rather, freeing the body to be open to new possibilities (Nettl-Fiol, 2006). This concept is centred around the idea of eliminating inference, meaning that if a bad habit interferes with the ease of movement in the body, the habit needs to be neutralised, therefore allowing the body to move with ease and free movement (Nettl-Fiol & Vanier, 2011).

The direction stage occurs after the inhibition; it allows the dancer to think about what movement they will make prior to making it (Nettl-Fiol, 2006). This is an essential

aspect of Alexander technique as it counteracts the habitual response. Dancers should visualise the movement they need to make without physically doing it because it allows them to focus on the lines of the movement rather than exhausting the musculature (Nettl-Fiol, 2006). By guiding the movement with intent, the dancer is able to make the movement more refined and defined (Nettl-Fiol & Vanier, 2011).

Overall, the Alexander principles should be able to be applied to any form of dance, as long as these stages are the foundation. By learning to discover why and how you are going wrong, how to stop this habitual pattern, and creating a method to redirect your movement into a more efficient pattern, you should be able to improve the nature of your movement (Nettl-Fiol & Vanier, 2011).

2.5.3. Ideokinesis

Ideokinesis can quite simply be defined as 'imagined action' or in other words, the idea of movement (Batson, 2007). This means that imagery and visualisation of movement is encouraged as it helps to create more efficient neuromuscular coordination and mechanical balance within the body (Good, 2015). The method of mental practice without physically moving helps to refine the lines of movement such as vectorial, plane, or rotational actions (Golomer, Arnaud, Mertz, & Keller, 2008). Ideokinesis promotes an understanding of muscular and skeletal anatomy. While it is not essential to have this knowledge, most practitioners will divide their lessons into theory and practical in order to grasp and apply these concepts (Brodie & Lobel, 2011; Good, 2015; Williams, 2011). Understanding the shape and location of the body's bones and muscles means that a dancer can visualise their most effective and efficient organisation in movement (Good, 2015). Particularly in dancers, the technical demands of movements can alter alignments and "deviation from an ideal alignment causes imbalances throughout the whole body as

the body attempts to maintain its balance against the force of gravity" (Good, 2015, p. 29). Ideokinetic principles aim to eliminate these imbalances by using imagery to create more efficient lines of movement and alignment. Imagery can be defined as using figurative language to describe objects, actions and ideas in such a way that appeals to our tactile senses (Good, 2015). Visualising anatomical structures when using Ideokinesis is an effective tool, meaning that having a basic understanding of anatomy is helpful. Good (2015) discusses visualising movement initiation from certain bony structures such as the scapula, and states that it encourages more coordinated movement pathways within the scapulohumeral rhythm. This is achieved by visualising the joint articulation of the scapula and humerus, and how they move with each other (Good, 2015). This anatomical imagery can further be explored by envisioning musculature around the joints. Good (2015) further states that thinking about individual muscles and their movements helps to create more efficient muscle sequencing, resulting in more efficient movement pathways.

As stated earlier, this imagery is effectively used in a non-moving position termed 'constructive rest' (Golomer et al., 2008). This is commonly a lying-down position with the knees raised and feet flat on the floor. By using this position it means that the body does not have to work against gravity and therefore can focus on refining smaller movements without tension (Matt, 2014). Visualisation in this position challenges the idea that repeated motor skills or physical actions will result in a greater efficiency of movement (Farnell, 1986). It instead suggests the most efficient form of practice would be to focus on the posture and holding of the body to help the performer become self-aware of how much they are deviating from neutral (Farnell, 1986). By applying this focus to mental practice, dancers can visualise their lines of movement throughout the body (Golomer et al., 2008).

Lulu Swiegard discusses Ideokinesis in terms of the nine lines of movement. These lines were determined off of the idea that the human body is constantly producing movements subconsciously, which results in certain postures and movements to become habitual (Matt, 2014). According to Pamela Matt (2014) and Richard Rosen (2011) the nine lines of movement are to:

1. Lengthen the spine downward.
2. Shorten distance between mid-front pelvis and 12th thoracic vertebra.
3. From top of the sternum to top of the spine.
4. Narrow the rib case.
5. Widen the back of the pelvis.
6. Narrow the front of the pelvis.
7. From centre of knee to centre of femoral joint.
8. From big toe to heel.
9. Lengthen the central axis of the trunk upward.

These movements are performed while in a constructive rest position, to reduce working against extra external forces such as gravity (Matt, 2014). The idea of these movements must be the sole stimulator and sole voluntary component. Extra components of voluntary control inhibit efficient performance, rather than promote it (Matt, 2014).

As stated, Ideokinetic principles encourage the dancer to use kinetic imagery that originates from within the body, rather than visual perception that originates outside of the body (Williams, 2011). As mentioned previously, the eyes should be in the direction of the line of movement in order to execute it with ease. However, the reliance on mirror images in the dance class can disrupt these lines (Williams, 2011). Furthermore, teachers then battle for dancers' attention as often, their feedback may contrast with what the dancer perceives in the mirror (Williams, 2011). Isolation of the visual sense shows the value that Ideokinetic principles will have in the dance class. Using imagery to not only picture what you would look like doing a movement but also, to imagine what it would

feel like within your body and how you would initiate the movements, holds the conscious intention of improving performance (Williams, 2011). Williams (2011) stated that it is impossible for a dancer to see themselves in the mirror executing a series of turns, yet most dancers will still attempt to look. This disrupts the lines of movement, resulting in an unbalanced turn. For movements such as a large leap, the dancer can sense how they should hold and position their bodies for take-off, how it would move during flight, and the coordination and feeling upon landing (Williams, 2011). This means that the dancer can use imagery to kinaesthetically be aware of every aspect of their leap, all without physically moving (Williams, 2011).

2.5.4. Applications in the Dance Class

A somatic approach has been considered for many dance styles, based on the common issue that dancers often understand the steps, but not the initiation or proper means of control of the movements (Gerber & Wilson, 2010). Even the most advanced dancers do not understand the underlying aspects of movement control, such as breath and muscle sequencing (Gerber & Wilson, 2010). Previous studies have shown that somatic practices have been successfully applied to other forms of dance, with ballet and contemporary dance included.

Application of the Alexander technique to ballet was conducted by Nettl-Fiol and Vanier (2011), in which they taught the technique by encouraging questioning and exploration from the student, rather than using the authoritarian manner of dictating material. As mentioned earlier, Irish dance is commonly taught with an authoritarian-style of teaching, indicating how the principles from Nettl-Fiol & Vanier's study could be applicable. When investigating the application of the Alexander technique to ballet, researchers believe that the dance form would need to be stripped of stylistic qualities in

order to implement the four principles of the technique. However, links were found between developmental movement and ballet, meaning that toddlers and young children moved their bodies naturally in similar movement patterns to ballet dancers (Nettl-Fiol & Vanier, 2011). The results of their study showed that the values of the Alexander technique were successfully applied to both barre and centre exercises, by using primary control to release excess tensions and encouraging inhibition and direction to move their bodies in a more natural manner (Nettl-Fiol & Vanier, 2011).

Weber (2009) applied Ideokinetic principles to contemporary dance technique, aiming "to balance the mind and body, rest and activity, and thinking and doing" (Weber, 2009, p. 246). Due to contemporary dance not having as many technical restrictions as ballet and Irish dance, movement could be explored by using imagery to improvise and create new combinations of movement (Weber, 2009). She stated that Ideokinetic facilitation of exploring fluid systems such as cerebrospinal, lymph, blood and synovial allowed dancers to access a multi-system support for the muscular patterns, creating a more efficient ease of movement (Weber, 2009).

There has been a previous application of somatic values to Irish dance, in which the researcher had a focus on Alexander technique (Buck, 2012). Buck developed the idea of a 'centre-line support system' to cater for the unique characteristics of Irish dance, such as turnout and cross-over occurring over the medial line of the body (Buck, 2012). This, in combination with the upright posture, means that by focusing on five points of the body within the centre-line support system, the alignment of the body will improve (Buck, 2012). A key finding from this study was that by using Alexander technique to inhibit and redirect movement, leaps and large kicks became easier, with a focus on supporting from the medial core (Buck, 2012). However, this study was only conducted on one dancer which limits the validity of the results.

Encouraging an Irish dancer to use somatic practice has the potential to be beneficial in terms of individual practice and self-determined motivation which, as mentioned previously, helps to lower stress and anxiety in the dancer (Good, 2015; Lakes, 2005). This is because by enhancing kinaesthetic awareness, the dancer gets feedback on their movement without relying on a mirror, video or teacher feedback (Good, 2015; Hutt, 2010). Not only does this encourage individual practice, but also ensures that the dancer is aware of their body and is making changes from internal proprioception. By encouraging the dancer to use their kinaesthetic senses, they will be able to get constant feedback throughout their movement without disrupting their lines and balance (Williams, 2011).

2.6. Summary

In this chapter, the technical and aesthetic demands and issues of Irish dance have been established. I have illustrated that stiff-legged landings onto the ball of foot during large leaps subject the dancers to a higher risk of injury. It has also been shown that, during these landings, internal and external rotation moments at the knee and ankle joints as result of misalignments of the body are amplified. The literature suggests that turnout is a key contributor to these misalignments, due to most dancers using frictional force to hold the foot out further than the hip. This is thought to be due to improper technique training by the Irish dance teachers, as a result of their lack of knowledge in the musculoskeletal field and teacher training courses. The literature also suggests that over time, the repetitive actions in a misaligned position overload areas of the body, resulting in muscular tension which disrupts the aesthetic quality and functionality of the dancer. Furthermore, this chapter has addressed the literature surrounding somatic practices and

their application to dance as a way to reduce tension and realign the body. I have discussed the principles of Alexander technique and Ideokinesis as a way to inhibit poor habitual responses and allow the body to naturally realign itself. In relation to this, these techniques have been considered to address some of the issues in Irish dance, namely tension and injuries. The literature has shown that somatic practice is effective at encouraging self-awareness, kinaesthetic perception and muscular efficiency, which has the potential to promote healthier movement for Irish dancing bodies.

3. Methods

3.1. Participants

Thirteen participants between the ages of 18 and 25 were recruited to take part in the study. A sensitivity test with inputs of a = 0.05 and power (1-b) = 0.80 indicate that the study will be sufficiently powered to detect medium effect sizes (d = 0.59) with 13 participants. Individual characteristics are shown in Table 1. All participants were New Zealand *An Coimisiún Le Rincí Gaelacha* (C.L.R.G.) Irish dancers, and had either competed at a national/international level or performed at a national event. For each participant, the number of years trained in dance, dance school and level, as well as training in other dance forms were recorded. Those who had had any lower limb injuries in the past six months that has led to absence from training for more than two weeks were excluded. This study was reviewed and approved by the University of Otago Human Ethics Committee (Approval Number H19/032).

Table 1: Participants' descriptive data (mean ± SD (range)).

(n = 13)	
Age (y)	22 ± 2 (18 – 25)
Height (cm)	165.2 ± 6.1 (154.0 – 176.0)
Body mass (kg)	64.9 ± 10.3 (49.8 – 92.5)
Years of dance experience	11 ± 5 (5 – 21)

3.2. Procedures

All data were collected in the School of Physical Education, Sport and Exercise Sciences (SPESES). Commencing in the study, participants read the *Participant*

Information Sheet[15] and signed the *Consent Form for Participants*[16]. Each participant was asked to attend two data collection sessions and six two-hour long somatic practice sessions. Upon arrival to the first data collection session, participants completed questionnaires and had anthropometric measurements taken in order to collect demographic information. These consisted of age, weight, height, dance experience and injury history.

3.2.1. Biomechanical Data Collection

After changing into their own dancing shoes as well as minimal, tight-fitting clothing for motion capture, participants underwent a brief warm-up to prepare themselves for the study. Each participant performed a typical warm-up preceding training or competition, including practice *flys*. Following the warm-up, participants were fitted with 6 mm reflective markers. Ten Vicon© MX T20 infrared cameras tracked the motion of 22 retroreflective markers placed on the pelvis and right lower limb, as shown in Figure 2. Nexus software reconstructed their positions in 3D space, with a sampling rate of 100 fps. A biomechanical model was then created from the markers, displayed in Figure 3.

[15] Refer to 7. Appendix C. a).

[16] Refer to 7. Appendix C. b).

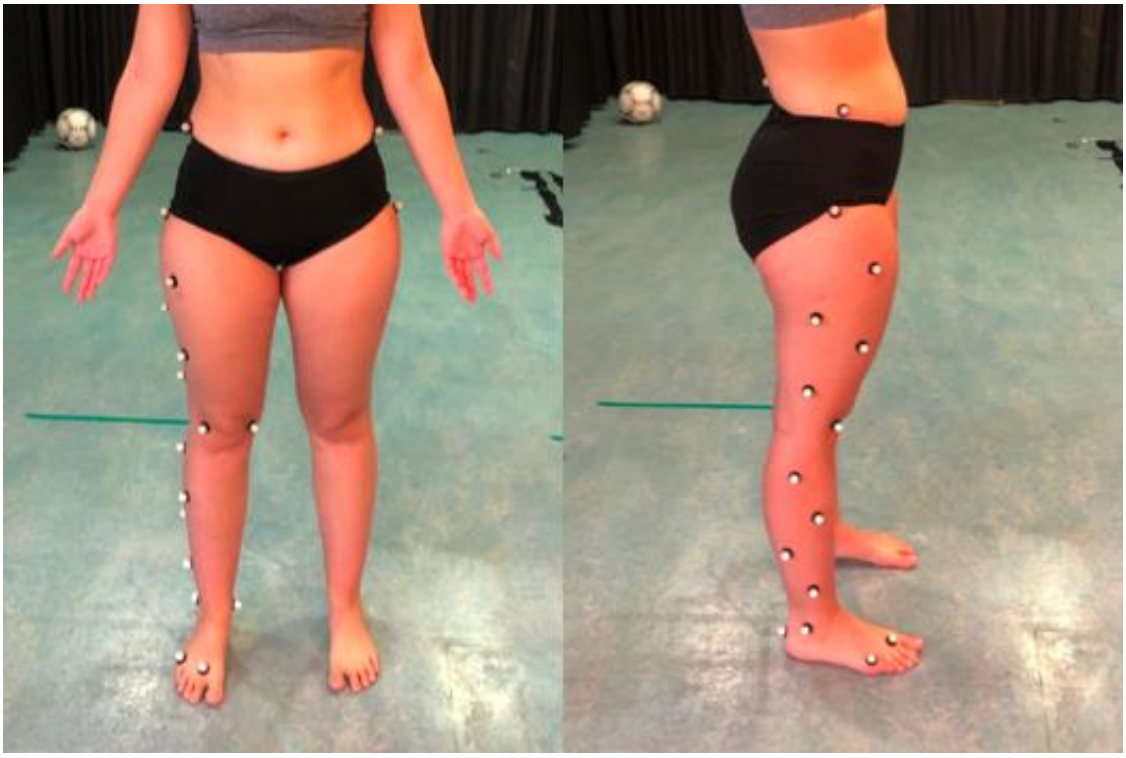

Figure 2: Participant displaying retroreflective marker placement

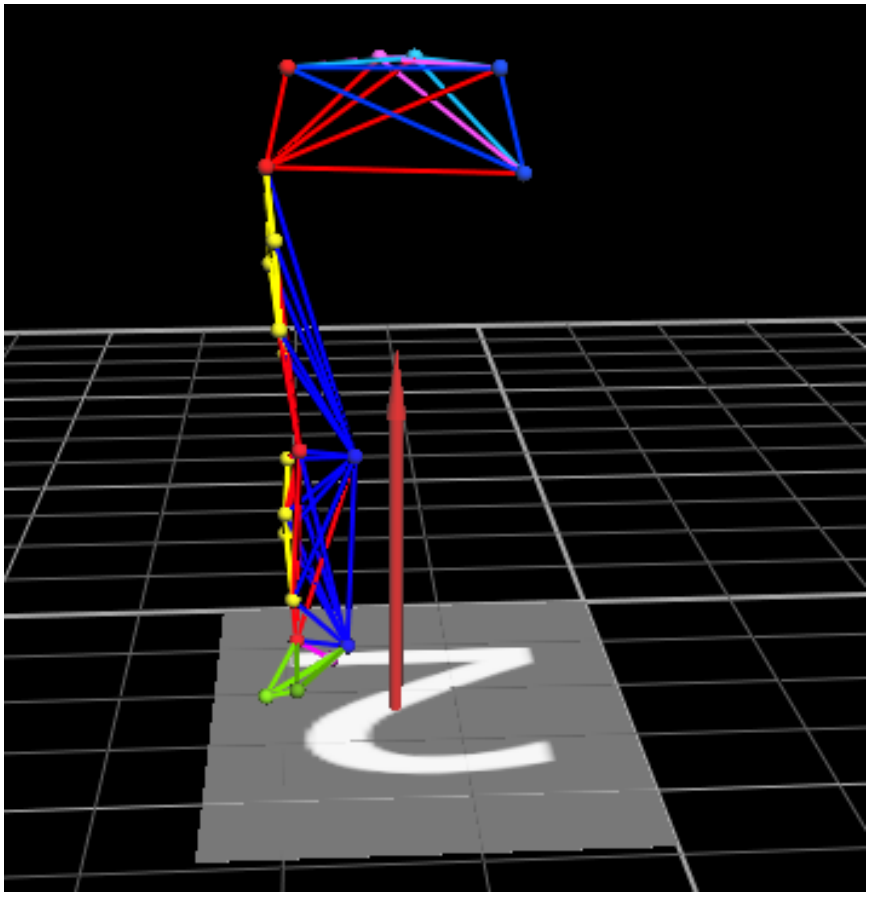

Figure 3: Marker model displayed in Vicon Nexus

Each participant then performed a minimum of ten trials of the *fly* to the best of their ability. Each trial was performed on the participant's right leg with steps leading in and out of the *fly*. This study looks at landings of the right leg as opposed to dominant leg, as Irish dancers are trained to lead from the right foot in all dances, regardless of gender (Cromie, Greenwood, & McCullagh, 2007). Trials were performed to a metronome set to 113 bpm to ensure consistency of the leap in terms of musicality and timing, as well as the progression out of the leap. The *fly* itself was landed on a large rectangular force platform (AMTI LG6-3-1, AMTI, USA) collecting at 1000 Hz with an amplifier gain of 1000 which recorded ground reaction force and moment data. All trials were recorded by an Edgertronic SC1 (Sanstreak Corp, high-speed camera set up in the sagittal movement plane, ensuring a visual of the whole body during the trial was on record. Upon completion of the ten leaps, participants were given the opportunity to warm-down and all markers were removed at the conclusion of their warm-down.

3.2.2. Segment Definitions

The marker set chosen followed guidelines provided by C-Motion (C-Motion, 2013). The **pelvis** segment was defined by markers placed on the right and left greater trochanter (RGT, LGT) to specify the distal end of the segment, the right and left iliac crest (RIC, LIC) to specify the proximal end of the segment, as well as the right and left posterior superior iliac spine (RPSI, LPSI) for tracking (C-Motion, 2014). The **thigh** segment was defined by markers on the right greater trochanter (RGT) to specify the proximal end of the segment as well as the right lateral epicondyle (RLE) and the right medial epicondyle (RME) to specify the distal end of the segment. The **shank** segment consisted of markers on the right lateral epicondyle (RLE) and the right medial epicondyle (RME) which defined the proximal end of the segment, and the right lateral

malleolus (RLM) and the right medial malleolus (RMM) which defined the distal end. The **foot** was a one segment kinetic foot, consisting of markers on the right posterior surface of the calcaneus (RCA), the head of the second metatarsal (RMH2) and the head of the fifth metatarsal (RMH5). Another eight markers were used for segment tracking, with four markers placed laterally on both the thigh and shank segments. A **functional hip** was created relative to the tracking markers on the thigh segment and pelvis (RPSI, LPSI) in order to specify the joint centre (C-Motion, 2013). A **virtual foot** was also created in order to calculate foot progression. The proximal end of the segment was defined by the medial/lateral epicondyle markers (RME, RLE) and the medial and lateral malleoli (RMM, RLM) defined the proximal end. Additionally, the **kinetic** foot was used in the inverse dynamics calculations, whereas the virtual foot was used for kinematics such as foot progression[17].

These markers were also used to define the orientation of the segments. The horizontal line between the left and right iliac crest markers defined the mediolateral axis (X) of the pelvis, the longitudinal axis (Z) was perpendicular to the X-Y plane and the sagittal axis (Y) was the cross-product of the X and Z axes. For the thigh and shank segments, the X axis ran through the medial and lateral proximal markers, and the positive direction was to the right. The Z axis was perpendicular to the X, and ran through the midpoint between the proximal and distal markers. Similar to the hip segment, the Y axis was then found as the cross-product of X and Z. Lastly, the virtual foot orientation was defined by the same coordinate system as the shank, with the use of the proximal and distal foot markers. The Y axis was relative to the lab (C-Motion, 2019).

[17] Foot progression can be defined as the Y axis of the virtual foot relative to the Y axis of the lab in the XY plane (C-Motion, 2019).

3.2.3. Data Processing

Following the capture of the trials, marker reconstruction was undertaken in Vicon Nexus v2.7 (Vicon, Oxford, UK). Marker trajectories were smoothed and gaps were filled using a Woltring spline filter. Files were then exported to c3d file format and imported into Visual3D v6 (C-motion, Inc., Germantown, MA) where a biomechanical model was created from the marker positions. Local coordinate systems for the pelvis, thigh, leg, and foot were derived from the standing calibration trial. Inverse dynamics calculations were performed to determine joint moments, and a set of relevant variables were calculated. This consisted of right hip angle, right knee moment, right ankle moment and foot progression, as well as 3D ground reaction forces and 2D centre of pressure. This data were then exported to mat file format for further processing in MATLAB R2017b (The MathWorks Inc., Natick, MA). Independent and continuous dependent variables were initialized, and calibration trials were excluded. Landing durations were then defined by initiation and completion of ground contact on the force plate. To allow for any noise in the trials, ground contact was considered any force (F_z) above 70 N.

3.2.4. Intervention

Participants attended a two-hour somatic practice training session once a week for six-weeks. This was subject to time availability and commitments from participants. During these sessions, an experienced somatic practitioner[18] took participants through a

[18] Miriam Marler (M.DanceStudies, PGDip.CreativeInjurys, B.PSA) is the founder of GASP! Dance Collective and is a conscious movement facilitator (contact improvisation and somatic practice). She has been trained in a variety of methods and has developed her own somatic approach.

warmup, followed by a series of postural alignment exercises based on Alexander Technique and Ideokinesis[19]. Both of these practices focus on musculoskeletal alignment and efficiency in movement coordination by reducing excessive tension and promoting attention to internal awareness. Whilst it is acknowledged that Irish dance is primarily a lower body activity and this particular study is primarily focused on hip turnout, the basis of somatic practice is to approach the body in a holistic sense. As a result, the sessions were designed to draw awareness and initially reduce muscular tension in other areas of the body before specifically targeting the hip joint.

The sessions were structured based on the Alexander Technique principles of 'non-doing', 'inhibition' and 'direction', as described in chapter 2 and followed a progression starting on the floor and proceeded to standing, moving and jumping. This was in order to work on alignment without resistance to gravity, improve efficiency in breathing patterns and release tension to encourage mobility at the joints.

For the first two sessions, the majority of exercises were performed in constructive rest[20], and had a focus on unlocking tense areas in the body and encouraging relaxation. Developing an understanding of anatomical imagery was also a key objective of this session, and was achieved by using 'body-mapping'[21]. This was to bring the participants' attention to different joints and limbs to help to train their kinaesthetic perception and was also used in order to develop efficient breathing patterns. Some of

[19]Refer to 2.5.2. and 2.5.3.

[20] A position in which the participants lay supine with their hips flexed, feet flat on the floor and knees resting against each other. This means that no muscular work is needed to maintain equilibrium in this position (Swiegard, as cited in Isiguen, 2015).

[21] A body map refers to an image of the individual's body and how it moves which, in turn, allows the body to move more efficiently (Batson, 2008).

the lines of movement[22] were introduced while on the floor, such as lengthening the spine, widening the pelvis and narrowing the ribcage, to further visualise anatomical alignment. The practitioner used touch to develop movements and release tension in the joints and muscles, beginning with the neck, head and shoulders, then progressing onto the pelvis, hips and knees. Importantly, she did not use forceful manipulations but instead, allowed the participant to focus on their own postural change (Batson, 2008).

The programme then moved on to apply these principles while standing and moving, as releasing tension in small, everyday movements served as a progression into dance movements. These were movements such as walking, and sitting down and standing up out of a chair. Standing up from a chair reflects the motions used when preparing to jump and, similar to jumping, can cause unwanted preparatory tension before the movement has even started (Brennan, 2011). Practicing movement in the chair can encourage effective engagement of the quadricep, hamstring and gluteal muscles, sustain the length of the spine, and allow for more effective use of the psoas muscle during jumping. Participants were encouraged to think about primary control[23] when initiating movement out of the chair and walking, in order to perform these actions without excess tension, therefore retaining the work done in constructive rest. The lines of movement were reintroduced in these exercises and external touch was used to draw awareness to tension in the upper fibers of the trapezius in order to facilitate primary control and improve the neck line while dancing.

Following these sessions, the somatic principles were applied to more dynamic movements. The key objective was for participants to be aware of their alignments while

[22] Refer to 2.5.3.

[23] Refers to the dynamic relationship of the head, spine and back, and suggests that due to the bodily reflexes at this location, we should lead movement from the head in order to control and direct the rest of the body in an aligned manner (Brennan, 2011).

performing movements that relay into Irish dance, such as leg lifts, turnout and small jumps. The practitioner also encouraged participants to think about preparatory tension in these movements, as this is common to see in dance leaps. Additionally, as mentioned in chapter 1, Irish dancers' tendency to attempt to hold the torso, arms and head perfectly still throughout large movements mean that there is excessive muscular tension in those areas. These sessions were to encourage dancers to allow their body to make small, natural deviations from alignment, and imagine the body as balanced, not rigid.

The final session was used to progress into the *fly* movement, utilising the principles from the earlier sessions. With this session, participants were brought back down to constructive rest, performed exercises similar to the first sessions to release tension and also, encouraged to visualise their ideal *fly*. Participants were to then slowly progress through the movement and if any muscular tension was identified, they reset back to visualisation and focussed on the line of movement in which the issues was occurring. As the *fly* does primarily focus on leg height and jump, we will encourage participants to simply isolate the movements. This means to raise the leg slowly, keep the psoas muscle soft and focus on breath, as outlined in previous sessions.

It is also important to note that the sessions were subject to change; the use of somatic practice depends largely on the response to each exercise from the participants. This meant that the practitioner had the freedom to deem it necessary to deviate from the original programme design. Key observations of and comments from the participants were recorded throughout each session. The sessions concluded with a warm down and a discussion on the participants' observations and sensorial experience. A specific description of the programme exercises can be found in Chapter 7. Appendix D.

3.3. Data Analysis

Data visualization and analyses was completed in MATLAB R2017b. Mean and standard deviations (±) were calculated for all dependent variables. Rotation moments were normalised to participant height and bodyweight, and all dependent variables were time-normalised to 100 frames. Additionally, hip external rotation and ankle/knee rotation moments were identified at maximum force. This was then used to establish the association between hip external rotation and internal rotation moments of the knee and ankle by performing a correlation coefficient analyses with a 95% confidence interval. Correlations were also performed for hip angle and foot progression. Data were then presented in scatter, line and angle-angle plots.

To evaluate the effect of the intervention on hip external rotation, data of both sessions were firstly tested for normality using a Kolmogorov-Smirnov test. A Wilcoxon rank sum test was then conducted to compare hip external rotation between sessions, with significance presumed at $p = .05$. Mean and standard deviation (±) between sessions, as well as relative differences (%) were computed. Differences between all other dependent variables were also calculated, and presented in line plots.

4. Results

4.1. Overview

This study aimed to explore the relationship between hip external rotation and joint rotation moments of the lower limb throughout an Irish dance landing. This was in order to further understand how compensatory turnout mechanisms can affect the dancer's body, providing insight into risk of injury. In addition, we aimed to explore the effectiveness of a somatic training programme in bringing about increased turnout. We had hypothesised that, for the primary objective of this study, there would be an inverse correlation between hip external rotation, and knee and ankle internal rotation moments. The hypothesis for the secondary objective was that an increase in turnout or hip external rotation would occur as a result of the somatic intervention. All participants completed six 2-hour somatic practice training sessions, with each session separated by 7 ± 2 days. The sessions began within 7 days of baseline testing and final testing occurred within 7 days of completing the programme.

The following chapter will present kinematic and kinetic data obtained from both motion capture sessions and the subsequent statistical analysis. The results of this study will be presented by firstly addressing the primary objective of examining the relationship between hip external rotation, and knee and ankle moments. Following this, the secondary objective of this study will be addressed by evaluating the effectiveness of the somatic practice intervention.

4.2. The hip turnout and rotation moment relationship

The relationship between hip external rotation and external/internal rotation moments of the ankle and knee were examined both prior to and following the

intervention. It should be noted that the hip angle in an anatomical standing position is approximately 0º and external rotation is in the negative direction.

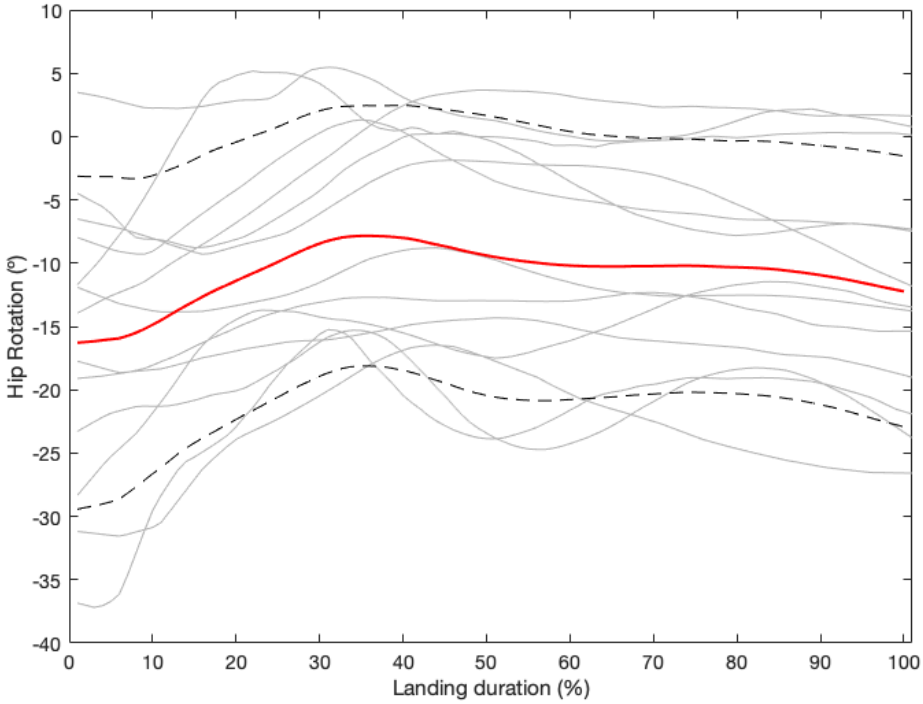

Figure 4: Hip rotation (º)(mean + SD) of all participants over duration of landing (%). Mean of all trials for each participant in grey, red is grand mean for all participants and dashed is standard deviation of the grand mean.

Figure 4 illustrates the hip rotation (*DM*[24] = -10.9º ± 2.4) of both sessions during the landing phase of the *fly*. This shows that participants tended to initialise the landing with the hip externally rotated to its maximum (*M*[25] = -16.0º) but as vertical ground reaction forces increased, external rotation decreased. At around 30-40% of the landing phase, the hip was minimally externally rotated (*M*= -7.8º). Following this, hip external rotation began to increase as the participants reached the end of the landing phase and their movement.

[24] Double mean. This is the mean value across all participants and across normalised time frames

[25] Mean value across all participants.

There is a wide variety of hip rotation movement profiles across participants. While the degree of hip external rotation varies, most participants decreased their external rotation as landing forces increased, with maximum external rotation occurring in the first 20% of the landing.

As all participants exhibited different movement patterns, peak hip rotation angles occurred at different points in time, as did peak ankle and knee rotation moments. Therefore, this relationship was assessed by examining the moments and angles at the time of maximum vertical force; where the dancer was most likely to be subjected to large rotation moments. The relationship between hip rotation angle, and knee and ankle internal/external rotation moments is presented in Figure 5.

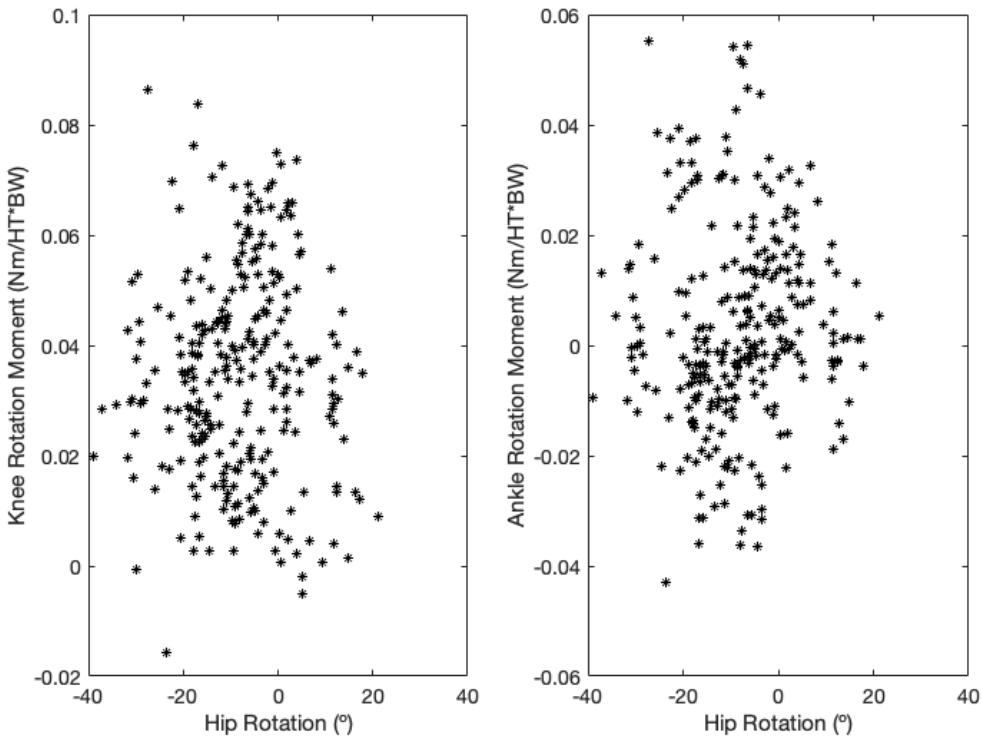

*Figure 5: Relationship between knee/ankle rotation moments (Nm/HT*BW[26]) and hip rotation angle (º) at maximum vertical force*

[26] Height multiplied by bodyweight.

There was no correlation found between hip rotation angle and knee rotation moments at maximum vertical force (r = < .01, p = .95, *95% CI* [-.12, .12]) and a very low positive correlation between hip rotation angle and ankle rotation moments (r = .05, p = .38, *95% CI* [-.07, .17]). This negligible correlation is reflected in Figure 5, where there is no visible trend.

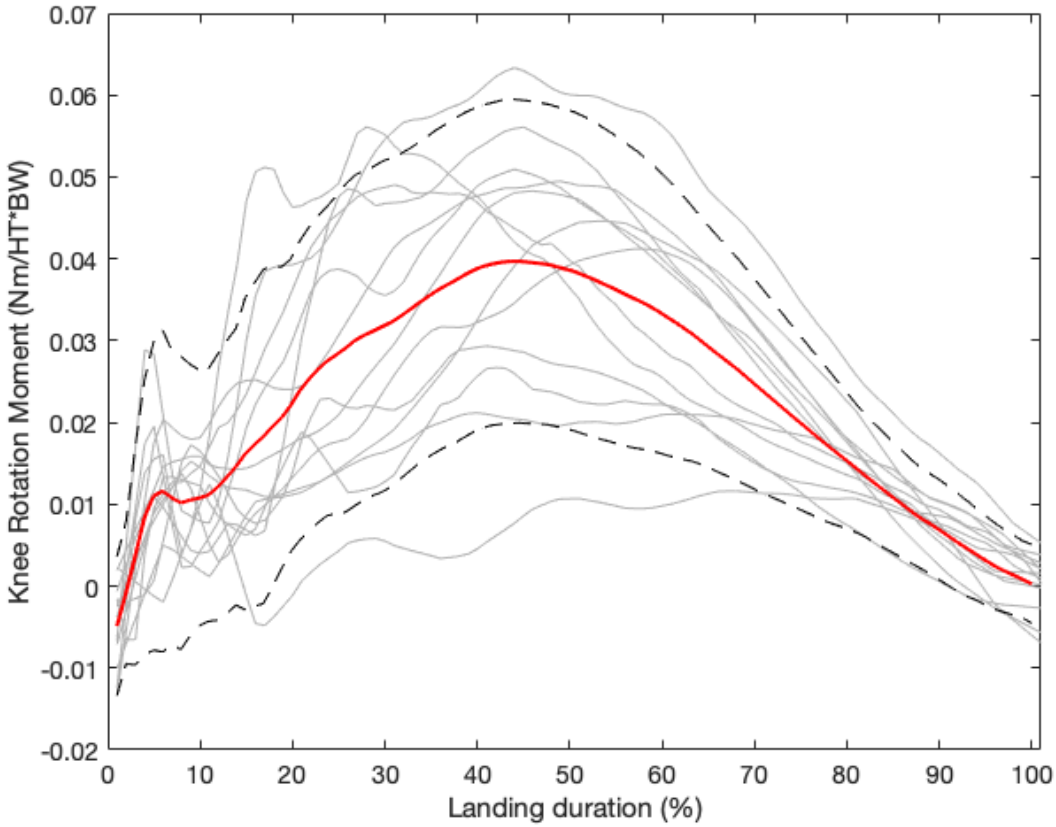

Figure 6: Knee rotation moment (mean + SD) of all participants over duration of landing. Mean of all trials for each participant in grey, red is grand mean for all participants and dashed is standard deviation of the grand mean.

Figure 6 displays the mean knee rotation moments (*DM* = .022 Nm/HT*BW ± .008) of both sessions for all participants. It is evident that most participants experienced an increase in internal rotation moments as landing forces increased, with maximum knee

internal rotation moments (*M* =.042 Nm/HT*BW ± .015) occurring at 40-50% of the landing phase.

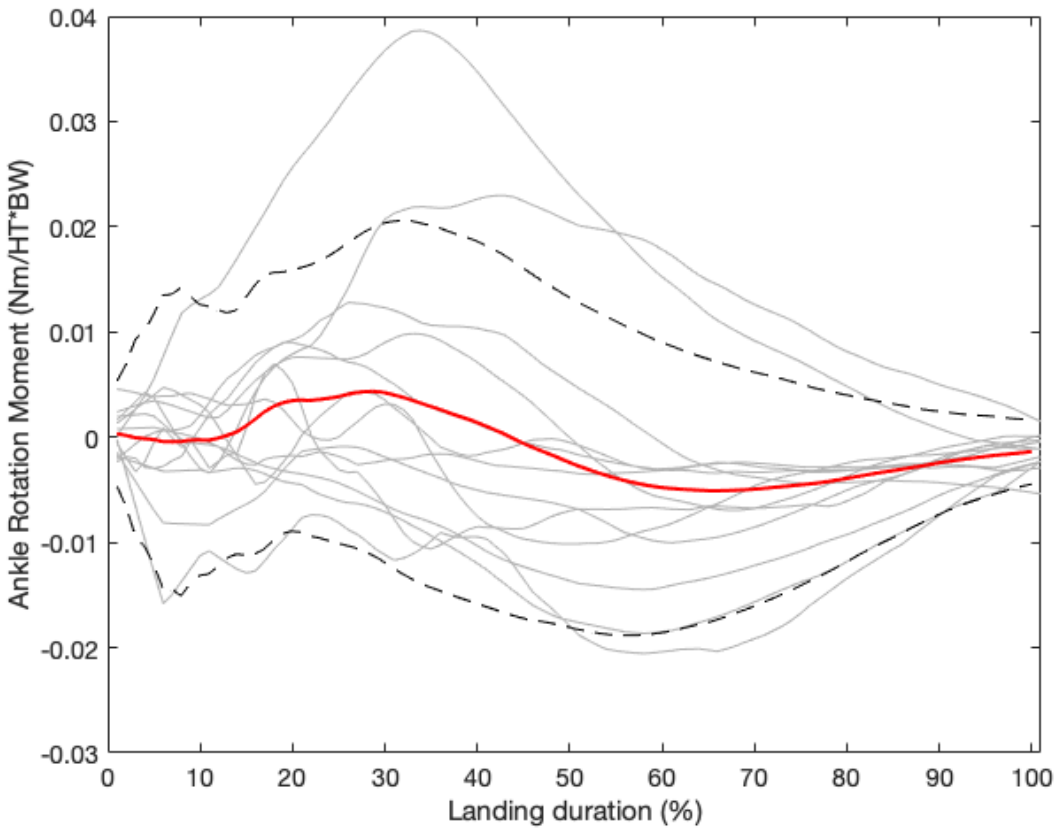

Figure 7: Ankle rotation moment (mean + SD) of all participants over duration of landing. Mean of all trials for each participant in grey, red is grand mean for all participants and dashed is standard deviation of the grand mean.

Ankle rotation moments varied notably between participants, as displayed in Figure 7, with a double mean ankle rotation moment of -.001 Nm/kg ± .008. Internal rotation moments tended to increase at 20-30% as landing forces increased and external rotation moments increased at 60-70% the landing phase as these forces decreased.

4.3. Hip Rotation and Foot Progression

As stated in previous chapters, many dancers do not utilise rotation at the hip when attempting to turnout their leg and instead, twist at the knee in order to force turnout

at the foot. As there was no correlation between knee rotation moments and hip rotation but still a large increase in knee internal rotation, placement of the foot relative to the lab (foot progression) was investigated. Toe-out rotation of the foot are represented as negative numbers, with neutral alignment represented as approximately 0º.

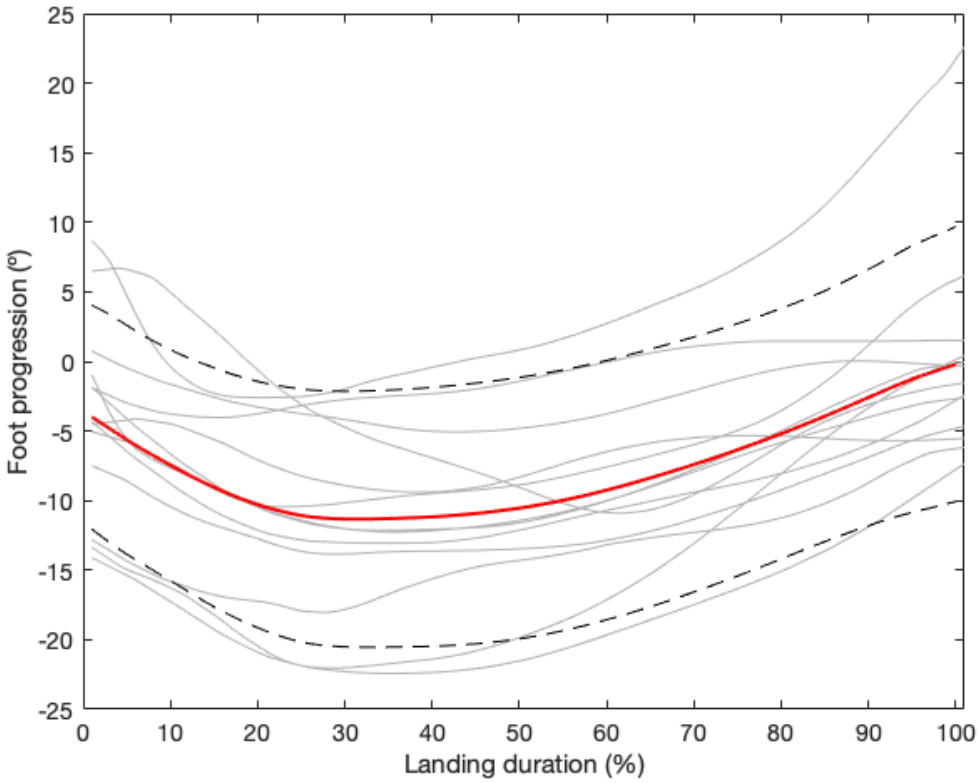

Figure 8: Foot progression (mean + SD) of all participants over duration of landing. Mean of all trials for each participant in grey, red is grand mean for all participants and dashed is standard deviation of the grand mean.

Figure 8 indicates that mean foot progression (*DM* = -7.6º ± 6.0) increased as landing forces increased, with maximum external foot placement (*M* = -12.0º ± 6.2) occurring at 30-40% of the landing phase. This placement became more neutral as the participants reached the end of their landing and stepped off of the force plate; however, the degree of which varied across participants.

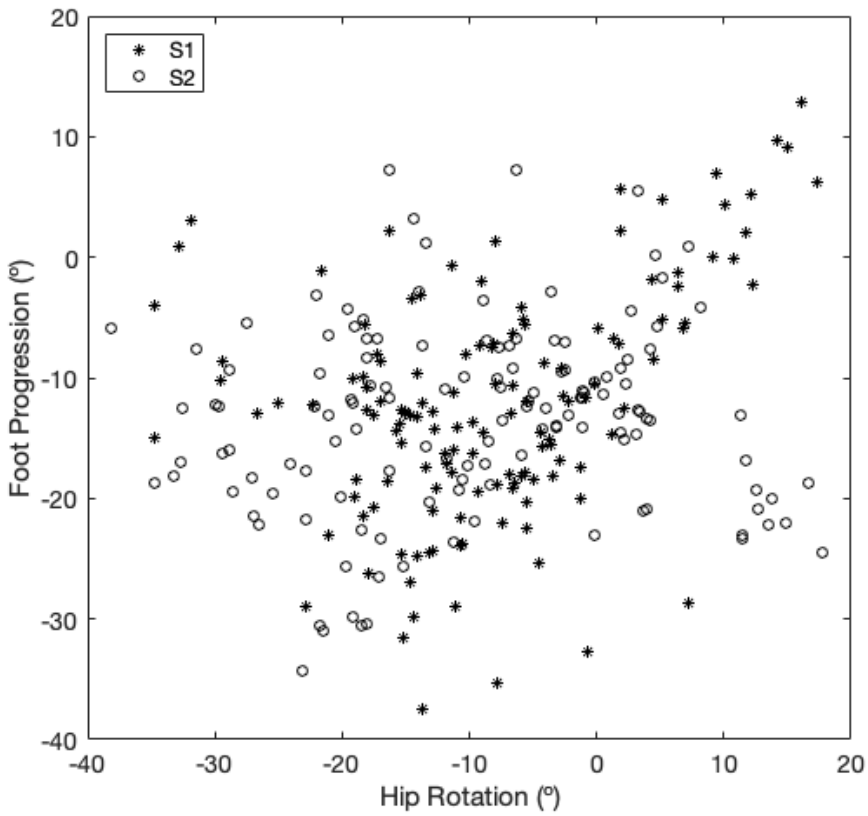

Figure 9: Foot progression (º) and hip rotation (º) at maximum force (fZ) for session one and two

As indicated in Figure 9, there was a weak positive correlation between hip rotation and foot progression at maximum force (r = .24, p = <.01, *95% CI* [.12, .35]). This suggests that there is a relationship between the angle of the hip and placement of the foot, which allows us to evaluate how this may affect knee and ankle rotation moments.

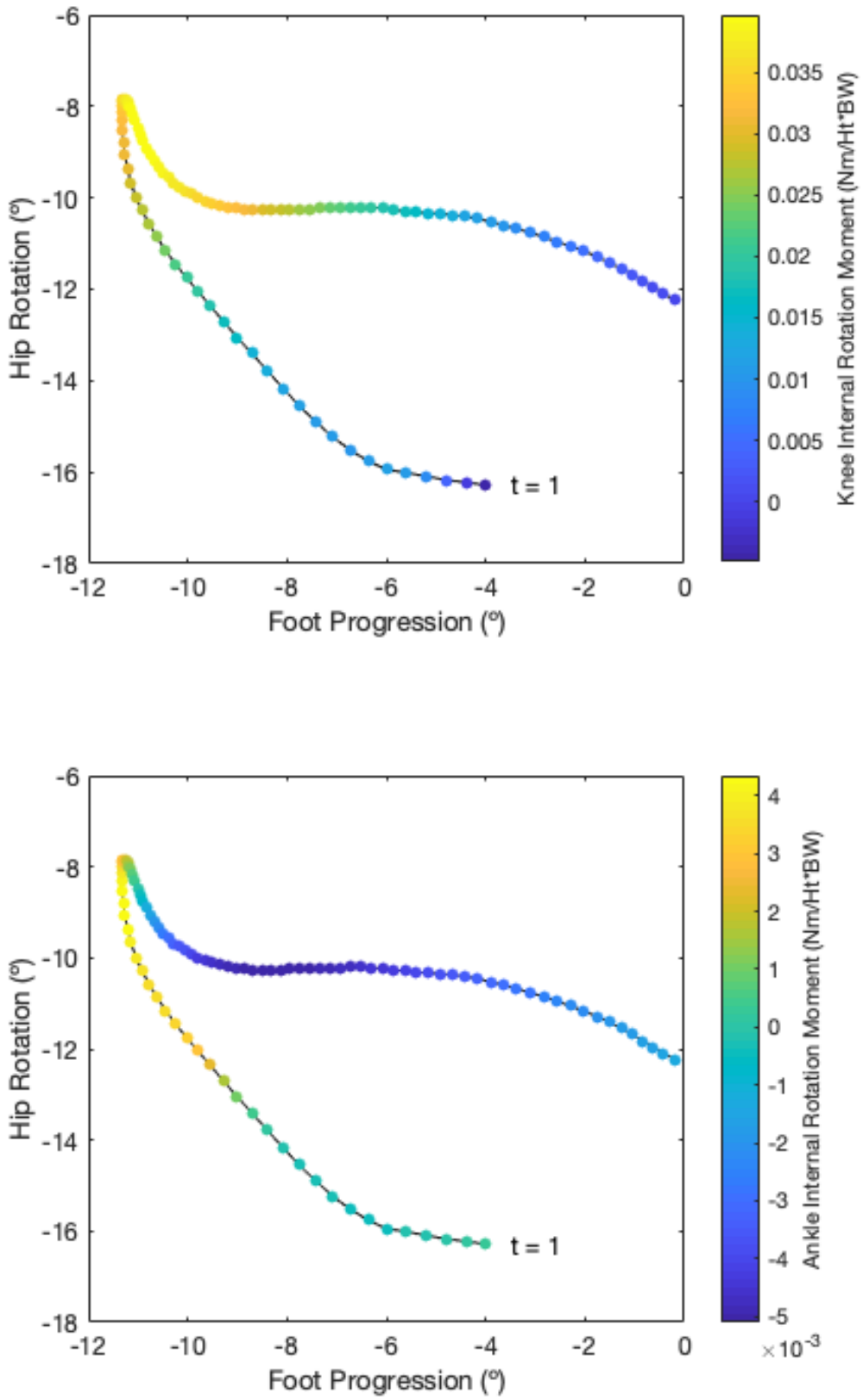

*Figure 10: Mean hip-foot angle-angle plot and associated knee and ankle moments (Nm/HT*BW) for both sessions. Plot starts at (t=1).*

Figure 10 suggests that hip rotation and foot progression have an anti-phase relationship. This means that as hip turnout magnitude decreases, foot progression increases, indicating that turnout has been achieved through the interaction of the foot on the floor[27]. Knee internal rotation moments are higher when the difference between the hip and foot is at its greatest, as reflected in the top left of the graph. There was a weak positive correlation established between the hip-foot relationship and knee internal/external rotation moment (r = .15, p = .01, *95% CI* [.03, .27]). Furthermore, when considering foot progression, a weak positive correlation was found between the hip-foot relationship and ankle internal/external rotation moment as well (r = .20, p = <.01, *95% CI* [.08, .27]). Although this was not stated at the outset of this study, accounting for foot progression means that we can better understand how issues with turnout and forcing turnout affect the ankle and knee internal/external rotation moments.

4.4. Somatic Practice and Turnout

Table 2: Mean ± SD and relative difference of all dependent variables for session 1 and 2

	Session One (*DM* ± SD)	Session Two (*DM* ± SD)
Hip Rotation (º)	-9.8 ± 8.7	-11.9 ± 11.4
Knee Moment (10^{-3} Nm/H*BW)	-2.1 ± 1.1	-2.3 ± 9.4
Ankle Moment (10^{-3} Nm/H*BW)	1.0 ± -9.0	-3.2 ± .9.6
Foot Progression (º)	-6.9 ± 9.3	-8.3 ± 7.5

As described in Table 2, there was a 21.4% relative increase in mean external hip rotation following the somatic practice intervention, as hypothesised. However, a Wilcoxon rank sum test indicated that there were no statistically significant differences

[27] Refer to 5.1.5.

between the sessions (Z = 1.13, p = .26). Despite an increase in hip turnout magnitude in the second session, mean hip turnout between sessions for this sample did not provide sufficient evidence to conclude that an effect from the intervention exists.

Although statistically no significant differences were observed between session one and session two, graphical representations of moments and angles throughout the landing phase display some apparent trends.

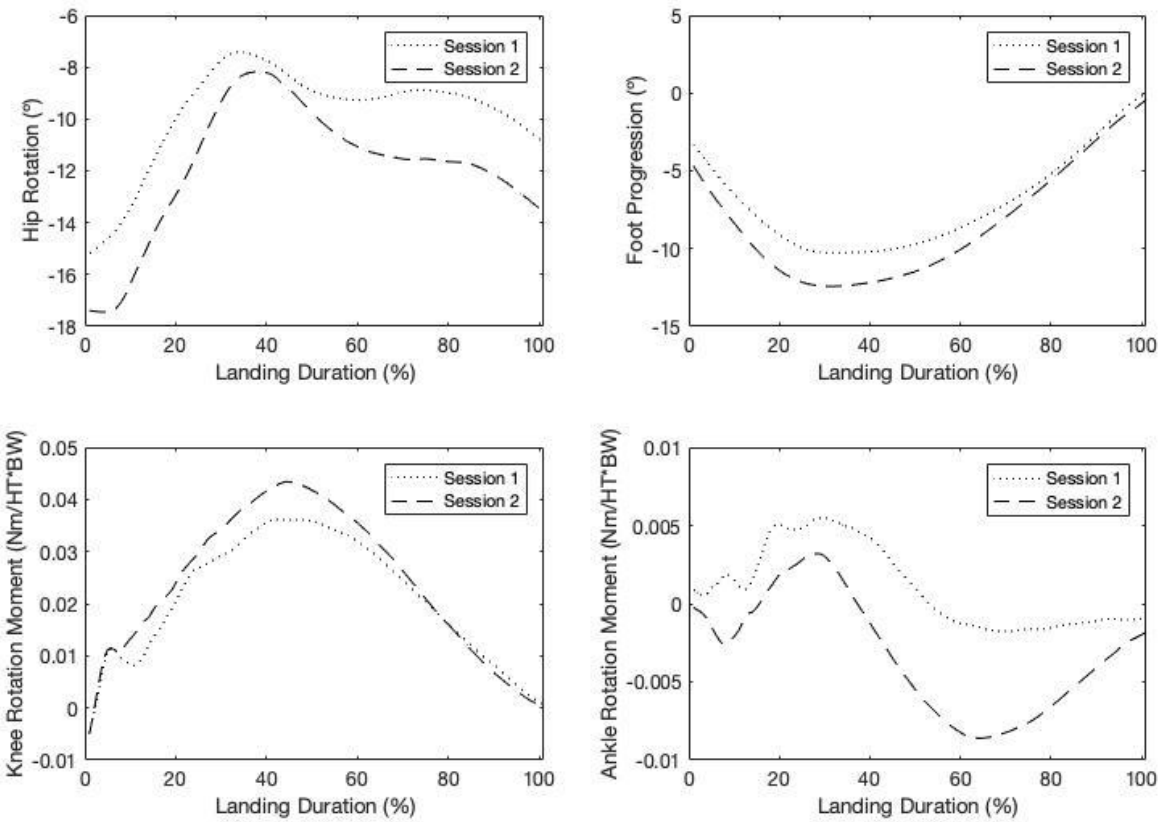

Figure 11: Mean difference of all dependent variables for session 1 & 2.

As shown in Figure 11, there were slight changes in the mean landing profiles following the intervention. While hip rotation increased in session two, there was less of a difference between sessions as hip turnout magnitude decreased. This means that there was more variability in degree of turnout for the duration of the landing, which ideally should be consistent throughout. Additionally, foot progression decreased, meaning that

there was a larger difference between the hip and the foot, and in turn, generated larger internal rotation moments at the knee.

4.5. Summary

The results indicated that there was a low correlation between hip rotation angle and internal/external rotation moments at the knee, as well as between hip rotation angle and internal/external rotation moments at the ankle. The null hypothesis for this objective proposes that there would be no statistically significant correlation between variables. As neither correlation was statistically significant, there was not sufficient evidence to reject the null hypothesis.

An a posteriori analysis of the data indicated that a low positive correlation ($p = < .01$) was found between hip rotation angle and foot progression angle. Additionally, the correlation between the hip-foot relationship at maximum vertical force, and both knee and ankle internal/external rotation moments was assessed. A statistically significant low correlation was found for both variables.

In terms of the effectiveness of the somatic practice intervention, results showed that there was a slight increase in mean external hip rotation in the session 2 data. However, the differences between sessions were not statistically significant, meaning that we do not have sufficient evidence to determine the overall effect of the intervention.

5. Discussion

The aim of this thesis was to assess the relationship between external rotation of the hip and knee and ankle internal/external rotation moments upon landing of an Irish dance *fly* leap. In relation to this, the present study aimed to evaluate the effectiveness of a somatic practice training programme in bringing about increased external thigh rotation. These objectives were addressed by firstly examining the rotation of the hip throughout the landing of the *fly,* as well as investigating the nature and direction of knee and ankle rotation moments. The relationship between hip angle and the knee and ankle rotation moments was then established. Following this, foot progression was investigated in order to understand the joint rotation moments, then a comparison of foot progression relative to hip angle was made. Lastly, to address the secondary objective of the effectiveness of a somatic training programme, comparisons were made between hip angle prior to and following intervention.

It was hypothesized that there would be an inverse correlation between hip external rotation, and knee and ankle internal rotation moments. The results suggested that there was a negligible correlation between hip rotation angle and internal/external rotation moments at the knee, and a very low positive correlation between hip rotation angle and internal/external rotation moments at the ankle. Neither correlation was statistically significant, therefore there was not sufficient evidence to reject the null hypothesis. There was however, a low positive correlation (r = .24, p = < .01) between hip rotation angle and foot progression angle. This variable was overlooked initially when using mean turnout in the previous correlation. The foot turns out as the hip turns in, which causes a peak in rotation moments; a concept supported by previous literature stating that the foot is placed out more than the hip in dance (Carter et al., 2018; Champion & Chatfield, 2008; Grossman, 2003; Quin et al., 2015; Shippen, 2011). It is

therefore important to the purpose of this study and warrants discussion. As a result of this relationship, the correlation between the difference of hip rotation and foot progression at maximum vertical force, and a) knee internal rotation moment and b) ankle internal rotation moment was assessed. This showed a statistically significant low positive correlation for both the knee and ankle.

The hypothesis for the secondary objective was that the sessions following the somatic intervention would show an increase in hip external rotation. Results indicated that there were no significant differences between sessions; however, group mean data suggests hip external rotation was higher in session two. Nevertheless, there was not sufficient evidence to conclude that a somatic practice programme had an effect on turnout at the hip.

This chapter will firstly evaluate the results from this study in terms of the primary objective, by discussing the movement profiles of hip rotation and the effects on rotation moments at the knee and ankle. Additionally, individual differences and potential causes of these differences will be examined. Following this, the whole-body responses of participants to the somatic practice intervention will be discussed, as well as what these responses reveal about hip rotation and overall turnout of the dancer. The potential implications of these findings to the dancers, teachers and Irish dance Commission will then be discussed. Lastly, potential future research considerations, and limitations and delimitations of the study will be evaluated, followed by a brief summary of the chapter, as well as an overall summary of the thesis to conclude.

5.1. Effects of Turnout on Joint Moments

5.1.1. Overview

From an anatomical perspective, external hip rotation is the strongest predictor of turnout when looking at an extended knee. However, previous literature has shown that 'forcing' turnout by utilising tibial torsion and friction of the floor plays a large role in sustaining turnout at the foot but not the hip (Cahalan, Purtill, O'Sullivan, & O'Sullivan, 2015; Klopp, 2017; Russell, 2013; Shippen, 2011). As mentioned in the literature review[28], tibial torsion contributing to turnout results in rotational pressures at the knee, leading to an increased risk of injury. Furthermore, using the friction of the floor to externally rotate the foot subjects the ankle joint to high internal rotation moments (Cahalan et al., 2015; Klopp, 2017; Russell, 2013; Shippen, 2011). By investigating turnout of the hip throughout the duration of landing, variations in the degree of turnout could be identified, thereby providing insight into how to maintain external rotation throughout the leap.

5.1.2. Patterns of turnout at the hip joint

The results from this study, as shown in Figure 4, indicated that as a group, participants tended to begin the landing of their *fly* with an externally rotated hip. However, as the landing progressed and vertical ground reaction forces increased, turnout began to decrease at the hip. Participants tended to regain an increased degree of turnout as they reached the end of the landing phase. Studies suggest that 60-70º of turnout is contributed by the hip to obtain an overall ideal turnout of 90º (Champion & Chatfield,

[28] Refer to 2.3.1.

2008; Shippen, 2011). As an ideal turnout is anatomically rare, it is expected of dancers to achieve a minimum of 45º at the foot from the anteroposterior of the body (Khoo-Summers et al., 2013). Interestingly, mean results from both sessions showed that the most turnout at any point from any participant was 37º, with the double mean indicating only 11º. This means that if a perfect turnout was presumed, the hip joint was a very small contributor. Furthermore, if these particular dancers were to meet a 45º minimum expectation, most participants would be contributing at the foot and knee; a position that is not ideal for the demands of Irish dance. Due to turnout only being measured in this study at the hip throughout the landing of the *fly*, we cannot determine whether turnout increased or decreased following the leap itself. Studies would suggest that turnout at the feet is higher when in contact with the floor due to the opposing friction; however, this does not confirm what may be happening at the hip at this point (Franklin, 2004; Holt, 2014; Klopp, 2017; Quin et al., 2015; Shippen, 2011; Weiss & Zlatkowski, 1996). This concept will be explored further in section 5.1.5.

5.1.3. Individual discrepancies in turnout at the hip

There was a wide variety of movement profiles between participants in terms of hip rotation[29]. One dancer exhibited internal rotation at the hip throughout the entirety of the landing, and two more dancers experienced internal rotation as landing forces increased. This is an example of the anatomical discrepancies between dancers, as these dancers came into the study with self-reported malalignments. One of the dancers had bow legs or *genu varum*, characterised by visible femoral medial rotation, whereas the other two experienced knock-knees or *genu valgus* (Hatef, Babakhani, Balouchi,

[29] Refer to 4.2. (Figure 4)

Letafatkar, & Wallace, 2020; Quin et al., 2015). As a result of this, these dancers were likely to experience higher rotation moments at the knee and therefore high tensile and compression stresses at the joint (Franklin, 2004). In particular, dancers experiencing *genu valgus* presented with higher external rotation of the foot, meaning the internal rotation moment at the ankle was greater. The remaining participants demonstrated the same pattern of the mean hip rotation throughout landing; however, they differed in magnitude and timing throughout landing. This alludes to how different dancers can achieve visually similar movements in agreement with the rules, but do use with surprisingly different kinetics and kinematics. This highlights the importance of the dancers needing to be considered as individuals, with discrepancies in not only physical characteristics, but also in their psychological traits (Koutedakis & Sharp, 1999; Quin et al., 2015). This means that even at the highest level when movements are refined, aspiring to mimic an 'ideal' or successful dancer is ineffective and potentially unsafe, as superior technique is reserved for each individual.

5.1.4. Pelvic tilt and rotation

Another factor thought to affect the amount of external rotation available at the hip is pelvic tilt, due to overloading the iliopsoas (Quin et al., 2015; Weiss & Zlatkowski, 1996). It was common to see an anterior pelvic tilt in participants as they were performing the movements leading into the *fly*, as well coming out of the movement. However, as stated in chapter 2, dancers commonly force their leg up when performing high leg extensions, resulting in flexion of the trunk and a posterior pelvic tilt (Quin et al., 2015). When looking at videos from the motion capture session, these motions were observed in some participants which could have affected the degree of hip rotation upon landing. However, it was more notable that dancers were displaying differing degrees of pelvic

rotation in the transverse plane as they entered the push through/landing phase of the *fly*[30]. This meant that as the left (take-off) leg was brought through to extend in front of the dancer, the pelvis rotated to anticlockwise around the longitudinal axis. In addition to crossing the legs[31] due to the aesthetic requirements of Irish dance, this motion is likely to decrease the amount of turnout available at the hip of the right (leading) leg upon landing. This movement was not predicted prior to conducting this study and can be considered a large contributor as to why the small magnitude (11º) of external rotation occurred upon landing the *fly*. Further studies should consider examining the pelvic rotation and orientation, as well as the entirety of the movement in order to understand this relationship. A discussion of how somatic practices may assist in stabilising this movement will be presented in section 5.2.

5.1.5. The hip-foot relationship

As identified previously, a lack of hip external rotation during turnout is often compensated by utilising friction on the floor and tibial rotation, as a means to over-pronounce turnout at the feet (Klopp, 2017; Shippen, 2011). This meant that when it came to processing initial data, looking at hip rotation angle alone was not providing sufficient insight as to why knee and ankle internal rotation moments were occurring. Accounting for foot progression, or toe-out rotation, means that we can better understand how issues with turnout and forcing turnout affect knee and ankle joint internal/external rotation moments. It was demonstrated in Figure 8 that as a group, participants' foot progression increased as the hip turnout magnitude decreased. This meant that as the

[30] Refer to 7. Appendix A.

[31] Refer to 2.2.2.

dancers landed on the forefoot, they utilised the friction on the force plate to rotate their heel inwards and as a result, produced an opposing internal torque. This then validates the faulty technique and increased risk of injury. Furthermore, ankle eversion moments can often be coupled with ankle rotation moments, as a result of the combination of motions occurring at the subtalar and tibiotalar joints (Brockett & Chapman, 2016). This means that pronation of the foot can be expected when the participant forces the toe-out motion which in turn, leads to the knee moving medially and reduces the external rotation at the hip. The results from our study supports this concept because at the point of greatest difference between the foot and hip angle, knee and ankle internal rotation moments were at their highest. However, eversion force at the ankle was not reported for this study and future research could benefit from considering this motion at the ankle joint.

As stated previously, dancers prioritise a large turnout at the feet. It is therefore important to note that improving hip mobility and external rotation alone is not sufficient to reduce internal rotation moments at the knee and ankle. Our results established that the difference between the femur and foot position is the key predictor in magnitude of internal rotation moments at these joints. Thus, encouraging dancers to focus on keeping the placement of their foot in line with their hip, even if their hip turnout improves, is essential to reducing these forces.

5.1.6. Other contributing factors

The premise of this study is on the lack of proper turnout technique that Irish dancers are taught, due to prioritising the illusion of turnout at the foot, rather than teaching dancers how to utilise rotation at the hip[32]. It is therefore important to

[32] Refer to 2.3.5.

acknowledge that some participants had previous training in other dance forms, which may have affected their turnout technique. Notably, the dancer showing the largest degree of external hip rotation amongst participants was also trained in ballet and contemporary dance styles. Other dancers that had a history of ballet showed no visual difference in turnout at the hip when compared to solely-trained Irish dancers, but exhibited a smaller foot-progression angle. This supports the idea that improper technique training in Irish dance could be the key factor in turnout issues. As there are no current requirements for Irish dance teachers to have musculoskeletal or exercise-specific training, it is important that methods to reduce these malalignments are addressed. The somatic practice intervention was considered in this study due to the fundamental idea of inhibiting bad habits in order to let better movements occur naturally. This was in the hope that it would lead to a safer, aligned and more kinaesthetically-aware dancer without undermining the role of the teacher.

5.2. Effectiveness of Somatic Intervention

5.2.1. Overview

While there was no significant change in hip external rotation between sessions, the mean of all participants indicated that there was a slight increase following the somatic practice sessions. However, there was also a minor increase in knee internal rotation moments which contradicted our hypothesis but again, this was not statistically significant. It is important to note that while the mean showed an increase in turnout, there were a number of different changes in individuals as a result of their responses to the somatic practice sessions. Some participants increased their hip external rotation while others decreased, and some remained the same. Additionally, some participants

were very receptive to the somatic instructor whereas some struggled to adapt. This can relate back to the authoritarian teaching style used in Irish dance, as some dancers who were still competing were reluctant to put their best effort into the programme. This could be due to the fear of doing something different to what their teachers say and being reprimanded (Lakes, 2005). While this study is primarily investigating movements at the hip, somatic practice approaches the body in a holistic manner, which means that responses to the programme must be considered from all areas of body.

5.2.2. Body-mapping and alignment

A key concept underlying somatic practice is the importance of understanding anatomical principles, as this will allow the dancer to appreciate their body and movement as a kinetic chain. The programme used in this study focussed on bringing in anatomical imagery and vocabulary throughout its duration. This was in order to develop the participants' understanding of the sequencing of muscles and how it can affect their movements, posture and breathing. Research has shown that emphasising anatomical principles when using imagery helps to remind users of how the different areas of the body connect (Molloy et al., 2015). It is thereby important to firstly discuss how the whole body was addressed during this programme, and then how it affected mobility at the hip.

Body-mapping exercises were performed throughout the programme as a means of making imagery and self-awareness more effective (Batson, 2008). This included identifying and initiating movement from the atlantooccipital, glenohumeral and acetabulofemoral joints, as well as drawing awareness to the shape of the spine and the location of the lungs (Brennan, 2011). When these exercises were performed in the sessions, it indicated that there was a large amount of misunderstanding regarding

anatomical locations within the body. Participants, when asked to identify their head-spine joint, all pointed toward the back of the neck. Imagery and initiation of movement from that joint became a lot clearer when participants learned it was actually between the ears (Brennan, 2011). Throughout the sessions, participants were encouraged to use this imagery when lying down, walking and jumping. One participant, when walking around the room, stated:

> *That's crazy, I feel so much straighter … I think my head is usually more forward than this.*

In relation to this, several participants found that picturing their head balancing on this joint placed it in a more aligned position, and that many habitually either held their head anterior or posterior of the joint. It was also important to consider the concept of primary control when discussing the head-spine joint, as described in section 3.2.4. Initially, many participants were more cautious about moving in this position, and appeared to move slower and in a more restricted manner, with some participants reporting that they felt as if they were leaning back or pulling their head back. This is indicative of their habitual patterns and how the programme was attempting to inhibit them. Over time however, they began to relax and move with more ease, with participants who reported practising this outside of the class showing the most improvement. Primary control is an important factor of this programme because if the head is in an imbalanced anterior position, the weight of it pulls the spine out of its ideal vertical column (Brennan, 2011). This not only causes a flow-on effect of misalignments throughout the rest of the body, but also requires are lot more muscular tension to counteract the imbalance. If the head retains a balanced position on top of the atlantooccipital joint, the body is freed up of excessive muscular effort which in turn, will allow movement of the whole body to occur with

more ease (Brennan, 2011). As the still posture of Irish dance should ideally appear effortless, the encouragement of understanding and utilising primary control is validated.

In the body-mapping exercises, some participants also tended to struggle with identification of the shoulder girdle. While in the supine position, participants were asked to reach their fingers slowly up toward the ceiling until they felt their shoulder come off the ground. A couple of participants were at first unable to protract their shoulder in this manner and furthermore, were not kinaesthetically aware that they had not. One of them commented as follows:

I can't figure out how to move it … that's as far as it goes.

However, after minor manipulation from the practitioner, both participants were able to perform this part of the exercise. This shows that the dancers were more responsive to external feedback and touch, and therefore suggests that we need to use more imagery in the dance class in order to help participants clearly identify joints and muscles. By doing so, this could develop their kinaesthetic awareness which would assist them in directing movement from these joints, in turn creating better alignment of the body and reducing injury risk. Furthermore, once initiation of movement has been established, we can focus on unlocking tense areas surrounding the joint.

Tension held in the upper body, particularly around the shoulder girdle, was observed during walking and leaping exercises, characterised by protraction and elevation of the shoulders, as well as 'winging' of the scapula. The serratus anterior is also responsible for holding the scapula flat against the back during shoulder protraction. However, if this muscle becomes tense or weak, the medial border of the scapula will move dorsally and in turn, a rounded posture (White & Whitten, 1993). Not only does

this affect the aesthetic of the dancer in competition, but can affect the alignment of other areas of the body, such as the shape of the spine and position of the hips. It is worth noting that, because the majority of our participants were university students, rounded posture as a consequence of spending a length of time at desks was considered. This is due to overload of the shoulder protractor muscles which can result in pain and tightness of these muscles (Rajalaxmi et al., 2019). As mentioned previously, the anterior 'slump' of the shoulders and the head creates malalignments of the spine and excessive muscular tension which in turn, affects pelvis and hip alignment. Additionally, addressing the shoulders would improve the aesthetic perception of the dancers in terms of posture. The practitioner addressed this issue by encouraging dancers to work on their partner's shoulder, manually moving the humerus in circular motions in order to improve mobility of the glenohumeral joint. This motion aimed to release tension held in the pectoralis majors and upper fibers of the trapezius, therefore allowing the shoulders to depress and retract into a more neutral alignment. Some participants, after only one of their shoulders had been worked on, had a visible shoulder depression on that side, as well as less prominent medial scapula border. This is indicative of the release of tension leading to a more neutral alignment (Brennan, 2004).

Another anatomical aspect that some participants struggled with was initiation of movement from the hip. When leading into large 'leg-up' movements and leaps, such as the *fly*, participants tended to 'over-swing' their leg past their natural range of motion. Furthermore, most dancers reported picturing their leg moving from the ankle as opposed to from their hip flexors. As a result, there were visual changes in the spinal curvature and pelvis position. Dancers tended to begin the movement with spinal hyperextension and an anterior pelvic tilt, and swing their leg up until their spine was in flexion, their

head moved anteriorly and their pelvis was posteriorly tilted. If dancers were to utilise only the momentum available from initiating movement at the hip, the aesthetic quality of the leap will be improved and the dancer will retain a more stable position. While in constructive rest, the instructor asked participants to rotate at the acetabulofemoral or hip joint and interestingly, one participant tended to move his knee more than his hip.

> *Oh I thought I was moving my hip. I don't know how to do that without using my knee … It feels very tight [in my hip].*

This is an example of how there were misinformed ideas about where to initiate movement from. An interesting observation was that when participants were circling their hip, movements arose in other areas of the body. In some dancers, we saw the opposing leg abducting, hips lifting off of the floor and an anterior pelvic tilt. This highlights tension surrounding and lack of initiation from this joint and further, reinforces the idea of the body as a kinetic chain. As mentioned previously in relation to primary control, we often see a knock-on effect when one area of the body is misaligned. This affects the functionality of movement and the aesthetic appearance of the dancer, particularly in terms of posture. The next section will discuss posture further, and how it can affect the hip joint and therefore, turnout.

5.2.3. Breath, posture and the effects on the hip

As the intervention began, the key focus was the 'non-doing' as to encourage dancers to release tension in order for the body to be re-educated (Raynor, 2010). In addition to the exercises being used, the language of the practitioner was important in releasing tension, as calm, encouraging language facilitates relaxation. This language would have been quite different to authoritarian language used the dancers' typical

classes, which meant that participants could have responded both positively and negatively to this change. As shown in Chapter 7. Appendix D., while in constructive rest, participants were asked to try three different types of breathing, and use their hands to help guide these breaths (Nettl-Fiol & Vanier, 2011). During the first sessions, it was observed that most participants preferred the feeling of high chest breathing, indicative of the habitual nature of breath in Irish dance. It is common to see dancers hold their breath leading up to and during a large leap, as well as be inconsistent with size, location and frequency of breaths (Franklin, 2004). Furthermore, high chest breathing offers little lateral stability and can add excess tension when performing, particularly during leaps (Buck, 2012). As the sessions progressed, we found that more participants began to utilise the low belly and lateral breathing techniques, meaning they were supporting with their diaphragm. It was important to begin bringing this breathing technique into the dancers' movements, particularly for the *fly*, due the diaphragm's connection to the psoas muscle. This means that exhaling before entering the leap will contract the diaphragm which, in turn, helps the psoas lift the leg (Buck, 2012; Franklin, 2004). Once comfortable with the feel of diaphragmatic breathing in constructive rest, participants were encouraged to use this relationship to lift the leg, beginning with on the floor. They were also prompted to think about the movement of their lower back on the floor and whether or not it was remaining still. Once the practitioner had intervened, one participant stated:

> *I never realised that's where my leg should move from, I can feel my ab[dominal]s for once.*

Following this, dancers then progressed into small leg swings, moving leg lifts and eventually jumping. For most participants, beginning a new or moving exercise resulted in them exhibiting old movement patterns, particularly with coming off the floor into

standing. However, with time and repetition, these habitual misalignments began to subside.

Another important aspect of using diaphragmatic breathing was the relationship to pelvic tilt as mentioned in section 2.3.2. Because the musculature used to lift the leg is attached onto the pelvis, the pelvis will continue to tilt and rotate during dance steps unless it is stabilised (Clippinger, 2007). Participants who utilised diaphragmatic breathing throughout movements engaged their core, meaning that the abdominal-hamstring force couple could be used to neutralise and stabilise the pelvis (Clippinger, 2007). This is because in a standing position, the proximal tendons of the hamstrings attach to the ischium of the pelvis, and the distal tendons of the abdominals attached to the pubis. Contracting these muscles groups will result in a more neutral and stable pelvis, with less load on the lumber region of the back and hip flexors (Clippinger, 2007; Franklin, 2004).

Continuing on this note, it was observed that some participants who responded well to breath in the sessions exhibited lesser degrees of hip external rotation in session 2 data. Videos of the data collection sessions indicated that those participants also appeared to have shown improvement in their posture during the leap, characterized by less elevation and protraction of the shoulders, as well as reduced anterior movement of the trunk and pelvis. However, it is important to note that no specific data was collected on posture, so observations made on posture are similar to that an Irish dance teacher and/or adjudicator. This indicates that the improvement in alignment potentially inhibited their hip external rotation. There are multiple reasons why this may have occurred, one of them being that due to the anatomy of the acetabulofemoral joint and the surrounding ligaments, more hip external rotation can be achieved when the hip is flexed. This is why

dancers instinctively tilt their pelvis forward to gain as much turnout as possible (Weiss & Zlatkowski, 1996). However, as mentioned in chapter 2 this shortens and overloads surrounding muscles and ligaments, and furthermore is aesthetically unappealing. Therefore, diaphragmatic breathing and activation of the core were effective in bringing about increased alignment and reduced tension for these participants, but had the ephemeral effect of limiting rotation at the hip joint. However, if participants were to continue this breathing method over a longer period of time, there is the potential to lengthen the ligaments surrounding the joint and strengthen the gluteal and abdominal muscles. This means they would be able to access more mobility and turnout at the hip.

5.3. Implications for dancers, teachers and the Commission

The multitude of different movement profiles across participants highlight the diverse capabilities within the group, despite only inviting dancers of a high technical proficiency to participate. This suggests that the individuals utilise different strategies when executing the *fly* leap, even within the strict nature of the dance form. These inter-individual differences could be explained by discrepancies in joint mobility, muscular strengths and weaknesses, as well their anthropometric attributes. An important part of the somatic practice programme conducted was ensuring that not only did each participant move at their own pace and with individual attention from the instructor, but also that they improved their kinaesthetic awareness. This means that when in the dance class, they can be mindful of their own individual capabilities and movement patterns, and better associate discomfort or pain with inefficient movements. The results from this study suggest that this concept is applicable, even while the athletes are performing within aesthetic constraints. Different strategies used to execute the *fly* also allude to the pedagogy of their training, suggesting different teachers instil a different technique in

their dancers. The presence of these different strategies between individuals resulted in no significant differences when looking at the group as a whole. This highlights the importance of examining single-participant data over group mean data, which should be considered in the dance class. Unfortunately, it is common in the dance class for teachers to overlook individual needs, due to the size of a group, limited number of teachers, as well as time constraints. However, adaptations where possible should be made (Quin et al., 2015).

This research could also prove useful for The Irish Dancing Commission (..G.) as registered teachers do not currently need to understand musculoskeletal, psychological or pedagogical factors in order to teach dancers. Given the intense physical demands of the dance style and prevalence of injury, in addition to dancers primarily being of a developmental age, C.L.R.G. should consider updating their requirements of a teacher to meet that of dancer. This could help to emphasise the importance of a physically and psychologically safe and healthy dance environment.

5.4. Limitations, delimitations and future considerations

The present study had several limitations and delimitations that should be considered. One of the key limitations was the availability of participants. It was known before commencing the study that only around 10-15 participants could be recruited, therefore limiting the statistical sensitivity of the study. This was due to the availability of competitive Irish dancers, as there is no C.L.R.G. school based in Dunedin. The option of being less-specific about participant requirements was contemplated; however, it was decided that if dancers recruited were not highly trained in competitive Irish dance, the results would be unavailing. This also influenced another delimitation in the study; the disuse of a control group. While it was considered, a control group was not feasible as

separating the small sample size into two groups meant that the sensitivity would be even lower. This meant that dancers continued to do their usual training throughout the somatic practice programme. Assumptions could be made that due to no major competitions nearing, no change in their own training would occur, therefore any changes seen were most-likely a result of the intervention. However, for any future studies looking to substantiate these findings, monitoring/controlling activities outside of the intervention should be considered. A larger sample size should be used to increase sensitivity and thereby, validity of results. Inclusion criteria could be broadened by conducting the study in an area with more access to competitive Irish dancers i.e. a city with a C.L.R.G. Irish dance school.

As sample size was already limited, another challenge we faced was the availability of the dancers for the somatic practice intervention, as well as additional limitations with funding and consequently, time of the practitioner. Ideally, the somatic practice programme would have ran for at least twelve weeks, in order to allow time for habit inhibition and change. However, in order to recruit as many participants as possible, the programme length was reduced and time spent in each session was increased. This was due to most of the participants being university students and not currently competing in Irish dance, therefore found it difficult to find time and motivation to partake. Future studies should consider running the programme for a longer period of time, which may be more achievable with participants who do not study and still compete. Additionally, compensation for time could be considered.

While still recruiting a specific type of participant, there remained a large variation of abilities between participants. This was due to having participants from

different dance schools, with different national rankings and out of competing for varying lengths of time. While only national or international level dancers partook, placings at competitions should be considered; some participants were national champions and world representatives, whereas some had not placed. Learning Irish dance from different teachers, as reflected in section 2.3.5. meant that dancers all performed their *fly* differently which made it difficult to evaluate the group as a whole. Future research could approach this topic by recruiting dancers from only one school (made easier by conducting the study in an area with an Irish dance school), or additionally could investigate the dissimilarities between different schools and their taught techniques. This could provide insight into whether there is a school that teaches a safer technique of Irish dance whilst adhering to the specific aesthetics.

As stated in section 5.1.2. evaluating turnout both at the hip joint and foot throughout the entirety of the *fly* could provide more insight into how turnout is lost and retained. Though the degree of turnout will always be different between individual dancers, a focus should be placed on keeping the difference between hip rotation angle and toe-out angle minimal across all movements. It is therefore important to consider how this varies throughout the different stages of the *fly* and in turn, how the variations can be minimised. This could then be explored further by investigating other movements in Irish dance.

Another consideration for future research is the inclusion of injured dancers. This study excluded any dancers that had had an injury in the past six months that had taken them out of training for two or more weeks. However, in doing so, it may have biased the sample to better aligned dancers, as poorly aligned dancers may be more likely to

have become injured. Nevertheless, for this particular study, it was out of scope to subject injured dances to repetitive impact forces, especially considering they would have been landing on a rigid force plate. This approach could be adjusted for future research by including injured dancers in a somatic training programme, and potentially looking at different movements within Irish dance so as to be ethically considerate.

5.5. Summary

In this chapter, I have interpreted the results from this study, evaluated the participant responses to the somatic practice programme and discussed their implications to the dance field. It has been shown that the difference between hip external rotation and foot toe-out progression at maximum force was the key contributor to large internal rotation moments at the knee and ankle. I have also described the individual differences of participants and how this affects the hip rotation movement profiles. The effect that pelvic tilt and orientation had on the alignment and turnout of the dancer has also been addressed, with an anterior pelvic tilt improving turnout out at the feet but actually overloads the structures surrounding the hip, therefore inhibiting hip turnout. This chapter further discussed how the somatic practice intervention targeted different alignment issues within the body, such as the protraction of the head and shoulders, curvature of the spine, tilting and rotation of the pelvis and using floor friction to achieve turnout at the feet. I also evaluated the responses to the programme, and took to into consideration why we may or may not have seen changes in the participants movement, whether it was due to psychological or physical factors. Implications of this research for dancers, teachers and The Irish Dancing Commission were then presented, in the hope that it would provide insight as to how we can use these findings to improve the approach

Irish dance style. To conclude this discussion, limitations and delimitations were conversed, as well as potential ways that research can be continued in this field.

5.6. Conclusion

The aesthetic and technical demands of Irish dance have been proven as improper to safe mechanics, but to state that it must be changed challenges the historical development of the dance style. While injury in Irish dance has been widely reported, many studies have failed to investigate effective ways to prevent and reduce risk of injury without compromising the aesthetic of the dance style. Furthermore, issues with the way dancers are taught and the lack of bodily knowledge from dance teachers mean that as the dance style is evolving, risk of injury is increasing. Current training methods in Irish dance involve adding more movements into faulty techniques in order to correct errors in performance. However, this counters tension with more tension, and lacks the focus of eliminating the error by identifying its origin. Without the acknowledgments of the underlying issues in performance, faulty habitual patterns cannot change.

This study aimed to address gaps in the literature by integrating kinaesthetic awareness into a biomechanical field, meaning that not only were we evaluating what was observable, but also how the dancers felt in their body. While overall results from this study were not of a large effect nor statistically significant, the premise of this research has created a dialogue between biomechanics and somatic practices in. This means that future investigators can look further into how one discipline may inform the other. This interdisciplinary relationship addresses what both fields are missing; the association between kinesthetics and mechanics. With this, we have taken a qualitative field and placed it within a quantitative framework, as to validate subjective findings with objective data.

Our underlying goal, like many teachers and dancers, was to reduce injury risk in Irish dance in order to develop a healthy dancing body. Even though a significant change did not occur with the degree of turnout at the hip, considering how the dancers felt and

visually moved is essential. This is because that while the hip was our site of interest, we know that one fragment of the body does not demonstrate the entirety of a holistic-based method. Therefore, this information should be considered firstly, to inform teachers, dancers and the Commission of the importance of safe dance practice and secondly, to guide future research in the general dance studies field.

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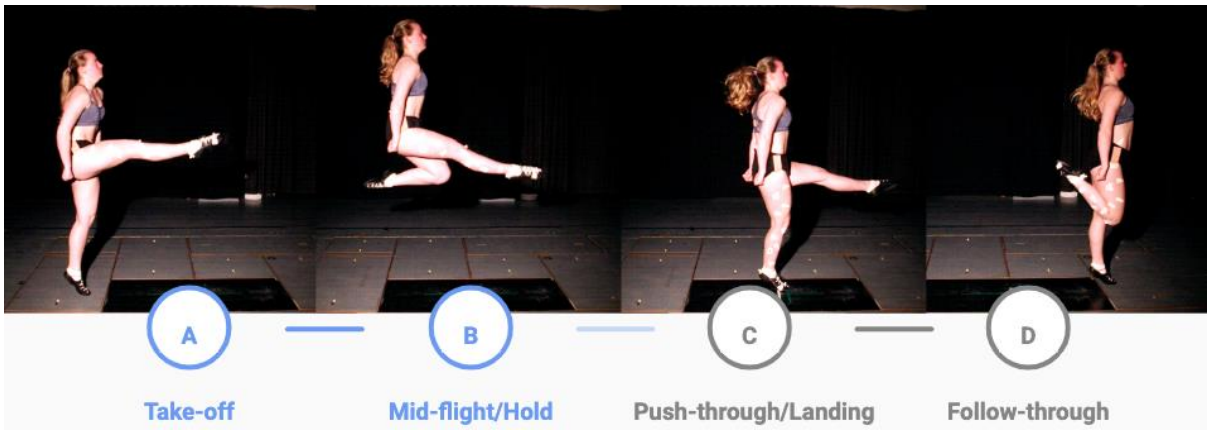
7. Appendices

Appendix A. What is the Fly?

The Fly



The **take-off phase** requires the dancer to push off the ground with a fully extended knee while flexing the opposite leg (leading leg) at the hip past 90° to the torso. The leading leg being lifted must have an extended knee and plantarflexed foot, as well as being maximally externally rotated at the hip.

The **midflight/hold phase** involves the dancer flexing their take-off leg at the hip and knee, with the foot still plantarflexed and touching the gluteal muscles. The leading leg must still be held at least 90° to the torso in the same position. This phase is held as an isometric contraction of all muscles involved for as long as possible.

The **push-through phase** requires the flexed take-off leg to sharply extend at the knee, whilst keeping the foot plantarflexed. As the knee is fully extending, external rotation at

the hip should occur as well, and the leading leg extends at the hip to land high on the toes. At contact, the take-off leg in the air should be at maximum height.

The **follow-through phase** requires the take-off leg to lower to the ground with a fully extended knee and plantarflexed foot after the leading leg has landed. There is generally a skip or another step at the end of a *fly* to control momentum.

Appendix B. Examination Guidelines

Teagascóir Coimisiúin le Rinci Gaelacha (T.C.R.G.)

Commission Certified Irish Dance Teacher Examination

In order to sit the Irish dance teacher examination, one must:

- Be over the age of 20 years at the date of application
- Come recommended by a registered teacher or adjudicator
- Have completed Grades 1 through 12 of An Coimisiún Le Rincí Gaelacha (C.L.R.G.) examinations[33]

The sections of the examination consist of:

- A practical test in stepdance
    - This is to ensure the applicant is capable of performing Irish solo dance and their ability to perform different dances within the 'light' and 'heavy' style, including traditional set dances.
- A written céilí dancing test
    - This is to prove the applicant has detailed knowledge of all traditional team dances in the handbook "Ar Rincí Céilí".
- A practical test in teaching céilí dancing
    - This is to exhibit the applicant's teaching capabilities, including the ability to break down a dance, instruct clearly, demonstrate basic steps and lilt[34]
- A practical test in teaching stepdancing.
    - This is to show how the applicant can teach steps of varying difficulties to dancers, and how they would identify and correct faults of key movements.
- A written music test
    - This includes assessing the applicant's ability to identify tunes by name, as well as stating their timing, and number of musical bars in the set and step.

[33] Examinations on the dancers' performative abilities and understanding of traditional céilí dances.

[34] To sing or speak rhythmically and with fluctuating pitch (Merriam-Webster, 2018).

- An oral Irish language test
    - This is to demonstrate the applicant's knowledge of terms and phrases connected with dancing in Gaeilge, as well as their ability to hold a simple conversation in the language. This is only mandatory if the applicant lives in Ireland. In New Zealand, applicants do not need to do this test.

Ard Diploma Coimisiúin le Rinci Gaelacha (A.D.C.R.G.)

Commission Certified Irish Dance Adjudicator Examination

In order to sit the Irish dance teacher examination, one must:

- Be over the age of 30 years at the date of application
- Have passed the T.C.R.G. examination
- Be currently registered with C.L.R.G.
- Have been an active teacher while officially registered with C.L.R.G. for at least five years. This period must have occurred within the three years prior to applying.

The sections of the examination consist of:

- A practical test in stepdance
    - This is to ensure the applicant is capable of performing Irish solo dance and their ability to perform different dances within the 'light' and 'heavy' style, including traditional set dances.
- A written céilí dancing test
    - This is to prove the applicant has detailed knowledge of all traditional team dances in the handbook "Ar Rincí Céilí".
- A written music test
    - This includes assessing the applicant's ability to identify tunes by name, as well as stating their timing, and number of bars in the set and step.
- A practical test in the adjudicating of stepdancing and céilí dancing, including an interview

- This is to demonstrate the applicant's ability to judge in a feis setting, noting strong points of performance as well as errors and faults. They also need to demonstrate notes that show why one dancer was placed higher than another. The interview requires the applicant to justify their results to the panel of examiners.

- A written test on marking
  - This assesses the applicants ability to add and transcribe marks, as well as determine places from marks. The applicant must be able to demonstrate that they can add marks, and place competitors in order using the official points system.
- An oral Irish language test
  - This is to demonstrate the applicant's knowledge of terms and phrases connected with dancing in Gaeilge, as well as their ability to hold a simple conversation in the language. This is only mandatory if the applicant lives in Ireland. In New Zealand, applicants do not need to do this test.

All information in this document was attained from the official An Coimisiún Le Rincí Gaelacha website[35].

[35] www.clrg.ie

Appendix C. Participant Information

a). Participant Information Sheet

Study title:	Effects of somatic training on landing biomechanics in competitive Irish dancers	
Principal investigator:	**Name:** Peter Lamb **Department:** School of Physical Education, Sport and Exercise Sciences **Position:** Lecturer in Biomechanics	Contact phone number: 03 479 9115

Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate.

If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the aim of this research project?

The aim of this research is to determine if somatic techniques, when applied to competitive Irish dance, will improve alignment and turnout of the dancer, and in turn, will reduce the risk of injury.

This research will contribute to improving health outcomes by providing knowledge of injury risk and landing techniques that can be utilised to provide benefits in Irish dance training.

Who is funding this project?

The University of Otago

Who are we seeking to participate in the project?

New Zealand Irish dancers that have competed at a national or international level are sought to participate in this study. Participants will be included only if they are apparently healthy, with no known physical disabilities that might place them at risk during physical exercise. A brief physical activity questionnaire should be completed in advance by participants. In particular, participants should be free of lower limb injury in the past 6 months and have no history of severe recurring lower limb injury. Here, an injury is defined as any injury that lead to absence from training for two or more weeks. This length of time has been chosen to eliminate minor injuries that dancers may still train and perform on (McGuinness & Doody, 2006).

If you participate, what will you be asked to do?

Should you meet the criteria and agree to take part in this study, you will be asked to:

1. Attend an initial session at the School of Physical Education Biomechanics Lab, which should take no longer than one hour. At this session we will:
    a. Determine if you are eligible using the inclusion and exclusion criteria
    b. Ask you to read the information sheet and sign the consent form if you wish to participate
    c. Ask you to complete a baseline questionnaire during which we will ask you questions relating to your demographics (for example: your age, sex, ethnicity), contact information, as well as information about your dance and injury history.
    d. Perform basic anthropometric measurements (height, weight) and assess your natural turnout and foot placement.

    e. Ask you to perform the *fly* step multiple times. There will be ten trials of the *fly* and you will be able to rest between each trial. You can perform steps leading into the fly and out of it, and will be asked to land the *fly* on a force plate. You will be asked to wear tight fitting clothing and/or minimal clothing and will be fitted with reflective markers for recording purposes. These markers will be on specified bony prominences of your hips, legs and feet. The researcher and technical staff present will have first-aid qualifications to ensure your safety.
    f. Proceeding this session, you have the option to partake in a six-week somatic training programme, with one 2 hour session per week.
2. Attend a series of somatic practices session. During these sessions, you will be asked to:
    a. Attend one 2 hour group session every week for six weeks.
    b. Take all instruction from a qualified somatic practitioner. This teacher will take you through a series of relaxation and postural alignment exercises, and explore different somatic concepts in each session. Please note that these sessions will <u>not</u> include high physical exertion. See the *Somatic Practice* document for more details.
3. Attend a follow-up session at the School of Physical Education Biomechanics Lab, which should take no longer than 1.5 hours. At this session we will:
    a. Ask you to perform the same *fly* trials in the same conditions as the initial session
    b. Complete a questionnaire outlining your experience throughout the study

Please be aware that you may decide not to take part in the project without any disadvantage to yourself of any kind.

Is there any risk of discomfort or harm from participation?

Due to lab conditions, the surface of landing may be stiffer than the floors you usually dance on, hence a thorough warm-up is encouraged. The markers attached to your lower limbs will feel unfamiliar but not uncomfortable. As a participant you will be free to rest, stop or withdraw from the study at any time if physical discomfort or exhaustion is experienced.

What specimens, data or information will be collected, and how will they be used?

We will collect the following information:

- Your name; date of birth; email address; phone number; height; weight
- Your dance experience and injury history
- Your reports of the experience
- Videos of the trials and somatic practice sessions
- Your *fly* movement and impact data
    - The reflective markers will allow for a 3D model to be built of your movement, as well as the force plate gives us information about impact forces. These allow the researchers to identify changes in movement that affect important variables and in turn, risk of injury.
    - All raw data will be assigned to a participant ID to preserve your anonymity. Anonymous raw data will be securely stored in such a way that only the researchers will be able to gain access to it. Data obtained as a result of the research will be retained for **at least 10 years** in secure storage.

What about anonymity and confidentiality?

We will collect participant contact details that only the researchers will have access to during the study. All raw data will be assigned to a participant ID to preserve your anonymity. Anonymous raw data will be securely stored in such a way that only the researchers will be able to gain access to it. Data obtained as a result of the research will be retained for at least 10 years in secure storage. After completion of the study personal information will be destroyed; no personal information will be published. Statistics describing gender, age and ethnicity will be reported in publications, but will not identify any individuals in the study. There will be no negative consequences to you should you decide not to supply any personal information. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand).

If you agree to participate, can you withdraw later?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

Any questions?

If you have any questions now or in the future, please feel free to contact either:

Name: Peter Lamb **Position:** Research Supervisor **Department:** School of Physical Education, Sport and Exercise Sciences	Contact: 03 479 9115 peter.lamb@otago.ac.nz
Name: Sofia Kalogeropoulou **Position:** Research Supervisor **Department:** School of Performing Arts	Contact: 03 479 8891 sofia.kalogeropoulou@otago.ac.nz
Name: Kelsi Wallace **Position:** Student Researcher **Department:** School of Physical Education, Sport and Exercise Sciences	Contact: kelsi.wallace@postgrad.otago.ac.nz

This study has been approved by the University of Otago Human Ethics Committee (Health). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

b). Participant Consent Form

Principal Investigator: Dr Peter Lamb (peter.lamb@otago.ac.nz)

Effects of Somatic training on Landing Biomechanics in Competitive Irish Dancers

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant:……..

1. I have read the Information Sheet concerning this study and understand the aims of this research project.
2. I have had sufficient time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.
5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project before its completion.
6. I know that as a participant I will be asked to engage in a somatic practice training programme for six weeks, with one 2 hour session each week.
7. I know that as a participant I will asked to perform the Irish dance leap known as the *fly* up to 10 times in each data collection session.
8. I know that each movement capture and somatic practice session will be video recorded.
9. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.

10. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.
11. I understand that the results of the project may be published and be available in the University of Otago Library, but I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study
12. I know that there is no remuneration offered for this study, and that no commercial use will be made of the data.

Signature of participant:	Date:

Name of person taking consent	Date:

c). Physical Activity Readiness Questionnaire (Informed Consent)

You are asked to perform an activity that may require you to reach close to maximum effort. The details of procedures are outlined in the Information Sheet for Participants. Please familiarise yourself with the protocol and feel free to discuss it with the researcher or research assistant before you complete this form. Exercise to near maximum effort can be dangerous for some people. Therefore, please read and answer the following questions:

Has a doctor ever advised you to avoid hard exercise?	yes	no
Has a doctor ever said you have high blood pressure?	yes	no
Do you suffer from heart disease, diabetes or asthma?	yes	no
Do you have a health problem that exercise makes worse?	yes	no
Do you feel particularly anxious or nervous about doing these tests?	yes	no

When you exercise…

…Do you have pain in your heart, chest, neck or arms?	yes	no
…Do you have severe pain in the legs?	yes	no
…Do you feel unusually faint, dizzy or breathless?	yes	no

If you answered "no" to all the above questions you may participate in this study.

Participant's declaration

• I have read the Information Sheet for Participants.
• I have answered "no" to all the above questions about exercise.
• I have no other existing medical conditions, particularly any that could possibly prevent me, or be made worse by, participating in this study (if in any doubt, discuss this with the researcher or research assistant).
• I hereby give my consent to be a participant in this study.
• I understand that I can withdraw my consent and stop participation at any time.

PARTICIPANT

Name ……. Signature …… Date …….

WITNESS

Name ……. Signature …… Date …….

This project has been reviewed and approved by the University of Otago Human Ethics Committee

d). Participant Baseline Questionnaire

PARTICIPANT ID (to be completed by researcher):	
First name:	
Last name:	
Sex (Male/Female/Non-Binary):	
Age (Years):	
Date of birth (MM/DD/YYYY):	
Ethnicity:	
Email:	
Cell phone:	
The results of this project will be available starting February 2020; would you be interested in seeing the results?:	Yes/No
If you answered "yes" to the question above, please provide your permanent home address where results may be mailed to you:	

Eligibility Screening

1. Are you currently free from injury, with injury being anything that has prevented you from training for two weeks or more?	Yes/No

2. Have you at one point competed at the TIDA New Zealand National Irish dancing championships? a. If yes, when was your most recent competition (year)? b. If no, please list the most prominent competitions you have competed at. Write *N/A* if you have not competed.	Yes/No Year: Comps:
3. Are you currently competing? a. If no, when did you retire (year)?	Yes/No Year:

General Health Information

(These will be taken upon your arrival to the lab)

Weight (lbs or Kgs)	
Height (inches or cm)	

Dance and Injury History

We would like to collect some information regarding your Irish dance experience and history of injury associated with this. Please know this information is kept confidential. Do not worry if you are unable to remember specific terms related to prior injuries. Do your best to provide a brief description of these prior injuries, thank-you!

1. How long (years) have you been trained in Irish dance?	
2. Which school do/did you dance for?	
3. List any other sports or physical activities that you participate in currently.	
4. Have you ever had any injury that has required surgery?	Yes/No
5. Have you ever had an injury that did not require surgery, but decreased your performance or activity levels (could be everyday lift or in dancing/sport)?	Yes/No

6. If you answered "yes" to question #4 and #5, can you describe the injury or the location of your body where this injury occurred? (Be as specific as possible, for example: left calf muscle OR front part of my right hip). Please list all injuries.	
7. Of the injuries listed in question #6, is there any area of concern/problem/pain/discomfort from a prior injury that you feel is not healed 100% today?	Yes/No
8. If you answered "yes" to the above question, please list that area of concern/problem/pain/discomfort.	

Thank-you very much for your time and participation in our research study!

e). Preparing for Motion Capture Analysis

Thank you for participating in this study!

In order to prepare for your first motion capture session, please read the following information carefully. If you have any concerns or queries, please email Kelsi Wallace at:

kelsi.wallace@postgrad.otago.ac.nz

What will happen and what will I need to do?

Firstly, we will collect more contact information and ask you to fill out some questionnaires regarding your physical well-being, dance background and demographics i.e. age, sex, ethnicity etc. Following this we will collect anthropometric measurements (height and weight), as well as assess your natural turnout. You will then get given a 10-15 minute period to warm up as you normally would for a dance session.

After you have warmed up, we will fit 21 reflective markers to your right leg, foot and pelvis. Please note that this process can take up to 15 minutes and will involve the research palpating for bony landmarks.

After the markers have been fitted, we will capture two calibration trials – one will be of you standing still on a force platform, the other will be you moving your leg. This helps the cameras to capture your movement more efficiently.

After calibration, you will be given 5 minutes to perform practice *fly*'s whilst wearing the markers. This will help you become adjusted to the floor and moving with the markers on your body

We then will start the trials. A trial is considered the steps leading up to the *fly*, the *fly* itself, and a step or two at the end. Trials will be performed to reel time (113bpm) and we can provide music or a metronome – whichever you would prefer! You will be asked to perform a minimum of 10 trials, with as much time in between trials as you would like. If you experience any discomfort or pain, or notice any markers coming off, please let the researcher know immediately.

After 10 trials have been captured, you will be able to cool down and stretch. The markers will be removed at the very end of the session.

How do I prepare?

We ask that you have had a decent meal no less than 2 hours before your session. It is also important that you are well-hydrated. This will make you feel more comfortable in the lab. We also ask that your legs are shaven and free of moisturiser and oils. This is important as it affects the markers adhesion to your skin. If you have any concerns about this, please contact the researcher as soon as possible. Please note that strapping tape will be used to help adhere the markers so please make the researcher aware if you have an allergies to certain tapes.

What do I need to bring/wear?

- Your personal pumps/soft shoes
- Thin ankle socks (no poodle socks please)
- Tight-fitting clothing
    - We would prefer if you could wear tight shorts and a crop top for females or no shirt for males. However, if you do not feel comfortable in these clothes, full length plain-coloured sports tights and a relatively tight singlet or t-shirt would suit.
- Drink bottle
- No jewellery or reflective surfaces
    - These can interfere with the cameras
    - Reflective logos on clothing can be covered up but try to keep them to a minimum

You are more than welcome to bring along a friend or family member for support if this would make you feel more comfortable.
Please let the researcher in advance if you would like to do so.
Thank you very much!

f). Somatic Practice Information

What is somatic practice?

Somatic practice is a field of movement study that encourages the learner to be aware of the body in a holistic sense by focussing on postural changes and movement evaluation. Somatic practice focuses on first-person perception or in other words, looks at the body from the 'inside out'. This is opposed to looking objectively from the 'outside in' as dancers would normally do through the likes of mirrors and videos. Simply put, somatic practice emphasises the idea of internal awareness and sensory perception.

How will somatic practice help Irish dance?

As we know, a key characteristic of Irish dancing is 'carriage' or how we hold our posture while we dance. An ideal posture is still, upright and controlled, but not forced or tense. It is common to see leaning, jerking and movement of the arms with large leaps which ruin the aesthetic of the dancer. Furthermore, these tensions create misalignments all throughout the body that could be placing you a greater risk of injury.

These sessions are specially constructed for you, as Irish dancers, to reduce tension in performance and correct these misalignments, and are primarily based on two somatic techniques: the Alexander technique and Ideokinesis.

The Alexander Technique

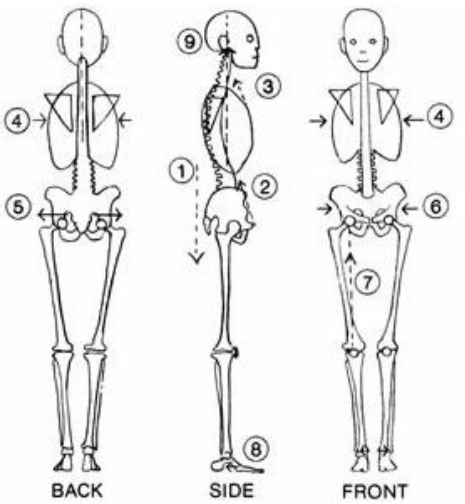
A key focus of the Alexander technique is to consciously change harmful habitual patterns. In dance, habits of excess tension and imbalance in muscle tone, compression in the joints and shrinking of the spine interfere with the optimal use and functioning of our systems. This is achieved by three key steps:

- *Means-whereby* indicates an over-eagerness of instant gratification or success.
- *Inhibition* means to stop the psycho-physical reaction to stimuli (or habit) of wanting to arrive at a particular goal immediately.
- *Non-doing* suggests to pause, to think and then act in an efficient, non-habitual manner.

These steps circulate the idea that if we actively stop doing the wrong thing, the right thing will do itself.

Ideokinesis

Ideokinesis uses visual and tactile-kinaesthetic imagery as a means of improving muscle patterns. By visualising motor imagery, we can alter our neuromuscular patterns to improve alignment and mechanical balance. This also means we can alter potentially injurious movements, as well as reduce unnecessary and unwanted tensions. This is achieved by focusing on 'The Nine Lines of Movement' which will be further explored in our sessions.



The Nine Lines of Movement

What can I expect in these sessions?

These sessions will be largely focused on relaxation and alleviating tension in your body. Whole body movements will be performed, with a large emphasis on your upper body. This is because alignment of the lower body originates from higher up. There will be hands-on contact in the session, from both the instructor and your peers. It is important to let yourself relax as much as possible in these situations to experience the full effect of somatic practice. Sessions will initially have a broad focus and become more specific to Irish dance as we get further into the programme.

Please alert the instructor prior to the session if you have any pain or niggles, including muscle soreness from exercise. Also, alert the instructor if you experience any pain or discomfort during the sessions.

Please be aware that each session will be video recorded. If you object to being videoed, please let the researcher or the instructor know as soon as possible.

What equipment do I need?

The equipment required for these sessions is largely focused on ensuring your comfortability. We suggest bringing a **towel** to roll up and place under your neck. A **yoga mat** or the likes thereof is also encouraged if you don't want to lie directly on the floor. **Loose and comfortable clothing** should be worn as to not restrict your movement. A **water bottle** is also encouraged.

How do I prepare?

We suggest not eating a large meal directly before a session as we want you to be as comfortable as possible. We recommend not doing any heavy exercise leading up to the session because it may leave you with soreness and tension in your muscles which can make the sessions uncomfortable.

How will I feel after each session?

Most students feel relaxed, light and sometimes sleepy following these sessions. We recommend not doing any exercise immediately following the sessions, as the relieved tension and changes in movement patterns may leave you slightly uncoordinated and unable to control fine motor movements for a few hours. However, you will still be able to carry on your day at University and/or work as normal.

We hope this information has helped you understand somatic practice. Any questions, please feel free to contact Kelsi at kelsi.wallace@postgrad.otago.ac.nz

Appendix D. Lesson Plans

a). Session One

Timing	Section	Details	Practitioner Notes
0 – 10 (10 mins)	Introduction	• What to expect • Roadmap the sessions • Housekeeping • Questions	Emphasize that there is no right and wrong
10 – 15 (5 mins)	Walk around the space *Aim: develop an understanding of orientation and become familiar with the space, the floor and other people*	• Move at whatever tempo/style they would like • Stop whenever they deem necessary • Find a space in the room where they feel comfortable	
15 – 45 (30 mins)	Constructive Rest *Aim: allow the body to relax on the floor without resistance to gravity or major impact. Allow breathing to be efficient and focused.*	• Supine position – start by sitting with their legs straight and lie down when feeling comfortable • Relax into the floor • Keep their limbs moving/adjusting so they are comfortable • Progress into semi-supine to help lower back sink into the floor • Draw awareness to breathing	

			Discuss the three types of breathing and get them to try all types to feel which one is more efficient 1. High Chest 2. Lateral 3. Low belly
45 – 75 (30 mins)	Body-Mapping (same position as above) *Aim: to develop an accurate anatomical understanding of one's body, making imagery and self-awareness more effective.*	• Head-spine joint • Arm-body joint • Hip joint • Shape of spine • Location of lungs	Try not to demonstrate (self-awareness, not mirroring)

	9 Lines of Movement
	Aim: to balance the muscles and bones and overall alignment of the body around its central axis. This will to release tension and activate muscles in a balanced manner (not to overload some and neglect others)
		• Lengthen the spine downward
		  ○ Release tension in the back muscles, especially lumbar
		• Shorten distance between mid-front pelvis and 12 thoracic vertebrae
		  ○ Lifts the front of the pelvis, release the muscles parallel to the spine, contributes more efficient weight support of the torso and head (most difficult line to achieve)
		• Top of the sternum to top of the spine
			Discuss while in constructive rest and bring into discussion when guiding movement. Only discuss lines that feel appropriate to what you are doing.

		○ Balances head on top of spine, releases tension in the muscles of the shoulders and neck, lengthens the spine • Narrow the rib cage ○ Release tension in the muscles of the rib case and shoulder, helps to improve breathing • Widen the back of the pelvis ○ Releases tension in the gluteal muscles and hips, improving flexibility at the joint and balances the pelvis on the heads of the femurs • Center of knee to center of femoral joint ○ Balances the muscles around the femur, especially by releasing tension in the outer hip, properly aligns the hinge-like knee joint and promotes primary control of the leg close to the pelvis. • Big toe to heel ○ Centers the weight of the body at the ankle joint, reduces the tendency to overpronate. Brings deeper flexion at the ankle and signals the Achilles tendon to lengthen and drop the heel	

		• Lengthen the central axis of the trunk upward ○ Encourages a variety of changes, largely the alignment of the spine and position of the head. Helps to understand the concept of centered control and movement of the body as a whole	
60 – end (30-45 mins)	Practitioner Touch	• Release tension around acetabulofemoral, patellofemoral and sacroiliac joint • Bring about a posterior pelvic tilt/neutral pelvis (lower back should sink into the floor)	Keep discussing 9 lines of movement Tell them what you're doing and why (total transparency) Make sure that the let you know if they experience any pain or discomfort
(10 mins)	Cool-down + recap	• Sit up when they are ready, roll out of position and begin to move around the room again, moving whatever limbs/parts of their body they feel • Discuss what has been achieved this lesson and what to expect following this session and brief outline of session two.	Researcher will discuss this.

b). Session Two

Timing	Section	Details	Practitioner Notes
0 – 5 (5 mins)	Introduction	• Roadmap the session • Questions	
5 – 10 (5 mins)	Walk around the space *Aim: develop an understanding of orientation and become familiar with the space, the floor and other people*	• Move at whatever tempo/style they would like • Stop whenever they feel like it • Find a space in the room where they feel comfortable	
10 – 30 (20 mins)	Constructive Rest *Aim: allow the body to relax on the floor without resistance to gravity or major impact. Allow breathing to be efficient and focused.*	• Supine position – get them to start by sitting with their legs straight and lie down when feeling comfortable • Relax into the floor • Keep their limbs moving so they are comfortable • Progress into semi-supine to help lower back sink into the floor • Draw awareness to breathing	1. High Chest 2. Lateral 3. Low belly
40 – 1.00 (20 mins)	Body-Mapping (same position as above)	• Head-spine joint • Arm-body joint • Hip joint	Try not to demonstrate (self-awareness, not mirroring)

	Aim: to develop an accurate anatomical understanding of one's body, making imagery and self-awareness more effective.	• Shape of spine • Location of lungs	
1.00 – 1.35 (30 mins)	Practitioner Touch (CRP and Standing) *Aim: to help the student to identify and release unwanted tensions or response to improve self-awareness*	• Release tension around acetabulofemoral, patellofemoral and sacroiliac joint • Bring about a posterior pelvic tilt/neutral pelvis (lower back should sink into the floor) • Release tension around glenohumeral joint and rotator cuff muscle group, as well as the pectoralis majors, upper fibres of the trapezius and rhomboids • Address the neck last, with a focus on the occipital joint and sternum (should help to correct breathing pattern)	Keep discussing 9 lines of movement Tell them what you're doing and why (total transparency) Make sure that the let you know if they experience any pain or discomfort

	9 Lines of Movement
	Aim: to balance the muscles and bones and overall alignment of the body around its central axis. This will to release tension and activate muscles in a balanced
		• Big toe to heel
		  ○ Centers the weight of the body at the ankle joint, reduces the tendency to overpronate. Brings deeper flexion at the ankle and signals the Achilles tendon to lengthen and drop the heel
		• Center of knee to center of femoral joint
		  ○ Balances the muscles around the femur, especially by releasing tension
			Discuss while in constructive rest and bring into discussion when guiding movement.
			
			Bring them to standing to describe some lines, use touch where necessary.
			When bringing to standing, get them it to slowly roll out of position and

	manner (not to overload some and neglect others)	in the outer hip, properly aligns the hinge-like knee joint and promotes primary control of the leg close to the pelvis.
		• Widen the back of the pelvis
		  ○ Releases tension in the gluteal muscles and hips, improving flexibility in the hips and balances the pelvis on the heads of the femurs
		• Narrow across the front of the pelvis
		  ○ Activates the muscles of the inner thigh. Balances the pelvis on the heads of the femurs
		• Shorten distance between mid-front pelvis and 12 thoracic vertebrae
		  ○ Lifts the front of the pelvis, release the muscles parallel to the spine, contributes more efficient weight support of the torso and head (most difficult line to achieve)
		• Top of the sternum to top of the spine
		  ○ Balances head on top of spine, releases tension in the muscles of the shoulders and neck, lengthens the spine
		• Narrow the rib cage
			gradually stand (this could take 1+ mins)
			
			At the end of the 9 lines (when standing), their head should balance on top of their spine, no muscular tension to hold the head up

		○ Release tension in the muscles of the rib case and shoulder, helps to improve breathing • Lengthen the spine downward ○ Release tension in the back muscles, especially lumbar • Lengthen the central axis of the trunk upward ○ Encourages a variety of changes, largely the alignment of the spine and position of the head. Helps to understand the concept of centered control and movement of the body as a whole	
1.30-1.40 (10 mins)	Partnered walking *Aim: to understand the primary control of the head-neck relationship*	• Get them to pair up. One person will lead their partner around the room by guiding them with their hand by their neck, as opposed to pushing through the back • Allows person to feel for excess tension and the partner can adjust themselves accordingly	Before starting, address the head/neck relationship as a source of primary control – we should lead our movements from our head
1.40-1.50 (10 mins)	Cool-down + recap	• Separate from partner and continue walking at any pace while guiding from the neck • Discuss what has been achieved this lesson and what to expect following this session and brief outline of session three.	Researcher to discuss this.

c). Session Three

Timing	Section	Details	Practitioner Notes
0 – 5 (5 mins)	Introduction	• Roadmap the session • Questions	No right or wrong
5 – 10 (5 mins)	Walk around the space *Aim: develop an understanding of orientation and become familiar with the space, the floor and other people*	• Move at whatever tempo/style they would like • Stop whenever they feel like it • Find a space in the room where they feel comfortable	Bring awareness to the way they walk – heavy/tense? Bring awareness to the neck from butterfly and sacrum. Notice the pressure of feet on floor (inside/outside – heel/toe)
10 – 30 (20 mins)	Constructive Rest and Breath *Aim: allow the body to relax on the floor without resistance to gravity or major impact. Allow breathing to be efficient and focused.* Body-Mapping (same position as above) *Aim: to develop an accurate anatomical*	• Supine position – get them to start by sitting with their legs straight and lie down when feeling comfortable • Relax into the floor • Keep their limbs moving so they are comfortable • Progress into semi-supine to help lower back sink into the floor • Draw awareness to breathing • Head-spine joint • Arm-body joint • Hip joint • Shape of spine	We focus on breathing because most Irish dancers do not breathe properly or in full while they are dancing – this leads to quick fatigue, rigidity in movement and difficulty in technical execution. High chest is more likely

	understanding of one's body, making imagery and self-awareness more effective.	• Location of lungs	what they habitually use but need to encourage lateral and low belly to deepen breaths and brace the core
30 – 50 (20 mins)	Practitioner and Partnered Touch *Aim: to help the student to identify and release unwanted tensions or response to improve self-awareness*	• Release tension around acetabulofemoral, patellofemoral and sacroiliac joint • Bring about a posterior pelvic tilt/neutral pelvis (lower back should sink into the floor) • Release tension around glenohumeral joint and rotator cuff muscle group, as well as the pectoralis majors, upper fibres of the trapezius and rhomboids • Address the neck last, with a focus on the occipital joint and sternum (should help to improve breathing pattern) • In standing, partner to mobilise shoulder joint, similar to practitioner. Scapular should be relatively flat on the back	Tell them what you're doing and why (total transparency) Make sure that the let you know if they experience any pain or discomfort Imagery of lengthening the arm away from the shoulder
50 – 1.00 (10 mins)	Spinal Curve Exercises *Aim: to identify and understand the primary and secondary curves in the spine. To draw awareness to how dancers carry their spine in their dancing posture*	• Roll over from CRP into fetal position • Feel curves in all regions of the spine • Open out with arms above the head into an arched position • Feel curves again, and draw awareness to any muscular tension	

		• Roll onto hands and knees and slowly do Cat-Camel exercise, arching back and curving the back	Notice how the cervical and thoracic spine curves when hands are in front
1.00 – 1.10 (10 mins)	Rocking Lunge *Aim: to identify how the spine adjusts and facilitates movement when lower body changes position*	• Wide fourth position with whatever foot they are most comfortable in front • First, bend the back knee and as they move into this lunge, allow the back to respond (will go towards primary curve) • Straighten the back leg to reset and then let the front knee bend, allowing the back to respond (will go towards secondary • Repeat rocking from back to front and eventually switch legs	Do not push or force this to happen Parallel and in gentle turnout 'Bowl of water' imagery See if they can facilitate this movement by leading from the head, with minimal changes in the spinal curvature (important for Irish dance posture). Lumbar curves will always move
1.10 – 1.20 (10 mins)	Chair Exercise *Aim: to become aware of habitual tensions we may carry in everyday life and draw awareness to how this can affect us in dance*	• Identify tension in upper fibres of trapezius (place hands on back of the neck) when sitting. Adjust head and spine accordingly • Try to stand up out to the chair without creating tension behind the neck • Following this, put hands by side and center feet flat on the floor. Move torso as one unit and hinge at the hip to stand • Hinge at hips to sit down again	Finger placement helps to detect any pulling back of the head – pressure on fingers indicates neck tension Draw awareness to what spinal curve they are experiencing and if it changes from sitting to standing Should experience a sensation of falling out of the chair Repetition = ease of movement
1.20 – 1.30	Butterfly Walking	• Ask them to pair up. One person will lead their partner around the room by guiding them with	Before starting, address the head/neck relationship as a source of primary

	Aim: to understand the primary control of the head-neck relationship	their hand by their neck, as opposed to pushing through the back • Partner should feel tension in the neck	control – we should lead our movements from our head Encourage bigger, slower steps – spine should still be free
1.30-1.50 (20 mins)	Cool-down + recap	• Separate from partner and continue walking at any pace while guiding from the neck • Discuss what has been achieved this lesson and what to expect following this session and brief outline of session four.	Researcher to discuss this.

d). Session Four

Timing	Section	Details	Practitioner Notes
0 – 5 (5 mins)	Introduction	• Roadmap the session • Questions	Emphasise that there is no right or wrong
5 – 15 (15 mins)	Walk around the space *Aim: develop an understanding of orientation and become familiar with the space, the floor and other people*	• Move at whatever tempo/style they would like • Stop whenever they feel like it • Bring awareness to the way they walk - Heavy on heel/toe? - Pressure on inside/outside • Discuss how it felt to walk after realigning their feet	*LINE:* LENGTHEN SPINE DOWNWARD - Bring awareness to the neck from butterfly and sacrum - Release tension in back muscles, especially lumbar *LINE:* BIG TOE – HEEL - Center at ankle joint - Reduces pronation/supination - Deeper ankle flexion and lengthen Achilles
15 – 30 (15 mins)	Rocking Lunge *Aim: to identify how the spine adjusts and facilitates movement when lower body changes position*	• Small lunge with whatever foot they are most comfortable in front • First, bend the back knee and as they move into this lunge, allow the back to respond (will go towards primary curve) • Straighten the back leg to reset and then let the front knee bend, allowing the back to respond (will go towards secondary	Do not push or force this to happen. Facilitate movement by leading from the head. Spine should not be fixed nor fluctuating Small movements in the spine (lumbar in particular) should be allowed. Otherwise adds to excess tension.

		• Repeat rocking from back to front and eventually switch legs • Repeat with small turnout		Perform in parallel first as to not to place excess tension on psoas muscle. *Observe whether a dancer is stuck in one curve or another*
30 – 50 (20 mins)	Chair Exercises *Aim: to understand how to facilitate efficient movement from a stable position*	Parallel	• Two feet normal stance • Two feet lunge stance • One foot	Move by hinging at the hip at leading from the head. Elongate neck and spine.
		Turnout	• Two feet normal stance • Two feet lunge stance • One foot	Encourage 'baby' turnout – less than what they'd use for starting position in Irish dance. Knees over toes (focus on back leg turnout as well). Swiss ball imagery.
50 – 1.00 (10 mins)	Leg Swings (Chair) *Aim: to identify and release tension in the hip flexors*	• Stand on edge of chair with one leg off • Allow hip to drop and release to swing freely • Repeat with hips square • Draw awareness to tilting of the pelvis		Same principles as previous: Spine should not be fixed nor fluctuating. Small movements in the spine (lumbar in particular) should be allowed. Otherwise adds to excess tension.
1.00 – 1.15 (15 mins)	Hands on Wall *Aim: to reduce tension in the pectoralis major, upper fibres of the trapezius and engage latissimus dorsi*	• Arm at 90 degrees to the wall and 180 from the body • Place pressure on the wall and hold • Should feel relaxed when bringing the arm down • Repeat on the other side		Isometric muscle contraction to engage the latissimus dorsi and release tension in the pectoralis major. Helpful in keeping shoulders neutral for posture and arm positioning in teams.

	Partnered Shoulder Mobilisation *Aim: to reduce tension in the pectoralis major, upper fibres of the trapezius and engage latissimus dorsi*	In standing, partner to mobilise shoulder joint, similar to the practitioner's work on the floor. Slightly lift up and rotate the humerus back to allow pectoralis major to lengthen and the upper fibers of the trapezius muscle to relax. Scapular should be relatively flat on the back	Imagery of lengthening the arm away from the shoulder
1.15 – 1.30 (10 mins)	Walking to Progress into Click-Throughs *Aim: to identify how the spine adjusts and facilitates movement when lower body changes position in larger movements* *To draw awareness to dynamic turnout mechanisms*	• Start in 'baby' turnout position • Walk around the room in turnout • Progress into walking click-throughs[36], pointing through the floor and leading from the heel • Progress into higher swings when bringing leg through	Will most like strike the foot with forefoot first when walking. LINE: LENGTHEN SPINE DOWNWARD Point from the ankle and extend the toes (encourage not to 'crunch' them)
1.30-1.50 (20 mins)	Cool-down + recap	• Walking at any pace while guiding from the neck/head, and think about movement on the floor	Researcher to discuss this

[36] Stepping forward in a turned-out position while extending the leading leg into a pointe. Similar to classical walk in ballet but with extended legs.

		• Discuss what has been achieved this lesson and what to expect following this session and brief outline of session five.	

e). Session Five

Timing	Section	Details	Practitioner Notes
0 – 5 (5 mins)	Introduction	• Roadmap the session • Questions	Emphasise that there is no right or wrong
5 – 10 (5 mins)	Walk around the space *Aim: develop an understanding of orientation and become familiar with the space, the floor and other people*	• Move at whatever tempo/style they would like • Stop whenever they feel like it • Bring awareness to the way they walk - Heavy on heel/toe? - Pressure on inside/outside • Discuss how it felt to walk after realigning their feet	*LINE:* LENGTHEN SPINE DOWNWARD - Bring awareness to the neck from butterfly and sacrum - Release tension in back muscles, especially lumbar *LINE:* BIG TOE – HEEL - Center at ankle joint - Reduces pronation/supination - Deeper ankle flexion and lengthen Achilles
10 – 25 (15 mins)	Floor Exercises *Aim: allow body to relax into the session, release tension and stresses*	• Focus on deep diaphragmatic breathing • Move pelvis around, lift off of the floor and gently lower each vertebra to the floor • Lift shoulder off of the floor and mobilise the glenohumeral joint • Feel for occipital joint between ears	Location of the lungs – expanding Shape of the spine – natural curves Think about tensions surrounding the glenouhumeral joint Reinforce primary control
25 – 40 (15 mins)	Walking for Alignment	• Begin in a standing position with feet parallel and body-map joints in this position	Bring in imagery of lines that had been explored on the floor

	Aim: to prepare the dancers for bigger movements by developing their kinaesthetic awareness in smaller movements	• Gently point toes in a tendu • Practice gentle turnout in first position • Lift and lower the leg in this position	Ensure they initiate movement from hip. Encourage awareness of pelvis and spine when turning out
40 – 50 (20 mins)	Turnout Tendus *Aim: to draw awareness to the supporting leg when performing small dance movements*	• Try tendus to the front, side and back and allow for natural spinal deviations • Progress onto lifting the leg slightly off of the ground in each tendu	Encourage imagery of each vertebra balancing on top of each other Focus on feeling for potential shifts in alignment
50 – 1.00 (10 mins)	Leg Swings *Aim: to identify how the spine adjusts and facilitates movement when lower body changes position in larger movements*	• Start with hand on wall for balance and feet together in natural turnout • Swing leg forward and back and notice how the head/neck/back adjust • Try again, but holding your head in place and notice how it affects hip mobility • Draw awareness to tilting of the pelvis - whether it's lifting up on one side	Minimal but not fixed – makes tense and forced posture • Observe whether a dancer is stuck in one curve or another
1.00 – 1.30 (30 mins)	Bouncing to Jumping *Aim: to identify changes in the spine when propelling into the air*	• In starting positions (first) with a natural turnout, jump into the air. Notice any movement in spine and ribcage • Stop and think about lengthening the spine, releasing the neck • Have a partner place hands on the lateral back of the ribcage	Dancers focus on end result of actually getting into the air and not the preparatory measures of *how* to get there.

		• Start bouncing and think about pushing the back into the hands, instead of thrusting into the ribcage • Progress into jumps and eventually, the partner should move away	Reinforce primary control, lengthening of the spine and other principles involved with chair exercises.
1.30-1.50 (20 mins)	Cool-down + recap	• Walking at any pace while guiding from the neck/head, and think about movement on the floor • Discuss what has been achieved this lesson and what to expect following this session and brief outline of session four.	

f). Session Six

Timing	Section	Details	Practitioner Notes
0 – 5 (5 mins)	Introduction	• Roadmap the session • Questions	Emphasise that there is no right or wrong
5 – 10 (5 mins)	Walk around the space *Aim: develop an understanding of orientation and become familiar with the space, the floor and other people*	• Move at whatever tempo/style they would like • Stop whenever they feel like it • Bring awareness to the way they walk - Heavy on heel/toe? - Pressure on inside/outside • Discuss how it felt to walk after realigning their feet	*LINE:* LENGTHEN SPINE DOWNWARD - Bring awareness to the neck from butterfly and sacrum - Release tension in back muscles, especially lumbar *LINE:* BIG TOE – HEEL - Center at ankle joint - Reduces pronation/supination - Deeper ankle flexion and lengthen Achilles
10 – 25 (15 mins)	Constructive Rest and Breath *Aim: allow the body to relax on the floor without resistance to gravity or major impact. Allow breathing to be efficient and focused.*	• Supine position – get them to start by sitting with their legs straight and lie down when feeling comfortable • Relax into the floor • Keep their limbs moving so they are comfortable • Progress into semi-supine to help lower back sink into the floor • Draw awareness to breathing	

	Body-Mapping (same position as above) *Aim: to develop an accurate anatomical understanding of one's body, making imagery and self-awareness more effective.*	• Head-spine joint • Arm-body joint • Hip joint • Shape of spine • Location of lungs	If feeling comfortable, encourage them to body-map in a standing position afterwards Encourage primary control as they pick up their blanket and move to standing
25 – 35 (10 mins)	Hands on Wall *Aim: to reduce tension in the upper fibres of the pectoralis major and engage latissimus dorsi* Partnered Shoulder Mobilisation *Aim: to reduce tension in the upper fibres of the pectoralis major and engage latissimus dorsi*	• Arm at 90 degrees to the wall and 180 from the body • Place pressure on the wall and hold • Should feel relaxed when bringing the arm down • Repeat on the other side • In standing, partner to mobilise shoulder joint, similar to practitioner. Scapular should be relatively flat on the back	Isometric muscle contraction to engage the lats and release tension in the pectoralis major. Helpful in keeping shoulders neutral for posture and arm positioning in teams. Imagery of lengthening the arm away from the shoulder
35 – 45 (10 mins)	Chair Exercise *Aim: to become aware of habitual tensions we may carry in everyday life and*	• Identify tension in upper fibres of trapezius (place hands on back of the neck) when sitting. Adjust head and spine accordingly • Try to stand up out to the chair without creating tension behind the neck	Finger placement helps to detect any pulling back of the head – pressure on fingers indicates neck tension

	draw awareness to how this can affect us in dance	• Once this is comfortable, hands by side and center feet flat on the floor, move torso as one unit and hinge at the hip to stand • Hinge at hips to sit down again • Repeat single leg	Draw awareness to what spinal curve they are experiencing and if it changes from sitting to standing Should experience a sensation of falling out of the chair Repetition = ease of movement
45 – 55 (10 mins)	Turnout Tendus *Aim: to draw awareness to the supporting leg when performing small dance movements*	• Try tendus to the front, side and back and allow for natural spinal deviations • Progress onto lifting the leg slightly off of the ground in each tendu	Encourage imagery of each vertebra balancing on top of each other Think about what shifts in alignment occur
55 – 1.10 (15 mins)	Bouncing to Jumping *Aim: to identify changes in the spine when propelling into the air*	• In starting positions (first) with a natural turnout, jump into the air. Notice any movement in spine and ribcage • Stop and think about lengthening the spine, releasing the neck • Have a partner place hands on the lateral back of the ribcage • Start bouncing and think about pushing the back into the hands, instead of thrusting into the ribcage • Progress into jumps and eventually, take the partners hands off	Dancers focus on end result of actually getting into the air and not the preparatory measures of *how* to get there.

1.10 – 1.20 (10 mins)	Breaking Down the *Fly* *Aim: to visualise themselves doing the fly in order to address efficient movement pathways*	• Lie back down on the floor and get them to visualise each stage of the *fly* • Work through all points from body-mapping at each stage	Include the steps leading into and out of the leap for preparatory tension and 'end-gaining'
1.20 – 1.40 (20 mins)	Practicing the *Fly* *Aim: to apply learned somatic principles to a common and physically-demanding leap in Irish dance*	• Let the participants do this at their own pace • Encourage breaking down the *fly* before moving into full leap • If they find tension or malalignments at any point, allow them to go back to visualisation, or partner up to release tension	Very important that they take as much time with this as is comfortable Encourage them to keep thinking about body-mapping, lines of movement, and breathing
1.40-1.50 (10 mins)	Cool-down + recap + general comments and feedback	• Walking at any pace while guiding from the neck/head, and think about movement on the floor • Discuss what has been achieved this lesson • Discuss how they are feeling, what they feel they have achieved from this intervention, and what they haven't	Researcher to do this

Appendix E. Ethical Approval Letter

H19/032

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

Academic Services
Manager, Academic Committees, Mr Gary Witte

28 March 2019

Dr P Lamb
School of Physical Education, Sport and Exercise Sciences
Division of Sciences
46 Union Street West

Dear Dr Lamb,

I am again writing to you concerning your proposal entitled "**Effects of somatic training on landing biomechanics in competitive Irish dancers**", Ethics Committee reference number **H19/032**.

Thank you for your email of 27th March 2019 with response and revised application attached addressing the issues raised by the Committee.

On the basis of this response, I am pleased to confirm that the proposal now has full ethical approval to proceed.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

A Final Report is required by the Committee upon completion of the study. The Final Report template can be found on the Human Ethics Web Page.

https://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Appendix F. Māori Consultation Letter

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KĀI TAHU

Wednesday, 27 March 2019

Dr Peter Lamb
School of PE, Sport and Exercise Sciences
University of Otago
PO Box 56
Dunedin 9054

Tēnā Koe Dr Peter Lamb

The effects of somatic training on landing biomechanics in competitive Irish dancers

The Ngāi Tahu Research Consultation Committee (the Committee) met on Tuesday, 12 March 2019 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states ″Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago″. As such, this response is not ″approval″ or ″mandate″ for the research, rather it is a mandated response from a Ngāi Tahu appointed Committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other Committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of interest to the dance, sports, and could also be of interest to kapa haka kaiako/teachers and groups.

The Committee suggests dissemination of the research findings to relevant Māori health organisations regarding this study, including Taeora Tinana, Maori Physiotherapists within the New Zealand Society of Physiotherapists. Consideration could also be given to involvement of researchers with an interest in competition level Kapa Haka for which competitors undertake intensive physical training, including leaps.

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtākou Incorporated
Kāti Huirapa Rūnaka ki Puketeraki
Te Rūnanga o Moeraki